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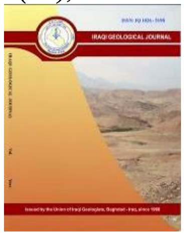

Sedimentological Investigation of the Euphrates River from Babylon to Basrah, Iraq

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Abstract

The Euphrates River is considered a famous one among the rivers in the world. The current study is an attempt to give information about the bed sediments from Hilla to Shatt Al-Arab at Basrah, through sedimentological investigations. Forty-two samples were subjected to grain size analysis, representing twelve core sampling sites. The sand fractions (fine-very fine) decrease from Hilla to Basrah cities, beside the interval depths from top to bottom, whereas the silt fractions increase in the same direction and the depth interval, because the water current declined. The light minerals are examined by a polarized transmitted microscope as well as scanning electron microscopy and energy dispersive X-ray spectrometer techniques. The light minerals consist of 95.7%, and the heavy minerals of 4.3% among the total counted grains. The rock fragments, particularly carbonate and chert are the predominant constituents and increase from Hilla to Basrah cities, followed by quartz reduced in the same pattern. In addition, the lowest abundance of feldspar minerals where recognize in lower values also decreases to the southern orientation. Monocrystalline quartz is higher than polycrystalline. However, plagioclase is lesser in proportion than potash feldspar (orthoclase and microcline). The river bed sands are litharenite classification, and petrogenically, are transition recycled to transition arc referring to orogenic recycled derivation.

Keywords: Grain size; light minerals; Basrah, submature; Monocrystalline; Microscope

1. Introduction

The Euphrates River is the longest in western Asia with a total length of 2940 km (1213 km which 40% of distance in Iraq) (Al-Bassam and Hassan, 2006). It originates in the mountains of eastern Turkey. the river runs through Syria and Iraq lands before meeting the Tigris near Qurna area at Basrah city forming Shatt Al-Arab, then drains in Arabian Gulf. Sedimentological study is important to recognize the palio-environment and ancient ecosystem of the source rocks (Wibe et al., 2001). It provides the time frame that allows us to interpret sediments of Euphrates River in terms of dynamic evolving environments (Nicols, 2009). Many previous studies related the investigated area were achieved such as; Darmoian and Lidqvist (1988), Al-Bssam (2000), Al-Bassam, and Al-Mukhtar (2008), Sedkhan (2009), Ahmed (2011), and Hussein and Al-Jaberi(2020).This study deals with mechanical analysis to determine the grain size of sand and mud. The polarized microscope investigation with scanning electron microscopy (SEM), and an energy dispersive X-ray spectrometer (EDS) techniques

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are achieved in order to determine the essential light minerals, mineral composition and other physical properties of fluviatile sediments in river bed, also to throw light on the sedimentologic and fluviatile conditions that influenced the different variables along the traverse of Euphrates River course within the study area.

The study area of the Euphrates River course extends from north Hilla to Basrah cities in Dear area. It crosses Hilla, Diwania, Simawa, Nasiria cities and reaches Basra in Qurna and Dear areas, for sampling as cores from middle river current (the taluk line). It lies between latitude 32 40 01.147 - 30 48 8.423 and longitude 44 19 21.214 – 47 35 19.32(Geographic system units) as shown in Fig.1. The length of the study area is more than 480 km.

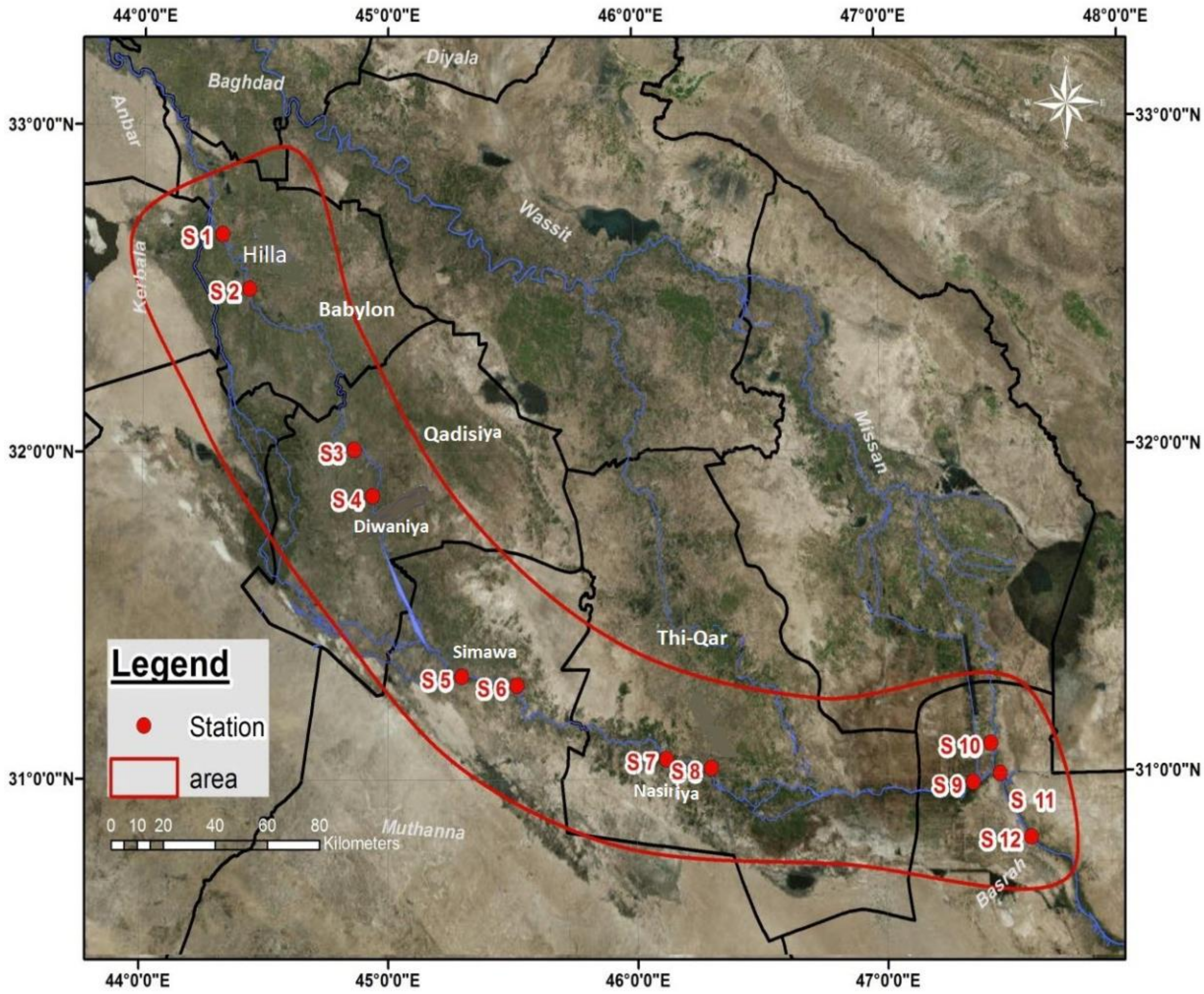

Fig. 1: Location map of the sampling sites in the study area

2. Geological Setting

The nature of geological rock formations of the Euphrates River has a significant impact on determining the nature of the river and its composition. The stratigraphic setting can be demonstrated as; Dammam Formation (middle-late Eocene), Euphrates Formation (early Miocene), Fatha Formation (middle Miocene), Nfayil Formation (middle Miocene), Injana Formation (late Miocene), Dibdibba Formation (Pliocene-Plistocene), Zahra Formation (Pliocene- Pleistocene), Quaternary Deposits (Pleistocene-Holocene) (Jassim and Goff, 2006; Bellen et al.,1959; as shown in Fig. 2.

Tectonically, According to Fouad (2010a), the study area of Euphrates River is located within Tikreet-Amara and Simawa-Nasiriya belts in the Mesopotamian zone within Mesopotamia Foredeep.

South of the Euphrates River course, between Simawa and Nasiria, the river abandoned its channel, due to the effects of Abu Jir fault zone which has several NW-SE trending faults. The trend of Abu Jir fault zone spreads from Ana Graben, across the Euphrates River valley to Heet, extending to Awasil, Abu Jir, Shithatha, and passing through the Euphrates River a long western side through Kerbala, Najaf and Simawa, until the west of Basrah and north west of Kuwait to meet Hafr Al-Batin lineament (Fouad, 2007).

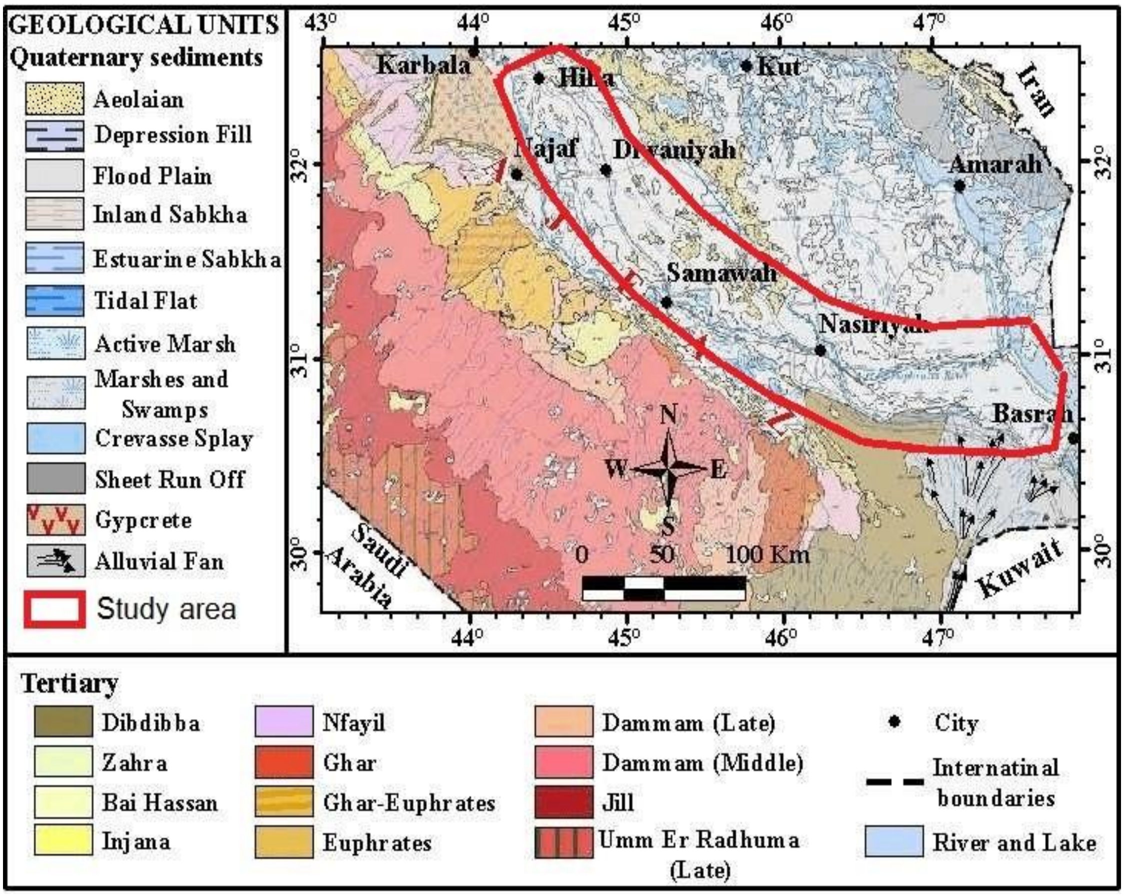

Fig. 2: Geologic map of Mesopotamian plain explained study area (after Sissakian and Fouad, 2012)

3. Materials and Methods

According to the scale of Wentworth (1922), used by Folk (1974), the Euphrates River sediments are sized into sand, silt and clay. All samples are wet-sieved using the sieve of 63 µm diameter. The fractions >63 µm were dried and weighted for sand content, whilst the fractions <63 µm were analyzed using pipette to separate clay fractions of < 3.9 µm from silt fractions of 3.9-63 µm .

Sand with a grain size from 0.0625 to 0.250 mm, and a weight 10 gms was suitable for the object of the current study, sand grains were immersed in the heavy liquid bromoform with a specific weight of 2.9 (Carver , 1971) to separate the heavy minerals from the light minerals which floated in the liquid (Mange and Maurer,1992). The sand grains are mounted on a glass slide with Canada balsam as cohesive matter and examined under the polarized microscope to determine the types, shapes and percentage of the minerals in each sample. The preparation of the light minerals of the study area were performed in the geochemical laboratory of applied geology department, in the College of Science at University of Babylon. The petrographical investigations and analyses were achieved in the lab of geology department, in the College of Science at University of Baghdad. SEM-EDS is a technique which used to determine the elemental composition of a surface of the samples (Mange and Maurer,1992). SEM and EDS analyses were carried out for the light and heavy minerals at the lab in the Collage of Pharmacy, University of Basrah by a ZEISS (SUPRA 55VP).

4. Results

4.1. Grain Size Analysis

Grain size distributions provide important clues of sediment provenance, transport history and depositional conditions (Sierra et al., 2013). In order to cover all the study area, forty two samples were selected from twelve cores. Each core is divided for several zones from top to bottom. Grain size analysis is done and classified according to Folk (1974) as shown in Tables 1, 2, and Fig. 3. At Al-Hilla city, two cores were chosen at two sites ; Hilla/1, and Hilla/2 represented by two cores (SI and S2). The depth of S1is 52cm which is divided into five zones, whereas S2 is 40cm divided into four zones. The data attained are summarized in tables 1, 2, and figure 2. The weight percentage of sand fractions in both sites ranged between 87 % to 97% with an average of 93 %, silt fraction was 0.5 to 11 % with an average of 5%, and clay fraction was 0 to 4 % with an average of 1.5%. Sand texture is the main in these sites. At Al- Diwania city, two sites were chosen which were Diwania/1 and Diwania/2 with two cores represented by S3 and S4. The depth of S3 was 33cm, divided into three zones, while the depth of S4 was 38cm divided into four zones. Sand fractions in both sites ranged between 80 to 92% with an average of 86%; whereas silt fractions ranged between 8 to 16 % with an average of 12%, and between 0 to 5 % for clay fractions, with an average of 2%. The texture of these sites was sand to silty sand.

Two sites at Al-Simawa city; Simawa/1 and Simawa/2 were conducted, two cores were chosen in those sites represented by S5 and S6. The depth of S5 is 30cm, divided into three zones, while the depth of S6 was 27 cm, and is also divided into three zones. In both sites, sand is restricted between 23 to 63% with an average of 43%, silt ranged from 26-62 % with an average of 44% and clay ranged from 11 to15 % with an average of 13%. The texture is sandy silt. Nasiria/1 and Nasiria/2 were selected at Al-Nasiria city, with two cores represented by S7 and S8. The depth of S7 was 23cm, divided into two zones, whereas S8 was 24cm, divided into two zones. In both sites, sand ranged between 11.5 to 33% with an average of 22%,while silt ranged between 48 to70% with a mean of 55%, and finally, clay ranged between 9 to 27.5% with an average of 18%. The dominant texture in these sites is sandy silt.

At Al-Basrah city, two main sites were chosen. The first in Al-Qurna area and the second in Al-Deer area. Three sites were selected in Al- Qurna area; first was Qurna/Furat in the Euphrates River , second was Qurna/ Dijla in the Tigris River, and the third site was Qurna /meeting where the Euphrates and Tigris Rivers are met. Three cores in those sites were chosen represented by S9,S10 and S11. The depth of S9 is 31cm, divided into three zones. The depth of S10 is 42 cm, divided into four zones. The depth of S11 is 32cm, divided into three zones. In these sites , the range of sand fractions is about 3 to 15 % with a mean of 9 %. The range of silt is 64-85 % with a mean of 71%, whereas clay fractions ranged between 4.5-27 % with an average of 19 %. The sediments texture in these sites tends to be silt. In Al-Deer area , only one site was selected with one core which is S12. The depth of this core is 58 cm, divided into six zones. Sand fractions restricted between 3 to-8% with a mean of 7%, silt is between 70 to 83 % with a mean of 77% and clay is between 10 to 26% with a mean of 16%. The texture in this site appears to be silt texture.

It seems obviously, as mentioned above, the grains of the sediments in river bed decrease, generally in their sizes southern trend (toward Basrah city). In the same time, the sediment texture is also changed from sand in Hilla city to silt at Basrah city.

On the other hand, the percentage of silt and clay fractions increase with the depth in all of studied sites, opposite of sand fraction contents, as mentioned Tables 1, 2, and Fig. 3. This phenomenon mayby attributed to fluctuate the hydrodynamic energy, which decreases from Hilla to Basrah cities (Al-Jeafir, 2020).

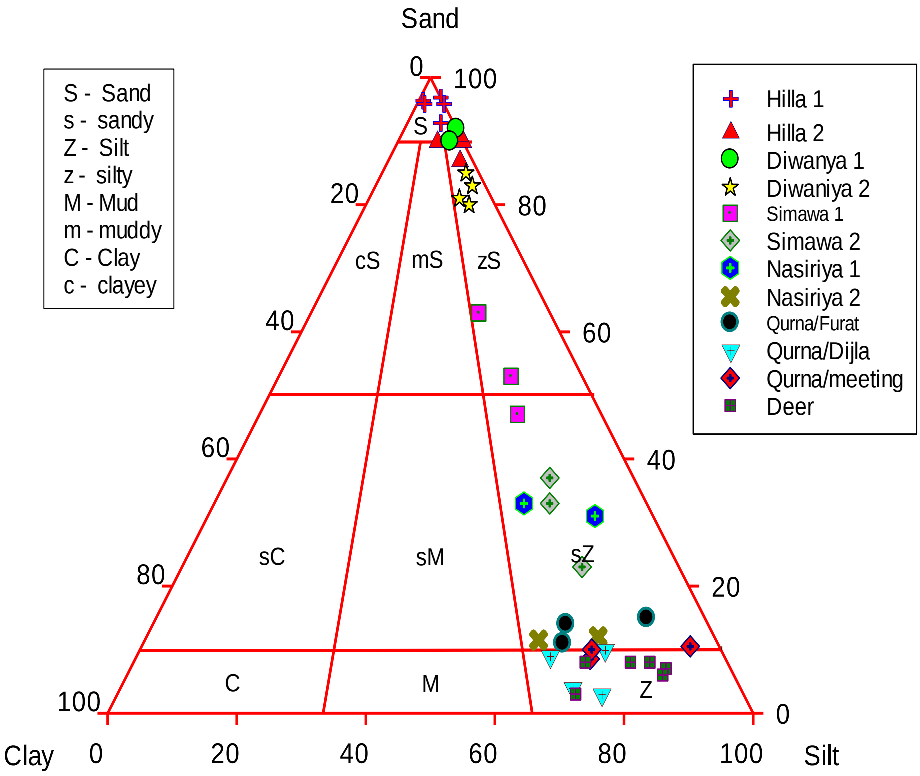

Fig. 3. Triangle classification of texture for the study area after Folk (1974)

Table 1. Grain size distribution and texture sediments in the study area

Site name	Core name	Sample name	Depth interval (cm)	Clay %	Silt %	Sand %	Sum. %	Texture
		1a	0-10	3	0.5	96.5	100	sand
		1b	10-20	0	3	97	100	sand
Hilla/1	S1	1c	20-30	3	1	96	100	sand
		1d	30-40	0	4	96	100	sand
		1e	40-52	2	5	93	100	sand
		2a	0-10	4	6	90	100	sand
Hilla/2	S2	2b	10-20	0	10	90	100	sand
		2c	20-30	2	11	87	100	Silty sand
		2d	30-40	0	9	91	100	sand
		3a	1-10	2	8	90	100	sand
Diwaniya/1	S3	3b	10-20	0	8	92	100	sand
		3c	20-33	2	8	90	100	sand
Diwaniya/2	S4	4a	0-10	4	16	80	100	Silty sand
		4b	10-20	2	15	83	100	Silty sand

		4c	20-30	2	13	85	100	Silty sand
		4d	30-38	5	14	81	100	Silty sand
Simawa/1	S5	5a	0-10	13	40	47	100	silty sand
		5b	10-20	11	36	53	100	silty sand
		5c	20-30	11	26	63	100	silty sand
Simawa/2	S6	6a	0-10	13	50	37	100	sandy silt
		6b	10-20	15	62	23	100	sandy silt
		6c	20-27	15	52	33	100	sandy silt
Nasiriya/1	S7	7a	0-10	9	60	31	100	Sandy silt
		7b	10-23	19	48	33	100	sandy silt
Nasiriya/2	S8	8a	0-10	27.5	61	11.5	100	Sandy silt
		8b	10-24	18	70	12	100	Sandy silt
Basrah/Qurna/ Furat	S9	9a	0-10	22	64	14	100	sandy silt
		9b	10-20	24	65	11	100	sandy silt
		9c	20-31	9	76	15	100	Silt
Basrah/Qurna/ Dijla	S10	10a	0-10	26	70	4	100	silt
		10b	10-20	18	72	10	100	silt
		10c	20-30	22	75	3	100	silt
		10d	30-42	27	64	9	100	Silt Sandy
Basrah/Qurna/ meeting	S11	11a	0-10	4.5	85	10.5	100	silt
		11b	10-20	21.5	70	8.5	100	silt
		11c	20-32	20	70	10	100	silt
Basrah/ Deer	S12	12a	0-10	12	80	8	100	silt
		12b	10-20	10	83	7	100	silt
		12c	20-30	15	77	8	100	silt
		12d	30-40	22	70	8	100	silt
		12e	40-50	11	83	6	100	silt
		12f	50-58	26	71	3	100	silt

Table 2: Grain size of the sediments particles in the study area

Site	v.coarse sand(%) 1-2mm	coarse sand (%) 1-0.5mm	m.sand (%) 0.5-0.25mm	Fine sand fraction (%) 0.25-0.125mm	v.fine sand fraction (%) 0.125-0.063mm	silt fraction (%) 0.063-0.004mm	clay fraction (%) 0.004-0.001mm	total
Hilla	0	0	0	42	51.5	5	1.5	100
Diwania	0	0	0	18	68	12	2	100
Simawa	0	0		15	28	44	13	100
Nasiria	0	0	0	4	23	55	18	100
Basrah	0	0	0	3	5.5	74	17.5	100
Range	0	0	0	3-42	5.5-68	5-74	1.5-18	
Average		0	0	16	35.5	38.5	10	100

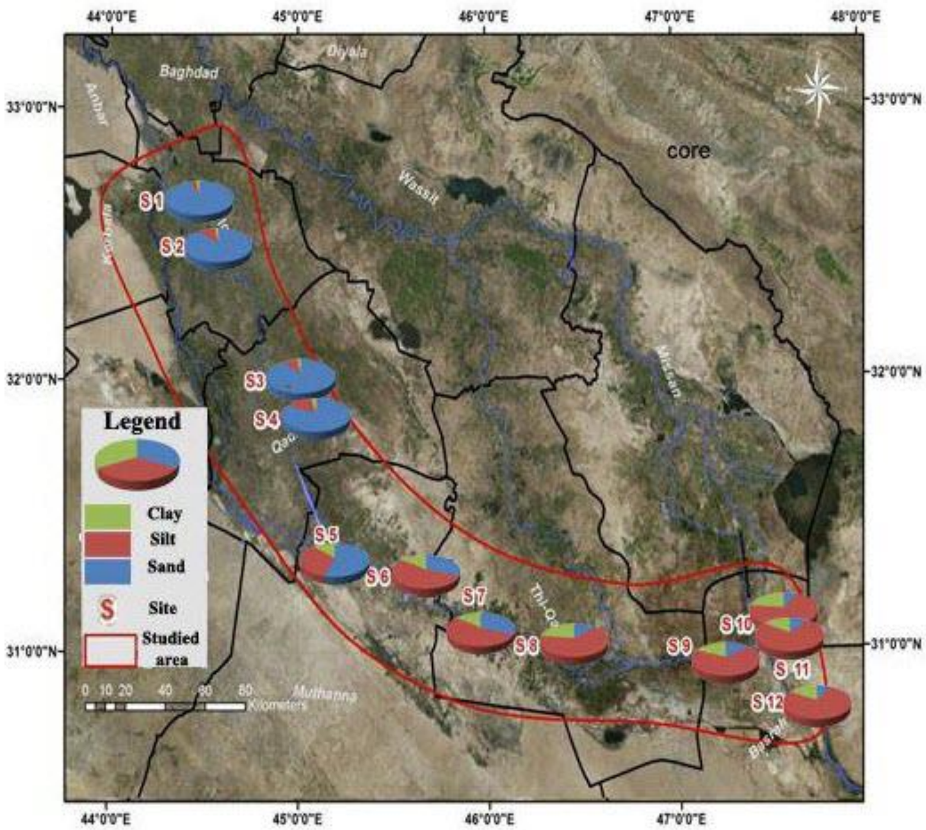

Fig. 4. Spatial distribution map of grain size (sand, silt, and clay) in the study area of the Euphrates River course

4.2. Petrographic Investigations

4.2.1. Light minerals

4.2.1.1. Rock fragments

From the polarized microscopic investigation, the rock fragments represent the major compenents of the light minerals with 52.4% of them. The carbonate rock fragments participated with a mean of 18.4% which are the major constituents of sedimentary rock fragments. They ranged from 13.7% in S1 to 23.7% in S12 (Table 3). Carbonate rock fragments can be seen in rounded and angular forms (Plate1b, and c, as well Fig. 5). Chert is the second major in the sedimentary rock fragments, that ranged from 11.8% in core S12 to 14.7% in core S1, with rounded or subrounded shape (Plate 2f) as in core sample 1a. Mudstone and evaporates are considered the minor components in sedimentary rock fragments. Mudstone ranged between 4.7% in core S7 to 7.3 % in core S12 (Table 3). Evaporates ranged from 4.1% in core SI to 6.2% in core S12,. Evaporate grain of secondary gypsum appeared as rounded form (Plate1a). Igneous rock ranged between 4.8% as a lowest amount in S1 to 6.5% as a highest abundance in S12 (Al-Jeafir, 2020) (Table 3 and Fig. 5). The grains are subangular shape (plate 1f). Metamorphic rock fragments had the lowest percentages in all studied samples due to either scarcity of metamorphic rocks in the supplying source or to mechanical fragmentation during transport. Schist fragments are noticed under microscope with elongated and subrounded form (Plate 1e).

Table 3: Light mineral distribution in the sampling sites of the study area

Site/ core name.	**Sample name**	**Quartz % constituents**		**Feldspar % Constituents**			**Rock fragment % Constituents**						
		Mono.	**Poly.**	**orthoclase**	**microcline**	**Plagioclase**	**Chert**	**Carbonate**	**igneous**	**metamorphic**	**Mudstone**	**evaporates**	**Total %**
	1a	34.4	4.5	5.3	3.7	5.4	14.8	13.6	5.0	3.9	5.5	3.9	100
	1c	35.4	5.0	5.4	4.4	4.3	14.4	13.5	4.4	3.7	5.4	4.1	100
Hilla 1 / S1	1e	34.2	4.9	5.2	3.7	4.3	15.0	14.0	4.9	4.0	5.5	4.3	100
	Mean	34.7	4.8	5.3	3.9	4.7	14.7	13.7	4.8	3.8	5.5	4.1	100
	4a	33.7	4.0	4.8	3.8	5.3	13.6	16.6	4.2	4.5	5.4	4.0	100
	4c	33.0	4.7	3.9	3.0	5.5	13.6	17.1	5.0	5.1	4.5	4.6	100
Diwania1/S4	4d	33.4	4.3	4.2	3.0	5.0	13.2	16.5	5.6	4.4	5.6	4.8	100
	Mean	33.4	4.2	4.3	3.3	5.3	13.5	16.7	4.9	4.7	5.2	4.5	100
	7a	33.0	3.7	4.0	4.1	5.0	13.7	16.8	5.3	4.5	4.6	5.3	100
Nasiria/1/S7	7b	33.0	3.2	4.7	4.0	4.5	13.0	18.0	5.3	4.1	4.8	5.4	100
	Mean	33.0	3.5	4.4	4.0	4.7	13.3	17.4	5.3	4.3	4.7	5.4	100
	9a	24.2	5.7	5.5	3.9	4.8	13.5	20.0	5.9	5.0	5.7	5.8	100
Basrah/Qurna/ S9	9c	22.8	5.2	4.3	4.2	5.8	12.9	21.6	5.6	5.6	5.5	6.5	100
	Mean	23.5	5.5	4.9	4.0	5.3	13.2	20.8	5.8	5.3	5.6	6.1	
	12a	21.0	3.8	4.9	4.5	5.5	11.3	23.4	6.7	5.8	7.4	5.7	100
Basrah/Deer/S12	12c	22.5	3.0	5.0	3.5	5.7	12.3	24.0	6.2	4.9	7.1	6.8	100
	Mean	21.7	3.4	5.0	4.0	5.6	**11.8**	**23.7**	**6.5**	**5.3**	**7.3**	**6.2**	100
Total mean		29.3	4.3	4.8	3.8	5.1	13.3	18.4	5.4	4.7	5.6	5.3	100

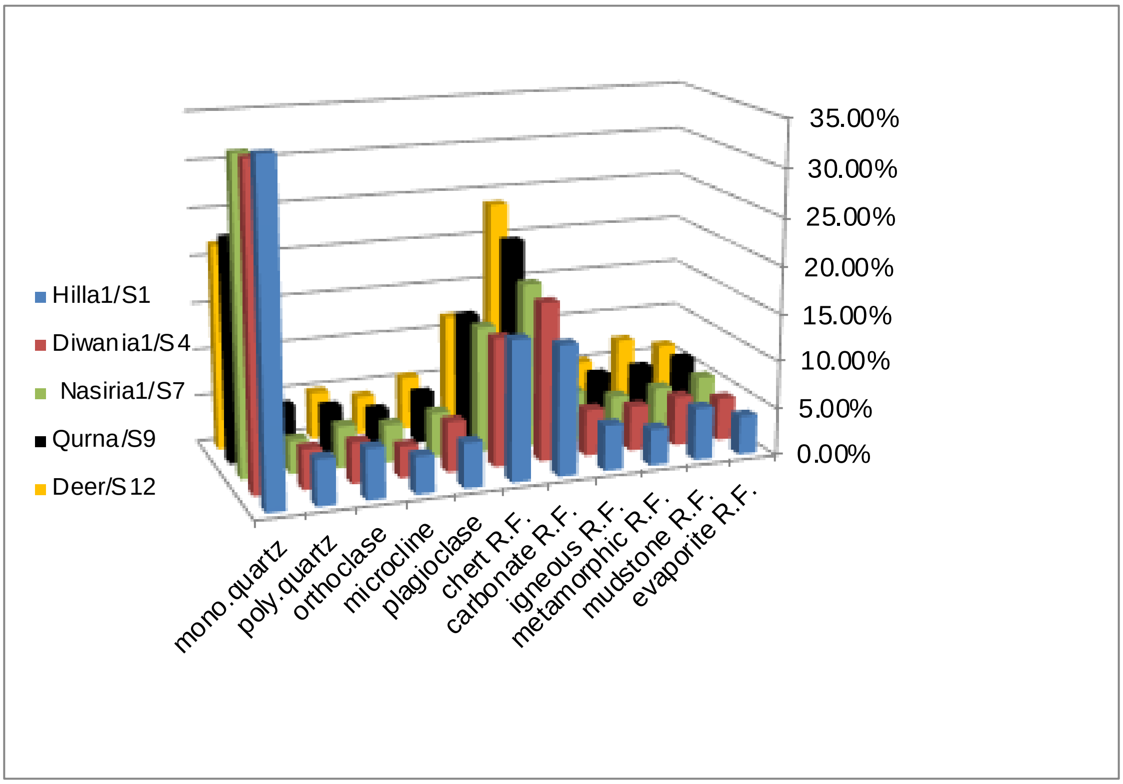

Fig. 5. The distribution of the light mineral in the selected samples of the study area

4.2.1.2. Quartz SiO2

Quartz is a resistant mineral to weathering processes during long-distance transportation (Tucker, 1991). Two types were recognized under polarized microscope; mono and polycrystalline quartz. The abundance and characters of each type are discussed below as in Table 3, and Fig. 5:

- Monocrystalline quartz grains consist of single crystal (Tucker, 1985). It represented the major quartz type observed in all studied core samples. Their percentage averages are 34.4% in S1, 33.4% in S4, 33.0% in S7, 23.5 in S9 and 21.7% in S12 (Table 3 and Fig. 5). Monocrystalline quartz is observed as a angular shape in sample 1a (Plate 2a).
- Polycrystalline quartz grain consists of two or more quartz crystal units of different optical orientation with different types of intergranular boundaries (Tucker, 1985). The highest amount was noticed in sample 9a with proportion of 5.7% in Qurna area, whereas the lowest abundance in sample 12c of 3.0% in Deer area. The form of polycrystalline quartz observed in core sample 9a (Plate 2b) is subrounded. Fig. 6 shows quartz under SEM-EDS,which suffered high weathering grade and soluble effects, whereas Fig. 7 display elongated, and moderately spherical quartz form under SEM. Quartz particles reduced, gradually toward Basrah city coinciding with the decrease of gran size due to the weakness of water currents.

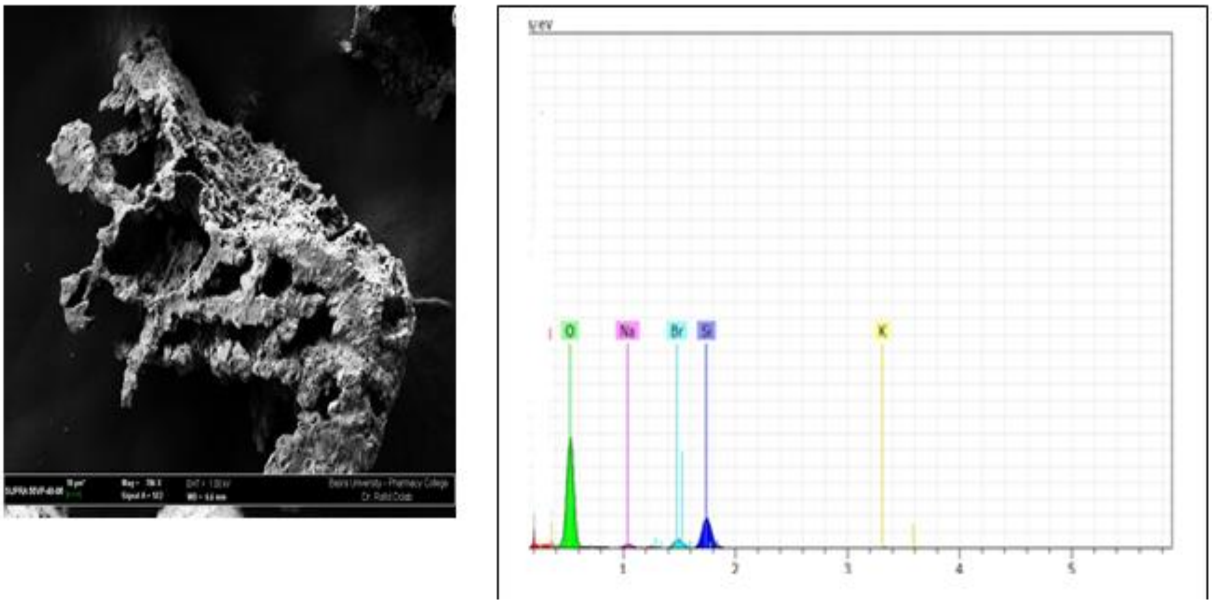

Fig. 6. SEM-EDS back scattered image showing quartz suffered high weathering grade and soluble effects in sample of 1e at Hilla (S1)

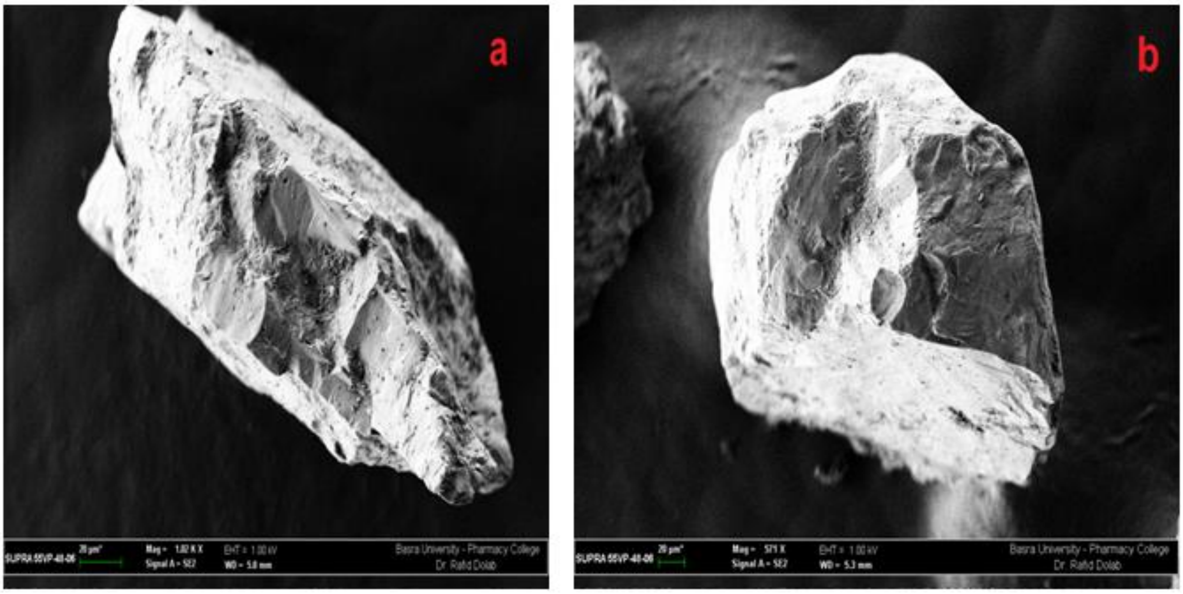

Fig. 7. 1 a, and b: Backscattered image using SEM technique shows sphericity of quartz grains in core sample of 1a (Hilla 1/S1), a is elongated, and b is moderately spherical (scales 20 micrometer)

4.2.1.3. Feldspar

Feldspar has a little resistance to weathering processes than quartz mineral (Khalaf et al., 1984), hence it weathered during long transportation. Feldspar minerals are divided into two groups, one of them is potash feldspar such as orthoclase and microcline; whereas the other is plagioclase. Plate 2 and Fig. 5 described the percentage of feldspar types.

- Potash feldspar should be more stable in weathering environments than plagioclase feldspars (James et al., 1981). Orthoclase ranged from 5.3% to 4.3% in S1(Hilla 1) and S4 (Diwania 2), respectively. It was an altered subangular form as in sample 12c (Plate 2c). Microcline was found in highest percentage in sample 12a, and the lowest amount in sample 4d, as shown in Table 3. Microcline shapes have cross hatch twinning, and observed as subrounded shape, with degrees of alteration (Plate 2d).

- Plagioclase represented the other group of feldspars observed in the studied samples. The greatest quantity noticed in Basrah/Deer site S12 with an average of 5.6%, while the lowest was in Hilla1 site S1 with an average of 4.7%, as clear in Table 3. The shape of plagioclase appeared subrounded (Plate 2 e) (Al-Jeafir, 2020).

According to the contents of rock fragments, quartz, and feldspar, noticed that quartz content decreased from north of the study area in Hilla city to south in Basrah city. In opposite, rock fragments and feldspar increased from north to south of the study area, as cleared in Fig.5. The classification of sand is litharenite according to Folk (1980) as shown in Fig. 8.

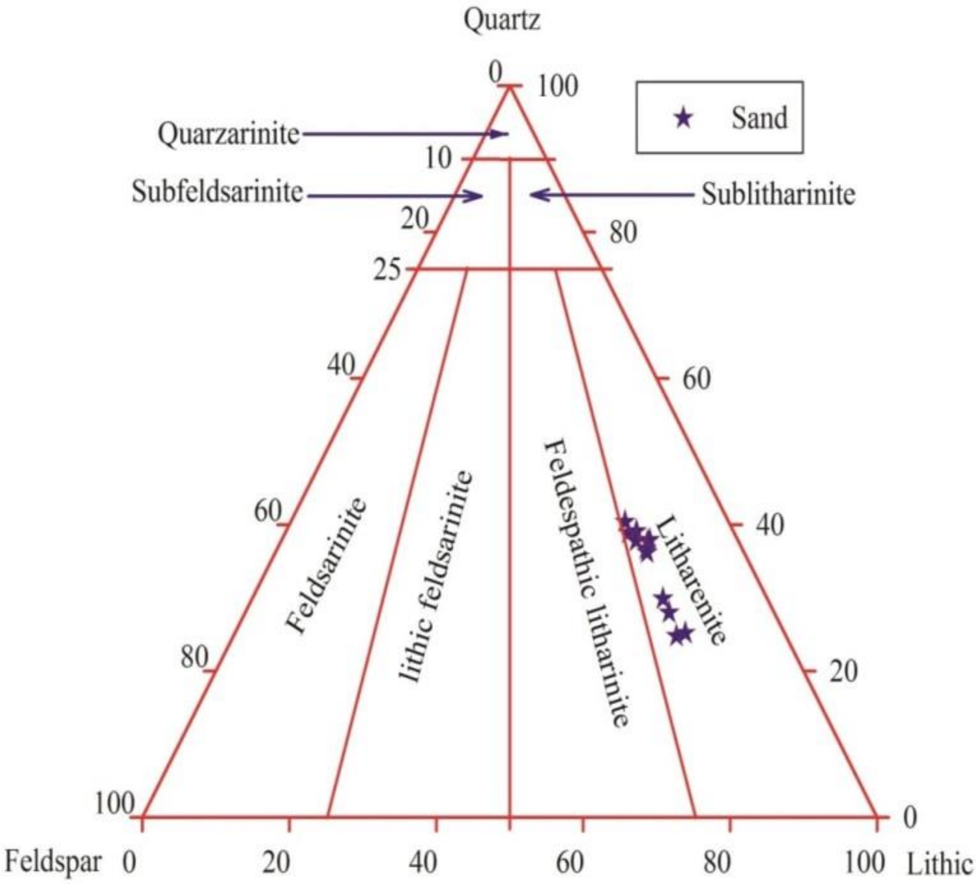

Fig. 8. Sand classification of the Euphrates River bed sediments according to Folk (1980)

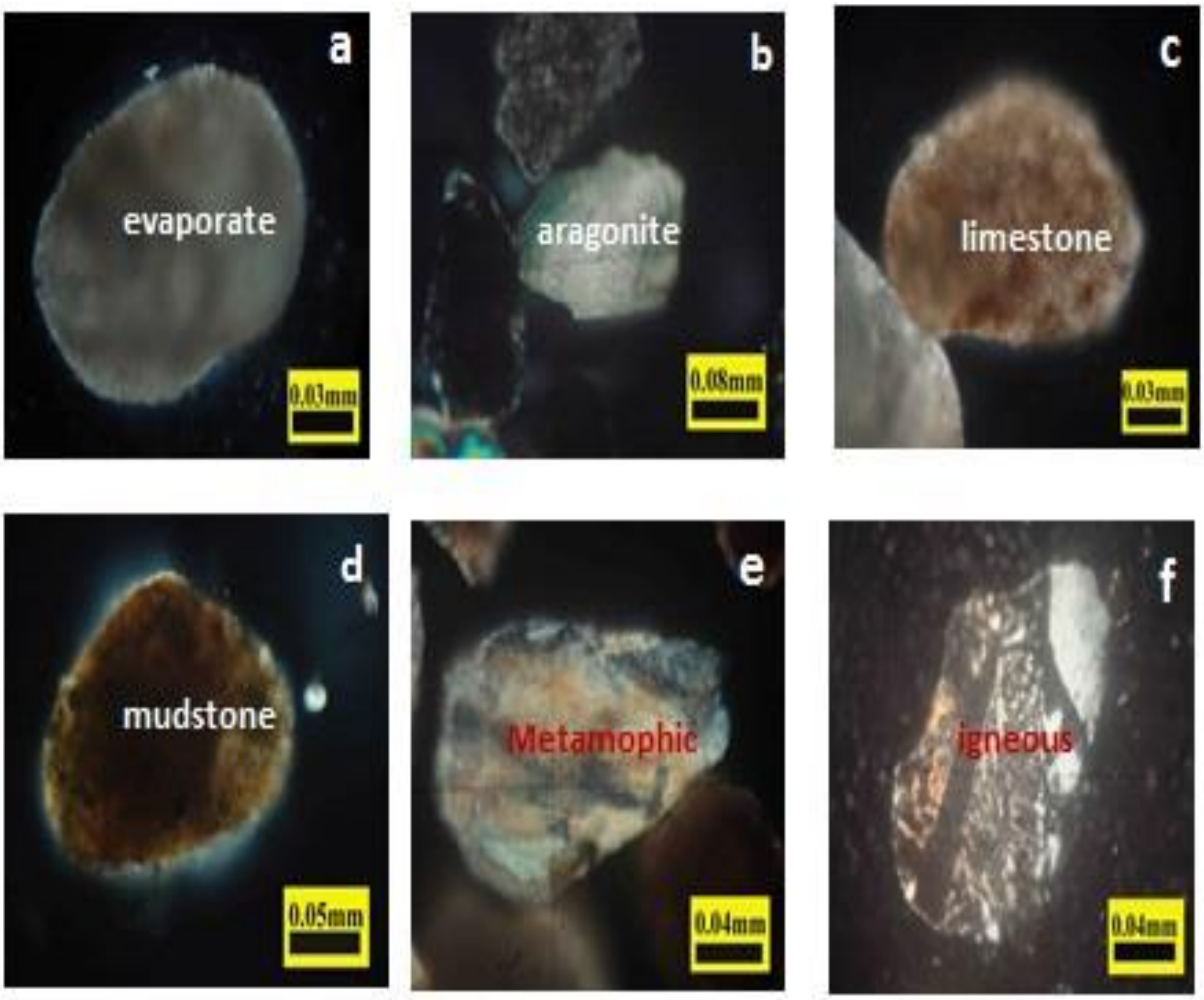

Plate 1. Micrographs of the Euphrates River bed sediments samples clarified:

a- rounded evaporite rock fragment (secondary gypsum), core sample 4a, under XPL.

b- angular carbonate rock fragment (aragonite shell), core sample 12c, under XPL.

c- subrounded carbonate rock fragment (Limestone), core sample 1a, under XPL.

d- rounded mudstone rock fragment, core sample 9a, under XPL.

e- Subangular metamorphic rock fragment (schist), core sample 9a, under XPL.

f- Subangular igneous rock fragment, core sample 4a, under XPL.

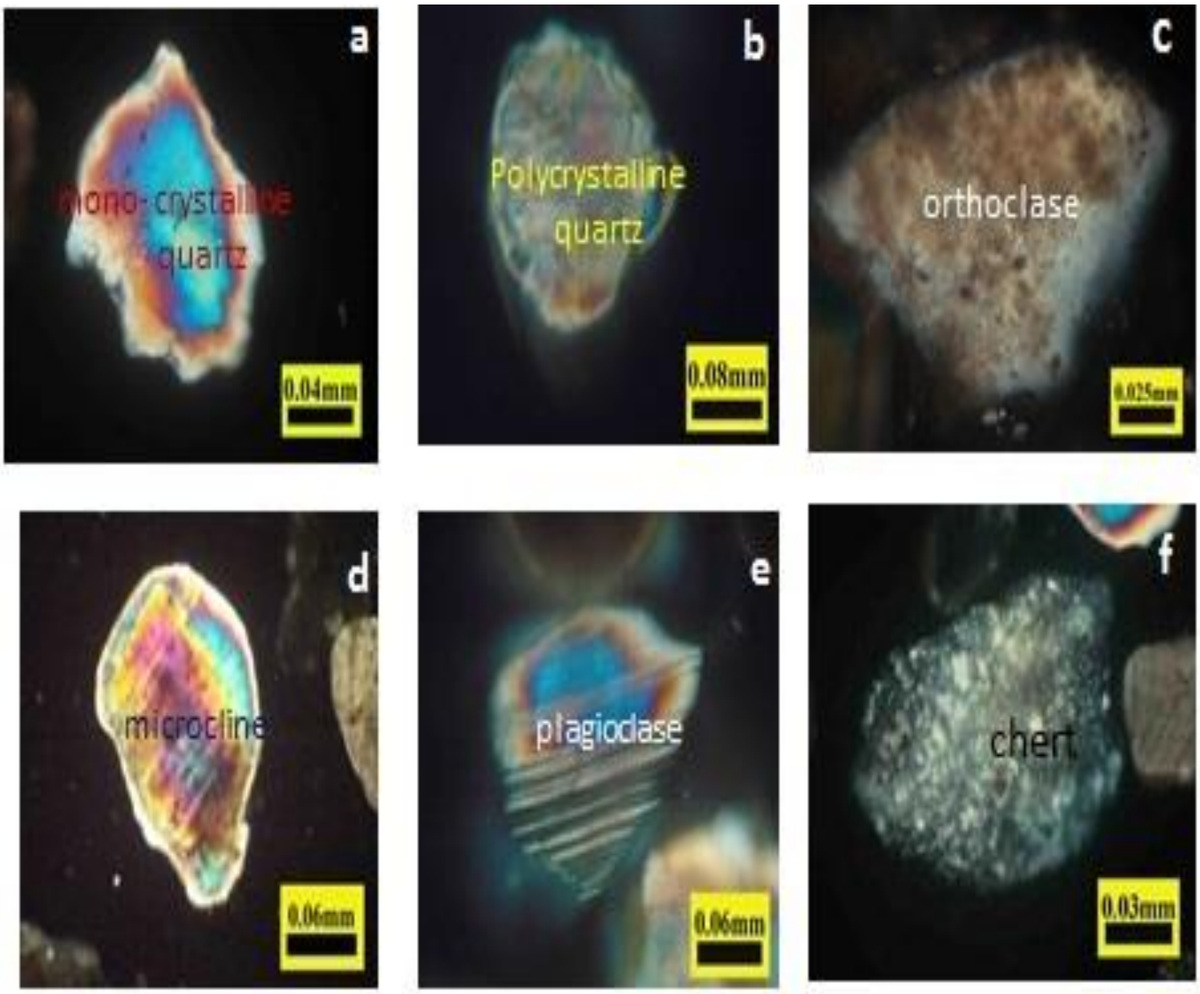

Plate 2. Micrographs of the Euphrates River bed sediments core samples clarified:

a-angular monocrystalline quartz, core sample 1a, under XPL.

b- subrounded polycrystalline quartz, core sample 9a, under XPL.

c-angular to subangular, altered orthoclase, core sample 12c, under XPL.

d-sub rounded, altered microcline,with cross-hatched extinction,core sample 1a,under XPL.

e- subrounded plagioclase feldspar, with carles bad twining, core sample 4a, under XPL.

f- subrounded chert rock fragment, core sample 1a, under XPL.

4.2.2. Petrogenesis

To interpret the tectonic discrimination source fields, the core sand samples of the studied area are plotted on the quartz-feldspar-lithic rock fragments (QFL) ternary diagram of Dickinson and Suczek (1979). The studied sand samples fall in the transitional recycled and extended to the border of transition arc field (Figure 9). These sediments are derived from orogenic recycled activity (Tucker, 2001).

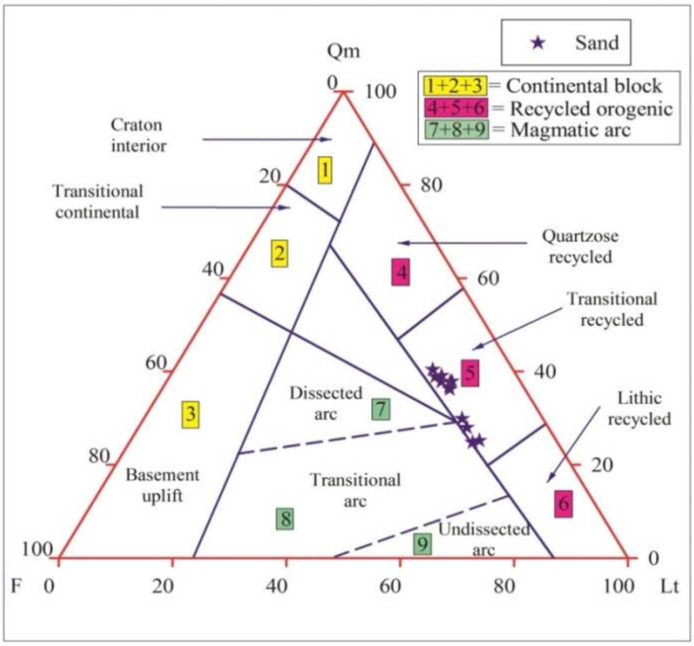

Fig. 9. Tectonic discrimination fields defined by Dickinson and Suczek (1979) on Quartz-Feldspar-Lithic rock fragment diagram showing sand modal of the Euphrates River bed sediments.

4.2.3. Maturity and paleoclimate

The mineralogical maturity index (MMI) = Q+Ch /F +RF, where Ch refers to chert rock fragments (Pettijohn,1957), that is determined for the Euphrates River bed clasts (Table 4).

The average value of MMI is 55.6 ranging from 54.8 to 57.5, indicated that studied sediments are generally, immature. Immature clastic sediments are represented either by arkosic or lithic arenites. The Euphrates River bed sediments are, generally litharenite sands (Fig. 8).

Table 4. Data of mineral maturity index (MMI) in investigated area

Site/core name	Sample name	Depth interval (cm)	MMI	Total Q/F+RF	Polycrystalline Qp/F+RF
Hilla 1/S1	1a	0-10	55.3	40.3	4.4
	1c	20-30	55.8	40.9	3.6
	1e	40-52	55.3	39.8	4.9
Diwania 1/S4	4a	0-10	55.0	40.9	4.1
	4c	20-30	55.0	40.2	4.8
	4d	30-38	55.0	40.0	5.0
Nasiria 1/S7	7a	0-10	55.3	40.5	4.2
	7b	10-23	55.4	41.0	3.6
Basrah/Qurna/S9	9a	0-10	54.8	38.0	7.2
	9c	20-31	56.6	36.8	6.6
Basrah/Deer/S12	12a	0-10	55.8	38.4	5.8
	12c	20-30	57.5	37.9	4.6

To discriminate the paleoclimatic conditions affected the Euphrates River bed sediments in the studied sites, a log/log plot of the ratio of total quartz (Q) to total feldspar (F) plus rock fragments (RF) against the ratio of total polycrystalline quartz to total feldspar plus rock fragments given by Suttner and Dutta (1986), was used as a sensitive discriminator of clastic sediments with different climate heritage as in Fig. 10 and Table 4. From this discrimination, the studied area occupied the humid field. Humid conditions may play a role in the dominance of rock fragments and reducing quartz and feldspars.

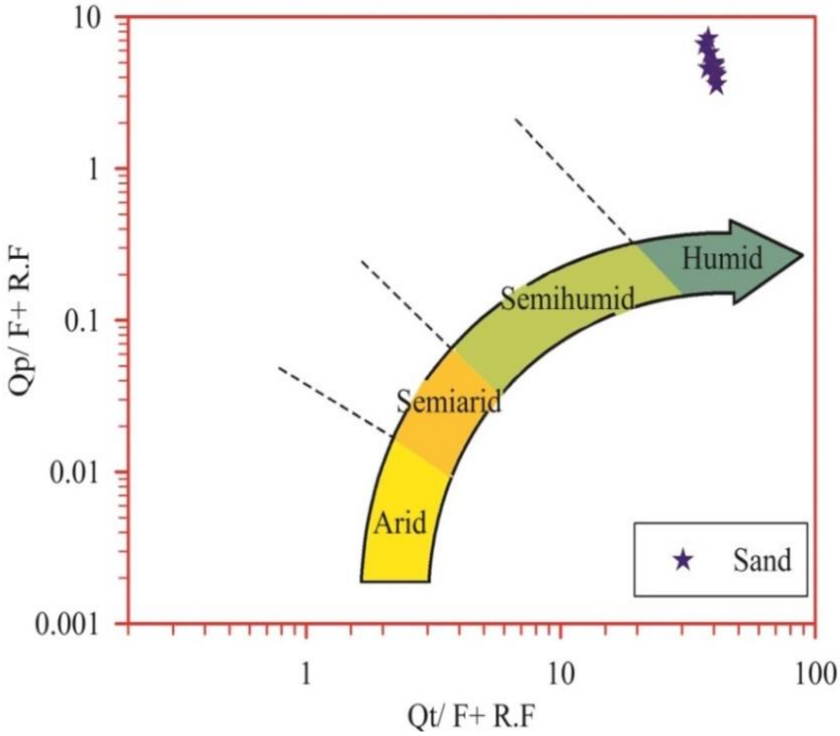

Fig. 10. Bivariant log/log plot of paleoclimate conditions affected the Euphrates River bed sediments in the studied sites (after Suttner and Dutta, 1986)

5. Discussion

From grain size analysis and the results of the study area, the size of particles decreased toward the south direction and downward with increasing depth intervals from Hilla to Basrah cities. That result is attributed to hydrodynamic agent and speed of water currents, which have high energy at Hilla and Diwania and then gradually, being slow toward the other cities.(Tables 1, 2, Figs. 3, and 4). The polarized microscopic study showed that carbonate rock fragments are the main type of lithic fragments which increase, gradually toward the south trend and downward according to the depth intervals, moreover those fragments are found in the fine particles, especially at Nasiriya and Basrah cities. It is derived from Euphrates and Dammam formations as mentioned above. Other rock fragment types refer to basic igneous and metamorphic origins, as well other sedimentary formations, such as Fatha or Injana formations as at Hilla and Diwania cities. The shape of these fragments ranged from sub angular, subrounded to rounded (Plate 1), which reflected the effects of water currents along the course of Euphrates River. Under polarized microscope, polycrystalline quartz is the lower amount (4.3%) than mono type (29.3%) as observed in Table 3. This result may be attributed to less stability of polycrystalline than mono during weathering and transportation, in addition to the metamorphic rock source of poly type. The increase of proportion of monocrystalline quartz is a reflection of igneous source rocks, and transportation of these grains for more than one sedimentary cycle. The present quartz is, generaly attributed to felsic (granitic rocks) sources which effectively, indicate continental origin. Subangular shape of the mineral in S1 site at Hilla city to subrounded in S9 site in Basrah city (Plate 2) gave a scientific indicator for the nature of deposition and the transportation distance. Generally, quartz mineral reduces southward to Basrah city due to reducing sand fractions. Feldspars characterized by the lower resistance to weathering processes than quartz (Khalaf et al., 1984), furthermore almost grains of feldspar are altered because of chemical and mechanical weathering (Table 3, and plate 2).

The tectonic discrimination source fields indicate that these sediments are derived from orogenic recycled activity (Moss, 1998; Tucker, 2001). From the discrimination of paleoclimate (Suttner and Dutta, 1986),the studied area occupied the humid field characterized by the dominance of rock fragments and reduced of quartz and feldspars (Fig.10).

6. Conclusions

- **1-**According to grain size analysis, sand fractions gradually, diminished from north Hilla to Basrah cities besides increasing silt fractions to the southern trend. Sand grains also reduced with increase depth intervals of sampling cores, whereas silt increased downward depth in all of sites.
- **2-** Petrographic study confirmed that the rock fragments especially, calcite and chert were the predominant constituents of light minerals, following quarts which comprised monocrystalline, as the main proportion, and poly type as a minor. Potash feldspar (orthoclase and microcline) were more than plagioclase, however feldspar types were considered as the lowest abundance among the others. The grain shapes of river bed sediments observed under polarized microscope and SEM-EDS technique were restricted between angular, subangular, elongated, and subrounded. Calcite increased toward the south trend, in contrast, to quartz which decrease in this direction.
- **3-** The bed sediments were litharenite classification, empathized the immaturity of these sediments and reflected humid climatic conditions.
- **4-** Patrogenically, the river bed sediments were within transitional recycled, extended to transition arc referred to the derivation from orogenic recycled activities.
- **5-** Humid conditions may play a role in the dominance of rock fragments and reducing quartz and feldspars.

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