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GRANULOMETRY OF THE QUATERNARY SEDIMETES IN THE NASIRIYA QUADRANGLE (SHEET NH-38-03), IRAQ

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Key words: Mesopotamian Plain; Depositional environment; Grain size parameters; Paleoflow velocity; Settling velocity.

ABSTRACT

Statistical analysis is conducted for 39 sandy samples selected from 24boreholes drilled in the Mesopotamian Plain, southern Iraq. The samples are tested for grain size analysis to reveal its textural characteristics, depositional environment, transporting mechanism, and mean flow velocity during deposition. The majority of the samples are muddy sand, few are silty and clayey sand and one sample is sand. A Graphic method of frequency distribution analysis reveals that the mean size ranges from medium sand, (1.42) φ to fine silt, (6.07) φ with an average size of (4.2) φ. Skewness parameters range from (0.15) φ (fine) to 0.89 φ (very finely skewed). About 92 % of the samples lies within the very fine skewness category implying excess of fine particles (>10) %, which is a characteristic feature of old age river sediments. Sorting values range from 1.43 φ (poorly sorted) to 4.33 φ (extremely poorly sorted) with the very poorly sorted samples dominate the population. The kurtosis values range from 0.59 φ (very platykurtic) to 3.25 φ (extremely leptokurtic). About 90% of the samples are spread within the mesokurtic to very leptokurtic categories. Scatter plot diagram of graphic mean size versus graphic standard deviation indicates a river deposition environment. Probability charts of the samples point to rolling and sliding transporting mechanism for the sediments larger than 2 φ in size, as well, the saltation mechanism for the sediments in between 1.63 and 3.7 φ in size and suspension mechanism for the grains finer than 8 φ in size. The mean flow velocity during deposition ranges between 7.34 cm/s for sample with mean size of 4.9 φ and 94.77 cm/sec for sample with mean size of 1.4 φ.

دراسة رواسب العصر الرباعي في لوحة الناصرية (خريطة NH-38-03)، العراق

ورود يوسف

المستخلص

تمت دراسة التدرج الحجمي الحبيبي والمعاملات الإحصائية لـ 39 نموذج رملي منتقاة من 24 بئر لبابي ضمن منطقة السهل الرسوبي في جنوب العراق وذلك لمعرفة الصفات النسيجية، البيئة الترسيبية، ميكانيكية النقل ومعدل سرعة الجريان أثناء عملية الترسيب. معظم النماذج هي رمل وحلي مع قليل من الغرين والرمل الطيني مع وجود نموذج منفرد من الرمل. يظهر منحنى التوزيع الحجمي ان معدل الحجم الحبيبي للنماذج يتراوح بين رمل متوسط 1.42 φ الى غرين ناعم 6.07 φ وبمعدل 4.2 φ يتراوح معامل الحيود بين 0.15 φ (الحيود الناعم) الى 0.89 φ (حيود شديد النعومة)، ويقع حوالي 92% من النماذج ضمن حيود شديد النعومة، ويعني ذلك زيادة الاحجام الناعمة بنسبة تتجاوز 10% وهذه خاصية تتميز بها ترسبات الأنهر القديمة. يتراوح معامل الفرز للرسوبيات بين 1.43 φ (فرز رديء) الى 4.33 φ (فرز رديء للغاية).

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يتراوح معامل التفرطح بين 0.59 φ (منبسط جدا) الى 3.25 φ (مرتفع للغاية) وتقع حوالي 90% من النماذج بين صنف التفرطح العادي الى التفرطح المرتفع جدا. تبين العلاقة بين معدل الحجوم ومعامل الفرز ان بيئة الترسيب نهرية. تشير منحنيات التوزيع الحجمي على مخططات الاحتمالية للتدرج الحجمي الى ان الترسبات تم نقلها بميكانيكيتين هما الدحرجة والزحف للرسوبيات ذات الاحجام الأكبر من 2 φ وطريقة الانتقال بالقفز للرسوبيات التي يتراوح حجمها بين 1.63 و 3.7 φ بينما الحبيبات ذات الحجم الأقل من 8 φ فقد تم نقلها كعالق. من ناحية اخرى فقد تراوح معدل سرعة الجريان اثناء الترسيب من 7.34 سم/ثانية للحبيبات ذات معدل حجم 4.9 φ و 94 سم/ثانية للحبيبات ذات معدل حجم 1.4 φ.

INTRODUCTION

Statistical analysis of the grain size parameters is the key to elaborate the prevailing circumstances through transportation and sedimentation, whereas its distribution is strongly controlled and related to transportation mechanism, media and depositional environment Friedman and Sanders, (1978). A systematic and coherent presentation of the particle size distribution will provide the knowledge about sedimentary processes and depositional environment. Devi (2014) advocated the application of statistical techniques to characterize the frequency distribution of clastic sediments.

The study area is located in the southern part of Iraq within the Mesopotamian Plain, represented by Al-Nasiriya Quadrangle (Sheet NH-38-03) on scale 1: 250 000. It lies between 45° 00' 00" – 46° 30' 00" longitude and 31° 00' 00" – 32° 00' 00" latitude with approximate area of 15000 Km^2 (Fig.1). The aim of this work is to study the depositional environment and transportation mode of the sediments from grain size parameters, as well as measurement of the paleoflow velocity during deposition of the Quaternary sediments in the area between Nasiryia, Fajer and Samawa cities.

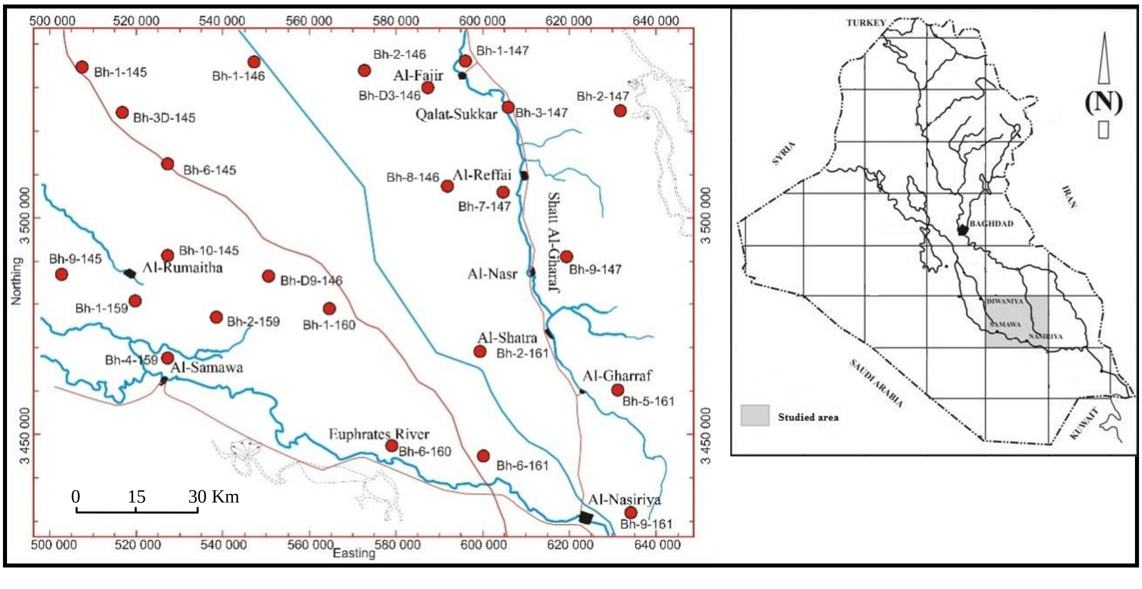

Fig.1: Location map of the study area. Right: map of Iraq showing the study araea. Left: map of the study area showing location of the boreholes with the main cities and rivers

PREVIOUS WORK

- Yacoub *et al*. (1985) studied the southern sector of the Mesopotamian Plain as part of the regional survey of the whole plain. They investigated the Pleistocene and Holocene deposits and reported that the fluvial deposits are dominating the entire Quaternary period as well as in Pliocene. The Fluvial deposits are frequently intercalated with thin layers of lacustrine origin. They suggested that the area was influenced by marine inundation during the Holocene, which caused the deposition of marine estuarine sequence of the Hammar Formation. The paleontological evidences revealed that the marine transgression reached as far as the Amara City on one side, and Al-Nasiriya City on the other side during the optimum rise of the sea level around (6000 – 5000) years B.P.

- Deikran and Mahdi (1993) compiled the geological map of the Al-Nasiriya sheet at scale of 1: 250 000. They classified the Quaternary sediments according to their genesis into: Fluvial, Lacustrine, Aeolian, Polygenetic, Anthropogenic, and Gypcrete.
- Aqrawi (1993) studied the fluctuation in climate, sea level and sedimentation rate of the Tigris – Euphrates Delta in the last 100 000 years and identified five main stratigraphic units with other sub units.
- Aqrawi (2001) calculated the Holocene sedimentation rates for the lacustrine deltaic deposits of the lower Mesopotamian Plain depending on the radiocarbon dating of nine samples; five of which are organic-rich samples from boreholes, and four shelly samples from near surface. The results show relatively high sedimentation rates in the range of 1 to 1.8 mm/year throughout the Holocene; from 8400 years B.P. until about 3000 years B.P. During the late stage of the Holocene, the rate of 0.4 mm/year was not exceeded.
- Sissakian *et al*. (2007) studied the geological hazards in the study area, and identified these as: Floods, Sand dunes, Depressions, Sabkhas, Pollution, Marshes and Tectonic active zones.
- Al-Khateeb *et al*. (2013) investigated the study area in detail including the sedimentary environment and reported a remarkable decrease of sand ratio toward southeast, whereas no such change is seen in the northeast-southwest direction.
- Al-Jeburi and Al-Basrawi (2015) studied the type and depth of the groundwater and mineralized springs in the study area.

GEOLOGICAL SETTING

The area is mainly covered by Quaternary sediments of various types, whereas the outcrops of the Tertiary formations are restricted to a small area in the extreme southwest of the studied area, represented by the Dammam Formation (Middle – Upper Eocene) and the Euphrates and Ghar formations (Lower Miocene). The Quaternary sediments are classified, based on their genesis, as polygenetic, gypcrete, fluvial, lacustrine, aeolian and anthropogenic sediments and lithologically consist of the following sediments according to Yacoub *et al*. (1985) and Al-Khateeb *et al*. (2013) (Fig.2).

- **Sand**

It represents about 35% of the lithological sequence and is generally fine to medium grained, friable to fairly compacted, whereas compacted and cemented layers are rare. It is dominantly brownish grey or greenish grey in color. Occasionally grayish brown, bluish brown, yellowish and pale grey to whitish colored beds of sand also appear in the sequence.

- **Silt**

About 9% of the lithological sequence is composed of silt. It is very often clayey in the studied sediments; pure silt occurs as a thin layers intercalated with sand and clays. The common colors of silt and clayey silts are brown with variable including reddish, pinkish, grayish or yellowish shades and pale greenish or bluish grey beds.

- **Mud**

It is the most predominant lithologic constituents of the fluvial sediments, forming 54.5% of the studied lithological sequence. The color is mainly brown, but grayish, yellowish and greenish beds are also noticed.

- **Clay**

Clay fraction is the less abundant lithologic constituents of the Quaternary sediments in the studied area and represents only 1.5% of the lithological sequence (Al-Khateeb *et al*., 2013). It usually exists as thin (few decimeters) intercalations, while the layers of silty clays could reach few meters in thickness. The color is mainly reddish, pinkish or ochre.

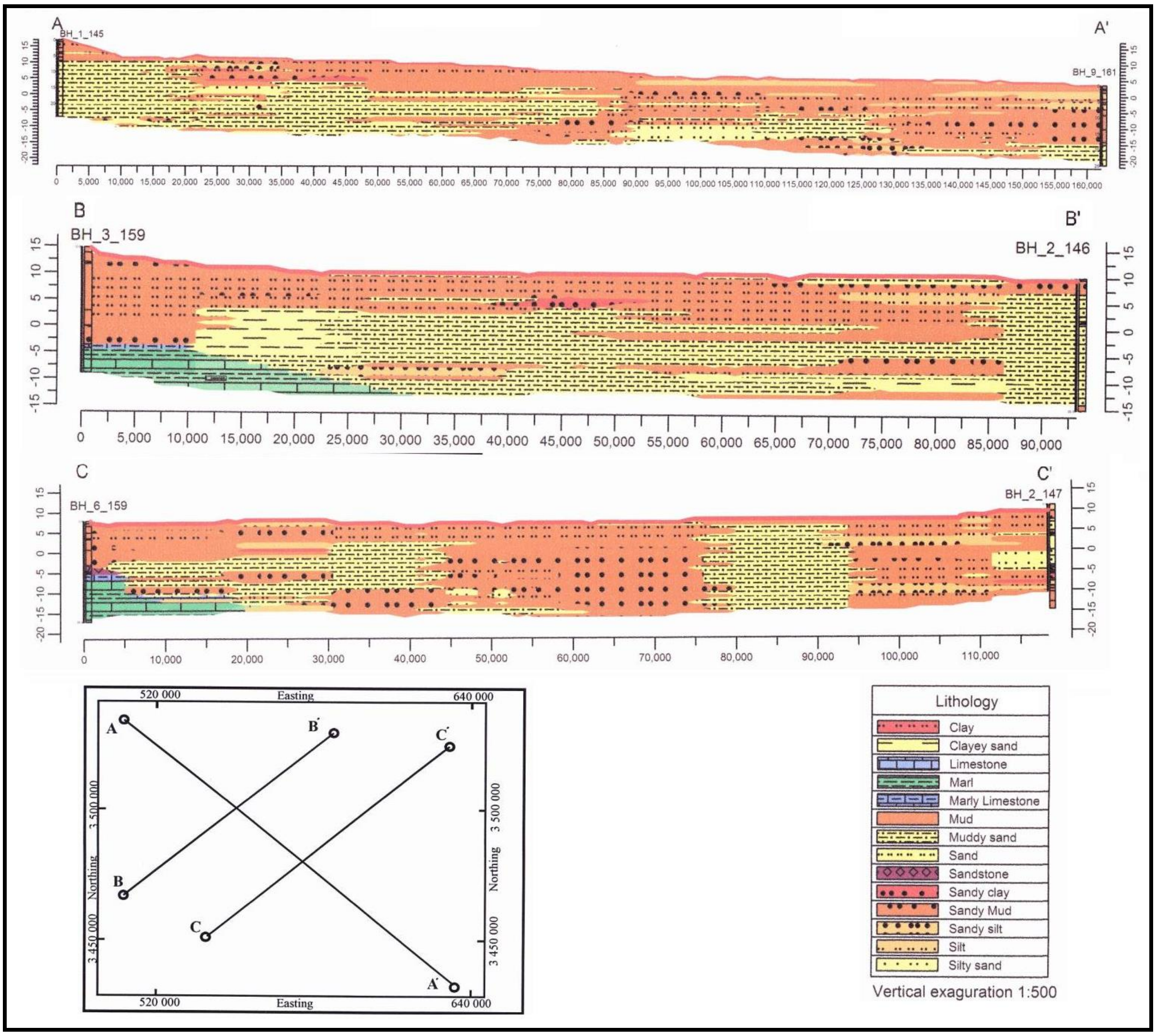

Fig.2: Geological cross sections A-A', B-B' and C-C' in the study area (after Al-Khateeb *et al*., 2013)

METHODOLOGY

Thirty nine sandy samples were selected from 24 boreholes for grain size analysis. The analysis was conducted according to the standard of the American Society for Testing and Materials (ASTM) D422 (1982). Folk (1954) ternary diagram is used to reveal texture of the samples, whereas, mean size, sorting, skewness and kurtosis are determined graphically as suggested by (Folk and Ward, 1957). Graphical presentation of grain size (in phi units) with cumulative percent are plotted on probability chart to get cumulative frequency curve for the samples after the method introduced by Otto (1939).

Arithmetic grain size scale is seldom used in sedimentology since too much emphasis is placed on coarse sediment and too little on fine particles (Mc Manus, 1988). As such, logarithmic Udden-Wentworth grade scale, (Udden, 1914 and Wentworth, 1922), is widely employed and adopted by most sedimentologists. Krumbein (1934) further proposed that grade scale to be transformed from logarithmic scale into phi (φ) values as follows:

$$\text{Grain diameter in } \varphi = -\text{Log}_2 d \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ 1$$

Where d is the grain diameter in millimeter.

Four major statistically-derived parameters are usually used to describe grain size distribution, these are: Mean (average grain size), Sorting, Skewness, and Kurtosis. Folk and Ward (1957) presented the following equations to compute these parameters graphically.

- **Grain size**

One of the things that the size of the particles reflects is the processes of transportation and deposition such as the ability of wind or water to move and drop the particles (Friedman and Sanders, 1978).

$$M_z = \frac{\varphi 16 + \varphi 50 + \varphi 84}{3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ 2$$

Where M_z refers to the average grain size, φ16, φ50, and φ84 represent the sizes at 16, 50 and 84 percent of the sample by weight respectively. Mean is also measured in φ units and is the most widely compared parameter.

- **Sorting**

It represents the degree of grain size variation of a sample, and is generally expressed by the spread of data along the x-axis. Sorting is a powerful indicator of origin of the sediments. It is calculated as follows:

$$\sigma_1 = \frac{\varphi 84 - \varphi 16}{4} + \frac{\varphi 95 - \varphi 5}{6.6} \quad \ldots\ldots\ldots\ldots\ldots\ldots \ 3$$

Where: σ_1 is the sorting value; φ 84, φ 16, φ 95 and φ5 represent the phi values at 84, 16, 95, and 5 percentiles.

- **Skewness**

It indicates the symmetry of the cumulative curve of the sample, calculated as follows:

$$SK_1 = \frac{\varphi 16 + \varphi 84 - 2\varphi 50}{2(\varphi 84 - \varphi 16)} + \frac{\varphi 5 + \varphi 95 - 2\varphi 50}{2(\varphi 95 - \varphi 5)} \quad \ldots\ldots\ldots \ 4$$

Where φ values represent the same percentages as those for sorting, skewness indicates the prevailing of the finer or coarser materials on the account of the other.

- **Kurtosis**

Peakedness of a grain-size distribution compares the sorting in the central portion of the grain size distribution with sorting in the tails (ends) of the distribution; it is less commonly used in grain size interpretations than skewness. It is calculated as:

$$K_g = \frac{\varphi 95 - \varphi 5}{2.44(\varphi 75 - \varphi 25)} \quad \ldots\ldots\ldots\ldots 5$$

Where φ values represent the same percentages as those for sorting.

Mean size may be translated to average grain size. Sorting, or standard deviation, refers to measure of spread of the distribution around the mean, while both of skewness and kurtosis are functions of the "internal" sorting of distribution, (Cadigan, 1961). Folk and Ward (1957) presented descriptive classification for Sorting, Skewness, and Kurtosis (Table 1).

Table 1: Descriptive classification for Sorting, Skewness, and Kurtosis, (Folk and Ward, 1957 and Folk, 1968)

Sorting		Skewness		Kurtosis	
Very well sorted (V.W.S.)	<0.35	Very fine skewed (V.F.S.)	> +0.3	Very platykurtic (V.P.)	<0.67
Well sorted (W.S.)	0.35 – 0.5	Fine skewed (F.S.)	+0.1 to +0.3	Platykurtic (P)	0.67 – 0.90
Moderately well sorted (M.W.S.)	0.5 – 0.71	Symmetrical (S)	-0.1 to +0.1	Mesokurtic (M)	0.90 – 1.11
Moderately sorted (M.S.)	0.71 – 1	Coarse skewed (C.S.)	-0.3 to -0.1	Leptokurtic (L)	1.11 – 1.50
Poorly sorted (P.S.)	1.0 – 2.0	Very coarse skewed (V.C.S.)	< -0.3	Very Leptokurtic (V.L.)	1.50 – 3.00
Very poorly sorted (V.P.S.)	2.0 – 4.0			Extremely leptokurtic (E.L.)	>3.00
Extremely poorly sorted (E.X.S.)	>4.00				

Paleoflow velocity during deposition for each sample is based at Komar's (1985) hydraulic model, accordingly; the mean flow velocity is given by the following equation (6);

$$\bar{u} = \frac{w_m}{\sqrt{C_f}} \quad \ldots\ldots\ldots\ldots 6$$

Where ū is the mean flow velocity during deposition, *Wm* is the settling velocity of the 50th percentile and C_f is a dimensionless drag coefficient. C_f value is 0.004 as proposed by Komar (1985). The calculation of settling velocity was done following modified Rubey's law proposed by Watson (1969), equation (7).

$$V = \frac{\sqrt{9 \times Z^2 \times \mu^2 + \frac{4}{3} \times W \times R^3 (\rho\ particle - \rho\ fluid) \times g} - 3 \times Z \times \mu}{W \times R \times \rho\ fluid} \quad \ldots\ldots\ldots\ldots 7$$

Where:
V = fall (settling) velocity in cm/sec; ρ = mass density in g/cm^3; R = particle radius in cm; μ = dynamic viscosity, poise in dyne-sec/cm^2; g = gravitational acceleration980 cm/sec^2; W = pressure drag coefficient, dimensionless, equal 0.5305; and Z = viscous drag coefficient, dimensionless, equal 0.622;

Falling velocities of 50th percentile of the samples are calculated according to equation number (7), after which mean flow velocities during deposition are calculated using equation number (6).

RESULTS AND DISCUSSION

The test results are plotted on the ternary diagram of Folk (1954) to reveal the texture of the studied sediments (Fig.3). It appears that the muddy sand (mS) is the predominant type of the sediments, followed by silty sand (zS) and clayey sand (cS), with one sand sample (S). The results of texture, grain size parameters; mean size, sorting, skewness and kurtosis are tabulated in Table (2). Cumulative probability charts of the samples (Fig.4) referred to rolling and sliding transporting mechanism for grains larger than 2 φ in size, saltation mechanism for grains between 1.63 and 3.7 φ in size, while suspension mechanism for grains smaller than 3.7 φ in size. Mode size of the samples ranges from 1 to 4 φ with an average of 3.02 φ (very fine sand). Mean size of the samples ranges from 1.42 φ (medium sand) to 6.07 φ (fine silt) with an average of 4.2 φ (coarse silt).

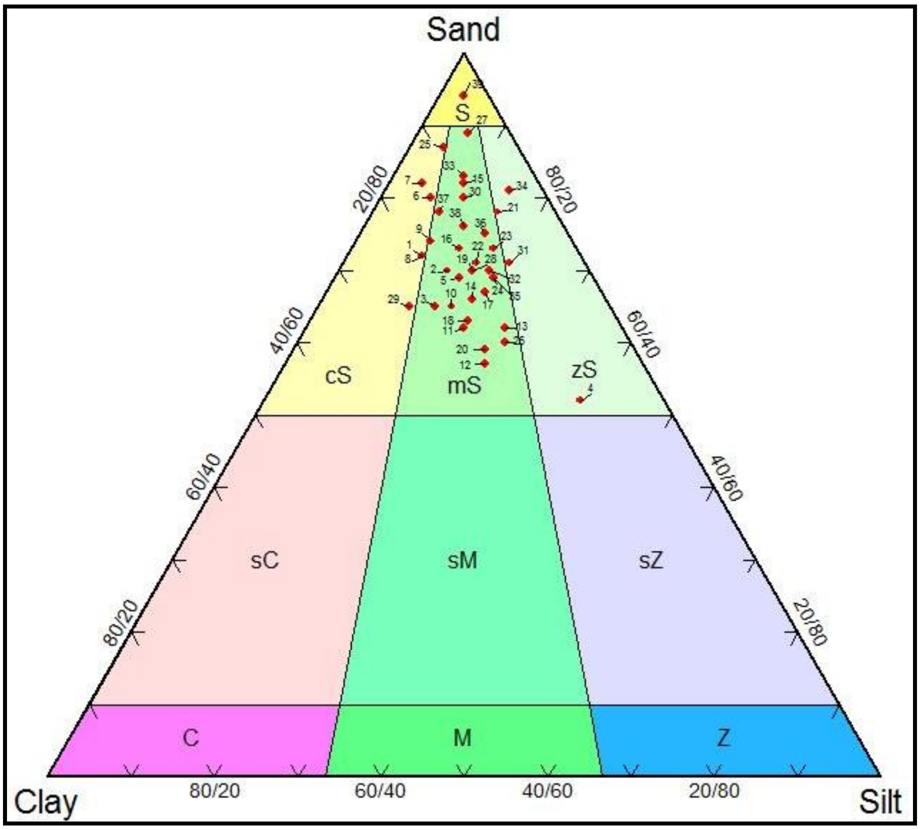

Fig.3: Ternary diagram of grain size distribution in the samples (after Folk, 1954). S: sand, cS: clayey sand, mS: muddy sand, zS: silty sand, sC: sandy clay, sM: sandy mud, sZ: sandy silt, C: clay, M: mud, Z: silt

Table 2: Average weight percent and statistical parameters of grain size of the studied samples

Sample Number	Sample reference	Sand %	Silt %	Clay %	Soil Type (Folk, 1954)	Mode	M_Z	σ1	SK1	KG
1	7/1/145	72	9	19	cS	4	5.08	3.15	0.78	1.304
2	9/1/145	70	13	17	mS	3	4.70	2.65	0.80	1.107
3	48/3/145	65	14	21	mS	4	5.23	3.50	0.76	1.02
4	7/6/145	52	38	10	zS	4	4.90	3.09	0.64	1.157
5	11/6/145	69	15	16	mS	3	4.75	3.36	0.80	1.101
6	11/9/145	80	6	14	cS	3	3.80	3.85	0.47	1.486
7	17/9/145	82	4	14	cS	1	3.10	3.32	0.56	1.577
8	10/10/145	72	9	19	cS	3	4.70	3.64	0.75	1.407
9	15/10/145	74	9	17	mS	3	4.45	3.39	0.73	1.577
10	11/1/146	65	16	19	mS	3	4.97	3.51	0.75	1.035
11	8/2/146	62	19	19	mS	3	4.97	3.69	0.89	1.14
12	49/3/146	57	24	19	mS	3	5.17	3.49	0.71	1.111
13	56/3/146	62	24	14	mS	3	4.90	2.80	0.63	1.03
14	3/8/146	66	18	16	mS	3	4.83	3.43	0.85	1.408
15	17/8/146	82	9	9	mS	3	3.47	1.78	0.75	2.925
16	5/9/146	73	13	14	mS	3	4.40	3.06	0.82	1.77
17	31/9/146	67	19	14	mS	3	5.04	3.35	0.75	1.163
18	13/1/147	63	19	18	mS	3	4.97	2.53	0.71	0.857
19	3/2/147	70	16	14	mS	3	4.57	3.13	0.87	1.482
20	11/2/147	59	23	18	mS	4	4.90	2.40	0.65	0.625
21	11/3/147	78	15	7	zS	3	3.37	1.43	0.71	1.358
22	4/7/147	71	16	13	mS	3	4.53	2.90	0.80	1.526
23	7/7/147	73	17	10	mS	3	4.29	2.48	0.77	1.639
24	13/9/147	69	19	12	mS	3	4.43	2.93	0.77	1.425
25	13/1/159	87	4	9	cS	3	2.38	2.04	0.23	1.181
26	20/1/159	60	25	15	mS	3	3.85	2.76	0.22	0.599
27	9/2/159	89	6	5	mS	3	2.78	2.63	0.55	3.256
28	16/2/159	70	16	14	mS	3	4.16	2.51	0.71	0.868
29	4/4/159	65	11	24	cS	4	6.07	4.33	0.85	1.134
30	6/1/160	80	10	10	mS	3	3.54	1.73	0.78	1.908
31	14/1/160	71	20	9	zS	2	3.36	2.56	0.85	0.969
32	14/6/160	70	18	12	mS	2	3.83	3.35	0.77	1.347
33	17/6/160	83	8.5	8.5	mS	3	3.80	1.90	0.82	1.568
34	15/2/161	81	15	4	zS	3	3.52	1.69	0.72	1.389
35	10/5/161	69	19	12	mS	4	4.59	3.22	0.77	2.183
36	13/5/161	75	15	10	mS	3	3.72	2.25	0.74	2.139
37	8/6/161	78	8	14	mS	3	4.42	2.55	0.77	2.14
38	11/9/161	76	12	12	mS	3	3.90	2.25	0.80	1.819
39	18/9/161	94	3	3	S	2	1.42	1.67	0.15	1.018

cS = Clayey sand, mS = Muddy sand, zS = Silty sand, S = Sand, M_Z = mean size, σ1 = sorting, SK1= skewness, KG = kurtosis

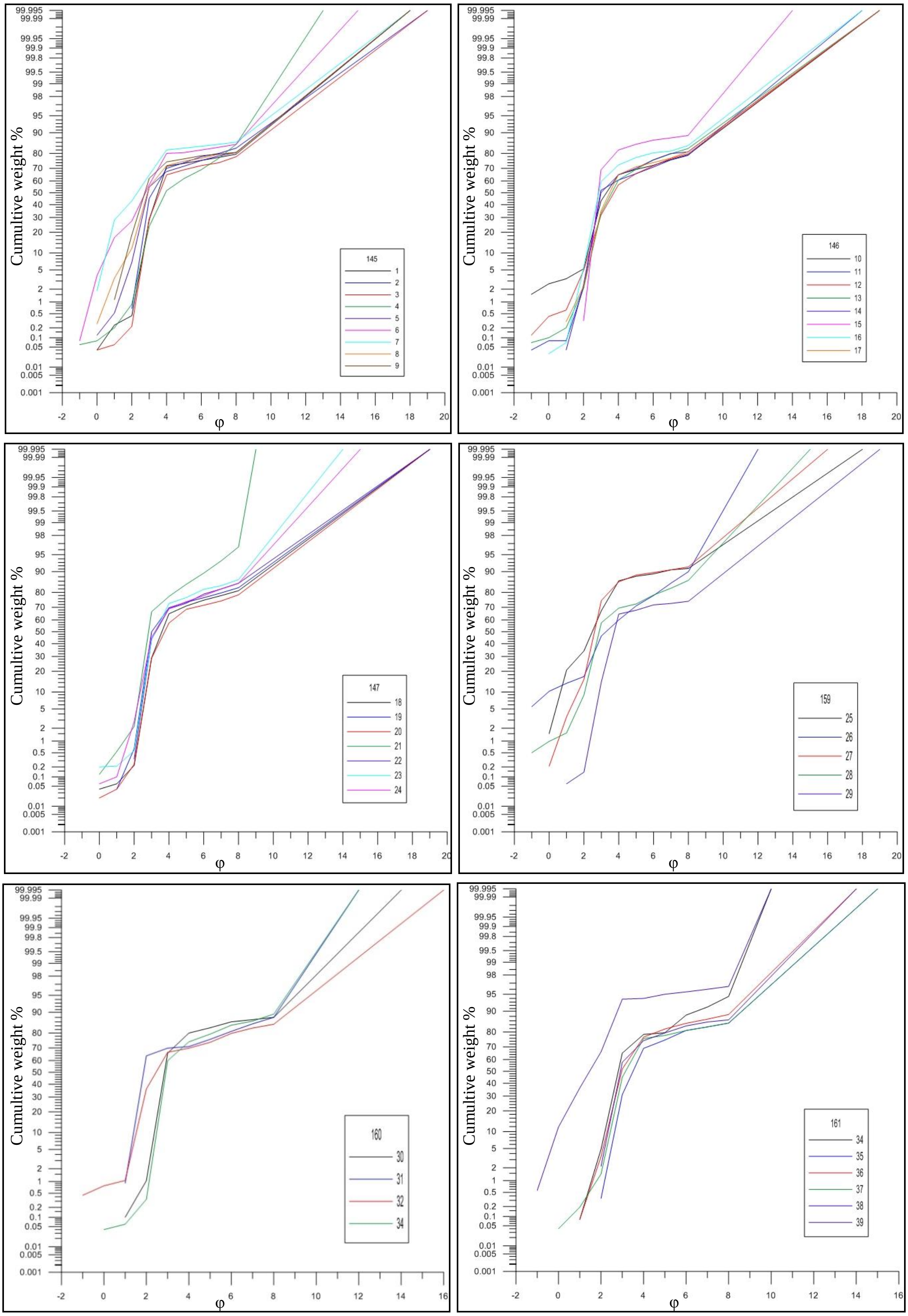

Fig.4: Probability charts of the studied samples

The values of inclusive graphic standard deviation for σ_1 range between 1.43 φ (poorly sorted) to 4.33 φ (extremely poorly sorted) with an average of 2.8 φ (very poorly sorted). However, only one sample falls within extremely poorly sorted category, whereas the majority of the samples are very poorly sorted and a minority within the poorly sorted category. Inclusive graphic skewness SK_1 ranges from 0.15 φ (fine skewed) to 0.89 φ (very fine skewed) with an average of 0.7 φ (very fine skewed). Graphic kurtosis ranges from 0.59 φ (very platykurtic) to 3.25 φ (extremely leptokurtic) with an average of 1.42 φ (leptokurtic). It is obvious that almost all the samples contain about more than 10% and up to 20% of clay fraction, reflecting low stream velocity and low hydraulic gradient, which, is in turn, a characteristic of an old age river. The excess of clay fraction is reflected in the measured grain size parameters, the difference by more than 1 φ in size between mode and mean size, poor sorting of the samples, positive skewness and average of platykurtic samples.

Scatter plot of the mean size versus standard deviation (Fig.5) shows a positive relationship in which the increase in size is associated with better sorting; such relation is expected with the clay fraction exceeding 10% as is the case in the studied samples. The combination of mean size versus standard deviation is most effective in the differentiation between beach and river sands and river and coastal dune sands (Moiola and Weiser, 1968). Therefore, a river environment is proposed for the samples, as the whole population falls within river zone (Fig.5).

Plotting skewness against standard deviation shows positive relationship (Fig.6). Friedman (1961) suggested that the lake and inland dune sands possess standard deviation values that do not exceed 0.50 φ, whereas most river sands have standard deviation more than 0.50 φ which again reveals that all the samples had been deposited in river environment. The Scatter plot of skewness versus kurtosis (Fig.7) shows positive relationship between them.

In Figures (5, 6 and 7), the studied grain size parameters are controlled or highly affected by clay content. As shown in Figure (8), more clay content refers to more positively skewed, more platykurtic, more poorly sorted samples and of course smaller mean grain size. Mean flow velocity during deposition ranges from 7.34 cm/sec for sample with mean size of 4.9 φ to 94.77 cm/sec for sample with mean size of 1.4 φ, with an average of (25.38) cm/sec. The results with representative layer thickness are shown in Table (3). From all above, it is obvious that the Euphrates and Al-Gharaf rivers are in their old stage as they are characterized by very low gradient, flat surrounding areas and with width exceeding the depth.

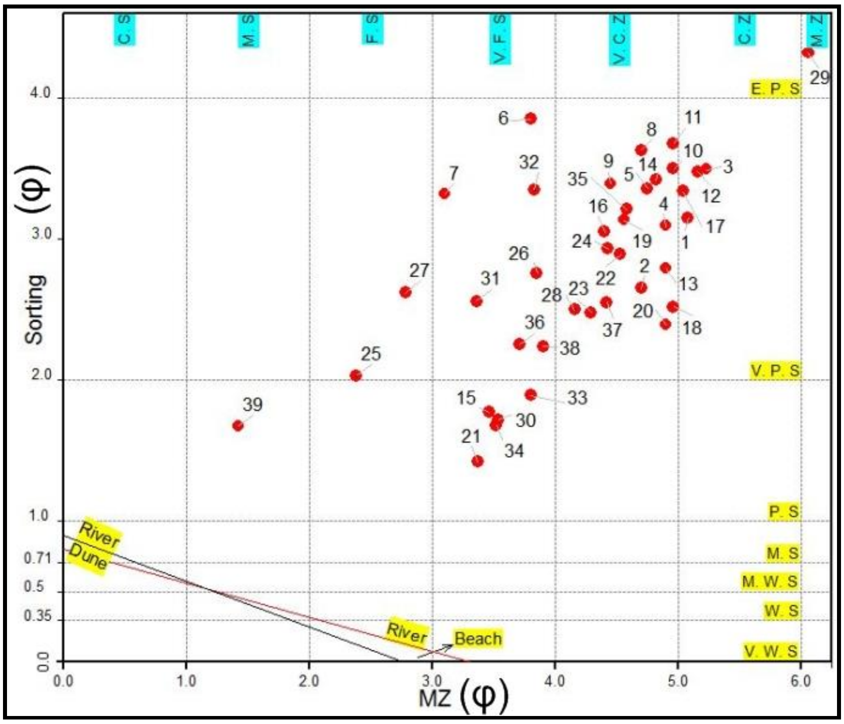

Fig.5: Scatter plot of mean size versus sorting, showing positive trend (Moiola and Weiser, 1968)

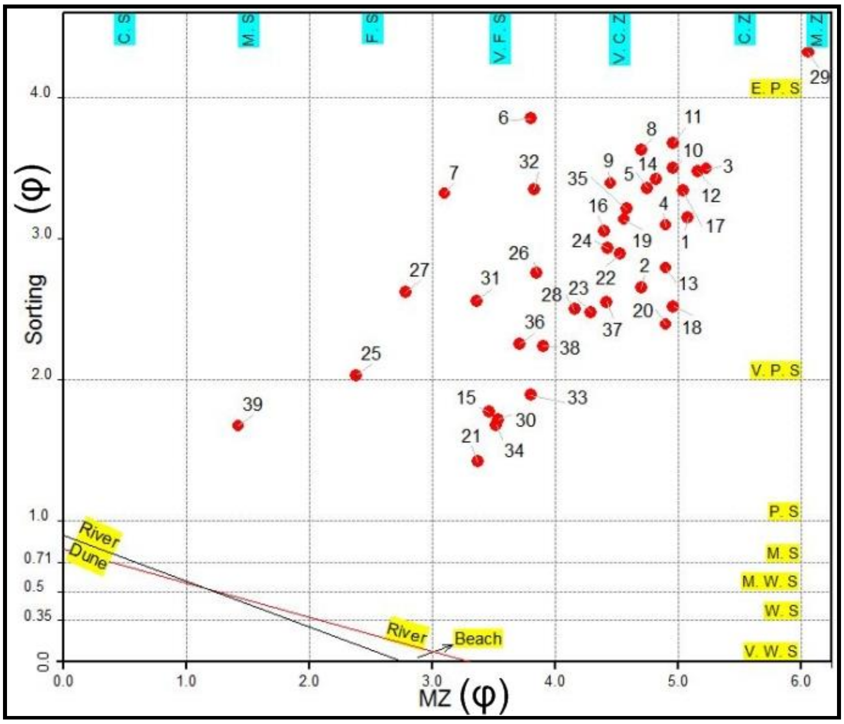

Fig.6: Scatter plot of skewness versus sorting, (Moiola and Weiser, 1968)

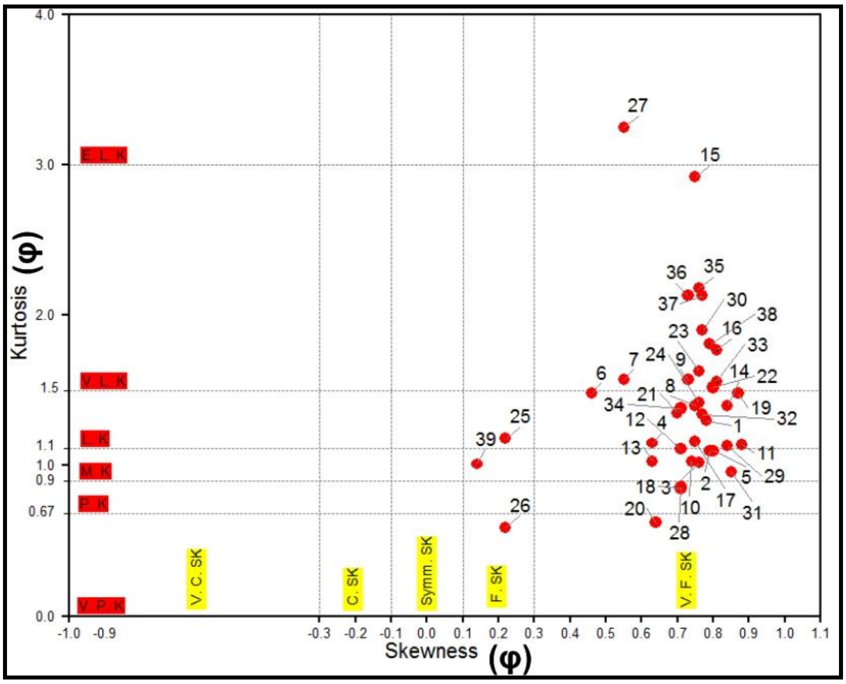

Fig.7: Scatter plot of kurtosis against skewness

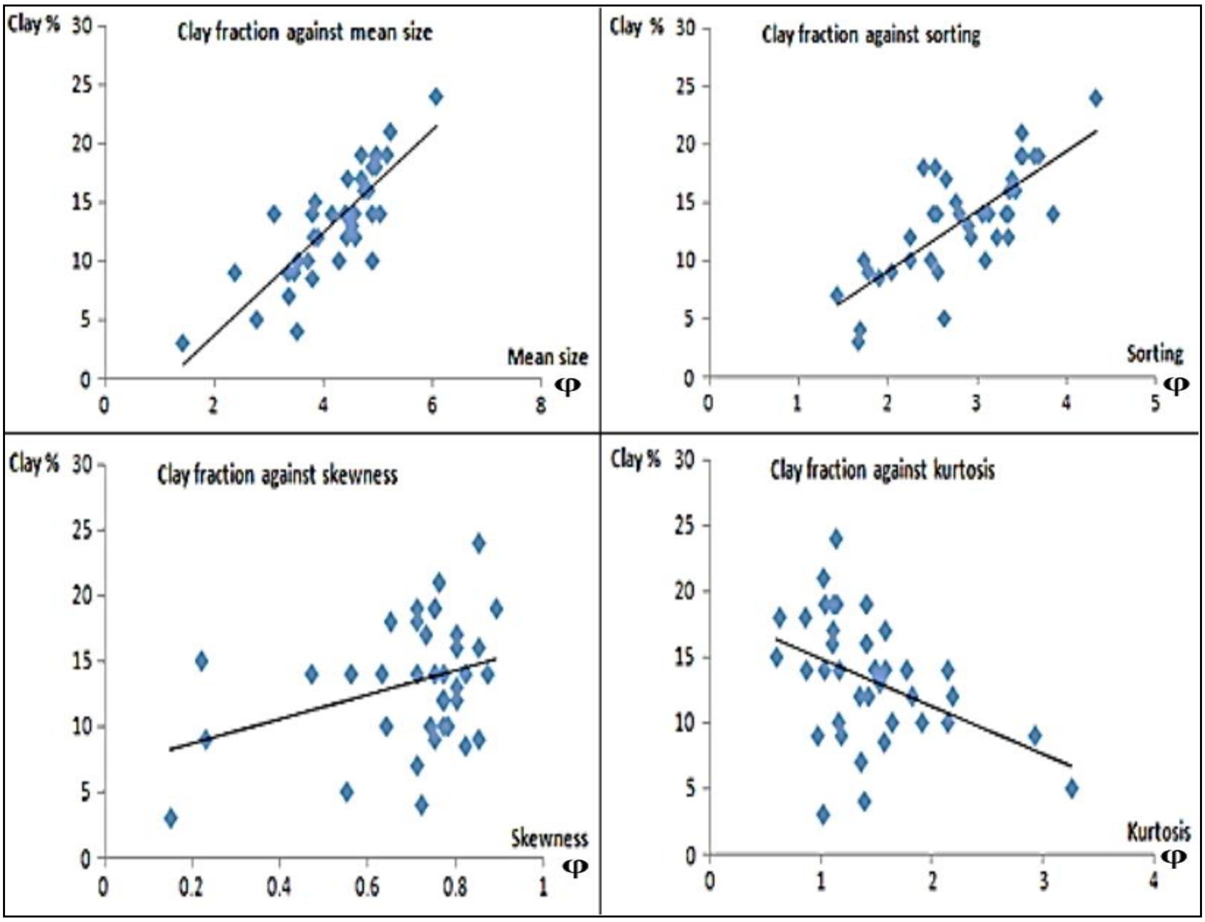

Fig.8: Grain size parameters trend with clay content of the studied samples

Table 3: Falling velocity with mean flow velocity during deposition of the studied samples

Sample Number	Sample reference	Soil Type (Folk, 1954)	Layer thickness (m)	Layer interval (m)		Sample interval (m)		Settling velocity (cm/s)	Mean flow velocity (cm/s)
				From	To	From	To		
1	7/1/145	Clayey sand	17.50	6.50	24.00	8.00	8.20	0.857	13.56
2	9/1/145	Muddy sand				12.75	13.00	1.27	19.93
3	48/3/145	Muddy sand	1.40	77.10	78.50	77.40	77.60	0.761	12.04
4	7/6/145	Silty sand	2.20	9.80	12.00	10.00	10.25	0.464	7.34
5	11/6/145	Muddy sand	4.35	18.750	23.35	20.75	21.00	1.69	26.74
6	11/9/145	Clayey sand	2.65	11.20	13.85	13.30	13.50	1.797	28.43
7	17/9/145	Clayey sand	1.15	21.85	23.00	22.40	22.60	0.98	15.57
8	10/10/145	Clayey sand	10.10	8.50	18.60	9.20	9.40	1.69	26.74
9	15/10/145	Muddy sand	3.50	21.50	25.00	24.20	24.40	1.899	30.05
10	11/1/146	Muddy sand	2.40	10.00	12.40	11.30	11.60	1.04	16.42
11	8/2/146	Muddy sand	15.40	8.50	23.90	17.60	17.80	1.797	28.43
12	49/3/146	Muddy sand	10.45	88.00	98.45	91.10	91.40	0.713	11.28
13	56/3/146	Muddy sand	10.30	99.70	111.00	109.60	109.90	0.507	8.02
14	3/8/146	Muddy sand	0.65	1.75	2.40	2.00	2.20	1.609	25.46
15	17/8/146	Muddy sand	2.00	23.00	25.00	24.50	24.75	1.708	27.02
16	5/9/146	Muddy sand	7.50	8.00	15.00	9.80	10.00	1.83	28.98
17	31/9/146	Muddy sand	6.50	50.80	57.30	54.00	54.20	0.869	13.75
18	13/1/147	Muddy sand	0.45	16.80	17.25	17.00	17.20	0.764	12.08
19	3/2/147	Muddy sand	3.80	3.50	7.30	5.80	6.00	1.606	25.41
20	11/2/147	Muddy sand	0.80	20.00	20.80	21.20	21.50	0.64	10.15
21	11/3/147	Silty sand	0.95	15.30	16.25	15.80	16.00	1.96	31.09
22	4/7/147	Muddy sand	22.00	3.00	25.00	6.00	6.30	1.22	19.3
23	7/7/147	Muddy sand				13.10	13.30	1.226	19.39
24	13/9/147	Muddy sand	1.80	14.30	16.10	15.50	15.80	1.25	19.77
25	13/1/159	Clayey sand	9.00	8.00	17.00	12.80	13.00	2.88	45.56
26	20/1/159	Muddy sand	6.00	17.00	23.00	21.80	22.00	1.19	18.82
27	9/2/159	Muddy sand	1.10	9.90	11.00	10.20	10.40	2.42	38.29
28	16/2/159	Muddy sand	3.50	21.50	25.00	22.20	22.50	1.84	29.11
29	4/4/159	Clayey sand	8.70	0.80	9.50	3.30	3.50	0.619	9.79
30	6/1/160	Muddy sand	11.20	4.50	15.70	9.40	9.70	1.9	30.06
31	14/1/160	Silty sand	9.30	15.70	25.00	20.30	20.50	4.64	73.41
32	14/6/160	Muddy sand	7.80	9.00	16.80	13.50	13.70	2.88	45.56
33	17/6/160	Muddy sand	1.40	20.50	21.90	20.60	20.80	1.52	24.05
34	15/2/161	Silty sand	7.30	11.50	18.80	12.10	12.40	1.99	31.48
35	10/5/161	Muddy sand	0.70	11.50	13.00	12.70	12.90	0.87	13.76
36	13/5/161	Muddy sand	2.30	13.70	16.00	15.20	15.50	1.60	25.31
37	8/6/161	Muddy sand	5.90	7.00	12.90	8.50	8.70	0.58	9.17
38	11/9/161	Muddy sand	4.40	9.30	13.70	11.60	11.90	1.52	24.05
39	18/9/161	Sand	6.30	18.70	25.00	19.80	20.00	5.99	94.77

CONCLUSIONS

- The studied Quaternary sediments have three main types of texture: muddy sand, silty sand and clayey sand, in addition to one sand sample.
- Almost all samples contain clay fraction within the range of 10 – 20 %, indicating low stream velocity and low hydraulic gradient that are characteristics of old age rivers.
- The excess of clay fraction is reflected in the measured grain size parameters by the difference of more than 1 φ in size between mode and mean size, poor sorting, positive skewness and the platykurtic type of the sediments.
- Mean flow velocity during deposition ranges from 7.34 cm/sec to 94.77 cm/sec with an average of 25.38 cm/sec.

REFERENCES

Al-Jeburi, H.K. and Al-Basrawi, N.H., 2015. Hydrogeological and hydrochemical study of Al-Nasiriya Quadrangle (NH-38-3), scale 1: 250 000. Iraq, GEOSURV, int. rep. no. 3586.

Al-Khateeb, A.A., Capigian A.O., Benni T.J., Al-Basrawi N.H., Al-Mukhtar L.E., Al-Jeboree B.S., Mohsen W.Y., Mohamad M.A., Al-Sattar M.A., Mohamed G.K. and Ranka R.G. 2013. Geoenvironmental information system of Al-Nasiriya Quadrangle, Sheet NH-38-3. Iraq, GEOSURV, int. rep. no. 3422.

Aqrawi, A.M., 1993. Stratigraphic signatures of climatic change during the Holocene Evolution of the Tigris-Euphrates, Lower Mesopotamia, p. 21 – 31.

Aqrawi, A.M., 2001. Implication of Sea-level fluctuation sedimentation and new tectonics for the evolution of the Marsh lands (Ahwar) or southern mesopotamia, Quaternary Proceeding 1. Cambridge. Vol.28, issue 1 – 4, p. 267 – 283.

ASTM D422, 1982. American Society for Testing and Materials Annual Book of ASTM Standards, Part 19, Natural Building Stones; Soil and Rock, 710pp.

Cadigan R.A., 1961. Geological interpretation of grain-size distribution measurements of Colorado Plateau Sedimentary Rocks, the Journal of Geology, Vol.69, No.2 (Mar., 1961). The University of Chicago Press. p. 121 – 144.

Deikran D.B. and Mahdi A.I. 1993. Series of Geological Maps of Iraq. Scale 1: 250 000, Al-Nasiriya Qudrangle NH-38-3 GM33. Iraq, GEOSURV, int. rep. no. 2258.

Devi, T.D., 2014. Textural characteristics and depositional environment of Olistostromal Sandstone of Ukhrul, Manipur. Journal of Recent Development in Engineering and Technology, Vol.2, No.1, p. 92 – 100.

Friedman, G.M., 1961. Distinction between dune, beach, and river sands from their textural characteristics. Jour. Sed. Pet., Vol.31, p. 514 – 529.

Friedman, G.M., and Sanders, J.E. 1978. Principles of Sedimentology. Wiley, New York. 792pp.

Folk, R.L., 1954. The distinction between grain size and mineral composition in sedimentary rock nomenclature. Jour. Geol., Vol.62, p. 334 – 359.

Folk, R.L., Ward W.C. 1957. Brazos River Bar, a Study in the significance of grain size parameters. Journal of Sedimentary Petrology, Vol.27, p. 3 – 26.

Folk, R.L., 1968. Petrology of Sedimentary Rocks: Austin, University of Texas Publication, 170pp.

Komar, P.D., 1985. The hydraulic interpretation of turbites from their grain sizes and sedimentary structures. Sedimentology, Vol.32, p. 395 – 407.

Krumbein, W.C., 1934. Size frequency distribution of sediments. Journal of Sedimentary Petrology, Vol.4, p. 65 – 77.

Mc Manus, J., 1988. Grain size determination and interpretation. In Techniques in Sedimentology, M. Tucker (Ed.), Blackwell, Oxford, p. 63 – 85.

Moiola, R.J., and Weiser, D., 1968. Textural parameters, an evaluation: Jour. Sed. Pet., Vol.38, p. 45 – 53.

Otto, G.H., 1939. A modified logarithmic probability graph for the interpretation of mechanical analysis of sediments. Jour. Sed. Pet., Vol.9, p. 62 – 76.

Sissakian, K., Dikran, I. and Shaker, A., 2007. Series of Geological-Hazard Maps of Iraq, Al-Nasiriya quadrangle scale 1:250 000 NH-38-3, 28pp.

Udden, J.A., 1914. Mechanical composition of clastic sediments. Geol. Soc. Am. Bull., Vol.25, p. 655 – 744.

Watson, L.R., 1969. Modified Rubey's Law Accurately Predicts Sediments Settling Velocities. Water Resources Research, University of Texas at Austin, Austin, Texas, https://doi.org/10.1029/WR005i005p01144, Vol.5, No.5.

Wentworth, C.K., 1922. A scale of grade and class terms for clastic sediments. Journal of Geology, Vol.30, p. 377 – 392.

Yacoub, S.Y., Roffa, S.H. and Tawfiq, J.M., 1985. Geology of Amarah, Al-Nasiriya and Al-Basrah area. Iraq - GEOSURV, int. rep. no.1386.

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