Mesopot. J. Mar. Sci., 2010, 25 (2): 45 - 56

Geochemical and mineralogical study of the fluvial deposits at Abul Khasib area, south east of Iraq

S.H. Al-Ali
Geology Department, College of Science, University of Basrah, Iraq.
e-mail: safaahussein79 @yahoo.com

(Received: 1 June 2010 - Accepted: 3 October 2010)

Abstract - Nine sediment samples were collected from three sites at the banks (levees) of Sarraji, Hamdan and Abul khasib creeks branching from Shatt Al-Arab river, southeastern Basrah with depths of 0.5, 1.0 and 1.5m, respectively. Grain size distribution and statistical parameters revealed that the deposits are mainly composed of silt and clay with very small portion of sand, and have mud type texture. There is a tendency of increasing in silt percentage from Sarraji toward Abul Khasib area and decreasing in clay percentage with depth. Generally, the sediments are poorly sorted, coarse to strongly coarse skewed and platykurtic to very platykurtic deposited in quiet environment and low energy conditions. Chemical analysis showed that all samples have high concentration in SiO_2 and CaO in comparison with Al_2O_3, Fe_2O_3, MgO, SO_3, K_2O and Na_2O. These results are generally in agreement with the mineral composition. Mineralogically, the sediments understudy consists of quartz, feldspar, calcite, dolomite and gypsum. Clay minerals assemblages are: chlorite-montmorillonite mixed layers 37%, Illite 20%, Chlorite 18%, Kaolinite 14% and Palygorskite 11%. Increasing in Ch-Mont. percentage could be an evidence of high intensity of diagenetic alteration processes in depositional environment. The clay mineral assemblages proved that the recent sediments of the studied samples were derived from the basic igneous and metamorphic rocks, while acidic igneous and sedimentary rocks sources are less important. The deposition environment of these minerals may be characterized by an arid to semi-arid climate in the source area.

Key words: Clay minerals, grain size analysis, fluvial deposits and Abul Khasib.

Introduction

Mud deposits are the most abundant of all the rocks of the earth's crust, constituting some 45 to 55% of the components of sedimentary rocks (Tucker, 1981). They have a wide distribution in different parts of Iraq, especially in the central and southern regions (Mesopotamian plain), consisting of large fluvial sediments transported by Tigris and Euphrates rivers and their tributaries. The term clay materials refer to those materials having earthy properties and become elastic when mixed with water. They consist of hydrous alumino phyllosilicates, magnesium and iron as well as organic matter and soluble salts. They resulted by various weathering and erosion processes of igneous, metamorphic and sedimentary rocks, which can be deposited practically in any environment, although the major depositional sites are river floodplains and lakes, large deltas and the ocean floors.

There is no comprehensive study of recent sediments has yet been carried out in the area under study, but there were some previous works around the area like that of Al-Dabbagh and Albadran (1995) concerning the clay minerals distribution of surface sediments of the northwestern part of the Arabian Gulf. Albadran (2000) studied clay minerals distribution in selected locations along Tigris and Shatt Al-Arab rivers. Al-Beyati *et al.* (2000) identified clay minerals percentage of mid-channel bottom sediments from the southern part of Shatt Al-Arab which represented by kaolinite, chlorite, illite, mixed layer illite-smectite and illite-chlorite. Al-Marsoumi *et al.* (2006) studied the sedimentological and mineralogical aspects of Khor Abdullah superatidal sediments, northwest Arabian Gulf. Other researchers studied the clay mineral properties of sediments (Saadallah and Salman, 1987; Khan *et al.,* 1992; Al-Mussawy and Basi, 1992 and Aqrawi, 1993).

Aim of the study:

This research aims to study the fluvial deposits of recent sediments at selected sites within Abul khasib area, southern Iraq, in order to identify its mineralogical, geochemical properties and sedimentary fabric to detect the prospected origin of clay minerals assemblages and their depositional environments.

Geological setting:

The study area is of about 82km^2 and located in the southeastern part of Basra city, southern Iraq between longitudes 30° 25' to 30° 30'E and latitudes 47° 45' to 48° 00'N, representing the southern part of Mesopotamian plain within the unfolded zone (Figure 1).

The surface of the area is smooth having no geological structures. The ground surface is almost flat slopping gently from northwest to southeast consisting of recent friable deposits suitable for agriculture. These deposits were formed by continuous deposition of the suspended and bed loads of Tigris, Euphrates, Karun and Shatt al-Arab rivers, as well as the fine particles transported by aeolian as a second source of these sediments (Al-Azzawi, 1996).

The main geomorphological features within the study area are Shatt Al-Arab delta, Khors, alluvial fan and Jabal Sanam. The study area elevated mostly in the range of few meters to 50m height over the sea level except Jabal Sanam, which is elevated more than 150m over the sea level.

Methodology

Nine sediment samples were collected from three sites at the banks (levees) of Sarraji, Hamdan and Abul khasib creeks branching from Shatt Al-Arab river, with intersection about 6km and with depths 0.5, 1 and 1.5m (Fig. 1).

All samples were dried overnight in an oven at about 65°C and then were disaggregated by the use of an agate mortar and pestle. Disaggregation was done gently in order to retain, as much as possible, the intrinsic grain sizes of the samples.

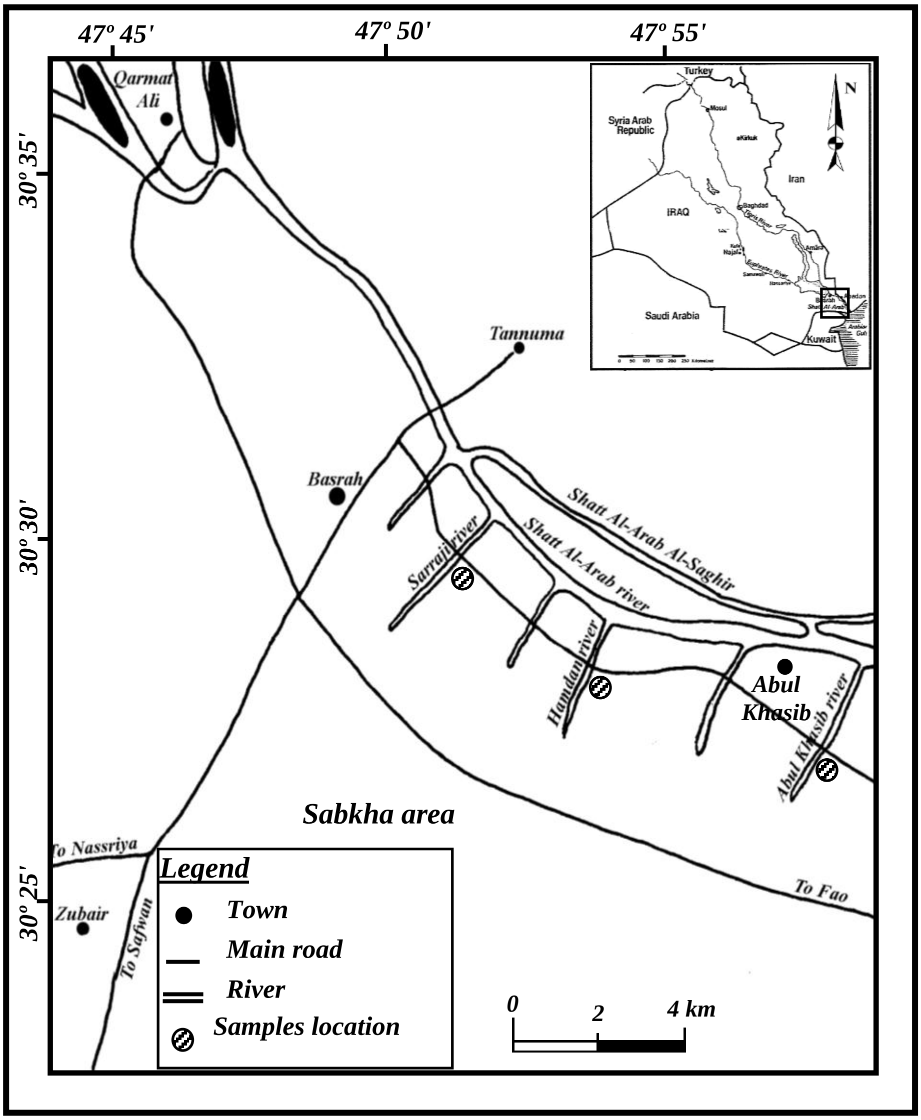

Figure 1: Map of south Iraq showing the sampling Locations.

Grain size analysis is carried out to separate sand from the mud using sieve 63 µm. The silt and clay proportions have been done and calculated by using Hydrometer method according to (ASTM C775-79, 1989). The statistical parameters of the grains were calculated using the equations proposed by Folk and Ward (1957), which included the mean size (M_Z), sorting (σ), Skewnees (Sk) and Kurtosis (K_G).

Chemical analysis is performed for all samples in the laboratories of Kufa Cement plants, Najaf city according to Vogel *et al.* (1978). The analysis of SiO_2, SO_3 has been performed by using gravimetric methods, Fe_2O_3, CaO, MgO by volumetric methods, Al_2O_3 by colorimetry method and alkalis K_2O, Na_2O using flame photometer (type Corning 400). The loss on ignition (L.O.I) is calculated by burning the sample in the furnace (type Gallenkamp, Muffle furnace) in a temperature of 1050 °C for two and half hours (Cox *et al.*, 1977).

Mineralogical characteristics of the samples were determined by using X-ray diffraction analysis, type Panalytical Xpert PRO MPD with Ni-filtered and CuKα radiation, for the purpose of diagnosis and assessment of mineral components as well as identifying the type of clay minerals (<2 μm) in the isolated clayey size. Both randomly oriented powder and oriented slides samples were prepared depending on the procedures described by Carroll (1970) and Folk (1974). They were scanned over the range from 5° to 40° 2θ at a scanning speed 2° 2θ/min. The oriented slides were analyzed in different stages (non-treated, treated by Glycol ethylene at 60˚C/2 hr. in order to distinguish the expandable mineral phases, the slides were heated at 500˚C/2hr. for chlorite detection). All basal reflection peaks of minerals were diagnosed according to ASTM cards (Chao, 1969). The semiquantitative determination of relative amounts of major clay minerals was calculated by using Panalytical X'Pert HighScore software depending up on specific reflections and intensity factors.

Results and discussion

Grain size distribution:

The results of the grain size analysis of the studied samples are given in Table (1), which shows the percentages of the sediments components of sand, silt and clay. The results indicate of clearly a decrease in the percentage of sand in the sediments with the range between 1-3% with an average 1.8% , while the silt portion was high in all sites and depths 47-64% with an average 57.6%. The quantity of clays was relatively less than silt, and ranges between 33-52% and 40.7% in average, and its percentage declines inversely to the silt portions. There is a tendency of increasing in silt percentage from Sarraji toward the Abul Khasib area and decreasing in clay percentage with depth. According to Folk (1974) classification, the studied recent sediments can be characterized as Mud type (M).

Table (1) shows also the statistical parameters results of the grain size, where the values of the mean size range between 6.7-7.45Φ and 7.03Φ in average. The majority of sediments falls in the fine to medium silt category indicating that the sediments were deposited at low energy conditions. The sorting (standard deviation) is 1.69Φ indicating that the sediments are poorly sorted (Folk, 1974). The Skewness values indicate the majority of the sample grains concerning coarseness and fineness values fluctuated between coarse skewed in the Abul Khasib to strongly coarse skewed in the Sarraji and Hamdan areas, and its average was -0.40, the graphic kurtosis values range between 0.66-1.04 and 0.81 in average reflecting a platykurtic to very platykurtic classification (Folk, 1974).

Table 1: Results of the grain size analysis and statistical parameters of the studied samples.

Location	Depth (m)	Grain size analysis %			Statistical parameters of grain size			
		Sand	Silt	Clay	Mean	Sorting	Skewness	Kurtosis
Sarraji	0.5	1	47	52	7.45	1.55	-0.63	1.04
	1	1	53	46	7.3	1.61	-0.56	0.98
	1.5	2	58	40	7.23	1.60	-0.43	1.00
Hamdan	0.5	1	58	41	7.03	1.75	-0.49	0.80
	1	2	57	41	7.01	1.76	-0.48	0.78
	1.5	2	60	38	6.92	1.71	-0.35	0.71
Abul Khasib	0.5	3	64	33	6.70	1.78	-0.19	0.71
	1	2	59	39	6.88	1.72	-0.28	0.68
	1.5	2	62	36	6.76	1.73	-0.20	0.67
Range		1-3	47-64	33-52	6.70-7.45	1.55-1.78	(-0.63)-(-0.19)	0.67-1.04
Average		1.8	57.5	40.7	7.03	1.69	-0.40	0.81

Geochemistry:

The results of the chemical analysis of the major elements and the percentage of L.O.I are given in Table (2). The chemical composition of the examined samples changes in relative to their mineralogical composition. SiO_2 concentration is the highest percentage of the total oxides in all samples, where it ranges from 33.6-42.84%, with an average of (37.41%), its highest value in the Sarraji area is attributed to increasing of the silt fractions. The concentration of CaO ranges between 16.2 and 20.0% and 17.9% in average, it is correlated with calcite ($CaCO_3$), dolomite ($CaMg(CO_3)_2$) and mixed layer chlorite-montmorillonite that contributes to a few percentage (Figure 2), and these minerals have appeared in the XRD patterns (Figure 3 and 4).

The aluminum oxide (Al_2O_3) is nearly constant in all the sediments ranging from 9.63-11.4% and average 10.6%; while the iron oxide (Fe_2O_3) values range between 4.38-5.7% and average 5.18%. It was noted that magnesium oxide has a range between 5.37 and 6.22% and average 5.81%, and these values are correlated with dolomite and some clay minerals like Chlorite and palygorskite (Figure 2, 3 & 4). The percentage of the total alkalis (K_2O, Na_2O) ranges between 0.8 and 1.4% and average 1.08%, where as K_2O is controlled by the proportion of illite, and Na_2O is correlated to montmorillonite and dissolved salts. The percentage of sulfur oxide (SO_3) is 0.32% and it is almost constant in all samples. The source of the sulfate is dissolved salts of Shatt Al-Arab river as well as the contribution of the dry climate and high evaporation in the deposition of salts in the soil.

The percentage of loss on ignition (L.O.I) reflects the high proportion of carbonate, organic matter, free and crystallized water content and volatile gases during ignition range between 16.0 and 21.9% with an average of 19.5%.

Mineralogical analysis:

XRD patterns of the oriented and non oriented slides are obtained under different measurement conditions of the studied samples are shown in Figures (3 and 4), which reveals the existence of clay and non clay minerals.

Non-clay minerals are represented by quartz mineral that appeared at the basal reflections 3.34, 4.26, 2.46, 2.28 °A, calcite 3.04 °A, dolomite 2.89 °A, feldspar 3.2 °A and gypsum 7.56 °A; whereas the clay minerals include kaolinite that appeared at the basal reflections 7.16, 3.57 °A, illite 10, 5 °A, chlorite 14, 7.1, 3.53 °A, palygorskite 10.5, 6.5 °A and mixed layers of chlorite-montmorillonite 13-15 °A.

The clay mineral assemblages consist mainly of mixed layers of chlorite-montmorillonite 33-43% with an average of 37%. Illite 17-24% and chlorite 15-21% are in lesser abundance with averages of 24% and 20%, respectively. Whereas kaolinite 11-15% and palygorskite 10-13% are frequently present in small quantities in all sediments with averages of 14% and 10%, respectively (Table 3).

Table 2: Results of the chemical analysis of the studied samples.

Location	Depth (m)	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	L.O.I
Sarraji	0.5	38.77	11.1	5.61	16.92	6.22	0.3	1.4	1.22	17.31
	1	39.1	10.9	4.94	17.55	5.73	0.29	0.9	0.83	19.49
	1.5	42.84	10.74	5.7	16.23	5.72	0.43	1.33	0.99	16
Hamdan	0.5	35.2	9.63	4.96	20.03	5.52	0.28	0.8	1.18	21.15
	1	33.6	11.44	4.38	18.09	5.81	0.40	1.15	1.09	21.79
	1.5	36.6	10.88	5.3	17.04	6.1	0.33	0.98	1.2	20.23
Abul Khasib	0.5	34.6	10.3	5.02	19.91	5.37	0.32	1.12	1.03	21.9
	1	39.81	10.83	5.19	17.45	5.86	0.37	1.07	1.02	18.05
	1.5	36.24	10.46	5.56	17.9	5.97	0.23	1.1	1.13	20.04
Range		33.6-42.8	9.63-11.4	4.38-5.7	16.2-20.0	5.37-6.22	0.23-0.43	0.8-1.4	0.83-1.22	16.0-21.9
Average		37.41	10.69	5.18	17.9	5.81	0.32	1.09	1.07	19.5

Mineral	Composition (additional to hydrated alumino-silicate) Ca	Mg	Fe	K	Atomic lattice structure	Source	Rock name
Montmorillonite					Three-layer	Volcanics	Bentonite
Chlorite					Four-layer	Mafic minerals	
Glauconite					Three-layer	Submarine diagenesis	
Illite					Three-layer	Feldspars	
Kaolin					Two-layer	Feldspars	China clay Fire clay Tonstein

Figure 2: Summary of the salient features of the main groups of clay minerals and their associates, (Selley, 2000).

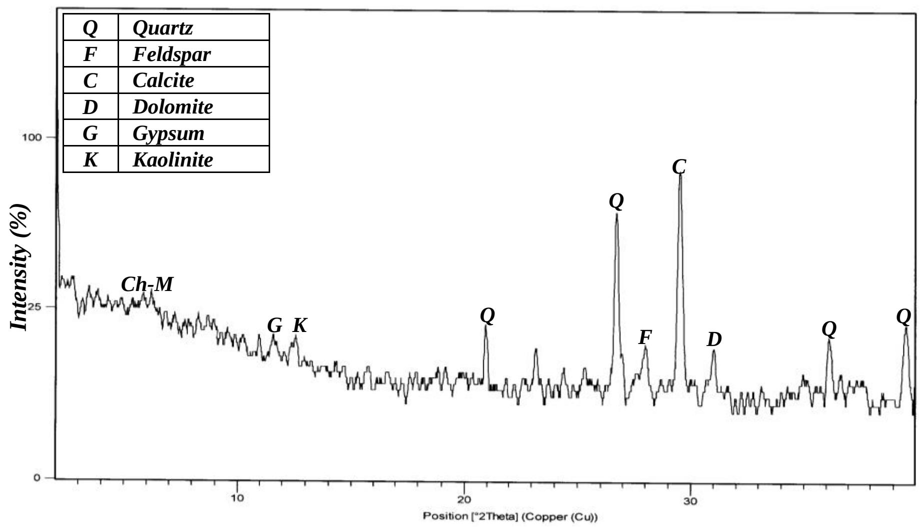

Figure 3: X.R.D pattern showing the main detected minerals of Abul khasib bulk sample.

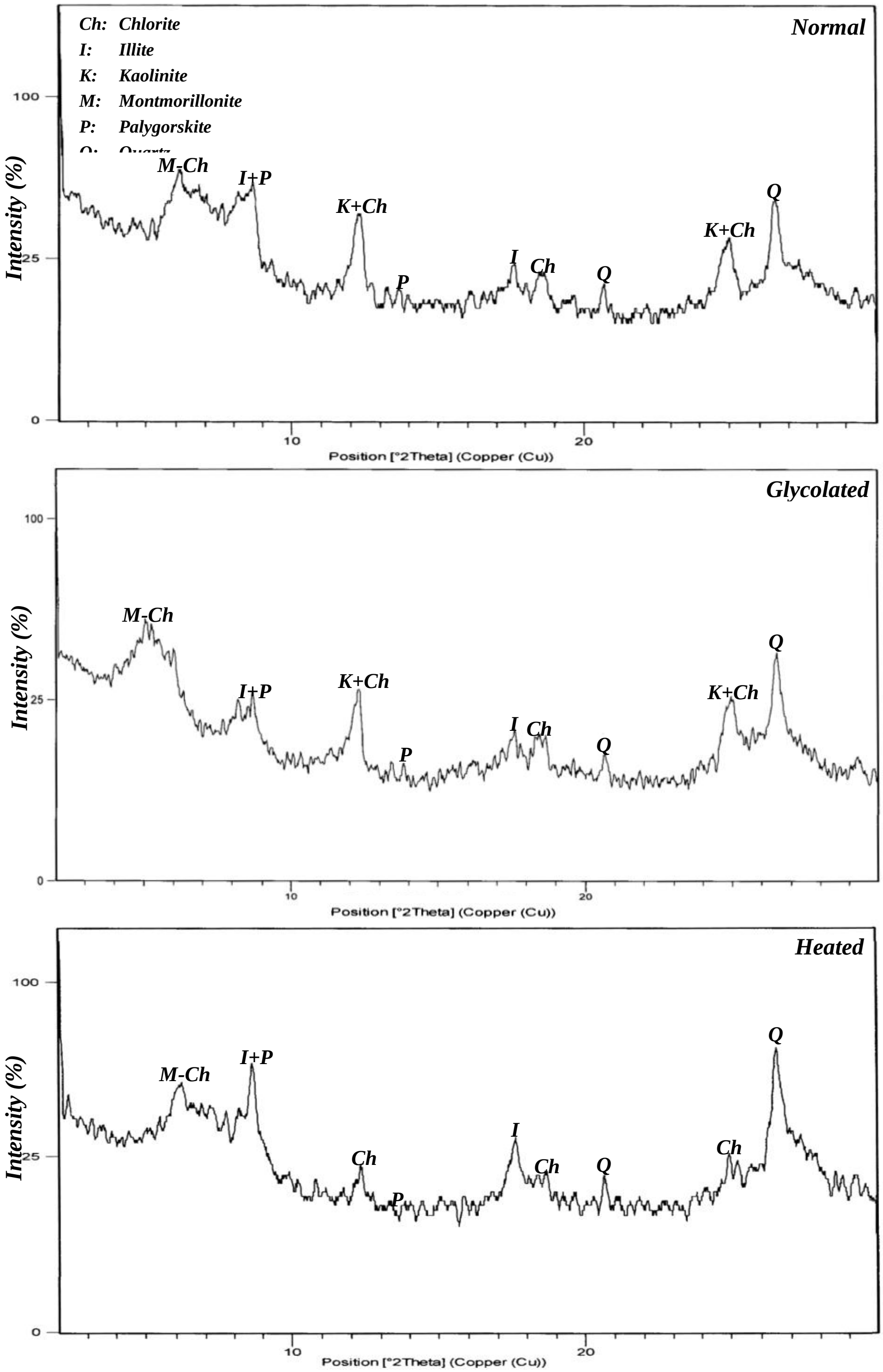

Figure 4: X.R.D patterns of oriented clay fraction of Abul Khasib sample in different treatments stages.

Table 3: Relative clay minerals abundances in the sediment samples (unit: %).

Location	Depth (m)	Chlorite-Mont.	Illite	Chlorite	Kaolinite	Palygorskite
Sarraji	0.5	36	22	17	14	11
	1	38	24	15	13	10
	1.5	37	20	17	15	11
Hamdan	0.5	36	18	20	14	12
	1	39	19	17	12	13
	1.5	33	19	20	15	13
Abul Khasib	0.5	43	17	16	13	11
	1	36	18	21	15	10
	1.5	42	20	15	11	12
Range		33-43	17-24	15-21	11-15	10-13
Average		37	20	18	14	11

Table 4: Comparison between the clay minerals in the present study and those surrounding if the areas.

Authors	Clay mineral								
	Ch	I	K	M	P	Ch-M	I-Ch	I-M	I-P
Abdullah, 1982 Euphrates river	15	-	14	30	-	-	present	-	29
Al-Mussawy and Basi, 1992 Khor Al-Zubair	15	15	17	37	16	-	-	-	-
Al-Beyati *et al.*, 2000 Shatt Al-Arab	23	23	24	-	-	-	10	23	-
Albadran, 2000 Tigris river	58	22	21	-	-	-	-	-	-
Present study	18	20	14	-	11	37	-	-	-

Ch: Chlorite, I: Illite, K: Kaolinite, M: Montmorillonite, P: Palygorskite, Ch-M: Chlorite-Mont, I-M: Illite-Mont., I-P: Illite-Palygorskite, I-Ch: Illite-Chlorite.

The type and relative abundance of clay minerals in the surrounding area and adjacent regions are summarized in Table (4), which may help to understand and distinguish the sources of the sediments in the present study area. The clay minerals diagnosed above were derived from different sources of igneous, metamorphic and sedimentary rocks. The clay minerals may be transported by rivers and deposited as fluvial deposits often bearing inherited properties from the weathered parent rock, so it is possible to use these minerals as tracer to elucidate the sources area.

Mixed layers of clay minerals are formed by the stacking of layers of different type or composition, and the diagentic alteration processes are the main causes of increasing mixed layers (Meunier, 2005). So, these processes are responsible for increasing in the abundance of chlorite-montmorillonite mixed layers of clay mineral in the study area.

Illite can be produced by the weathering of potasic feldspar minerals in a continental environment, but when it is found with chlorite indicating the shale or metamorphic source rocks (Grim, 1968; Millote, 1970). Chlorite and palygorskite minerals usually derived from the rich sources of iron, magnesium and calcium consisting these minerals (Figure 3). These minerals are alteration products of ferromagnesian minerals belonging to the basic igneous or metamorphic rocks (Millote, 1970; Weaver and Polland, 1973).

Kaolinite can be formed by weathering of potash feldspar minerals (Grim, 1968) or as a result of re-erosion of ancient sediments (Al-Rawi, 1977), it may exists in the fluvial or coastal environments (Grim, 1968). The original source is either detrital coming from the high drainage channels or as a result from diagenetic processes during transportation by leaching of other minerals. The origin of kaolinite in current samples could be detrital and transported by rivers as a well known mineral in the Iraqi sediments.

The absence of montmorillonite in all sediments may be due to its transformation to illite by illitization or to chlorite by chloritization or to mixed layers Ch-Mont. The illite or chlorite produced from montmorillonite when all the exchange positions are occupied by (K^+) or (Mg^{+2}) ions respectively from certain condition (Grim, 1968). Chemical analysis indicated the presence of these ions with sufficient concentration which are necessary to achieve these transformation processes. Therefore, the clay minerals found in the present samples indicated that they are derived from the basic igneous and metamorphic rocks, and the less acidic igneous and sedimentary rocks. The depositional environment of these minerals may be characterized by an arid to semi-arid climate in the source area.

Conclusions

1. The deposits are considered to be recent sediments composed mainly of silt and clay with very small portion of sand having mud type texture.
2. All samples have high concentrations in SiO_2 and CaO in comparison with Al_2O_3, Fe_2O_3, MgO, SO_3, K_2O and Na_2O, and that generally coincides with their mineral composition.
3. The origin of illite, chlorite, kaolinite and palygorskite clay minerals are detrital but chlorite-montmorillonite mixed layers are authogenic. They

resulted from the weathering of parent rocks and surrounding area during transportation.

4. The mixed layers chlorite-montmorillonite are the most abundant clay minerals in all sites and depths, indicating high intensity of diagenetic alteration processes in depositional environment.

References

Abdullah, M.B. 1982. Sedimentology, petrography, geochemistry and hydrochemistry of the recent sediments of Hor Al-Hammar in southern Iraq. Unpublished M.Sc. thesis, Baghdad University, 192P., (In Arabic).

Al-Azzawi, T. 1996. Morphosedimentary and morphotectonic of the head of the Arabian Gulf using remote sensing and machine analysis technique. Unpublished PhD thesis, Baghdad University, 225P., (In Arabic).

Albadran, B.N. 2000. Clay mineral distribution in selected locations along Tigris and Shatt Al-Arab rivers, South Iraq. Marina Mesopotamica, 15(2): 439-452.

Al-Beyati, F.M., Nasir, A.K.K. and Al-Marsoumi, A.H. 2000. Clay mineralogy of mid-channel bottom sediments from southern part of Shatt Al-Arab. Marina Mesapotamica, 15(1): 25-38.

Al-Dabbagh, S.M. and Albadran, B. 1995. Clay minerals in the sediments of the north west part of the Arabian Gulf, Iraq. Marina Mesapotamica, 10(1): 223-230, (In Arabic).

Al-Marsoumi, A.M.H., Al-Khafaji, S.J., and Al-Jabbry, M.H.A. 2006. Sedimentological and mineralogical aspects of Khor Abdullah supratidal sediments, North West Arabian gulf. Marina Mesopotamica, 21(1): 13-28.

Al-Mussawy, S.N. and Basi, M.A. 1992. Clay minerals of suspended-matter and surficial sediments of Khor Al-Zubair estuary, NW Arabian Gulf. Estuarine, Coastal and Shelf Science, 35: 1-11.

Al-Rawi, I. K. 1977. Sedimentological study of the alluvial plain deposits in Diwania area. Unpublished M.Sc. thesis, Baghdad University, 138 P.

Aqrawi, A.A.M. 1993. Petrology and mineral content of sea-floor sediments of the Tigris-Euphrates delta, North-west Arabian Gulf, Iraq. Esturine, Coastal and Shelf Science, 38: 569-582.

ASTM C775-79. 1989. Particle-size analysis of whiteware clays. Annual Book of ASTM Standard, 15.02: 248-253.

Carroll, D. 1970. Clay minerals: A guide to their X-ray identification. Geological Society of America, Special paper, 126, Colorado, 80P.

CHAO, G.Y. 1969. 2θ (Cu) table for common minerals, Geological paper 69-2, Ottawa, Canada, 34P.

Cox, F.C., Bridge, D. McC. And Hull, H. 1977. Procedure for the assessment of limestone resources. Institution of Geological Science, 30: 23-36.

Folk R.L. and Ward, W.C. 1957. Brazos River bar- a study in the significance of grain size parameters. Journal of Sedimentary Petrology, 27: 3-26.

Folk, R.L. 1974. Petrology of sedimentary rocks. Hemphill, Texas, 182P.

Grim, R.E. 1968. Clay mineralogy. 2nd Ed., McGraw-Hill Book Co., New York, 596P.
Khan, N.M., Albadran, A., and Albadran, B.N. 1992. Some engineering aspects of the alluvial deposits at Basrah region, South of Iraq. Iraqi Geological Journal, 25(1): 80-91.
Meunier, A. 2005. Clays. Springer-Verlag, Berlin, Heidelberg, 472P.
Millot, G. 1970. Geology of clays, Springer verlag, Berlin, 425P.
Saadallah, A.A. and Salman, H.H. 1987. Textural analysis of Shatt Al-Arab levee sediment, Southern Iraq. Journal of water resources, 1: 101-118.
Selley, R.C. 2000. Applied sedimentology, 2nd Ed., Academic Press, San Diego, 523P.
Tucker, M.E. 1981. Sedimentary petrology, an introduction. Blackwell scientific publications, 252P.
Vogel, A.I., Bassett, J., Denney, R.C., Jeffery, G.H., and Mendham, J. 1978. Vogel's textbook of quantitative inorganic analysis including elementary instrumental analysis. 4th Ed., New York, Longman, 925P.
Weaver, C.F. and Polland, L. 1973. The chemistry of clay minerals, Elsevier scientific publishing Co., Amsterdam, 213P.

دراسة جيوكيميائية ومعدنية للترسبات النهرية في منطقة أبي الخصيب، جنوبي شرق العراق

صفاء حسين العلي

كلية العلوم، جامعة البصرة، البصرة - العراق

المستخلص - جمعت 9 نماذج رسوبية من 3 مواقع تمثل ضفاف القنوات الرئيسة المتفرعة من نهر شط العرب، جنوبي شرق محافظة البصرة وهي السراجي وحمدان وأبي الخصيب وبأعماق 0.5، 1، 1.5م. اظهر التوزيع الحجمي الحبيبي ونتائج المعاملات الإحصائية إن الترسبات قيد الدراسة هي ترسبات حديثة تتكون بشكل رئيس من الغرين والطين مع وجود كمية قليلة جداً من الرمل، تزداد كمية الغرين من منطقة السراجي باتجاه منطقة أبي الخصيب وتتناقص نسبة الطين مع العمق، وأنها ذات فرز رديء وتفلطح منبسط إلى منبسط جداً وحيود خشن إلى خشن جداً ترسبت في ظروف بيئية هادئة ذات طاقة واطئة. بيّن التحليل الكيميائي ارتفاع نسبة أكاسيد SiO_2, CaO مقارنة بالاكاسيد الأخرى وفي جميع النماذج قيد الدراسة وهذا يتوافق مع تركيبها المعدني. معدنياً، تكونت الرواسب من معادن الكوارتز والفلدسبار والكالسايت والدولومايت والجبس، أما اهم المعادن الطينية فهي: طبقات مختلطة من الكلورايت-مونتموريللونايت (37%)، والإلايت (20%)، والكلورايت (18%)، والكاؤولينايت (14%) والباليكورسكايت (11%). إن ارتفاع نسبة المعادن الطينية المختلطة ذات الأصل مكاني النشأة قد يعود إلى الشدة العالية للعمليات التحويرية التي تعرضت لها الرسوبيات في بيئة الترسيب. تبين مجاميع المعادن الطينية إن الترسبات قيد الدراسة مشتقة من صخور نارية قاعدية ومتحولة مع مساهمة قليلة للصخور النارية الحامضية والرسوبية تكونت في بيئة ذات مناخ جاف إلى شبه جاف في منطقة المصدر.