Mineralogical properties of the Quaternary deposits in the Iraqi highway, east of Al Warka city- Southern Iraq

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Abstract. The study was carried out on sub-surface sediments of quaternary deposits in the southern part of the Iraqi highway-east of the Al Warka city, Southern Iraq. This study has been focused on the variety of sedimentary environments in the quaternary period. The variations in mineralogy and texture with depths gave an indicator of environmental change. Silt, sandy silt, silt loam and sandy loam are most of sediments texture variation with depths. Quartz, anorthite feldspar, dolomite, calcite, Mg-Ca calcite, and gypsum are most of the light minerals in the studied area. Quartz and feldspar are dominant form depth intervals between 1 to 5 meters. Calcite is predominant at depth 6 meters with high shell fragments reached 38% as an indicator to change of sedimentary environments from depth interval 6 to 12m. The rate of shells growth at 6m depth was much higher in the fine-sediment and nutrient-rich channel, this conclusion may be an indicator of environmental change at this depth, suggests a high nutrient content in the river at this period allowed for molluscs shell growth. Opaque minerals, Chlorite, Pyroxene, biotite, epidote, staurolite, zircon, tourmaline, and rutile are most of the heavy metals. Chlorite, biotite, pyroxene, zircon, garnet, and rutile are increase with depths, while opaque and celestite are decreasing with depths. Chlorite, illite, and kaolinite are most of the clay minerals. Illite and kaolinite are increase with depths, while chlorite is decreased with depths.

1. Introduction

The Iraqi land is covered mainly by sedimentary rocks, quaternary sediments and very rare igneous and metamorphic rocks. The sedimentary rocks are represented mainly by clastic, carbonates, and subordinate gypsum, shale, and marl [1]. The quaternary sediments cover considerable parts in Iraq, especially in the central part; they are represented by different types of alluvial sediments of the Tigris and Euphrates Rivers flood plains, and their tributaries. They form the main Mesopotamian Land. The sediments are mainly of silt, clay, sand with subordinate gravels. Moreover, gypcrete and sand dunes also cover considerable parts of the Iraqi Territory. The study area is part of the Mesopotamia plain, which represents a major subsidence basin that began from the middle ages to the recent [2]. The study area lies within the unstable shelf of the Arabian Plate [3]. The Mesopotamia Plain is a sedimentary unit and wide lowland with clear physiographic boundaries; it is bordered by the low folded zone from the northern and eastern sides, the western desert and Al-Jazira Area from the western side, and from the south to the Arabian Gulf [4]. The sediments of Holocene are characterized by different environments, such as the fluvial, lacustrine, estuaries, and Aeolian environments [5]. [6]explained that the deposition of this period was influenced by several factors, namely sedimentation rate, sea-level fluctuation, and neotectonic activities. The thickness of these sediments ranges between 15–20 m. Much of what has been written and published about the Mesopotamia Plain and quaternary sediments in southern Iraq, like [7-18] which concluded the mineralogy of the quaternary sediments shows significant variability in the depth distribution and size fractions. The aim of the present study is to detect the mineralogy and environmental variations in the three wells of quaternary deposits in the Iraq highway of Nasyriah city -east of the Al Warka city.

2. Location of the study area

The study area is located in the north of Nasyriah city- east of the Al Warka city, Southern Iraq (see Figure 1).

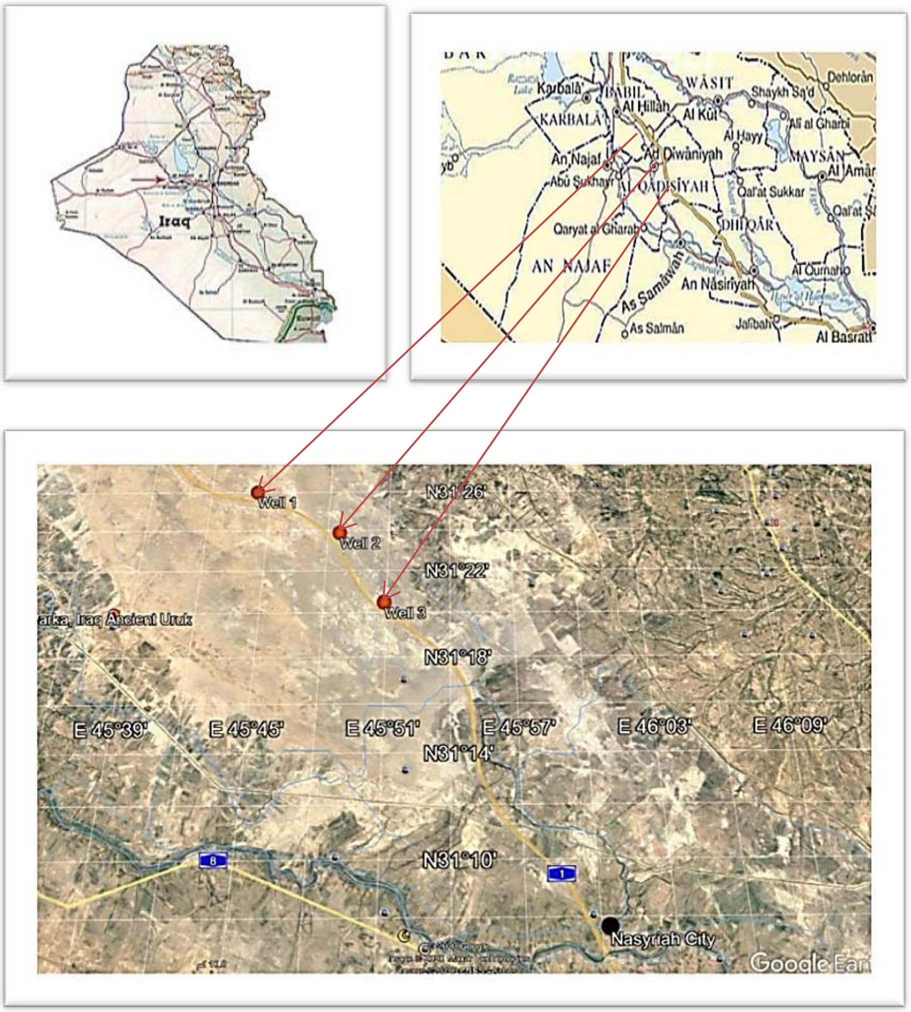

Figure 1. Study area

3. Materials and methods

Three wells at depths between 8-12m are collected. Figure 2 presented the depths of the studied wells. The core sample of any station is preserved and folded by aluminium foil sheets. Thereafter, dried under sunlight, then divided into several parts depending on the depth of each. All the samples from selected wells are ground well and mixed together to be a homogenous representative sample. The sample was placed in distilled water and disaggregated with a mechanical mixer. The suspension was then passed through a 300- mesh ASTM sieve and the material retained on the sieve was dried and saved for microscopic study. Light and heavy minerals for core samples measured using the Polarizer microscope and X-ray diffraction. The clay fraction (<2 F) was separated by a sedimentation procedure. Sodium Hex

IOP Conf. Series: Earth and Environmental Science **779** (2021) 012064 doi:10.1088/1755-1315/779/1/012064

metaphosphate used as the dispersing agent when needed. Clay minerals were measured using x-ray diffraction for three stages (Normal, Ethylene Glycol, and heating 550 °c).

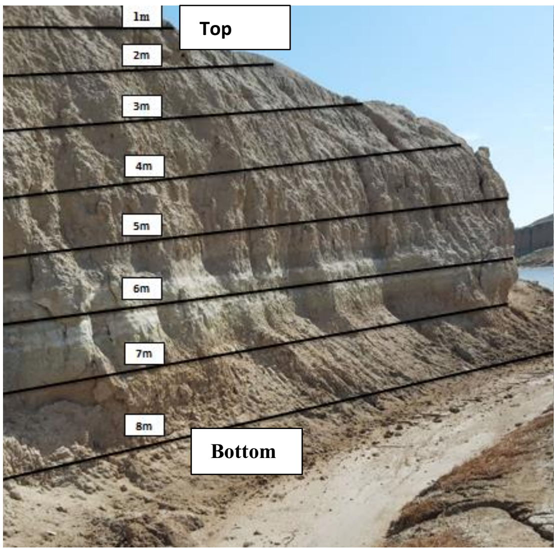

Figure 2. Explain the sequence layer from top to bottom

Figure 3. Shell fragments at 6m

4. Results

4.1. Grain size analysis

Sand, silt, and clay are presented in Tables 1, 2 and 3. Silt fraction is dominant compare with sand and clay. Silt, sandy silt, silt loam and sandy loam are the main texture in the sediments of the study area.

Table 1. Grain size analyses of the sediments in the study area at well 1

No.	Depth (M)	Sand%	Clay%	Silt%	Texture
1A	0.5	6.9753	7.41	85.6147	Silt
1B	0.8	25.2355	18.9	55.8645	Silt loam
1C	1	22.675	8.8	68.525	Silt loam
1Z	1.2	11.769	13.406	74.8249	Silt loam
1Y	1.7	17.25	11.1067	71.6433	Silt loam
1D	2	13.1255	9.655	77.2195	Silt loam
1E	2.5	19.5983	10.109	70.2927	Silt loam
1F	2.8	14.9215	13.875	71.2035	Silt loam
1G	3	7.7204	9.106	83.1736	Silt
1H	3.5	6.281	15.7053	78.0137	Silt loam
1K	4	12.6250	7.739	79.636	Silt loam
1M	4.5	12.238	24.856	62.906	Silt loam
1N	5	7.108	19.9160	72.976	Silt loam
1O	5.5	3.608	16.078	80.314	Silt loam
1P	6	3.6740	21.905	74.4209	Silt loam
1R	6.5	5.499	5.527	88.974	Silt

Table 1. to be contained

No.	Depth (M)	Sand%	Clay%	Silt%	Texture
1S	7	10.308	9.432	80.26	Silt
1T	7.5	1.096	30.551	68.353	Silty clay loam
1X	8	6.219	8.793	84.988	Silt
Range		1.096-25.2355	5.527-30.551	55.8645-88.974	
Mean		10.943%	13.83526%	75.22123%	

Table 2. Grain size analyses of the sediments in the study area at well 2

No.	Depth (M)	Sand%	Clay%	Silt%	Texture
1A	0.5	5.9755	8.4	85.6245	Silt
1B	0.8	22.2455	17.325	60.4295	Silt loam
1C	1	19.675	10.2	70.125	Silt loam
1D	2	14.8255	9.425	75.7495	Silt loam
1E	2.5	18.1415	10.025	71.8335	Silt loam
1F	2.8	15.5215	12.275	72.2035	Silt loam
1G	3	6.7005	8.105	85.1495	Silt
1H	3.5	5.371	12.725	77.62	Silt loam
1K	4	15.5525	4.575	79.8752	Silt loam
1M	4.5	12.063	20.4	67.537	Silt loam
1N	5	4.895	17.875	77.23	Silt loam
1O	5.5	2.527	18.55	78.925	Silt loam
1P	6	2.4545	21.775	75.7705	Silt loam
1R	6.5	7.466	4.45	88.084	Silt
1S	7	10.2955	6.4	83.3045	Silt
1T	7.5	-	27.225	71.5735	Silty clay loam
1X	8	5.371	8.475	86.154	Silt
1Y	1.7	14.3555	7.925	77.7195	Silt loam
1Z	1.2	12.063	15.2	72.1415	Silt loam
Range		10-12%	4.45-27.225	60.4295-88.084	
Mean		10%	12.7%	76.68%	

Table 3. Grain size analyses of the sediments in the study area at well 3

No.	Depth (M)	Sand%	Clay%	Silt%	Texture
1A	0.5	5.982	8.790	85.2280	Silt
1B	0.8	20.096	19.565	60.339	Silt loam
1C	1	17.983	7.872	74.145	Silt loam
1D	2	12.1255	10.852	77.0225	Silt loam
1E	2.5	19.9053	11.532	68.5627	Silt loam
1F	2.8	11.785	15.592	72.623	Silt loam
1G	3	6.8431	8.396	84.7609	Silt
1H	3.5	9.450	19.832	70.7179	Silt loam
1K	4	12.348	7.13	80.522	Silt loam
1M	4.5	10.209	20.81	68.981	Silt loam
1N	5	5.945	19.981	74.074	Silt loam
1O	5.5	5.751	17.756	76.493	Silt loam
1P	6	3.725	22.845	73.43	Silt loam
1R	6.5	8.588	6.853	84.559	Silt
1S	7	13.583	9.951	76.461	Silt
1T	7.5	2.964	27.569	69.467	Silty clay loam
1X	8	7.528	9.379	83.0929	Silt
1Y	1.7	12.936	5.525	81.5389	Silt loam
1Z	1.2	13.109	19.381	67.51	Silt loam
Range		2.964-20.096	5.525-27.569	60.339-85.2280	
Mean		10.52%	14.084%	75.37%	

4.2. Mineralogy study

4.2.1. Light minerals. Quartz, calcite, dolomite, anorthite, Mg-calcite, and gypsum are the main minerals in the study area, as presently in Table 4 and Figures 4 and 5.

Table 4. Light minerals in the study area

Sample No.	Depth	Gypsum (G) %	Anorthite (A)%	Calcite (Ca) %	Quartz (Q) %	High Mg-Calcite (Mg-Ca)%	Microcline feldspar (M) %	Dolomite (D) %
1	1mtr	3.56	10.46	34.8	34.4	6.049	6.03	4.48
2	3mtr	9.79	17.67	37.89	20.4	4.71	5.99	9.79
3	5mtr	3.899	10.960	35.560	24.482	5.419	6.818	7.856
4	6mtr	8.012	12.05	47.23	13.14	2.413	4.124	16.03
5	7mtr	2.21	5.951	44.745	31.854	5.790	3.078	6.371
6	8mtr	15.434	7.835	24.21	18.71	2.618	17.334	13.86
Rang		2.21-18.149	5.951-17.67	24.21-47.263	18.149-34.4	2.618-6.049	3.078-17.334	3.856-22.603
Mean		6.661	10.889	37.078	24.665	4.408	7.139	10.16

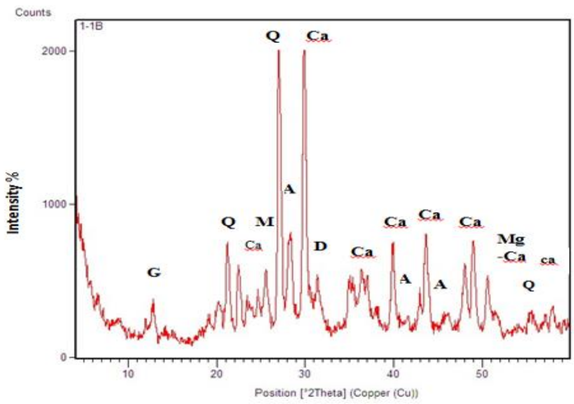

Figure 4. Light minerals detected by XRD

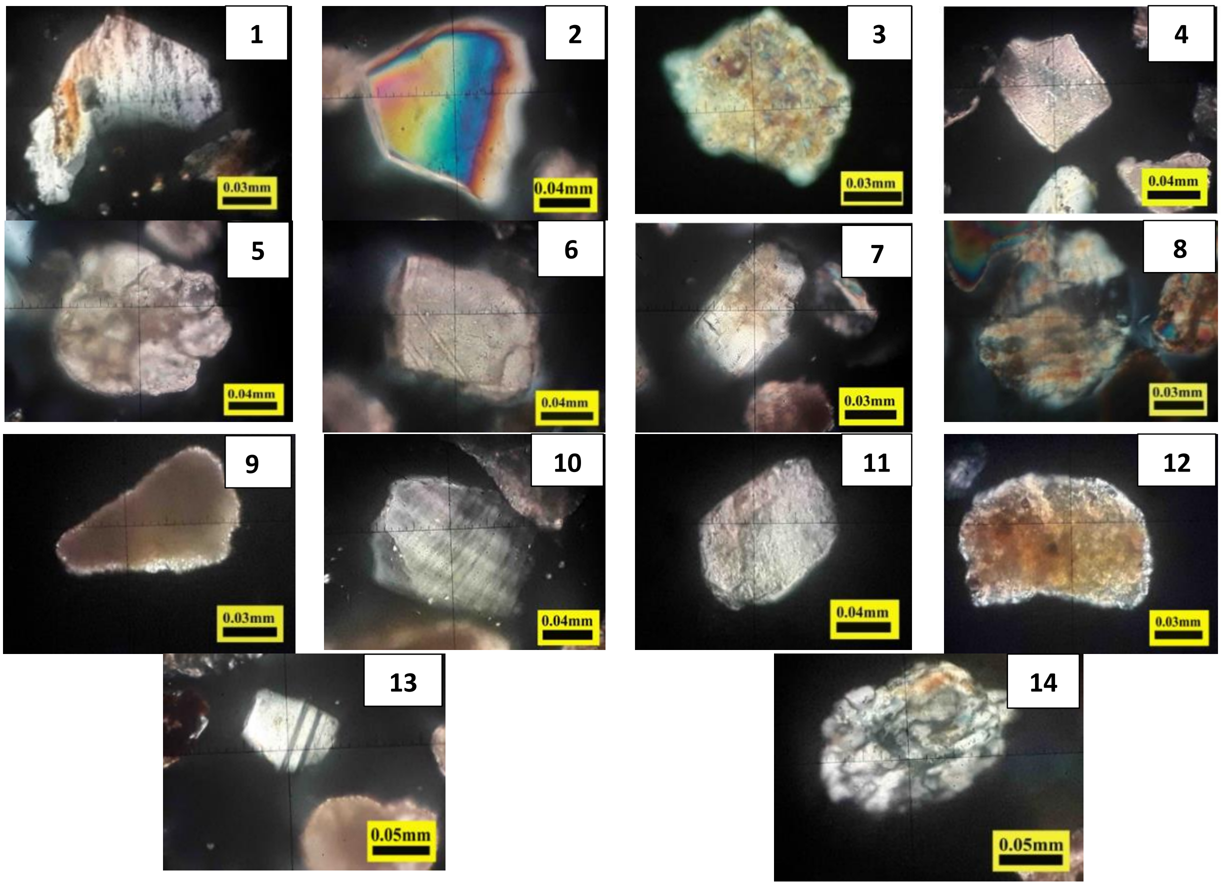

Figure 5. Light minerals under poharize microscope.XPL, (1) Angular igneous rock fragment,8m. (2) Angular monocrystalline quartz,7m. (3) Angular polycrystalline grain, 3m. (4) Carbonate rock fragment (aragonite shell), 3m. (5) Carbonate rock fragment (fossil grain), 8m. (6) Carbonate rock fragment, Dolomitic limestone, 7m. (8) Evaporite grain (gypsum), 7m. (8) Metamorphic rock fragment (schist),1m, XPL. (9) Mudstone rock fragment, 6mtr. (10) Potash feldspar (microcline), 3m. (11) Potash feldspar (orthoclase). (12) Rounded coated grain by clay, 8m.(13) Subangular Anorthite feldspar, 8m. (14) Subangular chert rock fragment,7m.

4.2.2. Heavy minerals. Zircon, tourmaline, hornblende, opaque minerals, pyroxene, epidote, chlorite, and biotite are the main heavy minerals in the sediment, as presented in Table 5 and Figure 6.

Table 5. Heavy minerals in the sediments of the study area

Heavy Minerals		**Samples Number**					**rang**	**mean**
		1mtr	**3mtr**	**6mtr**	**7mtr**	**8mtr**		
Opaques		44.1	43.6	40.5	36.2	43.2	36.2-44.1	41.52
Pyroxene Group	Orthopyroxene	4.2	4.3	4.8	4.9	5.1	4.2-5.1	4.66
	Clinopyroxene	2.1	0.9	1.8	1.5	1.2	0.9-2.1	1.5
Mica Group	Biotite	3.1	2.4	3.2	5.5	2.7	2.4-5.5	3.38
	Muscovite	7.0	4.8	6.8	7.3	5.4	4.8-7.3	6.26
	Chlorite	5.5	9.4	7.1	8.3	6.2	5.5-9.4	7.3
Amphibole Group	Hornblende	2.9	2.3	3.3	3.3	4.7	2.9-4.7	3.3
	Actinolite	0.9	1.2	1.0	1.2	1.5	0.9-1.5	1.16
	Glaucophane	-	0.7	0.5	-	0.3	0.3-0.7	0.3
Ultra-stable group	Zircon	5.6	5.0	6.9	9.7	6.2	5.0-9.7	6.68
	Rutile	2.5	2.2	2.2	3.9	3.2	2.2-3.9	2.8
	Tourmaline	2.9	4.4	4.9	3.2	3.6	2.9-4.9	3.8
Metastuble group	Kyanite	3.3	1.9	1.6	2.8	2.1	1.6-3.3	2.34
	Garnet	4.4	4.7	4.2	3.5	3.9	3.5-4.4	4.14
	Epidote	6.0	5.2	6.8	3.8	5.6	3.8-6.8	5.48
	Staurolite	2.0	1.4	2.5	2.4	1.8	1.4-2.0	2.02
	Celestite	2.5	3.7	-	1.2	2.1	1.2-3.7	1.9
Others		1.0	0.8	0.9	1.3	1.2	0.8-1.3	1.04

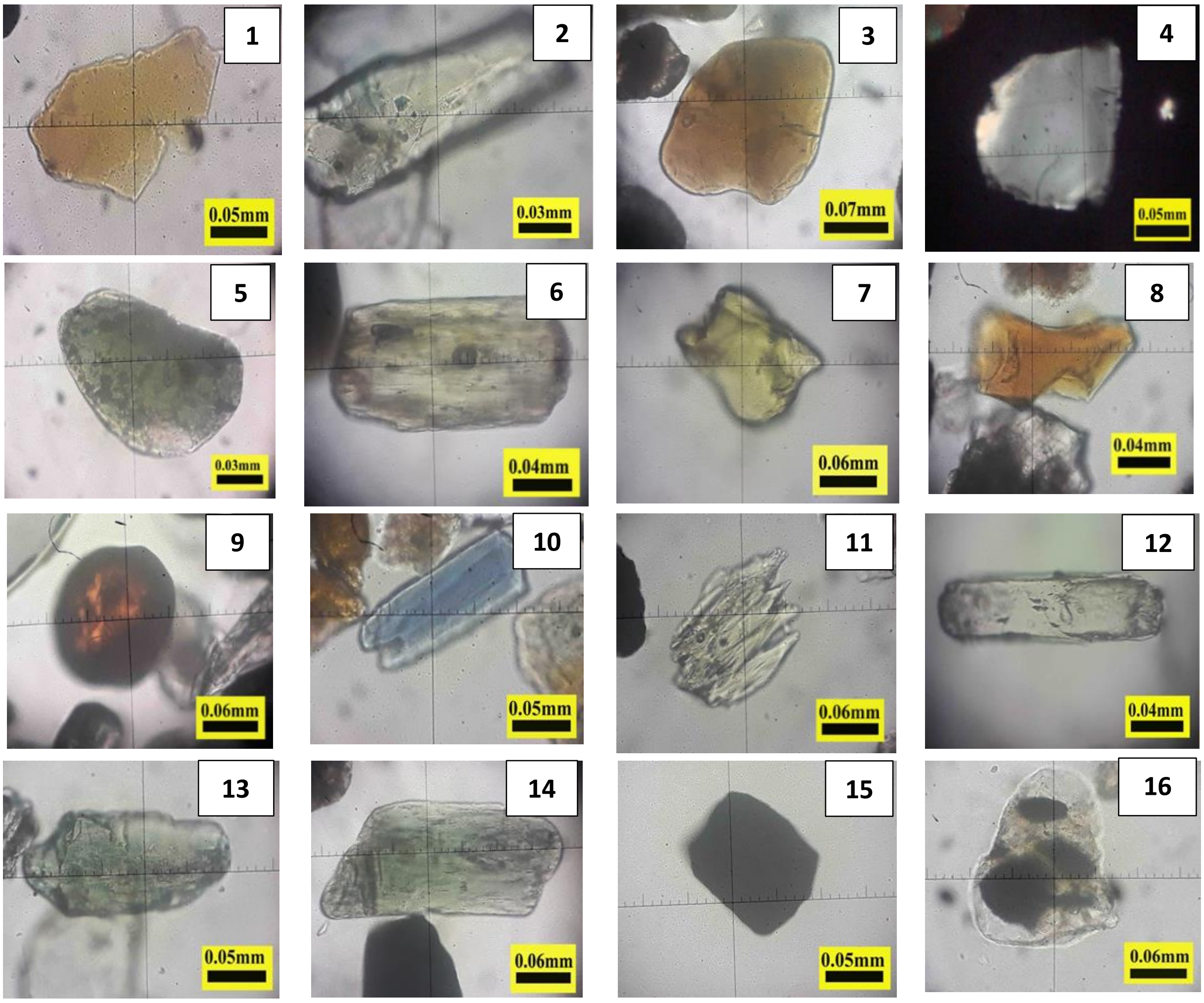

Figure 6 Heavy mineral under polarized microscope. PPL, (1) Brown colour, with strong pleochroism biotite mica, 6m. (2) High relief, elongated habit, color zircon, 8m. (3) Subrounded, honey colour with strong pleochroism tourmaline, 3m. (4) Flaky form, colourless muscovite mica,1m. (5) Flaky form, green colour chlorite, 7m. (6) High relief, subhedral,colorless orthopyrxene (enstatite),7m. (7) Angular, green colour epidote,6m. (8) Subrounded, yellowish colour staurolite,3m. (9) Well rounded, high relief, deep red colour rutile,1m. (10) Prismatic habit, blue violet colour glaucophane amphibole, 3m. (11) Medium relief, cockcomb habir, actinolite amphibole, 6m. (12) Medium relief, elongated habit, colourless celestite 8m. (13) Subhedral. prismatic habit, green clinopyroxen, 1m. (14) Subhedral, prismatic habit, green colour hornblende, amphibole, 7m. (15) Subhedral opque grain (iron oxide), 8m. (16) Flaky form, green colour chlorite with spots of iron oxides,7m.

4.3. Clay minerals

Chlorite, Illite, and kaolinite are the main clay minerals in the sediment, as presented in Table 6 and Figure 7.

Table 6. Clay minerals in the sediments of the study area

Sample No.	Type	Depth	Chlorite (Ch)%	Illite (I)%	Kaolinte (K)%
1	Normal	1mtr	55.825	23.106	21.068
3	Normal	3mtr	55.358	24.634	20.01
5	Normal	5mtr	60.602	23.919	15.477
6	Normal	6mtr	61	16.958	22.039
7	Normal	7mtr	44.403	30.7	24.896
8	Normal	8mtr	44.547	31.294	24.158
Rang			44.403-61	16.958-31.294	15.477-24.896
Mean			53.622	25.101	21.274

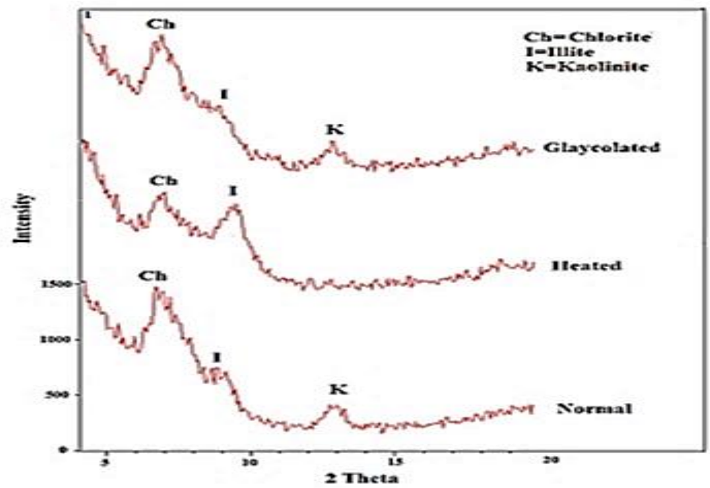

Fig 7. X-Ray diffractogram showing clay minerals

5. Discussion

Mineralogy analyses of three wells cutting in the southern part of the Iraq highway- north of Nasyriah city- east of the Al Warka city, Southern Iraq. The present study aims to recognize the mineral distribution during the Holocene sedimentation in southern Iraq. Tables 1, 2, and 3 presented the grain size analyses and sediment texture in the studied area. Grain size analyses showed that sand fractions were predominant at depths between 0.8m to 2.8m. Clay fraction started to increase from 17.325% at a depth interval of 0.8 m to 27.225% at 7.5m, while silt is found in a high content at 8m. Silt, silt loam, and silty clay loam textures are the main sediment textures. Calcite, quartz, anorthite feldspar, microcline feldspar, dolomite, high magnesium calcite, and gypsum are the dominant light minerals in the sediments of the study area as shown in table 4, and figures 4 and 5. Opaque group minerals, Mica group minerals (Biotite, muscovite, and chlorite), Amphibole group, Pyroxene group (Orthopyroxene and clinopyroxene) Ultra-stable group minerals (Tourmaline, Zircon, and Rutile), Meta-stable group minerals (garnet, kyanite, epidote, Staurolite, and Celestite) are most of the heavy minerals had been recognized as clear in table 5 and figure 6. In addition, clay minerals represented by chlorite, Kaolinite, and Illite are dominant in the sediments of the studied area as shown in table 6, and figure 7. Quartz has the highest values at a depth interval of 1m and the lowest at 6m. On the other hand, calcite is highest at a depth interval of 6m. There is a reverse relationship between quartz and calcite in the studied wells. High calcite percentage at 6 meters may attribute to a superabundance of shell fragments in this depth (see Figure 3). The shells are very useful in paleobiology and evolutionary biology because they form a rich fossil record and exposure to water energy and turbulence caused variation of shell morphology such variation has also been linked to sediment type. The rate of shells growth was much higher in the fine-sediment and nutrient-rich channel. In the present study, noticed the high abundance of shells at 6m, where fine sediments dominant represented by silt (75.7705%) and clay (21.775%), while the sand is lowest than the other depths, this conclusion may be an indicator to environment change at this depth, suggests a high nutrient content in the river at this period allowed to molluscs shells growth. Gypsum found in high content at 8 meters, which may be attributed to the dry climate and low river discharge. Opaque minerals, clinopyroxene, and kyanite are dominant at 1 meter. Chlorite, glaucophane, garnet, and celestite are main at 3 meters. Tourmaline, epidote, and staurolite are the main heavy minerals at 6 meters. While mica group minerals and ultra-stable minerals found at the highest values at 7 meters. On the other hand, orthopyroxene, hornblende, and actinolite are the main heavy minerals at a depth interval of 8 meters. According to the distribution of clay minerals in the studied area as summarized in table 6, chlorite has a positive relationship with calcite at 6 meters. Illite is found in high content at 8 meters, while kaolinite is highest at 7 meters.

References

[1] Sissakian V K and Saeed Z B 2012 Lithological map of Iraq, compiled using GIS techniques. Iraqi Bulletin of Geology and Mining, 8(3), 1-13.

[2] Buday T 1980 The Regional Geology of Iraq, Stratigraphy and Palaeogeography. State organization of minerals, Dar Al-Kutub Publishing House, Al-Mosul, Iraq, 443pp.

[3] Buday T and Jassim S Z 1987 The Regional Geology of Iraq Tectonism (Magmatism and Metamorphism). GEOSURV pub. Baghdad, 322 pp.

[4] Yacoub S Y 2011a. Geomorphology of mesopotamia plain. Iraqi Bull. Geol. Min., Special Issue, 4:7-32.

[5] Yacoub S Y, 2011b Stratigraphy of mesopotamia plain. Iraqi Bull. geol. min., special Issue,4: 47–82.

[6] Aqrawi AA 1995 Correction of Holocene Sedimentation Rates for Mechanical Compaction: the Tigris–Euphrates Delta, Lower Mesopotamia. Marine and Petroleum Geology, 12(4):409–16.

[7] Abdullah M B 1982 Sedimentology, Petrography, Geochemistry and Hydrochemistry of the Recent Sediments of Hor AL-Hammar in Southern Iraq. Unpublished MSc. Thesis, college of science, University of Baghdad, 192pp.

[8] Al-Azzawi TM 1996 Morphosedimentary and Morphotectonic of the Head of the Arabian Gulf Using Remote Sensing and Machine Analysis Techniques. Unpublished PhD. thesis, College of Science, Univ. of Baghdad, 224pp.

[9] AL-Baidhany A H, Darmoian S and Albadran B 2002. Evaluation of Holocene sedimentary environments of the southern part of Iraq. Basrah J. Science, B, 20(1):73-86.

[10] AL-Hamad S, Albadran B and Pournelle J 2015 Geological History of Shatt Al-Arab River, South of Iraq. International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064.

[11] Al-Jaberi M H 2017 Clay minerals variations in quaternary sediments of Basrah City-Iraq. Journal of Earth Science Research-Published by Canadian Center of Science and Education, 6(2):41-55.

[12] Al-Jaberi M H 2010 Sedimentological and environmental aspects of sub-surface Basrah sediments-South Iraq. Mesopt. J. Mar. Sci., 25(2):67-78.

[13] Al-Jibouri B S 1997 Paleontological Evidences for Climatic and Environmental Changes During Quaternary Period in Mesopotamian Plain. South of Iraq. Unpublished. M.Sc. Thesis, Univ. of Baghdad, 80 pp. (In Arabic).

[14] Al-Jumaily WA 1994 Quaternary Ostracods in Southern Iraq. Unpubl. Ph.D. Thesis, Univ. of Baghdad, 117 pp.

[15] Al-Sakini J 1993 New Window on the Mesopotamia History in the Light of Geological Evidences and Archaeology. Dar AL-Shaon AL-Thakafiya, ALAumah, Baghdad, 93pp.

[16] Macfadyen W A and Vita-Finzi C 1978 Mesopotamia: the Tigris—Euphrates delta and its HoloceneHammar fauna. Geological Magazine, 115(4): 287-300.

[17] Raji W and Salman B 1983 Paleontological and environmental study of the Mesopotamian plain in samawa- Nasiriya area. Geoserve, Unpubublish report, 1321P.

[18] Shareef N F and Mahdi M M 2015 Studying of recent environments in Faw, Khor Al-Zubair and Um- Qaser areas, Southwestern Arabian Gulf, Basrah, Iraq. Journal of Basrah Researches, 41(2):1-14.