Iraqi Bulletin of Geology and Mining *Vol.18, No.1, 2022* *p 21 – 34*

EVALUATION OF FEDHAT CLAYS IN AL-SALMAN AREA, SOUTHERN IRAQ, FOR THE MANUFACTURE OF CLAY BRICKS

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Received: 20/ 04/ 2022, Accepted: 18/ 08/ 2022
Keywords: Al-Salman area; Playa Lake; Compressive strength; Bulk density; Clay bricks; Iraq

ABSTRACT

Clay sediments were evaluated in playa lake called (Fedhat) in the south of Al-Samawa city within Al-Muthanna Governorate as a raw material for the bricks industry. These sediments are distributed in the specific area belonging to the Al-Salman district. Six samples were carefully selected from these sediments. These deposits are considered as a layer of fine-grained dark brown silt, interspersed with sandy lenses of various sizes. The chemical analysis showed that the major oxides are within the acceptable limits of the brick industry. The X-ray diffraction results of the samples showed two types of minerals; the clay minerals included (montmorillonite, palygorskite, kaolinite, chlorite, and illite), while the non-clay minerals are quartz, calcite, dolomite, and feldspar and gypsum.

The clay samples were ground to obtain fine sizes for each sample. Then, the sample was divided, squared, and sieved by a dry sieve device. The materials were mixed well by the continuous stirring of the sample and an amount of 600 grams was taken from each of the studied samples, and fermentation by adding an appropriate amount of water estimated at 18% to the sample for 72 hours for the bricks formed by extrusion method. As for the bricks manufactured by the semi-dry pressing method, water is an addition at a rate of 8% to the sample, which is equivalent to 48 milliliters, and then the samples were kept in sealed plastic bags for fermentation for 24 hours. Sixty samples were formed by extrusion method with a laboratory size (2.5 x 3.85 x 7.5) cm, and 60 samples by semi-dry pressing method with dimensions 5.12 cm^2 in diameter and height, the samples were squeezed under a pressure of 250 kg/cm^2. The drying process of the samples was carried out in two stages at room temperature for 48 hours, and in a binder oven, at a temperature of 100 °C (±5)° for 24 hours. These samples were burned according to a specific firing program at different temperatures (750, 950, and 1100 °C). When the prepared brick samples were fired under temperatures of 1100 °C, the fired samples have good results in terms of compressive strength, water absorption, gradual increase in bulk density, and the absence of cracks, in general, the external appearance of the bricks remained unbroken. It is important that a very large reduction of calcite was observed when temperatures rose to 1100 °C, as the mineral calcite does not decrease with increasing temperatures, calcite can react with other compounds and form new phases accompanied by glass phases resulting from the presence of molten materials. The reactions that occur during burning at a temperature of (1100 °C) lead to the formation of the mineral mullite in a crystalline form.

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تقييم أطيان الفيضات في منطقة السلمان جنوب العراق لصناعة الطابوق الطيني

خالد محمد احمد و سوسن حميد فيصل

المستخلص

تم تقييم الرواسب الطينية في البحيرات المؤقتة التي تسمى (الفيضات) في جنوب مدينة السماوة ضمن محافظة المثنى كمادة خام لصناعة الطابوق الطيني. تتكشف هذه الرواسب في منطقة تابعة لقضاء السلمان. اذ تم اختيار ست عينات من هذه الترسبات العائدة إلى العصر الرباعي. تتميز هذه الرواسب بطبقة من الطمي البني الداكن الناعم الحبيبات، تتخللها عدسات رملية بأحجام مختلفة. أظهرت نتائج التحليل الكيميائي للأكاسيد الرئيسية انها ضمن الحدود المقبولة في صناعة الطابوق. أظهرت نتائج حيود الأشعة السينية للعينات المستخدمة نوعين من المعادن، المعادن الطينية شملت المومونتموريلونيت والباليكورسكيت والكاولينيت والكلوريت والإيليت، اما المعادن غير الطينية تمثلت بوجود الكوارتز والكالسيت والدولوميت والفلدسبار والجبس.

تم طحن نماذج الأطيان للحصول على أحجام ناعمة لكل نموذج، ثم تم تقسيم وتربيع النموذج ومن غربلة بجهاز الغربلة، خلطت المواد جيداً بالتقليب المستمر للنموذج وأخذت كمية مقدارها 600 غراماً من كل عينة من العينات المدروسة وتخميرها عن طريق إضافة كمية مناسبة من الماء تقدر بـ 18% إلى النموذج ولمدة (72) ساعةً للطابوق المشكل بطريقة البثق، اما بطريقة الكبس شبه الجاف، فيضاف اليه ماء بنسبة 8% إلى العينة أي مايعادل 48 مللتراً، وحفظت العينات في أكياس نايلون مُحكَمة لغرض التخمير لمدة 24 ساعةً.تم تشكيل 60 عينةٍ بطريقة البثق بالحجم ألمختبري (7.5 × 3.85 × 2.5) سم، و 60 عينةٍ بطريقة الكبس شبه الجاف بأبعاد (12.5) سم^2 قطر وارتفاع، تم كبس العينات بضغط مقداره (250) كغم\سم^2. عملية تجفيف النماذج تمت بمرحلتين بدرجة حرارة الغرفة مدة 48 ساعةً، وفي فرن تجفيف كهربائي بدرجة حرارة (100) °م (±5) درجات لمدة 24 ساعة. ثم حرقت هذه العينات بحسب برنامج حرق معين وبدرجات حرارة متباينة (750، 950، 1100) °م. عند حرق العينات تحت درجات حرارة 1100 درجة مئوية، أظهرت العينات المحروقة نتائج جيدة لقيم مقاومة الانضغاط، وامتصاص الماء، وزيادة تدريجية في الكثافة وعدم وجود تشققات، وبشكل عام فان المظهر الخارجي للطابوق بقى سليما. والمهم في ذلك عدم انخفاض الكالسيت مع زيادة درجات الحرارة، حيث عند درجة حرارة 1100 درجة مئوية ممكن ان يتفكك الكالسيت ويتفاعل مع مكونات الخلطة مكونًا أطوارًا جديدة مصحوبة بمراحل زجاجية ناتجة عن وجود المواد المنصهرة. أن التفاعلات التي تحدث أثناء الاحتراق عند هذه الدرجة تؤدي إلى تشكيل معدن الملايت بشكل بلوري.

INTRODUCTION

The layer mud deposition is considered part of the stratigraphic sequence of a geological formation that was deposited in an ancient flood environment or a coastal marine environment and was exposed to natural burial and compaction and was exposed to weathering, their exposure becomes weak (Tucker, 1985). Clay is one of the basic raw materials that are used in many traditional ceramic industries, especially, in the manufacture of ordinary building bricks that are light in weight due to their plasticity when exposed to water and their hardening when dried or burned, in addition to the ease of manufacture and the low cost and abundance of their production (Shackelford and Daremus, 2008). Clay bricks are still a basic material in construction works in many countries, including Iraq, especially, in the middle and southern part of Iraq; and the most commonly used type of bricks (in Iraq) is clay bricks, for several factors, the most important of which is the availability of the raw material almost everywhere, its low production cost, heat insulation, and its resistance to fire and weather changes (Al-Dawaf, 1972). There are many previous local studies of the brick industry, the most important of these studies is (Garjis (1980), which conducted a study on the use of clay deposits suitable for the manufacture of clay bricks in the Al-Suwayer region in Al-Muthanna Governorate and reached the manufacture of bricks within the category (C) with a burning temperature of 950 C° (Muhammad, (2005) evaluated quantitatively and qualitatively the clays used in the manufacture of bricks south of Al-Samawa, in Al-Muthanna Governorate. Samples of laboratory bricks were made, and they were burned with a specific burning program at a temperature of 950 °C, and evaluation tests were conducted, as they gave positive results with a class (C). (Issa, (2006) evaluated quantitatively and qualitatively the clays used in the manufacture of bricks and concluded that the sediments belong to the alluvial deposits of the alluvial plain suitable for the manufacture of bricks, with classes (C) and (B).

- **Aim of the study**

The study aims to assess the chemical and physical properties of clay deposits and conduct evaluation tests to prepare ordinary clay bricks according to the requirements of Iraqi standard specifications No.25, 1993.

- **Location of the study area**

The study area is located in the southern Iraqi desert between longitudes (45° 07' 30") and (44° 52' 30") and latitudes (31° 00' 00") and (30° 45' 44"), about 52 km to the south and southwest, of AlSamawa city (the center of Al-Muthanna Governorate) within the administrative borders of Al-Salman district (Fig.1).

- **Geological and stratigraphic settings of the study area**

Geomorphologically, the region is relatively flat to little undulating and is characterized by newly formed horizontal clay deposits formed by successive floods, as well as plateaus, depressions, and isolated hills. Topographically, the area slopes slightly towards the east and northeastern region (Ma'ala, 2009).

While the tectonics of the study area is located according to the division referred by Getech and Jassim (2002) in the stable zone area within the Al-Salman area and is characterized by the fact that the base rocks are more stable during the Paleozoic period, and more dynamic during the Mesozoic and Tertiary era, although the depth of the base rocks in it generally ranges from 5 Km to 10 Km. The area is considered part of the stable platform (Salman Range). The region has been, greatly, affected by the Precambrian tectonic movements as these movements affected the base rocks in the form of cracks in the direction of (Northeast, Southwest) and (Northwest, Southeast), from a structural point of view, many structural elements appear in the study area, which are surface and subsurface folds and faults.

Geologically, the study area included an area containing a well-exposed succession of the formations that represent the Tertiary rocks, and the exposed rocks in that area represented by the Dammam and Zahra formations and the Quaternary sediments as secondary gypsum and halite (Barwary *et al*., 2002). Figure (2) represented the following:

1- **Dammam Formation (Early – Late Eocene):** it was first described by Brampkamp (1941) in (Bellen *et al*., 1959). It consists mainly of limestone, with a grayish to yellowish color and layers that are medium to lumpy, and this formation is affected by the processes of complete domolysis and re-doliation, and it is highly silicification (Al-Mubarak and Amin, 1983).

2- **Zahra Formation (Pliocene – Pleistocene):** The stratigraphic sequence of the formation of the flower consists of white limestone containing fossils of charophytes indicating a freshwater environment, as well as holes resulting from the activity of worms and ancient roots. Sometimes, they are filled with black materials, and this formation is widely spread in the western part and within the study area in Faydat Munif and Faydat al-Salhoubi in particular (Al-Haza'a, 1996).

3- **Quaternary sediments:** They dominate most parts of the study area, which have their origins in the Holocene-Pleistocene, such as silt, sand, secondary gypsum crystals, and halite (Barwary *et al*., 2002).

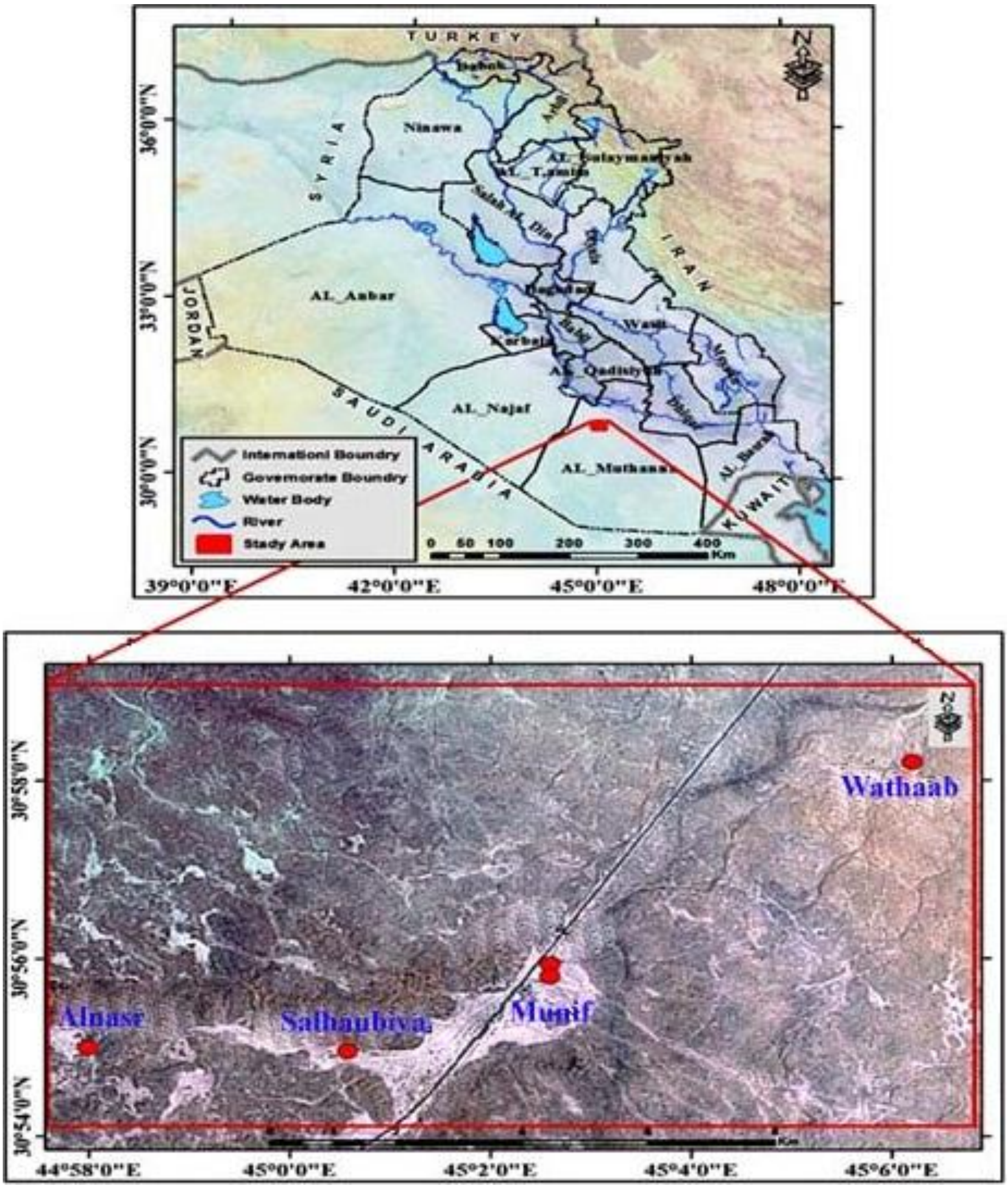

Fig.1: The location map of the study area

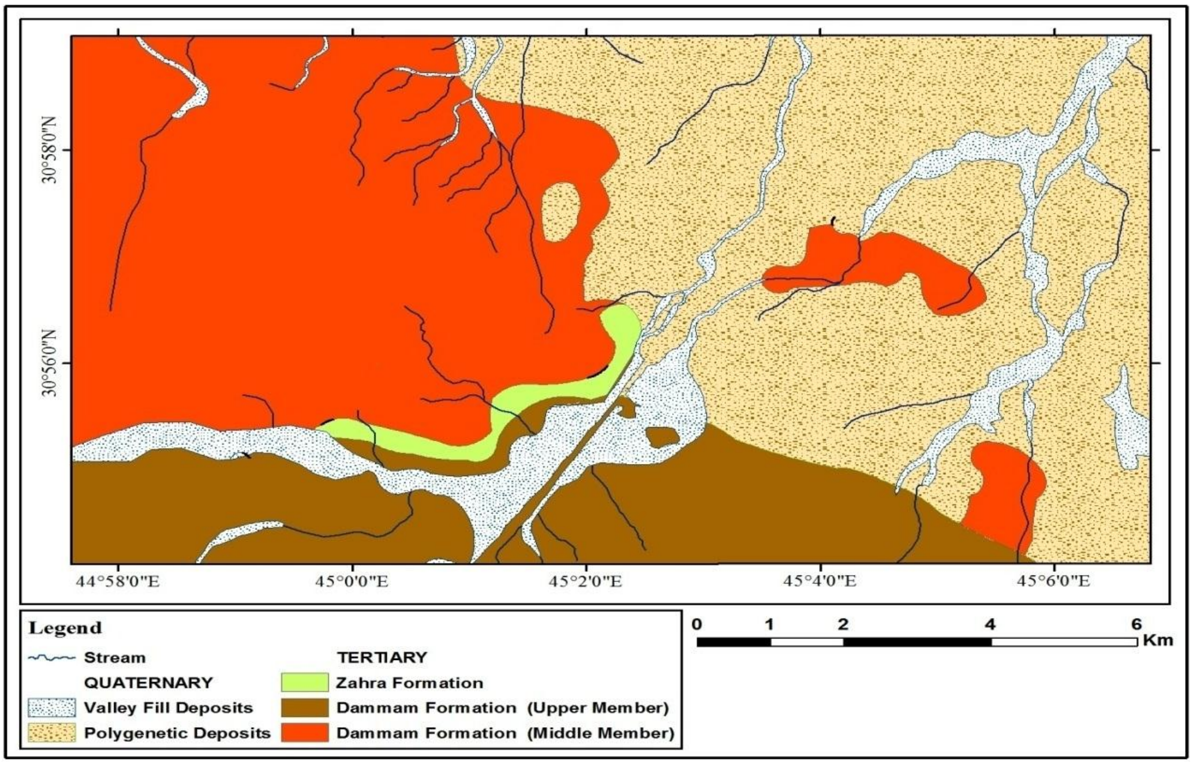

Fig.2: The geological map of the study area

METHODOLOGY

- **Fieldwork**

Several reconnaissance tours were conducted in the study area and its borders, based on the appearance of the surface and the topographic and economic maps of Al-Muthanna Governorate, at a scale of (25,000:1) and (100,000:1), and based on the quadratic coordinates (UTM) to determine the best locations for the exposed floods in the region. Four sites were selected depending on their area and thickness of the layers, in addition to their proximity to transportation routes, ease of quarrying and transportation, and the boundaries of the external flood sites, (Al-Salhaubiya (S), Munif (M), Wathaab (W), and Alnasr (N), After determining it on the topographical map of the area using the square coordinate system (X,Y) and its heights, as most parts of the study area vary within heights (8 – 36) meters from sea level using the Global Positioning System (GPS) device type (Garmin – Etrex).

- **Sampling**

The fieldwork was carried out in the Al-Salman area, south of the city of Al-Samawa in Eastern Iraq. The objectives of the fieldwork are to describe the geology of the study area and to collect mudstone samples from a fedhat of good exposures wide thickness and lateral extension. Four samples were collected from the sediments of the Quaternary sediments in the study area. The sampling was carried out vertically for the playa under study, two samples of the Alnasr (N) at a depth of (1.5) m, three samples of the Sahlobiya playa at a depth of (1.2) m, and four samples of the Wathab playa (W) at a depth of (1.2) m, and three samples from the Munif flood (M) at a depth of (1) m In total is it 4 samples, One sample was mixed from all the drill depth, until one sample represented from the surface of the earth to the bottom, and more than one sample was taken from each site; (10) kg for one sample, the samples were stored in plastic bags and subjected to crushing, grinding, and sieving for various mineralogical (XRD) and chemical (XRF) analysis.

- **Chemical Analysis**

Chemical analysis is the basis on which the clay brick industry by X-ray fluorescence (XRF) technology. Clay samples were taken weighting 10 kg after crushing and grinding using a grinder to break the mass parts and to obtain small particle sizes, then sieving to 75 micrometers, as the analyzes were carried out according to the American Standard (ASTM, D421, 2004). A hundred grams of each sample were prepared for conducting chemical analyzes to know the concentrations of the oxides of the main elements, and the chemical analysis of the raw materials was carried out by the method of wet analysis and according to the contexts of the Iraq Geological Survey in Baghdad (Salama, 2015). Using XRF techniques at the Iraq Geological Survey.

- **Mineralogical analysis**

The X-ray diffraction method (XRD) is the most widespread method used because it is a non-destructive method of mineral structure, and it is characterized by its speed and accuracy in the analysis (Lavina *et al*., 2014). Four samples of mudstone were selected to conduct an XRD identification at (2θ) range from (5° – 65°). Slides of clays taken from four sites were X-ray diffraction, after conducting the separation process without treatment, and after treatment with ethylene glycol, and heating it to a temperature of 350 and 550 C°, to identify the clay minerals and non-clay.

The successful samples of burnt bricks were examined by XRD to identify the mineral phases formed after the burning process. The X-Ray diffraction (XRD-7000) examinations were carried out at the Central Laboratories in Iraq Geological Survey.

- **Grain Size Analysis**

A hundred (100) grams were taken from each sample for volumetric analysis. The hydrometer method is used to separate its components silt and clay, according to the American Standard (ASTM C775-79, 1989). This method is accomplished in several steps:

- Sieving the samples using a sieve with a size of (75 microns), then it is washed with water to isolate sand from mud, and the remainder is placed in the sieve from sand in a beaker, dried in the oven for a whole day, and then weighed with a sensitive balance, either descending from the sieve which represents mud, then left in plain water for (24 hours) and then the water is withdrawn from mud using a pipette, and then the model is washed with distilled water several times to rid it of salts.
- The distilled water is withdrawn through a pipette and the samples are placed in a container for drying in the oven until dried after that weighed with a sensitive balance.
- The sample is placed in a graduated cylinder, and the volume is completed to (1000) milliliters by adding distilled water then adding a substance (sodium hexametaphosphate), which helps to reduce the speed of sedimentation of the (mud), and then shaking the cylinder well for not less than two minutes. It is based on the hydrometer method, the readings are taken according to the applicable time according to the American Standard (ASTM, C775-79, 1989).
- A quantity of the passing sample is weighed through a sieve (40 mesh) in the amount of 100 g to find the plasticity index, by calculating the soil texture, and Atterberg limits, according to the American Standard (ASTM, 1969).

RESULTS AND DISCUSSION

- **Chemical Analysis**

Chemical analysis of claystone showed that CaO is the dominant oxide having a range from 15.96% to 20.54% with an average of 17.75%. Its presence in clay bodies works to reduce the clay's plasticity and shrinkage, as well as it is remaining free in clay bodies after the burning process, and has a negative effect because it interacts with air moisture, forming calcium hydroxide, which crystallizes in a large size, which results in internal stresses that lead over time to the emergence of cracks in the clay bodies (Al-Qaisi, 2003). Silica oxide ranges from 37.71% to 40.71% with an average of 38.84%, high silica content in some cases may lead to the presence of free silica (in the form of quartz), which leads to reduced plasticity and reduced shrinkage during drying (Budinkove, 1964). The alumina ratio ranges from 6.77% to 9.54% with an average of 8.34%. Its presence in the paste makes the bricks a refractory material despite it being melted at high temperatures (Hirts, 1962). The percentage of iron oxide reached a range from 3.32% to 5.29% with an average of 4.43%, this oxide affects the color of the bricks, giving it a red or reddish-brown color at temperatures less than (800) °C, and yellow at temperatures above (1000) C° (Murray, 2007). Magnesium oxide MgO ranges from 4.62% to 6.19% with an average of 5.34%. The oxide of TiO_2 ranges from 0.63% to 1.83%. Cl ranges from < 0.02% to 0.02% with an average of 0.01%. P_2O_5 with an average of 0.03% is considered very low. The value of LOI was an average of 19%.

The low content of sulfate, with an average of 0.26%, is one of the undesirable compounds in the brick paste. Alkalis content (Na_2O and K_2O) is also low with an average of 0.81%. All these oxides percentages in the present study are within the acceptable ranges of the raw materials for the bricks industry (Table 1).

Table 1: Chemical analysis of limestone samples

Sample	SiO_2%	Fe_2O_3%	Al_2O_3%	CaO%	MgO%	TiO_2%	SO_3%	K_2O%	Na_2O%	Cl%	P_2O_5%	LOI
M	39.21	4.24	8.085	17.91	4.90	1.67	0.22	0.98	0.635	0.02	0.02	18.63
W	38.98	3.32	6.77	20.54	6.19	0.86	0.23	0.75	0.57	0.01	0.03	20.66
N	38.40	5.29	9.54	15.96	5.42	1.35	0.36	1.18	0.66	< 0.02	0.03	17.90
S	38.43	5.06	9.25	16.45	5.30	0.63	0.27	1.14	0.64	< 0.02	0.05	19.18
Ran.	37.71 – 40.71	3.32 – 5.29	6.77 – 9.54	15.96 – 20.54	4.62 – 6.19	0.63 – 1.83	0.20 – 0.36	0.75 – 1.18	0.57 – 0.66	< 0.02 – 0.02	0.02 – 0.05	17.90 – 20.66
Avg.	38.84	4.43	8.34	17.75	5.34	1.23	0.26	1.00	0.62	0.01	0.03	19

- **Mineralogical analysis**

The results of the mineral analysis of the bulk sample consist of non-clay minerals that included quartz, feldspar, calcite, dolomite, and calcite present in high percentages (Fig.3), while the clay minerals consisted of montmorillonite, palygorskite, kaolinite, chlorite, and illite.

That the mineral montmorillonite is present in a high percentage (Fig.4), in all clay samples indicates the presence of good raw material for the manufacture of bricks consequences.

The results of the mineral analysis of the laboratory brick samples showed that new crystal phases were formed as a result of the combustion of the samples at this temperature and included only four phases, including wollastonite, feldspar, quartz, and augite as shown in (Fig.5). For brick samples that were fired at a temperature of 1100 °C.

- **Evaluation Tests of Brick Samples Prepared by Extrusion and Pressing Methods**

The physical and mechanical tests were carried out to the requirements of the Iraqi Standard No. 25 of 1993.

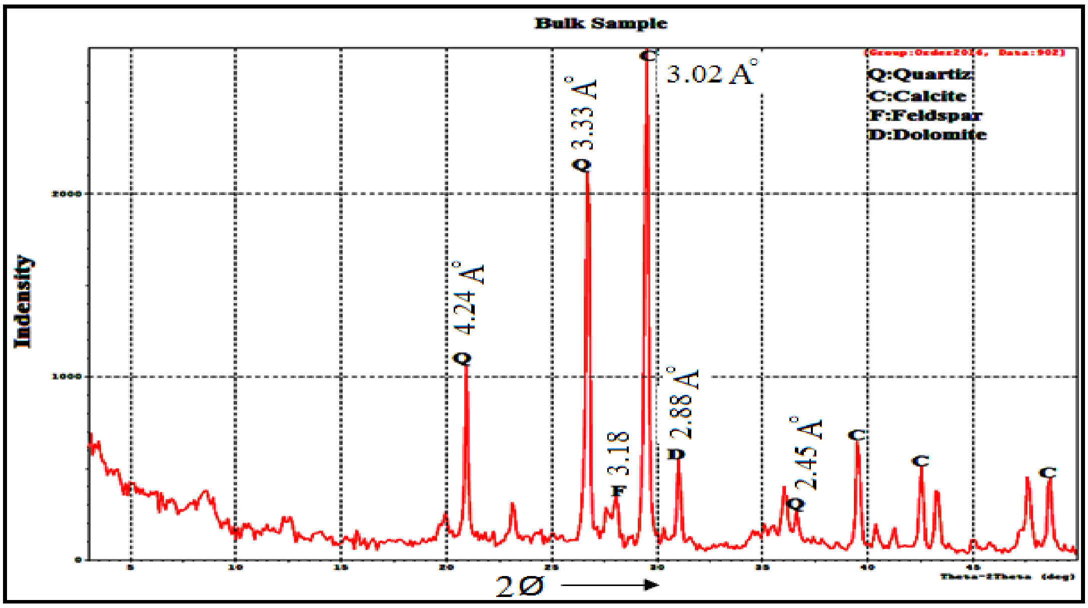

Fig.3: X-ray diffraction of the non-clay minerals (bulk sample)

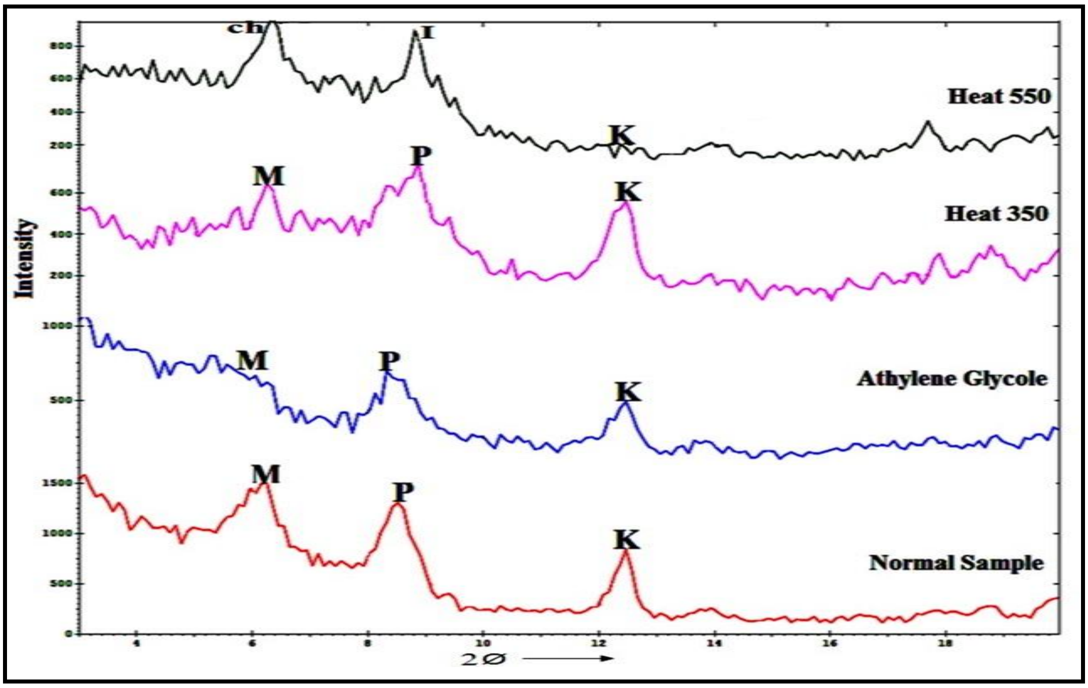

Fig.4: X-ray diffraction patterns for the clay minerals

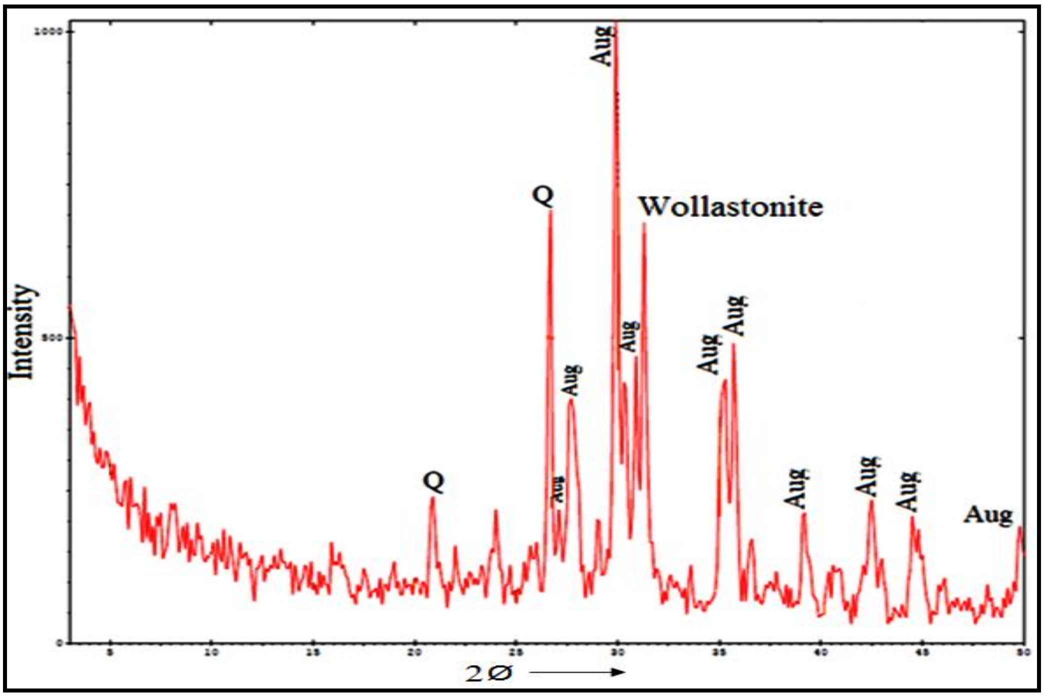

Fig.5: X-ray diffraction of the site after burning at 1100 C°

- **Physical Tests**

– **Shape and Color:** The samples that were burned at temperatures samples that were burned according to a burning program at temperatures of (750, 950, and 1100) °C, with an increase of time of 5 °C per minute, and with a soaking time of two hours (Table 2) were characterized by the flatness of their surfaces, the straightness of their edges, and their regular dimensions, except for some samples that were burned at temperatures 950 °C, and by the two methods (extrusion and pressing) and left for not less than 10 days that led to cracks in the samples may cause after burning, and some expansion that appeared on the surfaces of the samples, with the appearance of white scar (Figs.6 and 7).

It was found during the process of examining the physical properties the colors of the laboratory brick samples before burning, varied from brown to light reddish brown, after burning at temperatures (750, 950, and 1100) °C, their colors changed to light brown at a temperature of 950 ºC, while at a temperature of 1100 °C. The appearance of yellow and light-yellow color for bricks also can be attributed to the presence of gehlenite minerals that are later formed because of combustion (Mesrar *et al*., 2020). The predominant color was light yellow. The red color becomes pale at first to white and then finally turns to yellow (Yusuf and Hamadi, 1976).

Table 2: Burning and maturation periods for bricks Manufacture

Temperature Raise (Min/°C)	Ripening period (hour)	Burning period (hour)	Temperature (°C)
5	2	2.5	750
5	2	3	950
5	2	3.6	1100

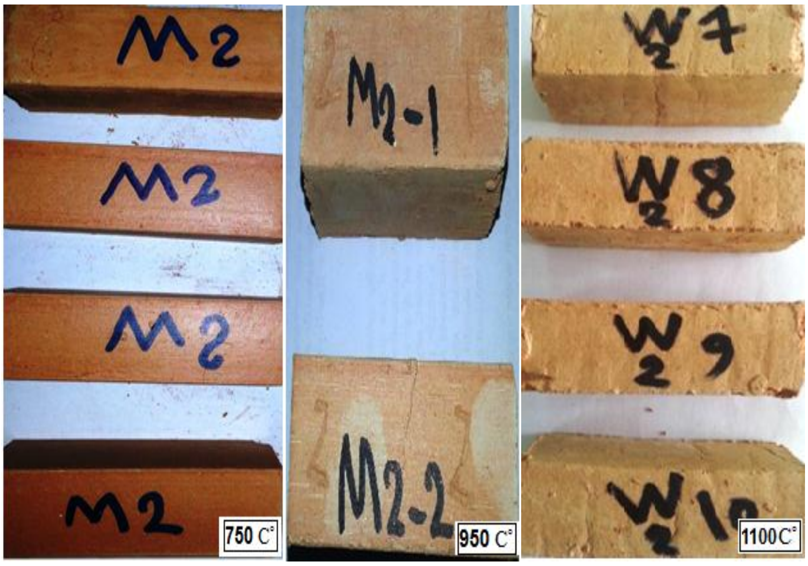

Fig.5: The bricks samples that were fired at (750, 950, and 1100) °C by extrusion

Fig.6: The bricks samples that fired at (750, 950, and 1100) C° by pressing

– **Linear and volume shrinkage:** The volume of bricks produced in the laboratory is of good shape and free of cracks before burning, After the burning process, it is noted that the samples have shrunk from their original length by a small percentage after drying and before burning, due to the loss of water within the crystal structure that leads to the collapse of the crystalline structure of kaolinite mineral at a burning temperature of 750 °C (Frank, 1975). The increase in silica minerals is important to control the firing shrinkage process because it decreases both linear and volumetric shrinkage (Merza and Faraj, 2017). Where it was found that the linear shrinkage rate by extrusion method for all samples ranged between 0.1 and 0.99%, while the volumetric shrinkage rate ranged between 1.25 and 3.78%. As for the linear shrinkage of the brick samples produced by the pressing method, its rates were between 0.4 and 1.21%, and the volumetric shrinkage ranged between 0.36 and 2.52%. The decrease of calcium carbonate content in the clay will increase the bulk density and decreases linear and volume shrinkage (Rashed, 2017).

− **Water Absorption (%):** The Iraqi Standard Specification No.25 (ISS, 1993). Table (3) stipulated that the absorption ratio of the types (A, B, and C) as the absorption rate of one brick is 20, 24, and 26% as a maximum, respectively, ten samples were taken for pressing, and 12 for laboratory-produced extrusions. The absorption rate of brick samples produced by the extrusion method at a temperature of 750 °C ranged between 15.20 and 19.30% (Table 4).

As for the samples of bricks produced by the pressing method, the water absorption rate increased compared with extrusion, it ranged between 15.9 and 22% for the samples that were burned at a temperature of 750 °C. This may be due mainly to the sediments containing a high percentage of carbonates, which usually disintegrate between 750 and 950 °C, releasing CO_2, and leaving voids.

Table 3: Iraqi Standard No. 25 in 1993

Efflorescence	**Maximum water absorption rate (%)**	**Minimum compressive strength (kg/cm^2)**	**Brick class**
light	20	180	A
Medium	24	130	B
high	26	90	C

Table 4: Test results for the study samples

Temperature (°C)	**Efflorescence**	**Maximum water absorption rate for extrusion (%)**	**Maximum water absorption rate forPressing (%)**	**Minimum compressive strength (kg/cm^2) or extrusion**	**Minimum compressive strength (kg/cm^2) For pressing**
750	light	17.49	18.83	57.01	32.59
1100	without	17.86	18.15	66.71	83.66

At a temperature of 1100 °C, we note that the rates of water absorption for extrusion samples range between 19.64% and 16.3% as for the pressing samples, the absorption rates ranged between 19.01% and 16.59%.

The increase in the burning temperature leads, in turn, to a decrease in the water absorption rate, due to the start of the sintering process at a temperature of 1000 °C (Frank, 1975). It binds the granules with each other and works to close the pores, and this leads to the occurrence of a decrease in porosity and water absorption of brick samples.

− **Bulk Density:** It is observed at a temperature of 750 °C, its ratio ranges between 1.76 g/cm^3 and 1.72 g/cm^3, and at a temperature of 950 °C, its ratio ranges between 1.78 g/cm^3 and 1.74 g/cm^3, while at a temperature of 1100 °C, its ratio ranged between 1.83 g/cm^3 and1.79 g/cm^3, and the reason for the increase in the values of total density with higher burning temperatures is due to the sintering and glazing process, as well as the formation of the liquid glass phase due to the fusion of some metals and other compounds, which in turn will fill the spaces between the particles and this leads to the gathering of the particles with each other and the reduction of the pores, which leads directly to a decrease in the percentage of water absorption and thus increases the total density (Al-Bassam, 2004).

– **Efflorescence:** The efflorescence rates for the samples ranged between light and destitute, runner of the (W) sample, as the rate of efflorescence was medium and dense, and the cause of blooming may be due to the condensation of burning gases, as calcium and magnesium carbonates that are slightly soluble in water do not move to the surface of the bricks during the drying process of the samples. The one along the surface reacts with the acids in the burning gas, forming efflorescence in all the samples burned at a temperature of 1100 °C, which was done by Iraqi Standard Specification No. 25 (ISS, 1993). Positive data appeared that no efflorescence appeared because these clays contain sulfide materials and gypsum materials in small proportions, and silica plays a role important in interacting with each of the components of calcium carbonate and sulfate, thus, removing the efflorescence at a temperature of 1000 °C (Singh, 1970). Due to the ability of silica to provide what the mineral phases need from SiO_2 to interact with other oxides resulting from the dissolution of salts such as (SO_3, MgO, and CaO) and others to those phases. Khan *et al*. (2012) found that the water absorption was initially decreased and increased for further increasing of binder content. The initial decrease in the percentage of water absorption was due to the densification process and a further increase was due to the formation of micropores following the dehydroxylation of the binder.

– **Mechanical Tests:** Measurement of the compressive strength of samples prepared by the extrusion method, which were burned at a temperature of 750 °C, ranged between 85.46 kg/cm^2 and 35.18 kg/cm^2, and the samples were burned at a temperature of 1100 °C, a discrepancy was between 118.02 kg/cm^2 and 28.9 kg/cm^2, while for the samples that were prepared by pressing method, and burned at a temperature of 750 °C and 1100 °C respectively, their rates ranged between 0 kg/cm^2 and 69.5 kg/cm^2 and 178.14 kg/cm^2 and 28.33 kg/cm^2, respectively (Table 4).

It is noted that the rates of extrusion samples burned at a temperature of 750 °C are relatively lower than that for samples burned under a temperature of 1100 °C, the reason may due to the positive relationship between the burning temperature and the compressive resistance.

Through the results, we note that the compressive strength of the samples increases with the increase of the burning temperatures due to the increase in the hardness of the monolithic minerals after burning, especially, at a temperature of 1100 °C, as the silicate minerals formed are more solid than those involved in the reaction, giving it strength and durability stronger and stronger upon cooling and lead to an increase in the compressive strength values (Virta, 2007).

CONCLUSION

- High percentage of carbonate materials in the clay samples under study is due to the effect of the carbonate contents represented by formations of Dammam and Zahra formations.
- The results of mineral analysis by (XRD) for raw materials showed an increase in non-clay minerals (calcite, quartz), which have a high effect on reducing the plasticity in clay.
- Through the process of burning the samples at different temperatures (750, 950, and 1100) °C, it was found that the best temperature for burning the clay samples under study

is (1100 °C), as it led to the disappearance of white scars, and the production of bricks free of cracks.

- The high percentage of carbonate materials in the clay models under study is due to the effect of the carbonate tectonics represented by the formation of Dammam and Zahra near the study area.
- It is noted that the compressive strength of sample (N) decreased by extrusion method and samples (W) by pressing method, with an increase in the burning temperature rages (750° – 1100°) this may be because of the increase in the decomposed calcium carbonate available in samples, which leads to reducing the density and then decreasing the compressive strength, while the other samples remained without any decrease despite the equal proportions of carbonate materials. This may be due to the failure of these materials to completely disintegrate, especially with the increase of dolomite mineral, which disintegrates at temperatures higher than 1100 °C.
- The muddy deposits provide the raw material for the industry of building bricks of classes (B) and (C) for the site (M) and respectively for bricks produced by (pressing) at a temperature of 1100 °C, especially, for the site (M), according to the requirements of the Iraqi Standard.

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