IASJ
المجلات الاكاديمية العراقية

Tikrit Journal of Pure Science

ISSN: 1813 – 1662 (Print) --- E-ISSN: 2415 – 1726 (Online)

Journal Homepage: http://tjps.tu.edu.iq/index.php/j

Assessment limestone of Ghar Formation in Al-Busaiyah Area in southern Iraq as Raw Materials for the Manufacture of ordinary Portland cement (OPC)

Khalid M. Ahmed , Sawsan H. Faisal , Faris N. Hassan

Department of Applied Geology, College of Science, Tikrit University, Tikrit, Iraq

https://doi.org/10.25130/tjps.v27i2.63

ARTICLE INFO.

Article history:

-Received: 6 / 10 / 2021

-Accepted: 28 / 12 / 2021

-Available online: / / 2022

Keywords:

Corresponding Author:

Name: Khalid M. Ahmed

E-mail:

Geofaris777@gmal.com

khalidgeo92@gmail.com

Sawsanhameed2004@gmail

Tel:

ABSTRACT

Six samples of limestone rocks were selected for the Early Miocene Ghar Formation in the Busayyah area south of Nasiriyah city in the southern desert of Iraq, and one sample of clay deposits of the Quaternary age was selected for the purpose of geochemical and mineral evaluation for the manufacture of ordinary Portland cement. The results of the analyzes of limestone for the formation of Ghar showed that it contains Ratios (less than 2%) of magnesium oxide, and the percentage of calcium oxide to more than (52%),Which was in conformity with the Iraqi and international specifications [1] and [2] for the cement industry. playa clays in the region study were analyzed for the purpose of testing and demonstrating their suitability for the cement industry, as recent clays have a high percentage of magnesium oxide, as well as its scarcity in the study sections, as the results showed their suitability for the cement industry. The ratios of lime saturation (LSF), alumina ratio (AR) and silica ratio (SR) were calculated for the mixture consisting of limestone to Ghar Formation, clay, Bauxite and iron oxides. (3) Mixtures of different exposed of Ghar formation were burned at a temperature of 1200 and 1450 °C, and the results showed the validity of the produced clinker and its conformity with international specifications when burning at 1450 °C, while the burnt clinker failed at 1200 °C due to incomplete form of cement phases. The proportions of the mineral phases of clinker were calculated after burning and it was found that the phases and minerals of belite, lalite, ferrite aluminate and portlandite.

Physical and mechanical tests were carried out on limestone from the Ghar Formation, where the compressive strength, specific weight, total density, moisture content and apparent porosity were analyzed.

Introduction

Cement is one of the most necessary construction materials, as it cannot be dispensed with in engineering and construction projects. The development of cement was linked to the manufacture of bonding materials that accompanied human development and urbanization over thousands of years. The cultural monuments of the Assyrians and Babylonians in Mesopotamia indicated the use of binding materials such as clay and bitumen that bind the bricks manufactured at that time. Ordinary Portland cement consists mainly of CaO, SiO_2, Al_2O_3, and Fe_2O_3. The chemical composition of Portland cement depends mainly on the chemical composition of the raw materials used, and knowledge of it gives information about the suitability of those materials for the cement industry.

Chemical parameters are calculated for the purpose of evaluating the chemical composition of raw materials and in preparation for the ratio of mixing raw materials through which it is possible to predict the ratio of good mixing and other corrected materials that must be added according to the Iraqi specification for the cement industry. There are three chemical treatments that play a very important role in the viability of raw materials used in the cement industry: LSF, SR and AR. Previously no one studied carbonate rocks of the Ghar Formation for cement industry; this study is the first evaluation of limestone of Ghar Formation. Some authors studied the limestone rock as a raw material for cement industry such in south of Iraq such as[3]conducted mineral investigations for limestone in Wadi Al-Fadwa and estimated the amount of limestone reserves suitable for the cement industry within category B & C. and [4]studied the chemical and mineral evaluation of raw materials suitable for cement industry in Kufa cement factories.

Successful cement clinker production requires a specific mixture of limestone, clay and additives including iron and bauxite, as well as the correct calculation of the proportions of the mixture for clinker.

The aims of the present study are: assessment of the carbonate rock from Ghar limestone Formation for manufacturing of ordinary Portland cement, evaluation of clay deposit recent in the same area from playa deposits for cement industry.

Geologic Setting of the studied Area

The study area is located in the Southern desert of Iraq, specifically to the northeast of Al-Busaiyah area, which is about 120 km south of Al-Nasiriya city in Dhi Qar Governorate (Fig. 1), and within coordinates (30˚ 34' 30"N−30˚ 19' 10" N) and (46˚ 31' 21"E − 46˚ 27' 01"E). The area is tectonically located in the Stable Shelf within the Salman belt of the Arabian Shield, which represents the edge of the northeastern part of the Stable Shelf of the Salman belt [5].

The Miocene rocks units in Iraq represent several formations, including the Ghar Formation (Early Miocene). Limestone is one of the important sedimentary rocks that consist largely of calcium carbonate ($CaCO_3$), sandy limestone and some other non-carbonate oxides and impurities. The Al-Ghar formation was described for the first time in Al-Zubair well (3) by [6]. It consists of sand, gravel, sandy limestone, clay and anhydrite deposited in a coastal environment or part of the delta environment, the thickness of the formation is about six meters. Recent clay deposits used in the cement mixture were used, located in the Al-Afaif area, near Wadi Abu Ghar, It is about one meter thick.

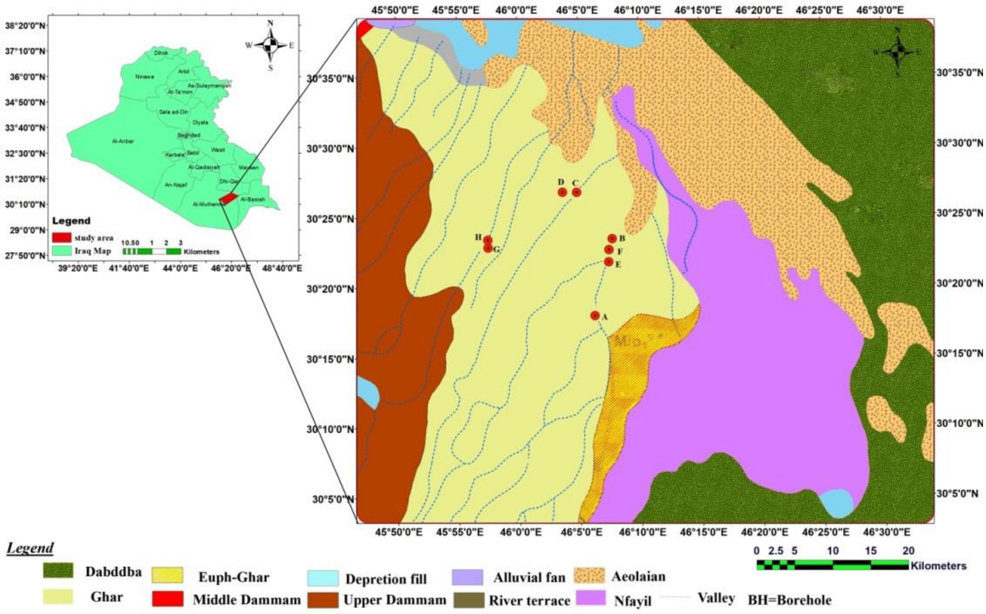

Fig. 1: Location of the studied area

Methodology

Chemical analyses were carried out for six samples of limestone belonging to the Ghar Formation collected from six exposed areas in the studied area distributed in the Abu Ghar area.

The laboratory study included conducting geochemical analyses to determine the concentrations of the main oxides and the percentage of Loss on Ignition (LOI) in the laboratories of Saman Cement factory and Kufa Cement factory using the American Standard [7]. The (XRF) of type device (GBW-7309, Spectro XLAB 2000), and the analysis was done at the laboratories of Saman Cement Factory in Al-Muthanna Governorate. the analysis was used after passing the samples from the sieve size (75 µm), and discs with a diameter of (32) mm. were made, with a time of half an hour according to the method[8].

Amixing ratio were made after calculated according[9]. (Table 4). The mineral components were examined by XRD of type (Shimadzu - 6000), the work was done in the materials research laboratory at the Ministry of Science and Technology in Baghdad, and insoluble residues were separated. The mechanical properties of five samples of limestone were examined in the laboratories of the National Center for construction research, while the physical properties were examined in the German laboratory in Baghdad University.

Results and discussion

The percentages of oxides present in the studied limestone were obtained for the Ghar Formation (Table 1), as the cement industry requires raw materials with a constant chemical composition. The chemical analyses were conducted for six samples for the purpose of determining their main and secondary components, their degree of homogeneity, and mixing ratios to form the raw mixture[10].The results showed Suitability of limestone rocks to form Ghar Formation as raw materials in the manufacture of ordinary Portland cement, according to [9]. (Table 1). The Quaternary representative clay sample was analyzed for main oxides (Table 2) .

Table 1: Concentrations of major and minor oxides in the studied limestone samples

Sample wt% / Oxide	KH1	KH2	KH3	KH4	KH5	KH6	Average	Range
SiO_2	2.07	8.54	3.53	12.24	6.26	5.82	6.41	2.07−12.24
Al_2O_3	0.56	0.26	0.60	0.42	0.19	0.26	0.38	0.60−0.19
Fe_2O_3	0.12	0.15	0.13	0.86	0.31	0.4	0.32	0.12−0.86
CaO	53.97	55.96	53.25	47.31	50.91	50.65	52	47.31−55.96
MgO	1.04	0.72	1.17	1.15	1.16	0.93	1.02	0.72−1.17
SO3	0.76	0.64	0.20	0.14	0.32	0.16	0.37	0.14−0.76
K_2O	0.045	< 0.0012	0.04	-	-	-	0.014	0.0012−0.04
Na_2O	0	0.73	0	-	-	-	0.061	0−0.73
Cl	0.045	0.012	0.04	-	-	-	0.016	0.012−0.04
LOI	40.87	32.16	40.45	37.74	40.59	41.31	38.85	41.31−32.16

Table 2: Concentrations of major and minor oxides in the studied clay sample.

Oxides wt%	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O	Na_2O	Cl	LOI	Sum
clay	38.59	9.04	5.09	16.24	4.22	0.5	1.34	0.56	0.00	22.80	99.38

The chemical analyses of the clays selected from the playa deposits showed that the MgO is low, alumina and silica is high, this mean this clay is suitability as auxiliary raw materials in the manufacture of ordinary Portland cement (Table 2). This component constitutes a small percentage of the mixture of raw materials, which includes clay rocks consisting of shale and claystone, which consist of alkali aluminum silicate minerals (feldspar and mica) and hydrated aluminum silicate represented by pure clay minerals or contain impurities such as sand, carbonate and some organic matters [9].

The insoluble residue minerals (IR) were calculated using the[11].method as most of the limestone contain small percentages of clay and silicate minerals as insoluble residues shown in Table (3).

Table 3: The percentages of insoluble residues in the limestone samples of the current study

Samples Number	Reacted with 10% HCl Acid			
	Weight of Sample (gm)	Weight of Sample after reacted with 10% HCl Acid	Weight of Insoluble Residue	Percentage of Insoluble Residue %
KH1	5	4.09	0.68	13.6
KH2	5	4.14	0.69	13.8
KH3	5	4.02	0.75	15.0
KH4	5	4.08	0.66	13.2
KH5	5	4.10	0.68	13.6
KH6	5	3.89	0.61	12.2

The results of the (XRD) examination of the clay component showed two types of minerals: clay minerals consisting of Palygorskite, Chlorite, Kaolinite, and Illite and non-clay minerals consisting of carbonates minerals and quartz (Fig. 2 & 3).

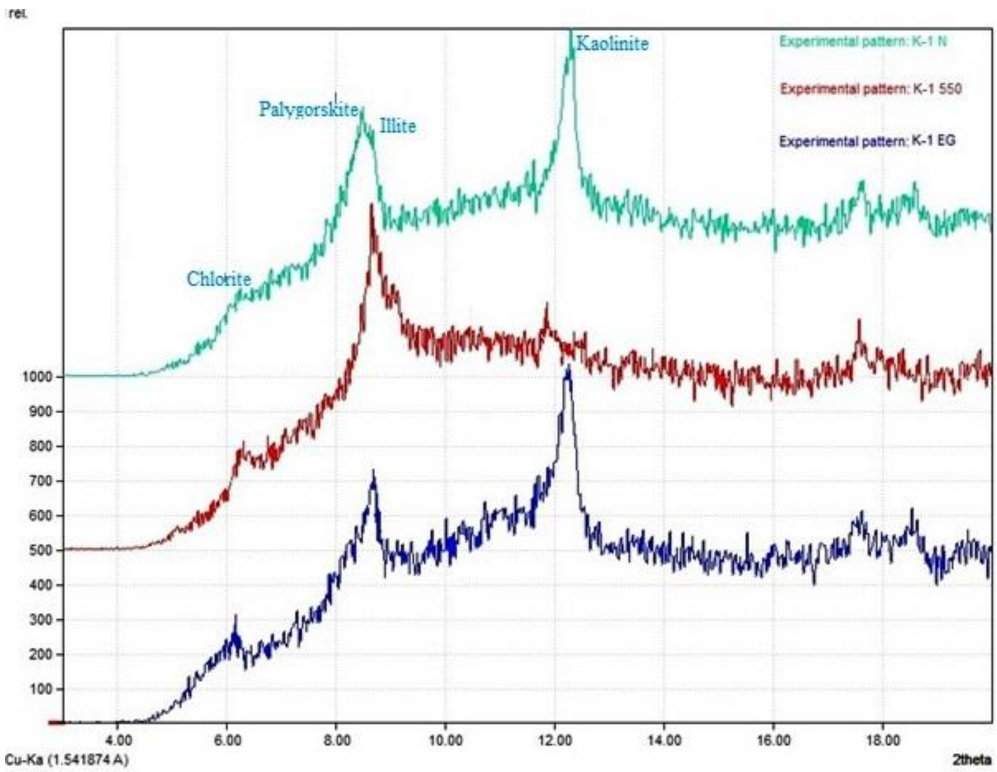

Fig. 2: XRD pattern of the studied Quaternary clay sample

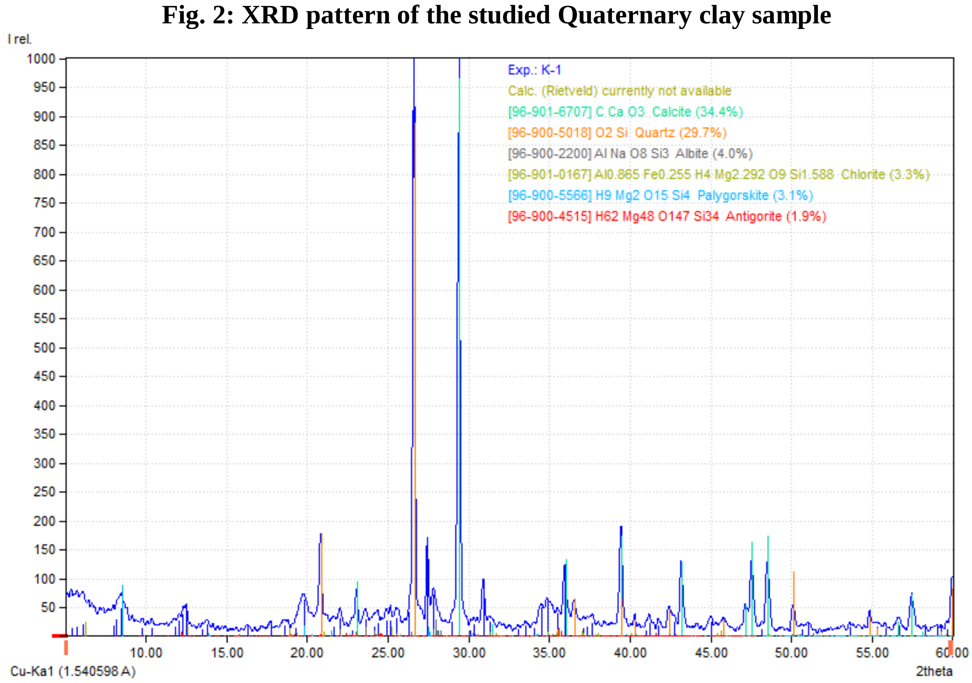

Fig. 3: XRD pattern of Bulk sample of the studied Quaternary clay sample

Raw Material Mixture

The mixing ratio of raw materials was calculated by which it is possible to predict the good mixing ratio. And other corrected materials (Table 4) to be added according to [1]. which includes high-silica clay Or iron additives to control the percentage of iron oxide in ordinary Portland cement and to give a degree of resistance to sulfate salt cement clinker and alumina additives such as bauxite by the equation of [12].

There are several stages for the cement industry, including calculating the proportions of raw materials in the cement mixture.[13]. Indicated that the proportion of raw materials must be calculated during the preparation of the raw mixture by mixing sufficient quantities of raw materials so that the cement produced will be according to the chemical composition required.

Table 4: Mixing ratios for raw materials entering the furnace.

Samples		KH 3	KH 4	KH 5
content	Limestone	80%	70.04%	73.98%
	Bauxite	0.4%	0.1%	0%
	Iron	0.6%	3.4%	3.6%
	clay	19%	26.46%	22.42%
	Total	100	100	100

for evaluating the chemical composition of the mixture of raw materials entering the kiln, the chemical parameters used for this purpose are calculated by the equation of [12].They are lime saturation factor (LSF), silica ratio (SR) and alumina ratio (AR)(Table 5).

Table 5: Chemical analyzes of produced cement clinker at temperature (1450^0)

Sample / Oxide wt%	KH5	KH4	KH3
SiO_2	20.01	20.16	21.00
Al_2O_3	6.58	6.70	5.87
Fe_2O_3	5.20	4.22	4.33
CaO	63.32	63.74	63.99
MgO	2.60	2.57	2.65
SO3	0.24	0.35	0.27
K_2O	Nil	Nil	Nil
Na_2O	Nil	Nil	Nil
LOI	0.30	0.42	0.45
CaO- Free	0.64	0.57	0.65
Total	98.89	98.73	99.21
LSF	94.26	95.00	93.36
SR	1.69	1.84	2.05
AR	1.26	1.58	1.35

1. Lime Saturation Factor (LSF): The range of this factor in cement is 90-100% according to the Iraqi cement specification[1]. In the current study, the ratio is between (93.36-95.00) It is used to find out how much lime is used in cement production. This factor is calculated by the following equation[9].

$$LSF = \frac{100\ CaO}{2.8\ SiO_2 + 1.2\ Al_2O_3 + 0.65\ Fe_2O_3}$$

2. Silica Ratio (SR): This factor is calculated by the following equation [14].

$$SR = \frac{SiO_2}{Al_2O_3 + Fe_2O_3}$$

The [15] indicated that a high percentage of SR causes a decrease in the burning of the mixture and vice versa. therefore, it is difficult for burning to take place, because the high percentage of this mixture will form poor coatings for the mixture the range of AR in cement is 2.2−2.6%.[9]. In the current study, the ratio is between (1.69-2.05).

3. Alumina Ratio (AR): It is calculated as following [16]:

$$AR = \frac{Al_2O_3}{Fe_2O_3}$$

This factor is the most influential on the formation of clinker at low temperatures and affects the color of clinker and cement. In general, the range of AR is 1.0-4.0 [17]. In the current study, the ratio is between (1.26-1.58)

Calculation of clinker content of mineral phases

The main purpose of the raw mixture factors and raw materials components is to derive the basic chemical compounds that include (belite C2S = $2CaO.SiO_2$), (alite C3S = $3CaO.SiO_2$), (aluminate C3A = $3CaO.Al_2O_3$), and (ferrite C4AF = $4CaO.Al_2O_3.Fe_2O_3$) formed in the clinker phases[18].The properties of Ordinary Portland cement were determined mainly by calculating the proportions of the four main phases of clinker, they represent the impure forms, and the most important phases formed in the clinker.

The relationship between the chemical compounds and the phases that make up the cement clinker is calculated using Bogue's equations[19,20,21] as follows:

C_3S=4.07 (CaO)-7.60 (SiO_2) -6.72 (Al_2O_3)-1.42 (Fe_2O_3)-2.85(SO_3).

C_2S=2.86 (SiO_2)-0.75 (C_3S).

C_3A=2.65 (Al_2O_3)-1.69 (Fe_2O_3).

C_4AF=3.04 (Fe_2O_3).

The proportions of the four clinker phases in the studied samples comply with the international specifications[1-23]. and [24]. of the Portland cement industry(Table 5). The ratio of C2S ranged between (16.22-18.59%), C3S (50.77-51.91%), C3A (8.21-10.60%), and C4AF (12.83-15.81%). By comparing these results with the basic components of phases in Ordinary Portland cement by [25]. as shown in (Table 6).

Table 5: the mineral composition of Portland cement ratios [25]

Cement notation	Typical (Mass %)	Typical (Mass %)	mineral phases in studied clinker samples
C_3S	57	38 – 60	50.77-51.91
C_2S	16	15 – 38	16.22-18.59
C_3A	9	7 – 15	8.21-10.60
C_4AF	10	6 – 18	12.83-15.81

Clinker Properties

Some important properties of cement clinker are calculated by [19]. and include the following:

Hydraulic Modulus (HM):

It is the optimal lime content in cement clinker, which is one of the main properties of clinker, which ranges between 1.7 and 2.3, but the high quality is (2) according to [20],The percentage in the study samples ranged between (2.1-1.9). The hydraulic modulus of cement clinker is calculated using the following equation [26]: $HM=CaO/SiO+Al_2O_3+Fe_2O_3$

Minimum Burning Temperature (MPT)

The coefficient represents the temperature at which the liquid phases begin to appear in the kiln. This coefficient depends on the ratios of Fe_2O_3 and Al_2O_3 in the raw materials mixture in the kiln, and the percentage of Fe-oxide is more effective than Al-oxide. The percentage in the study samples ranged between (1336-1296). This coefficient is calculated by the following equation by [27] :

$MBT°C = 1300 + 4.51 * C_3S – 3.74 *C_3A – 12.64 * C_4AF$

Burnability Index (BI)

It is the relative ease or difficulty of converting the kiln mixture into cement clinker. The burnability depends on the mineral composition of the raw mixture. The ratio of this coefficient in cement clinker is (2.6-4.5) according to [26]. This parameter is calculated by the following equation:

B.I = C3S / C3A + C4AF

The B.I ratio in the studied clinker samples is (2.21-2.42). These ratios are of good burnability, which means that all samples have an acceptable range of BI for clinker.

Liquid Phase at the Burning Zone

It is the amount of liquid formed at the temperature of clinker formation, and it depends on the burning temperature and the chemical composition of the raw mixture. The liquid phase is essential for the supplementary materials for the melting, which leads to a high percentage of the liquid phase during the burning process and the formation of clinker phases.The ratio of this coefficient in cement clinker is (23-27%)according to[26]. The L.Ph ratio in the studied clinker samples is(30.27-34.28). It was calculated from the formula proposed by [28].

Liquid phase (L.Ph) % = $3.0\ Al_2O_3 + 2.25\ Fe_2O_3 + MgO + K_2O + Na_2O + SO_4$(1450C°).

Mineralogical Study of the Produced Clinker

The mineralogical study of three samples of clinker prepared in the laboratory was carried out using (XRD) device of type (Shimadzu - 6000) the work was done in the materials research laboratory at the Ministry of Science and Technology in Baghdad to diagnose the main and secondary mineral phases. The diagnosis of cement phases was based on cards,(ICDD) International center for Diffraction Data, These phases are calculated using Bogue's equations[19] as follows:

$C_3S=4.07\ (CaO)-7.60\ (SiO_2)\ -6.72\ (Al_2O_3)-1.42\ (Fe_2O_3)-2.85(SO_3)$.

$C_2S=2.86\ (SiO_2)-0.75\ (C_3S)$.

$C_3A=2.65\ (Al_2O_3)-1.69\ (Fe_2O_3)$.

$C_4AF=3.04\ (Fe_2O_3)$.

These equations depend on the proportions of the composition oxides obtained from chemical analyzes of cement prepared according to American specifications[24]. The most important mineral phases that appeared in the clinker samples are shown in (Fig. 4) and for several chemical compounds which are:

1- Alite phase (C3S): It is the most important mineral phase in the clinker of ordinary Portland cement (OPC), as it constitutes about 38-60% of cement [29].This mineral phase appears when analyzed by XRD at the diffraction peak (2.77, 2.62 and 2.98A°) and it appears when it is in the monoclinic phase (1.76), (1.79), (1.66) A° [30]. And its presence in the studied clinker samples ranges between (50.77-51.91 %). This ratio was calculated by using Bogue's equations [19] .

2. Belite phase(C2S): It exists in various forms and is formed by the reaction of SiO_2 with CaO at about 1100 °C. In order to obtain this important phase, the cooling must be rapid to avoid the formation of 8-and B-polymorphs phases [31]. This mineral constitutes 15-38% of Portland cement [32]. This mineral when analyzed by XRD at the diffraction peak (2.45, 2.4) A° and overlaps with light and appears less strongly at (2.9, 2.88, 1.78, 2.1) A° (Fig. 4, 5, 6). Its presence varies in studied clinker samples ranges between (16.22-18.59%), which is within the acceptable rates of clinker [29].

3- Aluminate phase (C3A): This compound constitutes (7-15%) of the components of ordinary Portland clinker according to[29], and its chemical composition is $Ca_3Al_2O_6$. This phase is formed when Al-oxide and Ca-oxide are heated together above 1300°C. The pure form of it is found in the cubic system, and it is the most active in the Portland cement clinker, then the orthorhombic and monoclinic phase is formed, but it does not have a great importance in the clinker [33].This phase appears when analyzing the clinker with XRD at the diffraction peak (2.7, 2.68) A°, The percentage of the presence of this phase in cement clinker ranges between (8.21-10.60%), and it is within the allowed limits of Portland cement.

4. Ferrite phase (C4AF): It includes iron oxides and the rest of the other oxides and its chemical composition is $Ca_2(Al, Fe)_2O_5$ and constitutes (6 – 18%) of OPC[34]. This phase is formed after burning a 1330°C [34].It appears when analyzing the studied clinker by XRD at the diffraction peaks (2.68, 2.63) A°. it can be separated when there are diffraction peaks (2.66) and (2.7) A° [35].

5. Alkaline sulfate: This phase is formed in the last stages of cooling [30]. The presence of gypsum and bassanite was distinguished in the studied clinker and it appears when analyzed by XRD at the diffraction peak (7.67) A° and in a very small percentage in the studied samples.

6. Portlandite: It is present in microscopic sizes and has poor mechanical properties, but it is important in terms of hydration of Portland cement [36].It can be classified as soft brittle materials. This phase appears when analyzing the clinker by XRD at (17.16, 2.62, 1.9 A° and 4.9A°).

7. Free lime(F-CaO): It is defined as calcium oxide that is not combined with oxides of Si, Al and Fe, and it results either from incomplete reactions during burning in the kiln, or from a high LSF in the raw mixture. It is likely to result from its insufficient heterogeneity [37].The results of chemical analyses of free lime (CaO) in clinker produced at 1450°C showed that it ranged between (0.65-0.57). Free lime appears at the base reflection (1.39) A°, which is considered weak. [38]. indicated that if the presence of free lime in cement is more than (5%), the reflection (1.39) A° becomes very strong.

Figures (5,6,7) represent the patterns appeared from the X-ray diffraction of the studied clinker samples (KH3, KH4, KH5) which were analyzed within the angle range (2θ = 10-50°) and were distinguished according to d-spacing values according to [39].

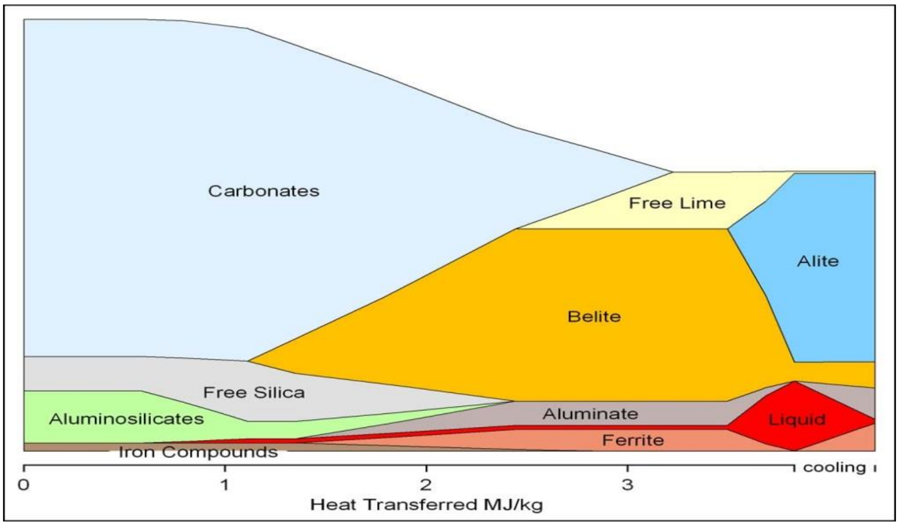

Fig. 4: Mineral phases formed when burning and after rapid cooling of clinker[40].

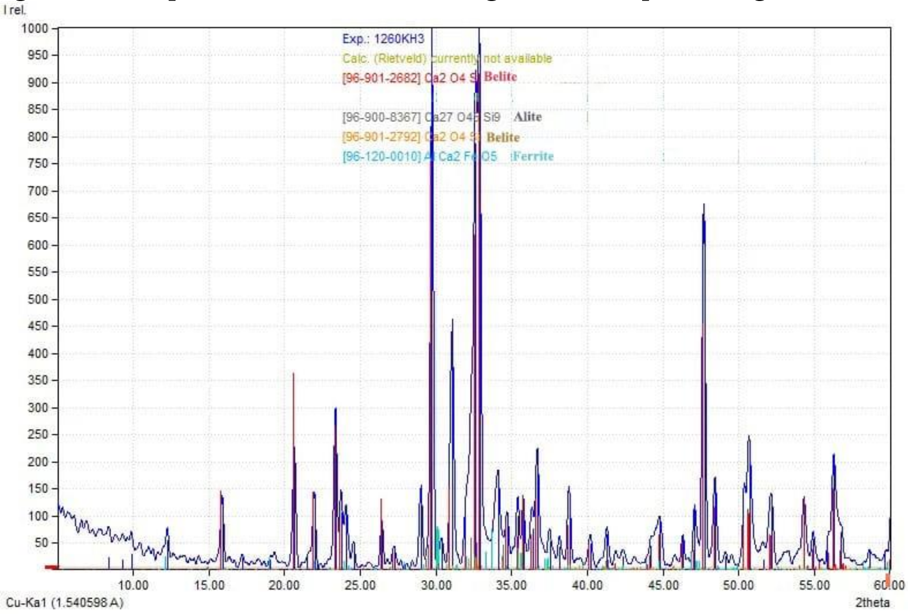

Fig. 5: XRD analysis of the mineral phases of the clinker sample (KH3).

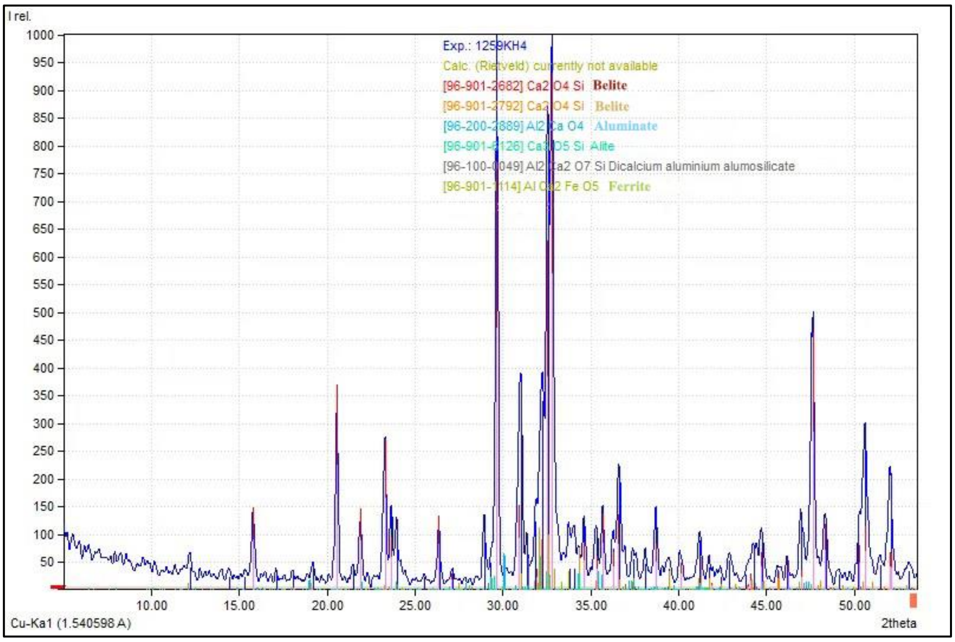

Fig. 6: XRD analysis of the mineral phases of the clinker sample (KH4).

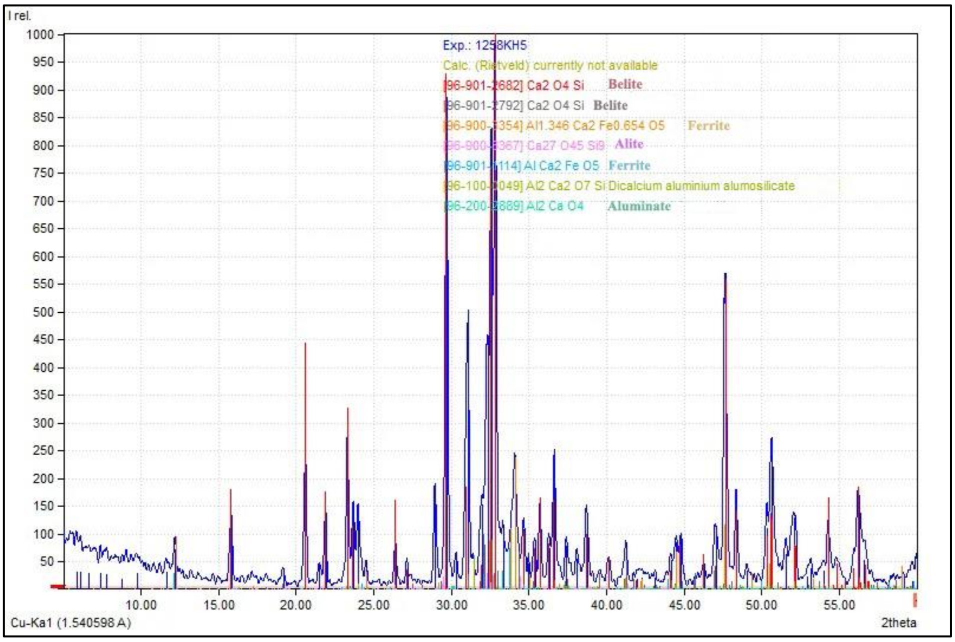

Fig. 7: XRD analysis of the mineral phases of the clinker sample (KH5).

Petrophysical and Mechanical Properties of the studied Limestone were made:

The context described by [41]. was used to deal with the physical properties of limestone of the Ghar Formation through the results shown in (Table 6). These properties are affected by many factors, including grain size and shape, effective pore size, fractures, and texture. These examinations included the apparent porosity, Moisture content, Specific gravity, total density and unconfined compressive strength (Table 6).

Table 6: results of physical and Mechanical properties examinations of limestone samples in the studied area.

Sample No.	Apparent porosity (%)	Moisture content (%)	Specific gravity	Total Density (g/cm^3)	compressive strength (cm2/kg)
KH8	1.75	11	2.28	2.28	40.08
KH4	4.82	12	2.34	2.71	140.1
KH20	2.60	15	2.61	2.61	87.19
KH22	1.03	12	2.42	2.42	33.9
KH5	1.04	13	2.63	2.63	40.70
Stander	IQS, No.8 (1984)	IQS, No.8 (1984)	ASTM, C_97,09,2004	ASTM-C- 97-09.2010	ASTM, C-170, 2004

1. The apparent porosity:The result showed that the apparent porosity was low, ranging between (1.03−4.82%). It is expressed in the following form:

$n\% = \frac{Vv}{Vt} * 100.$

Where n% = the apparent porosity Vv = the volume of voids Vt = the total volume of the rock

2. Moisture content: It is one of the basic properties of rock materials because of its relationship to the durability of rocks through the processes of water freezing and thawing, It is expressed by the following equation:

$$\textbf{Natural moisture content} = \frac{\textbf{Water weight (Ww) x 100}}{\textbf{Weight of solid component (Ws)}}$$

The moisture content of the studied samples in Al Busaiyah ranged between (11-15%).

3. Specific gravity: The current study relied on finding the apparent specific gravity, and this type depends on the pores in the sample according to the specification [42].

4. Total Density: It can be expressed as kg/m^3 and $gram/cm^3$. Density increases with increasing depth according to the specification [43].

$$\textbf{Bulk density } (gm/cm^3) = \frac{\textbf{Dry weight (gm)}}{\textbf{Saturated weight (gm) – submerged weight (gm)}}$$

The laboratory tests in (Table 6) showed that the density values ranged between (2.28 - 2.71 g/cm^3).

5. Mechanical Properties: The compressive strength was found according to [44].The compressive strength of the samples can be found by the following equation:

$$\textbf{Unconfined compressive strength} = \frac{\textbf{Force applied at failure}}{\textbf{Surface area of sample facing the apparatus plate}}$$

Conclusions

1-The chemical analyses of (6) samples of limestone and (1) samples of clays indicate that the limestone and clay contain a qualified raw material appropriate for the cement industry.

2- The geochemical study of the samples proved that the content of (CaO) falls within the permissible ranges for the raw materials, as well as the low percentage of (MgO) concentrations in the raw materials indicating that these rocks are suitable for the manufacture of Portland cement.

3- The results of the chemical tests of the produced cement clinker samples showed that they are suitable for the Portland cement industry and within the local and international specifications through the ratios of the mineral phases of Portland cement C3A, C4AF, C3S, C2S, .

4- Depending on the results of the physical and mechanical examinations shown by the current study of the studied rock samples, it was found that they are moderately
strong and moderately weak, in addition to the wide availability of limestone rocks within the study area, so it is a results of physical and mechanical properties of limestone are within the standard specification for Portland cement, that the dry method is preferred for manufacturing of ordinary Portland cement and easily can be quarried and crushed limestone during manufacturing

References

[1] IQS, No.5 (1984). Iraqi standard specification, Portland cement. (In Arabic).

[2] BS EN 197-1. (2004). Composition, specification and conformity criteria for common cements.

[3] Al-Koomy, M.I., 1982. Total reserve of clay deposits, Muthana Governorate (for cement industry). GEOSURV, int. rep. no. 1147.

[4] Al-Ali et al., 2004 studied the chemical and mineral evaluation of cement raw materials Industry in Kufa cement factories.
[5] Buday, T. and Jassim, S. Z., 1984: Tectonic map of Iraq, Scale 1:1000000, GEOSURV. Baghdad, Iraq.
[6] Owen, R.M. and Nasr, S.N., 1958: The Stratigraphic of Kuwait – Basrah area. In: Weeks L.G. (edit.), Habitat of Oil, a Symposium. Am. Assoc. Petr. Geol., Tulsa.
[7] ASTM. C114-03.„ "Standard Test Methods for Chemical Analysis of Hydraulic Cement""2003 Annual Book of ASTM Standards, Vol.04.01, Cement; lime; Gypsum, P. 109- 138.
[8] Johnson D.M., Hooper P.R., and Conrey R.M., (1999): XRF Analysis of Rocks and Minerals for Major and Trace Elements on a Single Low Dilution Li-tetraborate Fused Bead, International Centre for Diffraction Data, pp. 843-867.
[9] Duda, W.H., 1977: "Cement–Data–Book", International process engineering in the cement industry, 2nd edition, Bauverlag, GmbH. Wiesbaden and Berlin Macdonald and Evans, London, 539p.
[10] Schafer, H. U. and Koln, D. G. (1987). Crushing plants with double shaft hammer crushers for the comminution of raw materials for clinker production. Jour. Cement- Lime Gypsum. No. 10. Oct. pp. 277-281.
[11] Harrison, D. J. (1992): Limestone. Technical report, Mineralogy and Petrology Group, British Geological Survey, Nottingham, U.K.
[12] Kohlhaas, B. and 16 other authors (1983): Cement engineer's handbook. (4th ed.), Bauverlag GmbH, Wiesbaden and Berlin, 800p.
[13] Liu, X. and Li, Y., 2005: Effect of MgO on the Composition and Properties of Alite-Sulphoaluminate Cement. Elsevier, Cement and Concrete Research, Vol. 35, pp. 1685–1687.
[14] Czernin, H. C. W. (1980). Cement chemistry and physics for civil engineers. Georg godwin ltd. and Foreign publication Inc., Second Ed., London, New York, 196P.
[15] Alemayehu, F. Sahu, O. (2013): *"Minimization of variation in clinker quality":* Advances in Materials, Science Publishing Group, 2(2):pp.23-28.
[16] Lea, F.M., 1970, "The chemistry of cement and concrete". 3rd edition, chemical publishing company, Inc.,727p.
[17] Rao, D.S., Vijayakumar, T.V., Prabhakar, S. and Bhaskar Raju, G., 2011. Geochemical Assessment of a Siliceous Limestone Sample for cement making. Chines Journal of Geochemistry. Vol.30, Issue 1, p. 33 – 39.
[18] Neville, A. M., 2010: Concrete Technology. 2nd ed., Pearson Education limited, Harlow, England, 490P.
[19] Bogue, R. H. (1955): The chemistry of Portland cement. Reinjold publishing corp., second Ed., New York, 793P.
[20] Ghosh, S. N., 2002: Advances in Cement Technology; Chemistry, Manufacture and Testing. 2nd ed., Tech. books international, New Delhi, India. 804P.
[21] Neville, A. M., 2010: Properties of Concrete. 5th ed., Prentice Hall, London,UK. 872P.
[22] Neville, A. M., 2012: Properties of Concrete. 5th ed., Prentice Hall, London,UK. 872P.
[23] BS EN 197-1. (2004). Composition, specification and conformity criteria for common cements.
[24] ASTM,C 150-02a, (2002). American standard specifications for Portland cement.
[25] Newman, J. and Choo, B.S., 2003. Advanced Concrete Technology; Constituent Materials. 1st ed., Butterworth Heinemann, Elsevier, UK., 288pp.
[26] Peray, K.E. & Waddell, J.J., 1972. The rotary cement kiln, Chemical Publishing Co., Inc. New York, 194P.
[27] Chatterjee, A. K. (1979). Cement raw materials and raw mixes. A review of diagnostic interrelations. The physico- chemical characteristics of raw materials and the reactivity of raw mixes. Jour. Pit and Quarry. Part, Sept., PP. 103-111, part 2, Nov., PP. 73-80.
[28] Lea F.M. and parker1979: The chemistry of cement and concrete. 3rd ed. Arnold.
[29] Brandt, A. M., 2009: Cement-Based Composites. 2nd ed., Taylor & Francis, London, UK. 536P.
[30] Silva, L.A,Nahime ,B.O, Lima,E.C,Akasaki,J.L and Reis.I.C,(2020): XRD investigation if cement pastes incorporating concrete floor polishing waste. Ceramica 66,373-378pp.
[31] Rejmak. P., Dolado, j. S., Aranda , M.andAyuela.A.2019, First-principles calculations on polymorphs of dicalcium silicate Belite Amain component of Portland cement.J.Phys.Chem.123, 6768-6777pp.
[32] Al-Dieb, M.A. and Ibrahim, H.G. (2010): Variation of feed chemical composition and its effect on clinker formation– simulation process. World Congress on Engineering and Computer Science (WCECS), Vol. II, San Francisco, USA.
[33] Muller, A.,McGregor, H.V., Gagan, M.K. and lough, J.M. (2006).The effects of early marine aragonite,Mg-Calcite and vadose-zone Calcite diaggenesis on reconstruction of coral calcification rate and the oceanic sues effect. proceeding 10th international coral Reef symposium,Okinawa,PP 607-614.
[34] Cheng, X. Yang, Y. Liu, K., Mei, K. and Li,Z., 2018. Synthesis of microcrystalline brownmillerite Ca2(Al,Fe)2O5 and it's influence of mechanical properties to the class G oil well cement. J. Adhesion Science and Technology, Iss. 2 Vol.32,405-420pp.
[35] Taylor H F W. (1990). Cement Chemistry. Academic Press, Inc., New York.
[36] Zheng, Q., Jinyang, J., Xu, J. Tang, L. and Li, S., 2020. New insights into the role of Portlandite in the cement system : Elastic anisotropy ,thermal stability and structural compatibility with C-S-H .Crystal Growth Des 20, 2477-2488pp.

[37] Thanoon, T. A-R., 1984, "Industrial evaluation of limestone with particular reference to the Sinjar limestone formation in N.W. Iraq", Unpublished Ph.D. Thesis, University of Hull, 234P.
[38] Midgley,H.G.,1964,The formation and phase composition of portland cement clinker, In: Tylor, H.F.W.,1964, The chemistry of cements. Vol.1,Academic press.London and New York,pp.89-130.
[39] Taylor, H. F. W. (1964). The chemistry of Cement. Academic press. Taylor Ed, London and New York, Vol. 1, 460P. Vol.2, 442 P.
[40] Ylmen, R. and U. , 2013.Carbonation of Portland cement studied by diffuse reflection fourier transform Infrared spectroscopy.J.Concrete Structures and Materials, Vol.7, No.2, 119-125pp.
[41] I.Q.S No.31, 1981. Iraqi standard specification for measurement of Bulk density, specific gravity, moisture content, apparent porosity, Water absorption of limestone rock for product of Portland cement.
[42] ASTM- C97-09., (2004). Standard test methods for absorption and Bulk specific gravity of Dimension stone.p.3.
[43] ASTM- C, 127- 90. 2004: Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate, 6p.
[44] ASTM- D, 2938-95.,(2004):"Standard test methods for unconfined compressive strength of intact rock core specimens"3p.

تقييم الحجر الجيري لتكوين الغار في منطقة البصية جنوب العراق كمواد أولية لصناعة الاسمنت البورتلاندي العادي

خالد محمد احمد ، سوسن حميد فيصل ، فارس نجرس حسن
قسم علوم الارض التطبيقية ، كلية العلوم ، جامعة تكريت ، تكريت ، العراق

الملخص

تم اختيار ستة عينات من الصخور الجيرية لتكوين الغار في منطقة البصية جنوب مدينة الناصرية في الصحراء الجنوبية للعراق ، كما تم اختيار عينة واحدة من ترسبات اطيان العصر الرباعي لغرض التقييم الجيوكيميائي والمعدني لصناعة الأسمنت البورتلاندي الاعتيادي، حيث بينت نتائج التحاليل للحجر الجيري لتكوين الغار انها تحتوي على نسب (اقل من 2%) من اوكسيد المغنيسيوم وارتفاع نسبة اوكسيد الكالسيوم الى اكثر من (52%) والتي كانت مطابقه للمواصفات العراقية والعالمية لصناعة السمنت. تم تحليل أَطيان الفيضات في منطقة الدراسة لغرض تجربتها وبيان صلاحيتها لصناعة السمنت حيث أَن الاطيان الحديثة فيها نسبة اوكسيد المغنيسيوم عالية وكذلك ندرة وجودها في مقاطع الدراسة، أذ بينت النتائج صلاحيتها لصناعة السمنت. وتم حساب نسب الاشباع الجيري (LSF)ونسبة الالومينا(AR)ونسبة السليكا (SR) للخلطة المتكونة من الحجر الجيري لتكوين الغار والاطيان والبوكسايت واكاسيد الحديد، والمركبين الاخيرين هما لتصحيح نسب الاكاسيد اللازمة لصناعة الكلنكر. تم حرق(3)خلطات من مكاشف مختلفة من تكوين الغار لدرجة حرارة 1200 و1450 $م^0$ وبينت النتائج صلاحية الكلنكر المنتج ومطابقته للمواصفات العالمية عند الحرق على 1450 $م^0$ بينما فشل الكلنكر المحروق على 1200$م^0$ بسبب عدم اكتمال تشكل اطوار السمنت وظهور الجير الحر بنسبة تصل الى 20%. تم حساب نسب الاطوار المعدنية للكلنكر بعد الحرق وتبين تكون اطوار ومعادن البلايت واللالايت و الفرايت الالومينيت والبورتلاندايت.

تم اجراء الفحوصات الفيزيائية والميكانيكية على الحجر الجيري من تكوين الغار وتم تحليل المقاومة الانضغاطية والوزن النوعية والكثافة الكلية ومحتوى الرطوبة والمسامية الظاهرية واظهرت النتائج انها قوية باعتدال ضعيفة باعتدال وهي مطابقة للمواصفات العالمية اللازمة لصناعة السمنت.