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Petrophysical Study of Limestone Rocks for Al-Nfayil Formation –Bahr Al-Najaf Depression and Suitability for Industrial Purposes

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Abstract

Background:

Limestone is widely spread in nature and constitutes about (20-25%) of the total sedimentary rocks [1]. It is ranked third globally from mineral sources and extracted rocks [2]. Limestone represents the large ratio of the stratified column of Iraq [3].

Materials and Methods:

This study involves the evaluation of limestone rocks as construction materials of Al- Nfayil formation in Bahr Al-Najaf Depression by 15 stations distributed over a region. The research includes field and laboratory aspects.

Results:

Through the tests, the viability of limestone for construction purposes was determined. As it is suitable for construction because it succeeded the requirements of the building standard (ASTM, C568, 2004), and did not succeed in the requirements of the standard for railway control aggregates (O.R.B.D, 1999, Raymond, 1979). The study recommends estimating and calculating the amount of reserves of limestone rocks available in the study area for the purpose of calculating economic feasibility

Key words:

Limestone, Al-Nfayl formation, Bahr Al-Najaf depression.

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دراسة بتروفيزيائية لصخور الحجر الجيري لتكوين النفايل - منخفض بحر النجف وصلاحيتها للأغراض الصناعية

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الخلاصة

مقدمة:

ينتشر الحجر الجيري في الطبيعة على نطاق واسع وبشكل حوالي (20-25٪) من إجمالي الصخور الرسوبية [1]. وتحتل المرتبة الثالثة عالمياً من حيث المصادر المعدنية والصخور المستخرجة [2].

يمثل الحجر الجيري نسبة كبيرة من العمود الطبقي في العراق [3].

طرق العمل:

تقييم صخور الحجر الجيري كمواد بناء لتكوين النفايل في منخفض بحر النجف بواقع 15 محطة موزعة على منطقة الدراسة. اشتمل البحث على الجوانب الحقلية والمختبرية.

الاستنتاجات:

من خلال الفحوصات اللازمة، تم تحديد صلاحية الحجر الجيري لأغراض البناء. وكانت مناسبة للبناء لأنها نجحت في تلبية متطلبات معيار البناء (ASTM، C568، 2004) ولم تفِ بمتطلبات معيار صخور التحكم في السكك الحديدية (O.R.B.D، 1999، Raymond، 1979). لذا توصي الدراسة بتقدير وحساب كمية احتياطيات الصخور الجيرية المتوفرة في منطقة الدراسة لغرض حساب الجدوى الاقتصادية.

الكلمات المفتاحية:

الحجر الجيري, تكوين النفايل , منخفض بحر النجف.

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INTRODUCTION

Limestone rocks were used worldwide and largely for construction purposes, as the Assyrians 3000 years ago used them to build the archaeological wall of Nineveh around the city [4]. It was also used in building simple houses, palaces, ziggurat, mosques, and military castles. Today, limestone is one of the building materials that are widely used in Iraq, as raw stone is used in building houses and residential units, ceilings and building facades, in addition to be used as raw material and base of the cement industry [5] as well as the use of arbitration ruins railway or used as a class basis or under the basis of the roads. Limestone rocks were studied by many researchers due to their great economic importance for this reason, a petrophysical and geochemical study for these rocks of the Nfayil formation for construction purposes was proposed.

Aim of study

- The study of physical and engineering tests of limestone rocks of Nfayil formation in the Najaf Depression and its suitability as a construction materials.
- They can used as building materials, railway ballast.

Location of Study Area:-

The study area is situated in the middle of Iraq, west of Najaf Governorate (Bahr Al Najaf depression) and between the longitudes in the east (44 ° 02 ′ 33″ - 44 ° 01 ′ 44″) and latitudes north (31 ° 58 ′ 22″ - 31 ° 58′ 01″). Figure (1) represents a site map showing the stations of study area.

Geological and Stratigraphy of the Study Area

The geology of involved region is described briefly in terms of stratigraphy, structure and tectonics. Generally, the study area includes Quaternary deposits particularly of the Pleistocene and latest Holocene deposits that include Valley fill sediments, flood plain, lacustrine, marsh and Aeolian sediments, Aeolian sediments are distributed at many places in study area.

Startgraphically, the erosion processes have exposed a sequence of marine and continental sediments, which range in age from Paleocene to Pleistocene. The exposed rock units are shown in the geological map (Figure 2). The formations, which are exposed in Al-Najaf area in the up sequence are Dammam Formation (lower - upper Eocene), Euphrates formation (lower -middle Miocene), Nfayil Formetion (middle Miocene), Injana Formation (upper Miocene), Zahra Formation (Pliocene-Pleistocene), and Dibdibba Formation (Pliocene-Pleistocene) (Buday and Jassim, 1987).

Basic Properties

The basic properties are important in evaluating limestone rocks, that's give a comprehensive picture and an integrated description of the quality and extent of validity of these rocks as construction materials. And from Characteristics that have been measured laboratory include the following:

Bulk density: Density is defined as the weight of the sample to the total volume (solid volume with pore space volume) [6].

$$\rho_b = \frac{W_{dry}}{V_t} \quad \ldots\ldots\ldots \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$V_t = \frac{W_{sat} - W_{sub}}{\rho_w} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Whereas:

ρb Total density (g / cm^3)
ρw Density of water (g/cm^3)
Wdry Dry Form Weight (g)
Wsub Weight of submerged model (g)
Wsat Water saturated form weight (g)
Vt Total volume (cm^3)

Density effects on the mechanical properties of rocks where the values of these increase with increasing density [7].

Porosity

It is the percentage of the size of the pore volume to the total size of the rock sample and is often symbolized (n) (Duggal, 2008) and is calculated from the following formula:

$$n = \frac{V_V}{V_t} \times 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Whereas:

n Porosity (%)
Vv pore volume (cm^3)
Vt total volume (cm^3)

Water Absorption

Water absorption is defined as the ability of a rock to attract water and fluids to its pores and around the grains. The ability of absorbance in the rock changes with the factors affecting porosity [7]. The percentage of water absorption can be calculated by using the following formula:

$$W_W = W_{sat} - W_{dry} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

$$W_{Asb} = \frac{W_w}{W_{dry}} \times 100\% \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Whereas:

WAsb water absorption (%)
WDry sample weight (g)
Wsat sample weight saturated with water (g)
Ww Weight of water in voids (gm)

Apparent Specific Gravity

Specific gravity is defined as the ratio of the weight of a certain volume of a material to the weight of water volume (Duggal, 2008) and according to the following relationship:

$$Gs = \frac{W_1}{(W_1 - W_2)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Whereas:

Gs Apparent specific gravity.
W1 The weight of the solid which is dry (g).
W2 Weight of the same material submerged in water (g).

Engineering Properties

Uniaxial Compressive Strength

Compressive strength is known as rock resistance to the stress on it. Uniaxial compression strength is measured by applying stress on material in opposite directions and continuously until failure occurs. The stress represents the material's resistance and its unit of measurement is m2 / N or Pa (Pa), dependent on the mineral composition of the rock, texture, hardness, and water content (Ftouhi et al., 1990).

Uniaxial compression strength according to ASTM C170-90 and according to the following formula: -

q_u = W/A …………………(7)

Where:

qu Compression strength.

W Projected load upon collapse.

A calculated surface area projected load upon collapse.

Abrasion Tests

It is a rock hardness test, then knowing how it is resistant to friction that rocks are subject to it by the Los Angeles device, and the percentage of abrasion is calculated according to the Iraqi specification (Q. Q. No. 1387 of 1989) and from the relationship.

$$\%C = \frac{A-B}{A} \times 100 \quad (8)$$

Where:

C%: Abrasion percentage.

A: Weigh the sample before abrasion of grams.

B: The weight of the sample after abrasion of grams.

Flexural Strength

It is the resistance of the rock to flexion or bending [8] from [9]. This examination is one of the indirect methods to calculated the strong resistance to rocks by applying a vertical load, and it is considered one of the important tests to evaluate the rocks when used in construction as high sills of windows and the doors as well as in the air-conditioning vents (Grisafe, 1976) in (Saleh, 2012). Models were prepared using the standard specifications (ASTM, C 99-09, 2010) where this specification indicates that the samples are parallel in dimensions and approximate dimensions to 4 * 8 * 2.25 in (203 * 101 * 57 mm) (length * width * height) Flexural strength is calculated from the following equation (10).

$R = 3WL / 2bd^2$……………… (10)

Whereas:

R Flexural strength

W failure limit (the highest strenth the pattern shows after breaking)

L sample length

b sample width

d sample thickness

Conclusions and Recommending

1- The limestone rocks in the region are affected by weathering and erosion, the most important of which is melting, so that melting formed a high proportion of the gaps, which led to an increase in the porosity and absorption rates and reduced the compressive strength values of these rocks.
2- The validity of limestone in the study area for use as building stones in packaging, decoration and ornamental pillars, as well as covering walls that are not exposed to rainwater because they are characterized by high porosity and low density.
3- The rocks of the region were found to be unsuitable rocks to be used as cornerstone railway ballast because they do not meet the specifications required for this purpose.

Recommending

1- Conducting a study to measure the extent of the rocky layers of limestone rocks and determine their thickness, in order to know the quantity of these rocks in the area and determine their economic importance.

2- Study the possibility of using limestone rocks as aggregate in the production of lightweight building blocks that insulate heat and sound and study their suitability in other areas in paving the shoulders of roads and rivers.

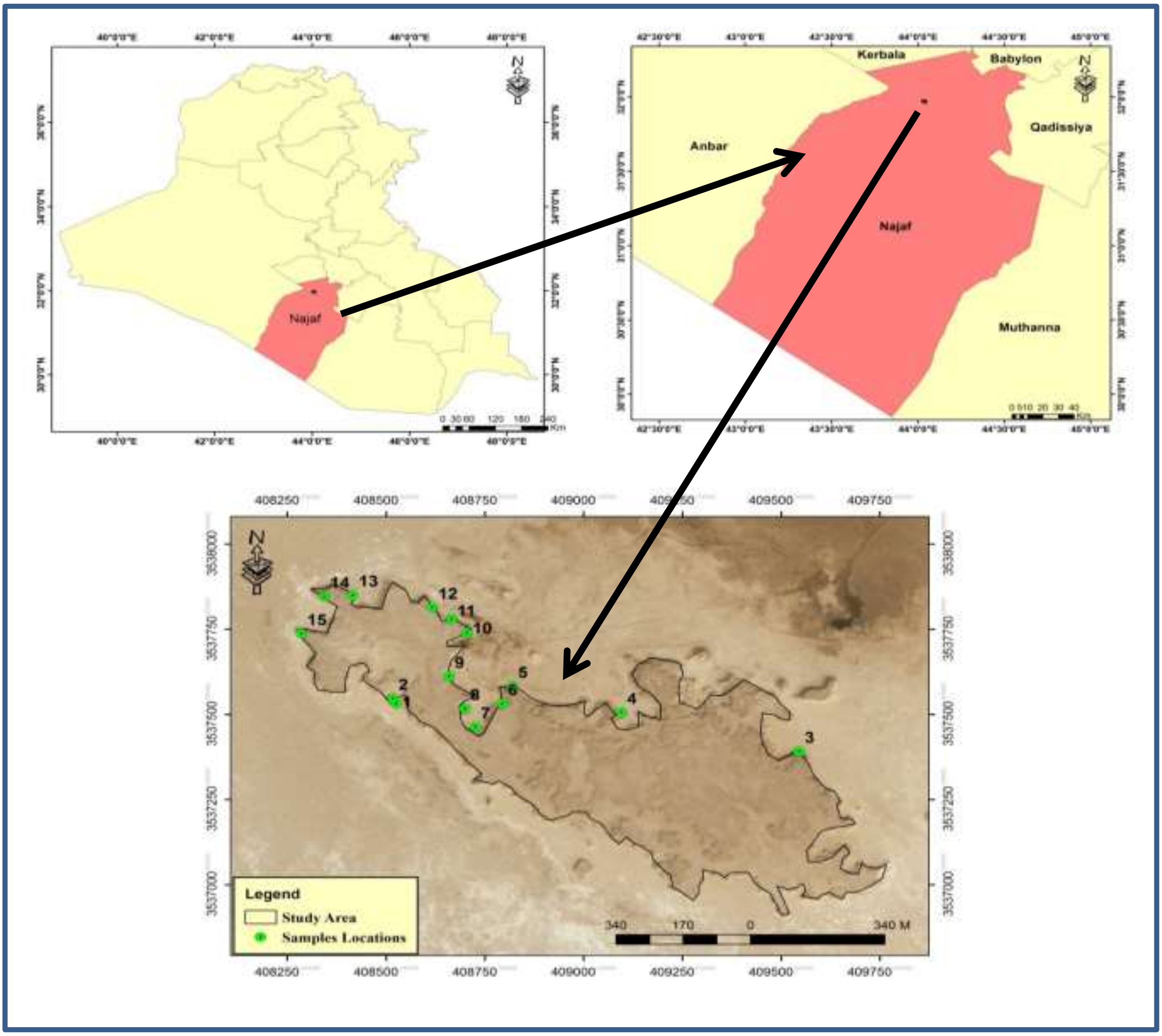

Figure (1) Location map represents the stations of the study area.

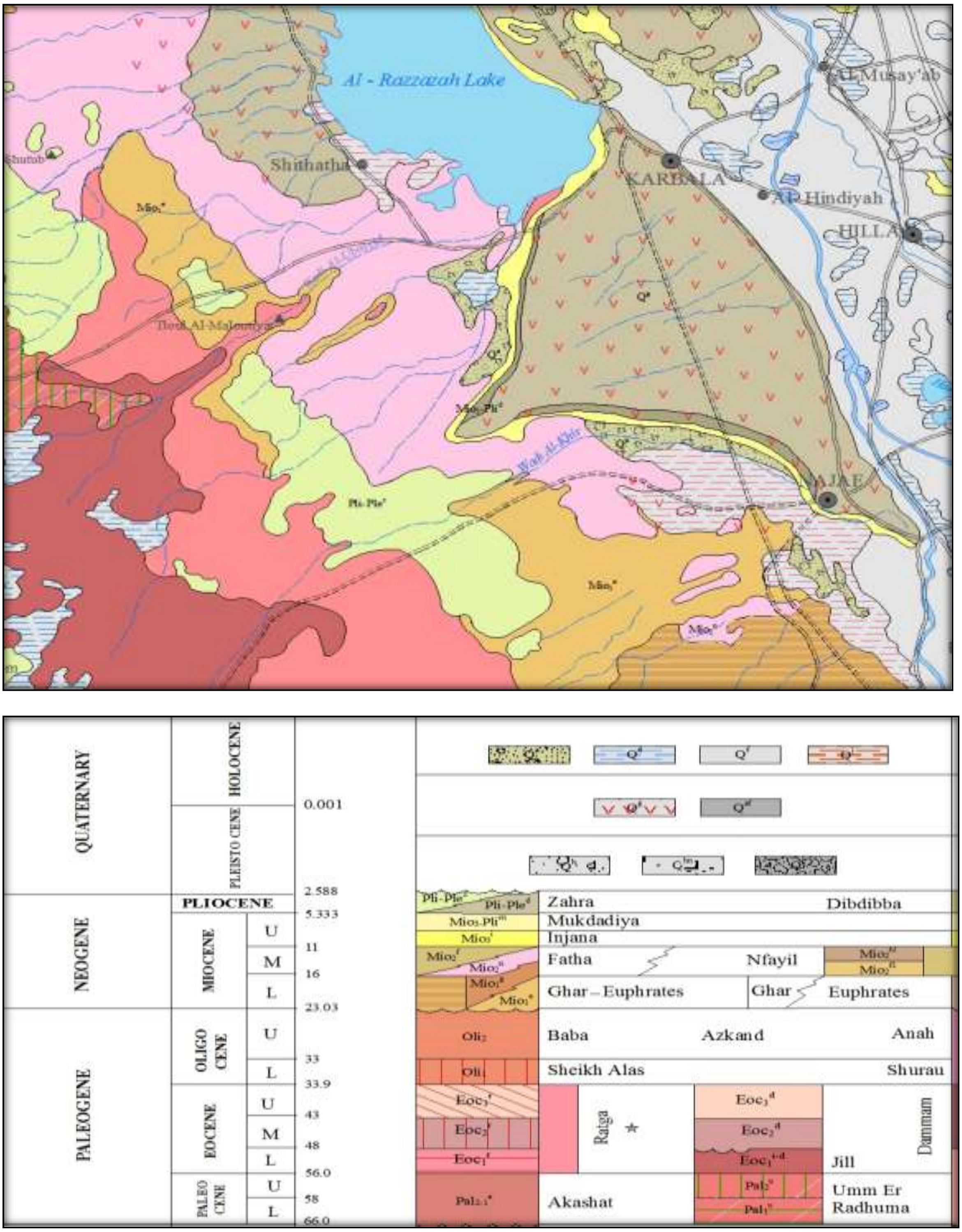

Figure (2): Geological map of the studied area (after Sissakian, V.K et al, 2015): (a) exposed geological formation; (b) stratigraphic column.

Figure (3): Laboratory Work

Figure (4) Flexural strength test

Table (1) shows the results of complete basic tests of limestone rocks for the study area.

No. of samples	Density gm/cm^3	Water Absorption	Porosity (%)	Apparent Specific Gravity
N 1	2.494	3.087	8.984	3.198
N 2	2.532	4.164	11.907	3.246
N 3	2.501	2.604	7.706	3.207
N 4	2.537	3.797	10.993	3.252
N 5	2.281	4.180	10.893	2.925
N 6	2.544	3.078	9.124	3.262
N 7	2.413	3.093	8.732	3.094
N 8	2.494	3.658	10.470	3.197
N 9	2.483	4.333	12.121	3.183
N 10	2.580	3.703	10.913	3.308
N 11	2.230	5.443	13.464	2.859
N 12	2.398	3.371	9.390	3.074
N 13	2.462	4.100	11.456	3.156
N 14	2.450	3.712	10.440	3.141
N 15	2.508	3.038	8.900	3.216
Average	2.46	3.691	10.366	3.154

Table (2) shows the results of complete Uniaxial Compressive strength test and mechanical abrasion test of limestone rocks for the study area.

No. of samples	Uniaxial Compressive strength (Mpa)	Mechanical abrasion (%)
N1	61.224	31.87
N2	60.782	31.64
N3	30.612	26.94
N4	51.498	28.00
N5	36.735	32.05
N6	52.041	28.30
N7	37.755	32.00
N8	32.653	28.61
N9	55.102	29.02
N10	60.204	27.46
N11	35.510	27.39
N12	42.857	26.05
N13	31.633	25.06
N14	45.918	33.14
N15	40.816	23.19

Table (3) shows the result of complete Flexural Strength Test of limestone rocks for the study area.

No. of samples	Sample length	Sample width	The thickness	Breakdown strength	Flexural Strength
N14	200	107	60	17618	10.29
N3	197	104	57	8598	5.53
N10	204	105	58	9071	5.62

Conflict of interests.

There are non-conflicts of interest.

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