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Sedimentology and Morphology of Al-Rahaliyah Quarries Gravel, Al-Anbar Governorate, Central Iraq

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Abstract

The present study covers a sedimentological study of the gravel deposited in Al-Rahaliyah quarries for building materials in Al-Rahaliyah city within Al-Anbar Governorate. Ten samples of sediments were collected from ten sites, Dry sieving was done to separate the gravel fraction. A sedimentological analysis was performed on the gravel samples, covering the grain size fractions and morphology of gravel samples. The morphology included determining the form, roundness, and sphericity of these samples.The main size fraction of the studied gravel was pebbles (4-64mm), while the main form types were bladed and plated formTexturally the studied gravel sample of Al-Rahalyiah quarries is classified as Muddy Sandy Gravel and Sandy Gravel. About the shape of the studied gravels, the total average roundness of the studied samples is 4.2 (rounded), while the total average sphericity was 2.3 (Sub Discoidal). The roundness and sphericity of the studied gravels are affected by the fact that the original limestone rocks are deposited in horizontal sedimentary beds, and this stratification affected the shape of the studied gravels.The gravel was identified manually and using thin sections. It was found that the main lithology is carbonate type, while the type of carbonate rocks includes fossiliferous packstone, peloidal packstone, dolomitic limestone, and lithoclastic mudstone types, and the origin of these gravels are the Euphrates, Dammam, Anah, and Nfayil Formations, which are located in the west, and southwest related to the slope of the valleys in the study area.

Keywords: Gravel, Quarries, Shape Analysis, Grain Size, Petrography

رسوبية ومورفولوجية حصى مقالع الرحالية ، محافظة الأنبار , وسط العراق

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الخلاصة

تناولت الدراسة الحالية دراسة رسوبية لجزء الحصى المترسب في مقالع الرحالية لمواد البناء في مدينة الرحالية ضمن محافظة الانبار . تم جمع عشر عينات من خليط الرواسب من عشرة مواقع ، وتم إجراء الغربلة الجافة لفصل جزء الحصى من خليط الرواسب . تم إجراء التحاليل الرسوبية على عينات الحصى ، وقد غطت هذه التحاليل التدرجات الحجمية للحبيبات ، ومورفولوجية عينات الحصى ، وتضمنت الدراسة المورفولوجية

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تحديد: الشكل ، والاستدارة ، والتكور لهذه العينات. الحجم الرئيسي للرواسب المدروسة هو الحصى (4-64 مم) ، في حين كانت الأنواع الرئيسية ذات الشكل النصلي والصفائحي.
من الناحية النسيجية تم تصنيف حصى مقالع الرحالية كحصى رملي وحلي وحصى رملي . أما بالنسبة لشكل الحصى المدروسة فقد بلغ معدل الاستدارة الكلية للعينات قيد الدراسة (4.2 مستديرة) ، في حين بلغ معدل التكور الكلي (2.3 شبه قرصية). تتأثر استدارة وكروية الحصى المدروسة بكون الصخور الجيرية الأصلية تترسب على شكل طبقات رسوبية أفقية ، وقد أثر هذا الترسيب الافقي على شكل الحصى المدروسة. من الناحية البتروغرافية تم التعرف على صخور حصى مقالع الرحالية المدروسة عن طريق عمل شرائح رقيقة من الصخور ودراستها من خلال المجهر المستقطب . وقد تبين أن الصخور الرئيسية هي من النوع الكربوناتية، بينما يشمل نوع الصخور الكربوناتية: الحجر الجيري المستحاثي ، الحجر الجيري الدملقي المرصوص ، الحجر الجيري الدولومايتي ، والحجر الوحلي الحاوي على المفتتات الصخرية ، ومنشأ هذه الحصى هو صخور تكوينات الفرات والدمام وعانة والنفايل ، والتي تقع في غرب وجنوب غرب منطقة الدراسة وهذا مرتبط بانحدار الوديان في منطقة الدراسة.

1. Introduction

An important portion of Iraq's natural resources is found in its building material quarries, which are made up of a mixture of recent sediments and gravel. These quarries are typically found around the Mesopotamian Zone's edges from all sides [1].

Many illegal quarries dispersed around the same territory, and the Iraqi Geological Survey and the council of governorates that contain these quarries contribute to their supervision.

The production plan of these quarries is characteristed by its lack of organisation and management; this production case leads to significant degradation in the quarry production area.Gravels are a significant constituent of building materials, serving as the primary material in concrete mixtures and other foundational uses The study area is a considerable gravel source in Iraq.

The current study aims to identify the source, origin, and lithology of Al-Rahaliyah quarry gravel.The current study also aims to conduct a sedimentalogical analysis, including the size gradients of the gravel, as well as a morphological study that includes determining the form roundness and spheristy.

2. Location of Studied Area

The areas of study represent the building materials quarries that are located in the area between Al-Habaniyah and Al-Razzaza Lakes Northwest of Al-Rahaliyah City in Al-Anbar Governorate. The location of the studied area is bounded by the longitudes (43°:10':00")E and (43°:28':00")E and latitudes (33°:10':00")N and (32°:55':00")N covering more than (60 Km²) (Figure 1), (Table 1).

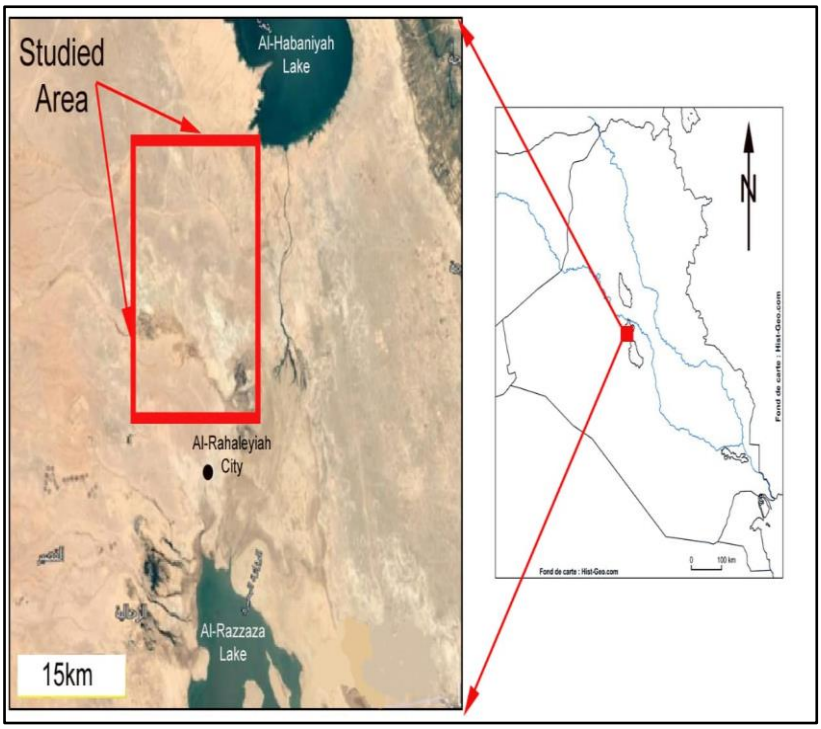

Figure 1: Location Map of the studied area [2].

Table 1: Coordination of sampling sites

Site of Sapling	Latitude	Longitude
ST1	33°:06':20" N	43°:18':59" E
ST2	33°:05':31" N	43°:18':31" E
ST3	33°:05':24" N	43°:18':23" E
ST4	33°:03':08" N	43°:18':02" E
ST5	33°:02':57" N	43°:18':38" E
ST6	33°:02':33" N	43°:17':45" E
ST7	33°:02':23" N	43°:17':58" E
ST8	32°:58':16" N	43°:16':37" E
ST9	32°:58':14" N	43°:16':56" E
ST10	32°:53':16" N	43°:20':35" E

3. Geology of Study Area

The field of study represents a part of quaternary deposits; these deposits was accumulated by floods the main valleys in the studied area.

The local names of these valleys are Wadi Al-Mejara, Wadi Thealba, and Wadi Al-Rodha (Figure 2).

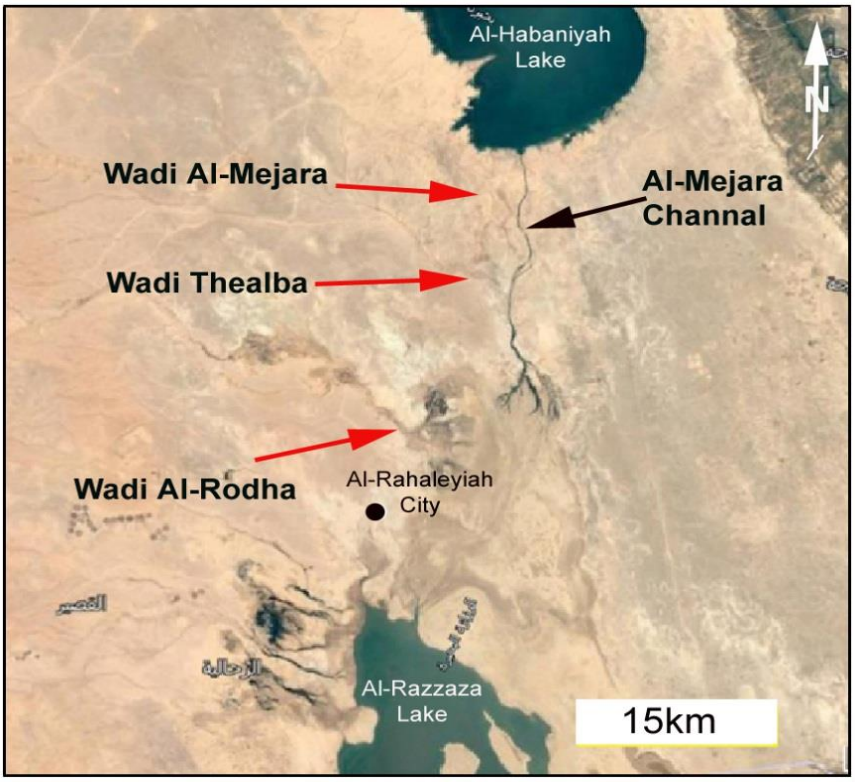

Figure 2: An Aerial photograph of the region under investigation contains the main valleys [2].

The production of the Quaternary sediments that are distributed throughout the study area was greatly aided by these valleys (gravel, sand, and mud), as these valleys had two waves of flooding during the flood seasons, leading to the formation of floodplains. this led to the accumulation of sediments, and the presence of gravel indicates the occurrence of high energy floods (Figures 3 and 4).

Figure 3: The main valleys in the studied area: Wadi Thealba**.**

Figure 4: The main valleys in the studied area, Wadi Al-Rodha.

The study area contains the outcrops of the Injana Formation (late Miocene-Pliocene). Injana formation represents the lower fine-grained molasse sediments deposited at the beginning in marine and progressively in fluvio-lacustrine environments [3]. The lithology of the formation consists predominantly of alternating red, brown and gray marls, siltstone and sandstone with rarely freshwater limestone; seams of gypsum are also present [4].

In the study area, the Injana Formation (late Miocene-Pliocene) is exposed in the form of scattered discoveries and horizontal sequences of the formation. The formation comprises several progressive cycles of sandstone, siltstone, and claystone with a predominant red coloring, The thickness of the exposed rock in the study area ranges from 5 to 12 meters (Figure 5).

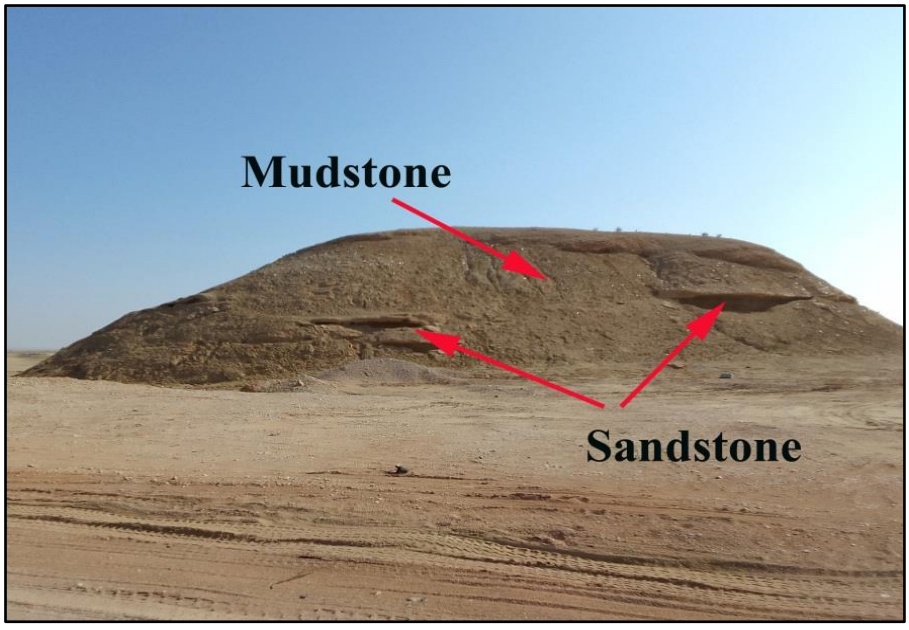

Figure 5: The outcrop of the Injana Formation (late Miocene-Pliocene) in the studied area.

Quaternary sediments were deposited on a major regional unconformity surface following intense deformation along the collision cone between the Arabian and Iranian Plates [5].

There is no evidence of bedding or stratification in the Quaternary layers, composed of Pleistocene and Recent layers. These include alluvium sediments composed of gravel, sand, silt, clay, and conglomerates of Post Pliocene Deposits. [6].

The Quaternary deposits in the area under study consist of gravel, sand, silt, and clay (Figure 6), representing river terraces and floodplain deposits (Figure 7).

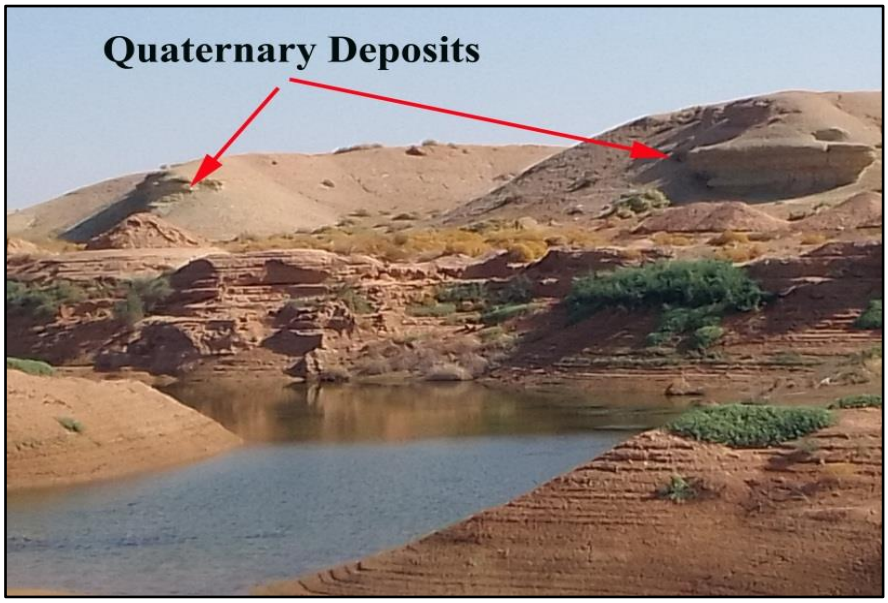

Figure 6: Quaternary deposits in the studied area (gravels, sand, and mud sediment).

Figure 7: Floodplain and river terrace deposits of the studied area deposits

The depositional environment that generated the Quaternary sediments of the study area is the environment of floodplains and river terraces, and these were generated by the torrents that flow through the valleys in the study area.

Tectonically, the area of study is located in the western limb of the Mesopotamian Plane (Figure 8)

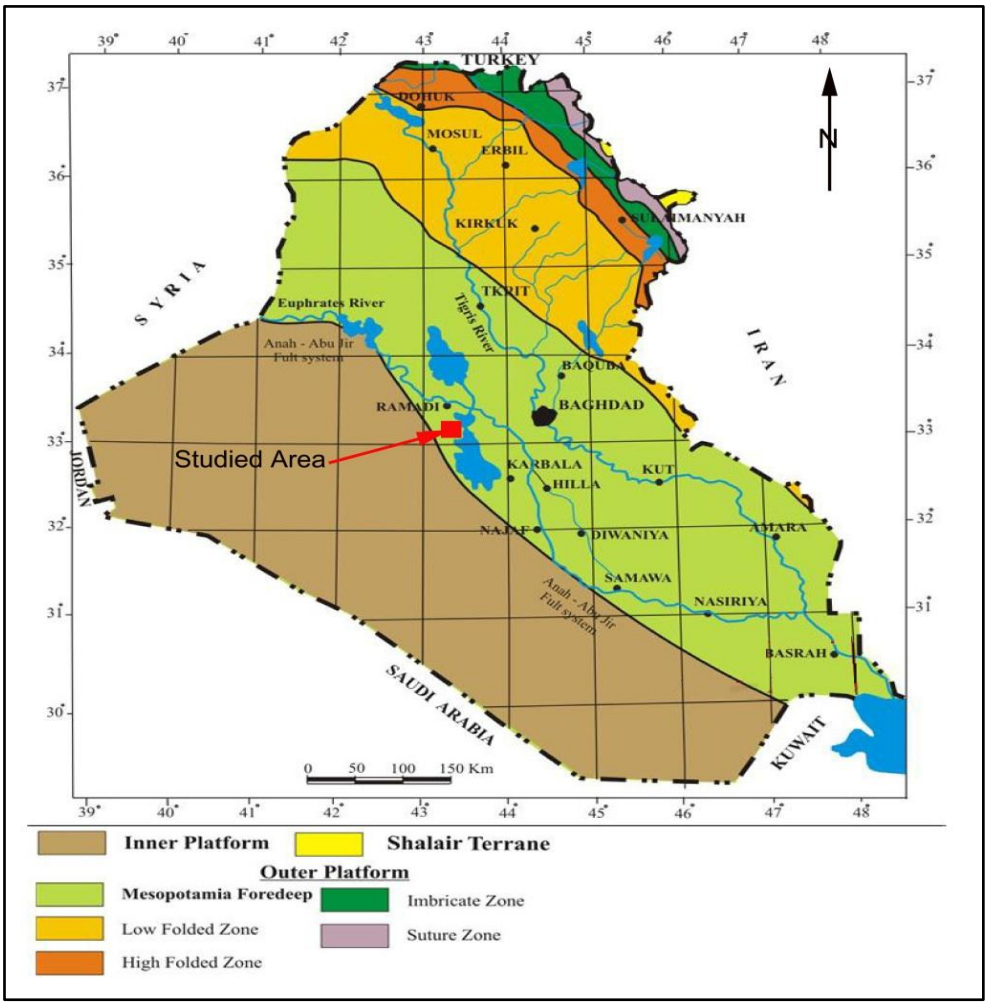

Figure8: Tectonic map of Iraq [7].

4. Methods of Study

Ten spot samples of the mixture of sediments were collected from ten sites (ten quarries) during the fieldwork. The sedimentological analyses in this work include the following tests:

a- Textural characteristics of the gravels after separation using dry sieving using standard sieving. The grain size study of gravels was carried out using a caliper vierner.The shapes of these gravels (roundness and sphericity) and from were done by compareing the gravel sample with the visual chart.

b- The gravel sample' color, hardness, reactivity with hydrochloric acid, and texture were used to define their mineralogical composition visually. A few samples chosen from each group for thin section and petrographic microscope examination in the Petrology and Mineralogy Laboratory in the Department of Geology, College of Science, University of Baghdad.

5. Result and Dissection

5-1Texture Characteristics of Gravels

5-1-1 Grain Size Analysis

The sieve size analysis was used on ten samples of a mixture of sediments (gravel, sand, and mud) to distinguish between gravel, sand, and mud. that were obtained from Al-Rahaliyah quarries. The results of this study are displayed in Table 2.

Table 2: Percentages of gravel, sand, and mud of Al-Rahaliyah quarries.

Samples No.	Percentage of Gravels %	Percentage of Sand	Percentage of Mud %
ST1	75.7	15.8	8.5
ST2	68.5	20.9	10.6
ST3	71.2	16.3	12.5
ST4	72.6	15.7	11.7
ST5	67.1	19.5	14.4
ST6	70.7	21.5	7.8
ST7	73.4	16.4	10.2
ST8	73.6	17.3	9.1
ST9	74.9	14.4	10.7
ST10	66.2	17.5	16.3

The ternary diagram proposed by [8] was used to plot the percentage of gravel, sand, and mud. This sediment categorization provides the textural name of the mixture of sediment or the nomenclature of gravel, sand, and mud mixture. As a result, muddy sandy gravel and sandy gravel make up the most of the average gravel, sand, and mud composition in the sediments of the Al-Rahaliyah quarries (Figure.9).

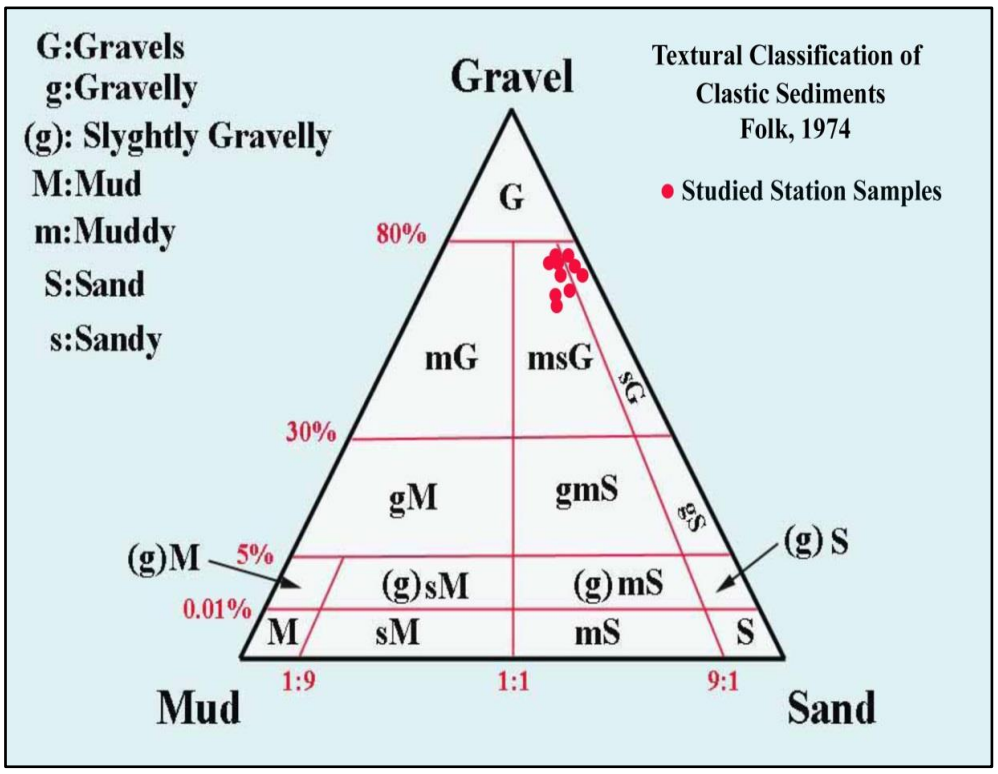

Figure 9: Classification of sediments of Al-Rahaliyah quarries [8]

The study examined the grain size distribution of gravels on undispersed samples obtained from sediment quarries. The total number of gravels from 10 sample stations is 1500 grains from the stations under investigation .The grain size of the gravels was measured along three perpendicular directions using a calliper vernier [9], but it didn't have to come to the same conclusion. [10] represent scale was used to group the data. The findings of the gravel size study are displayed in Table 3.

It is clear from the outcome that the (-4Ø) to (-5Ø) or (16-32mm) represents the highest size distribution among the pebble samples.

Table 3: The size distribution of gravels of Al-Rahaliyah quarries.

No. of Samples	Size Interval (mm)		Size Interval (Ø)	Number of Samples in the Interval	Percentage %
1500	Granules	2 - 4	(-1) – (-2)	185	12.33
	Pebbles	4 - 8	(-2) – (-3)	206	13.73
		8 - 16	(-3) – (-4)	263	17.53
		16 - 32	(-4) – (-5)	516	34.41
		32 - 64	(-5) – (-6)	190	12.66
	Cobbles	64-256	(-6) – (-8)	140	9.34

Through grain size analysis of the studied gravel samples, it was found that the percentage of pebbles was the highest percentage (78.33%), and the lowest percentage was cobbles (9.34%), while the percentage of granules was (12.33%), (Figure 10).

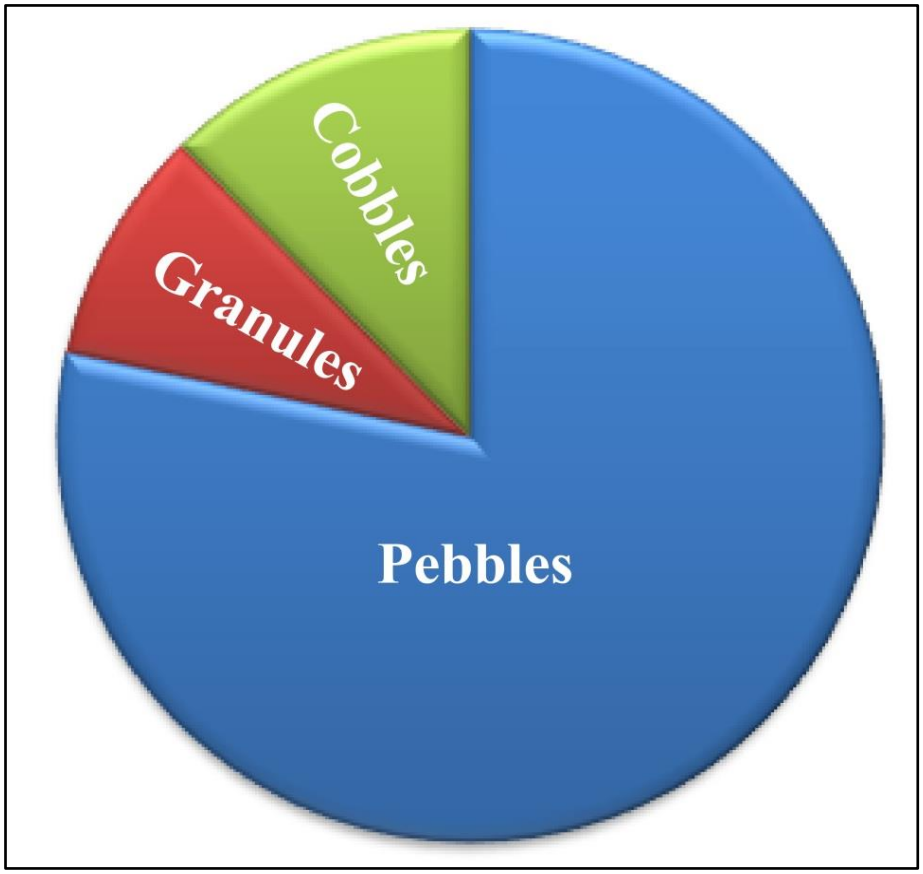

Figure 10: Pie diagram showing the percentage of gravel interval.

5-2 Shape Analysis

This study emphasised is stressed on only three aspects of shape namely form, roundness and sphericity. Methods applied for each type covering the studied size fractions of gravels and sands are show in Table 4.

Table 4: The methods applied for shape analysis for gravels and sand particles where L = longest dimension, I = intermediate dimension, and S = shortest dimension of gravel.

Aspect	Formula	Range	References
Form	L/l S/I	0-1	[11]
Roundness	[∑(nr/n)/Di]	0 to 1	[12]
Roundness	Visual chart	0 to 6	[13]
Spheriscty	Visual chart	-0.5 to 4.5	[13]
Sphericity	$\sqrt[3]{(S^2/LI)}$	0 to 1	[14]

Roundness and Sphericity are calculated in two main ways : A:The equation method, and B: the visual charts method.in the current study, the visual chart method was applied, where gravel samples are compared with the shapes found in the comparison chart suggested by [13], and then the average of roundness and sphericity is determined.

5-2-1 Form

In order to quantify shape, gravel's length, width, and thickness must be measured. There have been several distinct notations employed. The L, I, and S denoting long, Intermediate and short are attributed to[11] and will be followed in this study, Although they do not have to intersect at a single place, the majority of experts concur that the three dimensions should be orthogonal (perpendicular) to one another [9]; [15]. The L, I, and S dimensions can be measured in various ways, with particle size somewhat limiting the options.

Zingg's diagram [11] was used in this study to be inadequate in that it contained four classes, which divided the field of form variation very unequally. The data obtained from the measurement of Al-Rahaliyah Quarries Gravels are plotted (Figure 11).

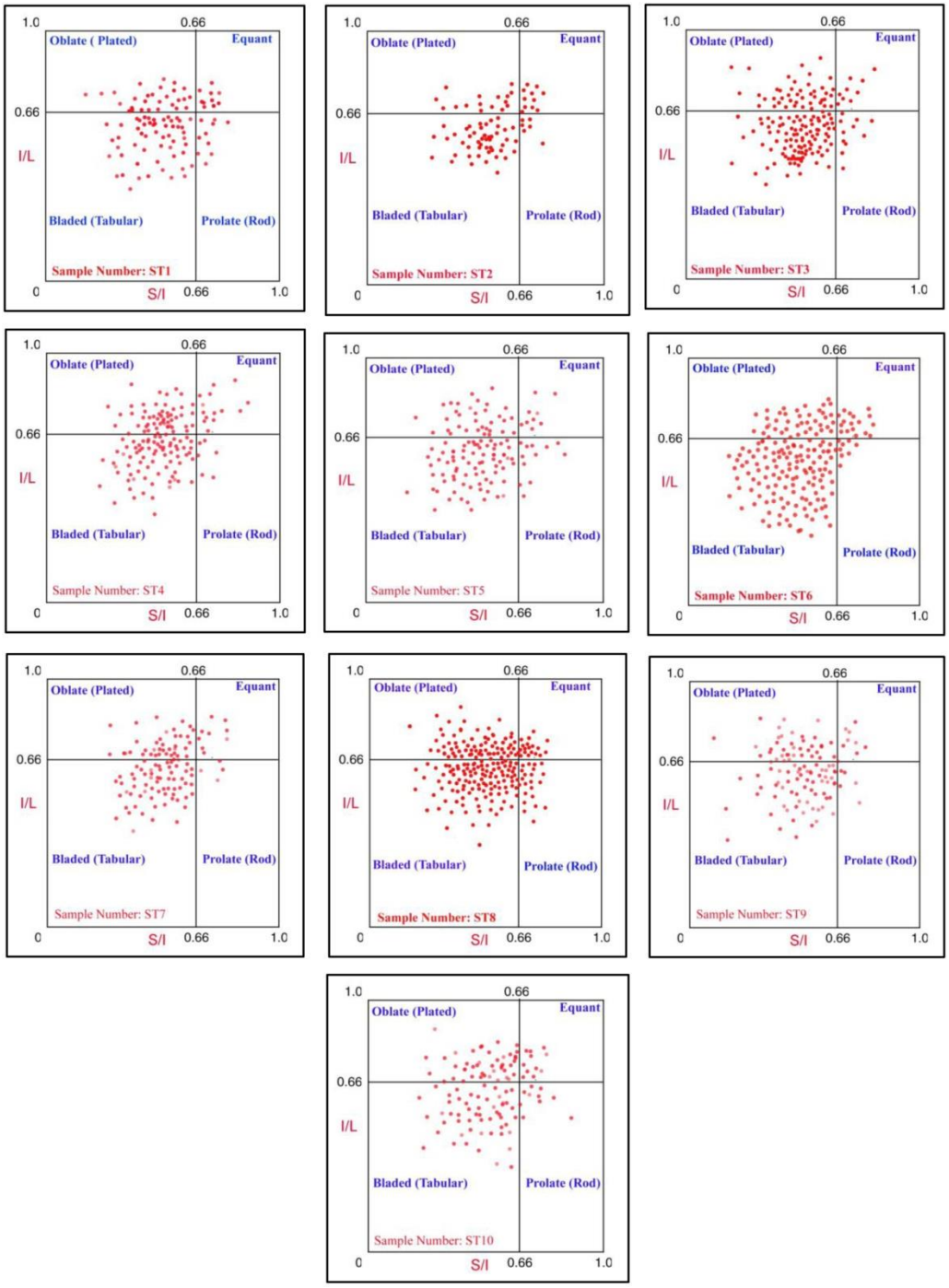

Figure 11: Projection of Al-Rahaliyah Quarries gravels on the form diagram[11].

The Zingg classification contains four morphological classes, and it was found that the largest percentage of samples was suppressed within the bladed field, followed by the second percentage that was located within the plated field, and a small amount was located within the spherical and rod field (Figure 12).

The main reason for this result is that carbonate sedimentary rocks are deposited in horizontal layers. When separated by weathering and transport, they acquire this type of shape.

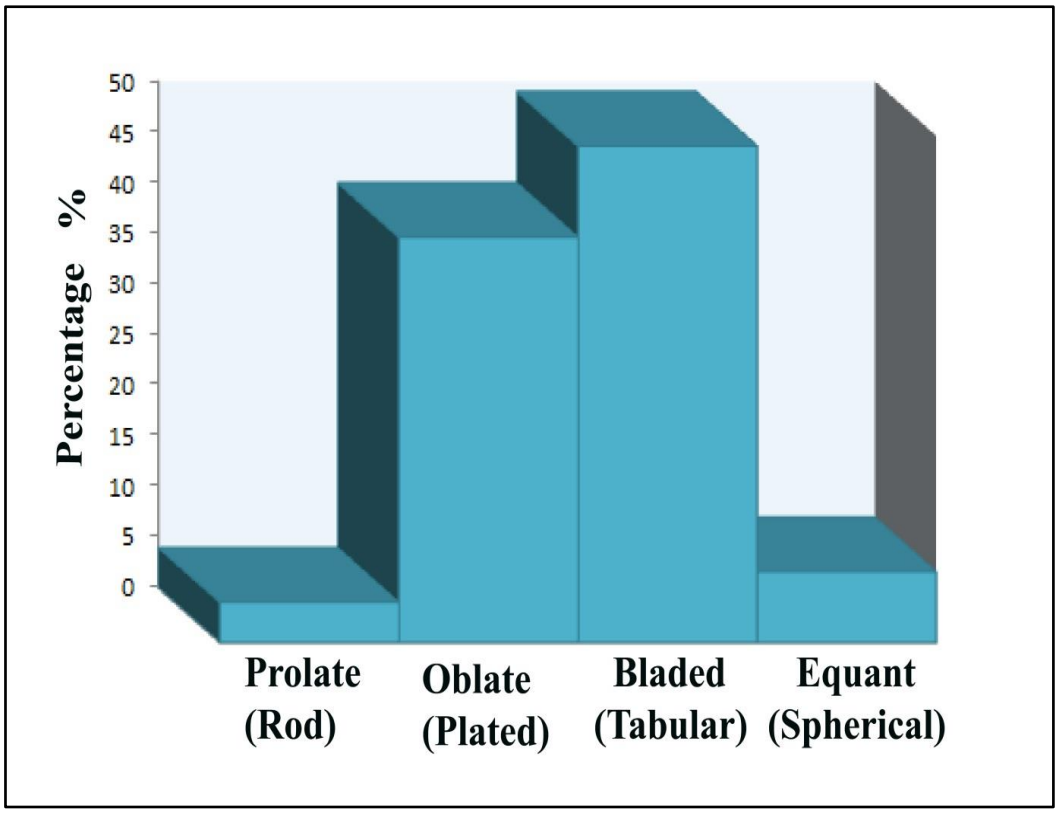

Figure 12: Bar chart showing the percentages of shape classes of Al-Rahailyah gravel quarries.

The greatest samples fall within the bladed and plated zones; this may be explained in terms of lithology, as carbonates make up the main percentage. Such gravels result from a short transportation distance of parent carbonates due its low hardness and the effect of bedding planes in parent carbonate sedimentary rocks.

5-2-2 Roundness

The gravel samples were compared with the visual degree of roundness in the power visual digram using a visual comparison of [13], presented in figure 13, and the roundness results are listed in Table 5 and presented in Figure 14.

5-2-3 Sphericity

The sphericity of the gravel samples was determined by comparing observed grain profiles with a visual comparator method stated by [13] (Figure 13). The results of sphericity are listed in Table 6 and presented in Figure 14.

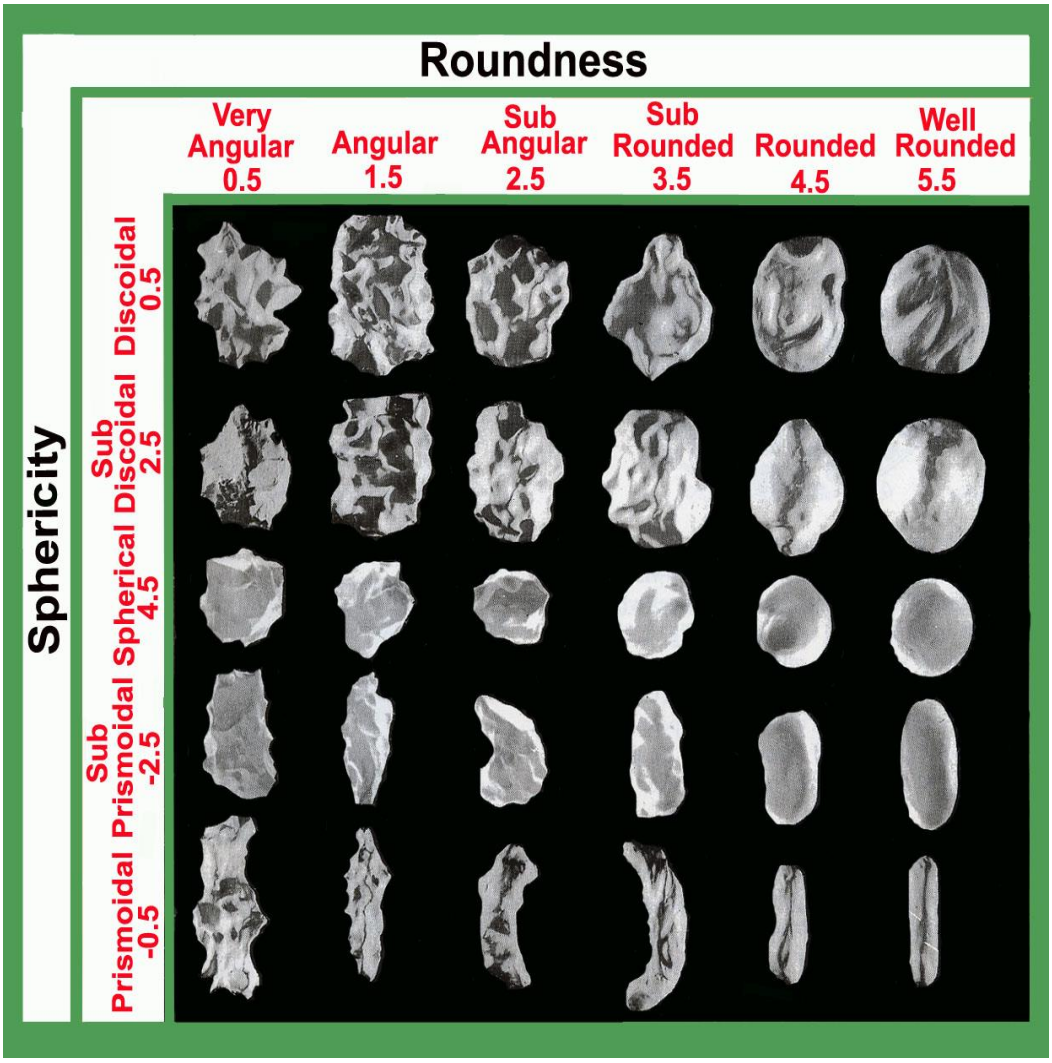

Figure 13: Visual chart of roundness and sphericity [13].

Table 5: The percentage of roundness values for studied gravel samples [13].

	Very Angular	Angular	Sub Angular	Sub Rounded	Rounded	Well Rounded
Number of Samples	15	20	36	650	680	99
Percentages %	1.00	1.33	2.4	43.33	45.33	6.61

Table 6: The percentage of sphericity values for studied gravel samples [13].

	Prismoidal	Sub Prismoidal	Spherical	Sub Discoidal	Discoidal
Number of Samples	17	25	183	652	623
Percentages %	1.13	1.67	12.2	43.47	41.53

As a result, the total average roundness value of Al-Rahaliyah Quarries gravels shows a relatively low average roundness equal to (4.2) after stated by [13], while the total average sphericity value equal (2.3%) for all studied gravel samples.

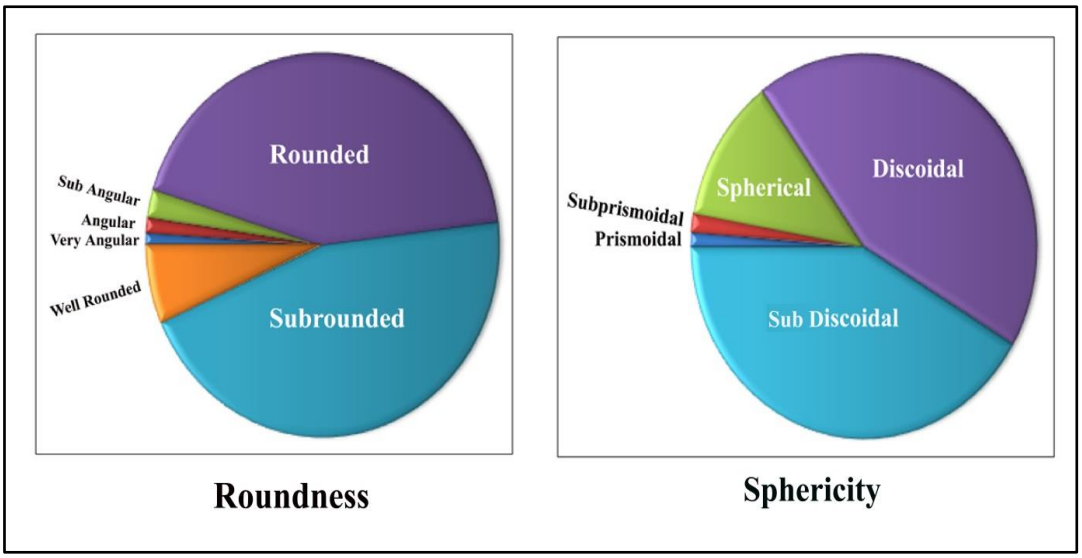

Figure 14: Pie diagrams showing the percentages of roundness and sphericity of studied gravel samples of Al-Rahaliyah quarries.

5-3 Gravels' Petrography

Ten thin sections of the gravel from the Al-Rahaliyah quarries were petrographically examined. A visual description and grouping of the mineral content of 1500 gravels from the ten sites was done based on texture, color, hardness, and reactivity with diluted hydrochloric acid (Figure 15), few samples were selected for thin section and petrographic microscope examination from each group. All of the examined samples' lithology's were mostly carbonate (Figure 16). A variety of carbonate sedimentary rock types were identified, including peloidal packstone, dolomitic limestone, lithoclastic mudstone, and fossiliferous packstone.

Figure 15: Samples of gravels of Al-Rahaliyah quarries.

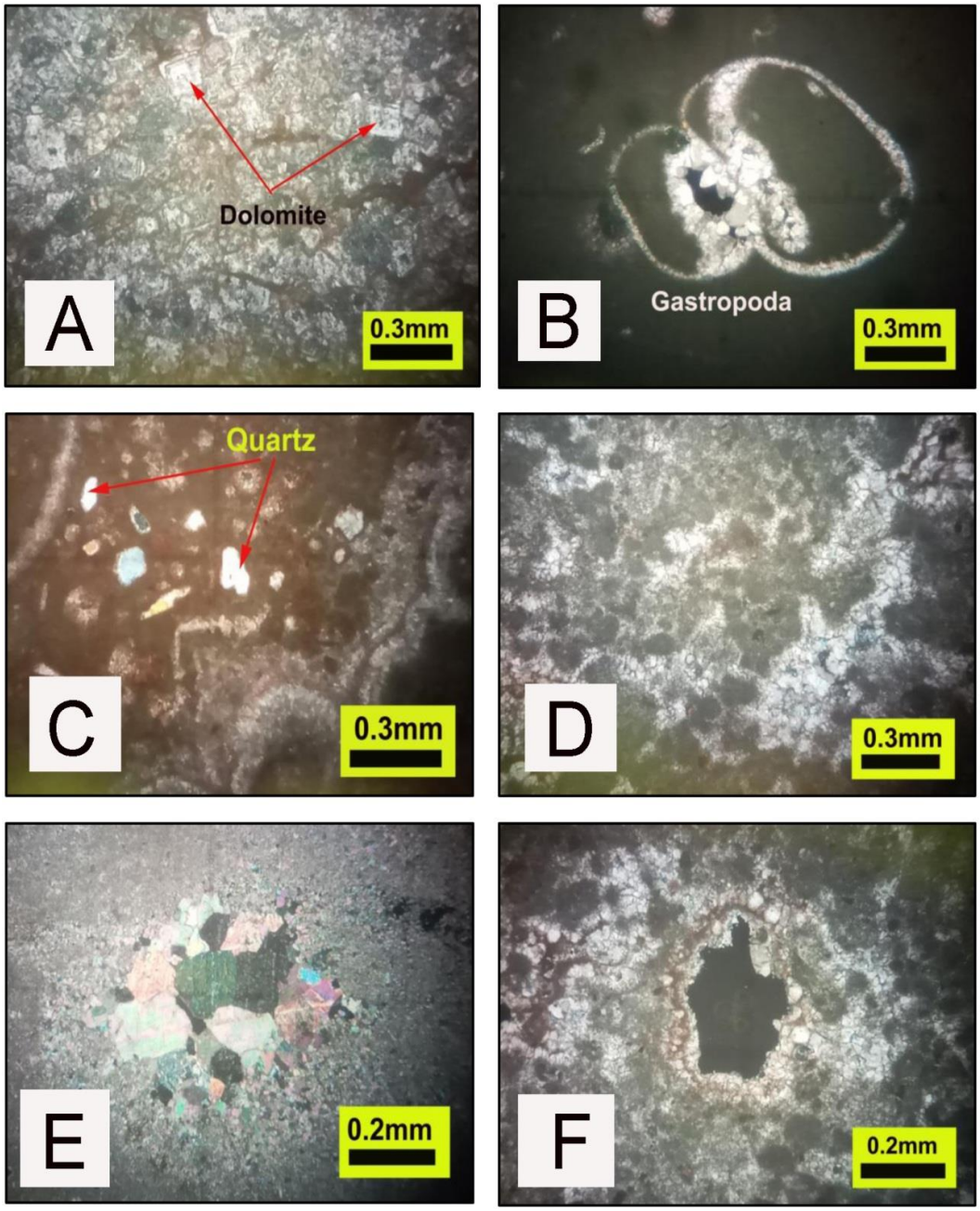

Figure 16: Photomicrograph of studied gravel samples in which: A: Dolomitic Limestone, B: Fossiliferous packstone, C: Lithoclastic mudstone, D: Peloidal packstone, E: Mudstone with recrystallization diagenesis, F: Fossiliferoui peloidal packstone with dissolution diagenesis.

By comparing the results of the lithology of the gravel of the Al-Rahaliyah quarries with some previous studies that were conducted on the formations located west and south west of the studied area, the current study shows that there is a good match between the lithology of the gravel of the Al-Rakaliyah quarries and the lithology of the Euphrates, Dammam, Anah, and Nfayil formations [16], [17], [18] and [19].

6. Conclusions

a- The Al-Rahaliyah gavel classified as muddy sandy gravel and sandy gravel.
b- The pebble fraction (4-64mm) represents the main size fraction in Al-Rahaliyah quarries gravel.

c- The form of Al-Rahaliyah quarries gravel is bladed and plated due to the bedding plane of the parent carbonate sedimentary rocks, short transportation distance , and low hardness.
d- The average roundness degree of Al-Rahaliyah quarry gravels equals 4.2 (rounded), the high roundness ualue is due to carbonate lithology's low hardness.
e- The average sphericity degree of Al-Rahaliyah quarry gravels is equal to 2.3 (sub discoidal), the low value of sphericity due to the effect of bedding planes, Which distinguishes carbonate sedimentary rocks and the short transportation distance.
f- The composition of Al-Rahaliyah Quarries Gravel is mainly carbonate, including fossiliferous packstone, dolomitic limestone, crystalline limestone, and peloidal packstone.
g- The gravel has a suitable property for building materials, having a composition that closely matches that of the Iraqi Quality Standard for concrete gravels.
h- The Al-Rahaliyah Quarries' source rocks Since the Euphrates and Dammam Formations' outcrops are situated west of the study region and are carried through its valleys, gravels served as a representation of the older Tertiary (late Miocene–Pliocene) formations.

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