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Mineralogical study of Sand Dunes Fields in Najaf Governorate, Southern Iraq

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Abstract

The purpose of the present paper is to define the minerals content in the Najaf Dunes fields and the origin of these sand sediments in the southwestern parts of Iraq. There are three types of dunes in this field were described, the barchan, longitudinal, and dome dunes and additional types e.g. Nabkha, Barchanoid ridges, and sand sheet dunes. The study area was divided into three areas according to the geographical position, and numerous samples were collected from this field.

The mineralogical study consists from three methods these are; the first: separation of sand samples into the light and heavy minerals by heavy liquids,where performed on 30 samples. The second method; carbonate content performed on 60 samples, and the third method; X-ray diffraction performed on 20 samples.

The light minerals contents composed from quartz, feldspar, and rock fragments, the rock fragments composed mainly of sedimentary, igneous, and metamorphic rock fragments. The heavy minerals are mostly composed from opaques minerals, chlorite group, garnet group, zircon, pyroxenes, amphiboles, epidotes, biotite, muscovite, tourmaline, kyanite, staurolite, rutile,and celestite.

The heavy minerals analyses of all dunes, in three areas, show to the many source areas, these recent sediments and nearby older Sedimentary formations around the study areas, especially Dibidbba formation were the great influence from other geological formations. While the high percentages of carbonate content was obtained due to the presence of neighboring formations, which consists of limestone rocks (e.g. Dammam, Euphrates and Nfayil). And the present study shows a clear relation between the carbonate percentages and the grain size, as they increase with finer sizes.

Keywords: Mineralogy, Sand Dunes, Heavy minerals.

دراسة معدنية لحقل الكثبان الرملية في محافظة النجف , جنوب العراق

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الخلاصة

الغرض من الدراسة الحالية هو تحديد المحتوى المعدني لحقول الكثبان الرملية في النجف , وكذلك اصل هذه الرواسب المتواجدة في الجنوب الغربي من العراق. توجد ثلاثة انواع من الكثبان في هذا الحقل وتوصف بالكثبان الهلالية والكثبان الطولية وكثبان القبة, بالاضافة الى انواع اخرى مثل كثبان النبخة وكثبان الحواجز المتفرعة وكثبان الصفائح الرملية .منطقة الدراسة قسمت الى ثلاث مناطق حسب الموقع الجغرافي لها وجمع العينات المتعددة من هذا الحقل .

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الدراسة المعدنية تتألف من ثلاثة طرق الاولى : فصل معادن الرمل الى المعادن الخفيفة والمعادن الثقيلة بواسطة السائل الثقيل , حيث تم فصل 30 عينة , الطريقة الثانية : تم تحديد محتوى الكاربونات في 60 عينة , الطريقة الثالثة: تمت بواسطة فحص حيود الاشعة السينية حيث تم تحليل 20 عينة.

المعادن الخفيفة تتألف من الكوارتز والفلدسبار والقطع الصخرية وهذه القطع الصخرية تتكون اساسا من قطع لصخور رسوبية ونارية ومتحولة .اما المعادن الثقيلة تتألف غالبا من المعادن المعتمة ومجموعة الكلورايت ومجموعة الكارنت والزركون والبايروكسين والامفيبول والابيدوت والبايوتايت والمسكوفايت والتورمالين والكاينايت والاسترولايت والروتايل والسليستايت .

يوضح تحليل المعادن الثقيلة لكل الكثبان في المناطق الثلاث بأن هناك عدة مناطق لمصادر الرسوبيات ومنها الرواسب الحديثة والتكاوين الرسوبية القديمة التي تقع حول منطقة الدراسة , خصوصاً تكوين الدبدبة ذو التأثير الكبير عليها مقارنةً مع التكاوين الجيولوجية الاخرى,بينما النسب العالية من محتوى الكاربونات حصل بسبب تواجد التكاوين المجاورة التي تتكون من صخور جيرية وهي تكاوين(الدمام والفرات والنفايل) , و الدراسة تبيَن ان هناك علاقة واضحة بين نسب الكاربونات مع الحجم الحبيبي, بحيث تزداد النسب مع الاحجام الانعم .

1. Introduction

Aeolian sand deposits are distributed in different parts of Iraq [1]. The Najaf dunes field sited in the west and southwest from Najaf city, these filed dunes extend in a prevailing wind NW-SE orientation. The dunes field consists of many morphological types of dunes, these are; the Barchan, Barnchoid, dome, Longitudinal, Nabkha, and Sand sheet dunes. The commonplace characteristics for all dunes, in all international climates, are that their formation suggests a considerable deliver of sand-sized sediment, strong sand-shifting winds and conditions favoring sedimentation of the sand [2].

The mineralogical of detrital deposits existing in sand or sandstone tool up a significant guide about its origin, including the lithology of source rocks and transportation record [3]. Aeolian sands are the combination of various minerals and several types of rock fragments, unconsolidated sediments incoming from naturally disaggregated result of erosion, transportation and deposition of the clastic of weathering from the sandy rock parent material by the wind in the arid areas [4- 6].

The concurrence of mineralogical characteristics of sand dunes has been performed to indicate the sand source of dunes, attributive of their properties, stabilizing the dunes, a study of sand dunes movement and their economical prominence [7] and [8].

The minerals divided into two types according density or specific gravity these are; the Heavy minerals and light minerals, where the heavy minerals have higher density light minerals, thus in practical examined, only those minerals that are heavier than the dense media most usually used in the laboratory bromoform (2.89 g/cm3) or tetrabromomethane (2.94 g/cm3), i.e. that sink in these media. In contrast, the lower density than heavy minerals,are floating in bromoform media these minerals called light minerals , e.g. Quartz, Feldspars, calcite, dolomite, aragonite, and evaporites [9] .

The heavy mineral analysis is one of the most susceptible and vastly used techniques in the placement of sand and sandstone provenance. The heavy mineral accumulation is not only controlled by the mineralogical composition of the source area but is also modified by sundry other operation that operates during the sedimentation cycle [10].

2.Geographical Location of studies areas:

The study area is located in the western and south-western parts of Najaf city center. The study area is divided into three localities according to the presence of sand dunes. The first area is located near the village of Al-Rahimiya (A), the second area south of Ain Mazlum(B), and the third area located in the northeast of Khan Rahba (C), Table-1, Figure-1.

Table 1-Geographical Location of studies areas

Study area	points	Latitude	Longitude
Area(A)	1	32º01′40″ N	44º03′53″ E
	2	32º02′15″ N	44º05′27″ E
	3	31º57′21″ N	44º09′50″ E
	4	31º56′42″ N	44º08′02″ E
Area(B)	1	31º53′41″ N	44º14′48″ E
	2	31º54′19″ N	44º16′00″ E
	3	31º50′36″ N	44º18′49″ E
	4	31º49′47″ N	44º17′33″ E
Area(C)	1	31º50′43″N	44º19′07″E
	2	31º51′13″N	44º19′59″E
	3	31º48′57″N	44º22′02″E
	4	31º48′23″N	44º21′06″E

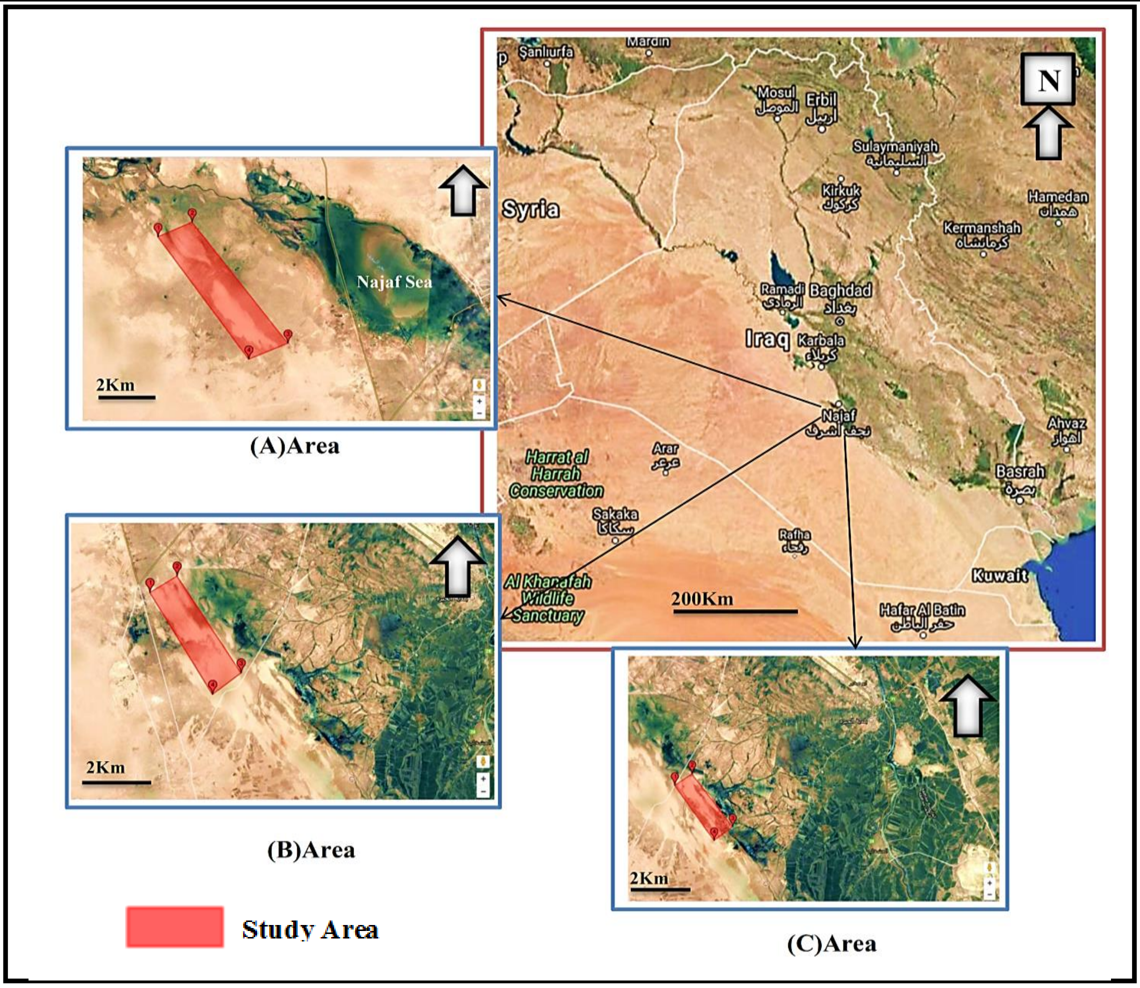


Figure 1-Satellite image of Iraq Shows the Study area (Earth Explorer).

3.Geology of study area:

The study area includes Quaternary deposits particularly of the Pleistocene and latest Holocene deposits that include: Valley fills flood Plain, marsh and aeolian sediments. aeolian sediments distributed in many places in study area. And Startgraphically, the denudation processes have exposed a sequence of marine and continental sediments, which range in age from Paleocene to Pleistocene. The exposed formations in Al-Najaf area in upward sequence are: Umm Er Radhuma Formation (Mid

Paleocene-Early Eocene), Dammam Formation (Middle-Late Eocene), Euphrates Formation (Lower - Middle Miocene), Nfayil Formation (Middle Miocene), Injana Formation (Upper Miocene), Zahra Formation (Upper Miocene-Pliocene) ,and Dibdibba Formation (Pliocene-Pleistocene)[11].

4. Aim of Study:

The aim of the study is to determine the Mineralogical composition in the Najaf dunes field and the origin of these sand sediments.

5. Methodology:

Many Field work were conducted; in the latter (Geographical Position System) (GPS) was used to indicate the exact points. Thirty sieved samples from two mixed sizes of fine and very fine sand (3 Phi, 4 Phi) were used for the heavy minerals separation using Bromoform (S.G. 2.89) [12- 15]. For mineralogical identification, each sample of the light and heavy fraction was mounted on glass slides using Canada Balsam. The petrographic microscope was used for identification of these minerals.

60 samples were treated by (10 % HCL) to find total carbonate content of bulk sample, and twenty two sieved samples of Coarse, Medium, Fine, and very Fine sand fraction (1phi, 2phi, 3phi, and 4 phi) were analyzed to determine the relationship between grain size and the carbonate content percentages following the procedure of [16]. And the XRD analysis was applied on twenty selected samples representing the three parts of study areas as a bulk sample from dune.

6. Result and Discussion:

Many types of minerals indicted in sand dunes are discussed below:

6.1. Light Components

The light mineral fraction of Najaf dunes samples comprises more than (98.5%) in weight of the total mineralogy , with main contents of quartz, rock fragments ,and feldspars minerals, the results of this analysis are summarized in Table-2 and Figure-2.

Table 2-Ranges and average of light components in dunes sand of studies areas (A), (B), and(C)

Light Components			Area(A)		Area(B)		Area(C)	
			Range	Average	Range	Average	Range	Average
Quartz	Monocrystalline Quartz		31.5-36.5	33.38	31.8-37.6	35.74	31-39.7	35.27
	Polycrystalline Quartz		2.1-4.6	3.56	2.1-5	3.81	2.8-5.2	4.14
Feldspar	Alkali Feldspar	Orthoclase	2.2-3.9	3.19	2.2-3.9	2.97	2.1-3.7	2.85
		Microcline	1.4-3.2	2.06	1.4-2.7	1.88	1.6-2.8	2.02
	Plagioclase Feldspar		3.4-4.9	4.22	3.1-4.9	3.98	3-4.9	3.97
Rock Fragments	Carbonate R. Fragments		18.8-24.3	21.43	17.6-23.8	21.08	18.4-23.8	21.92
	Chert R. Fragments		6.8-11.4	8.66	7.3-11.7	8.91	6.8-11.6	9.36
	Igneous R. Fragments		2.1-5.8	3.74	2.4-5.7	4.03	2.1-5.8	4.32
	Metamorphic R. F.		1.8-4.8	3.1	1.2-3.6	2.6	1.2-3.5	2.37
	Mudstone R. Fragments		1.6-3.9	3.29	2.8-3.8	3.14	1.5-3.5	2.46
	Evaporates		2.1-7.5	4.81	2.3-7.8	4.58	2-6.5	4.33
	Coated Grains By Clay		1.1-3.9	2.35	1-3.5	2.04	1.3-2.9	2.11
	Light Muscovite		2.4-5.9	4.30	2.5-3.9	3.31	2.5-4.9	3.49
	Others		1.4-2.4	1.80	1.1-2.6	1.93	1.1-1.8	1.49

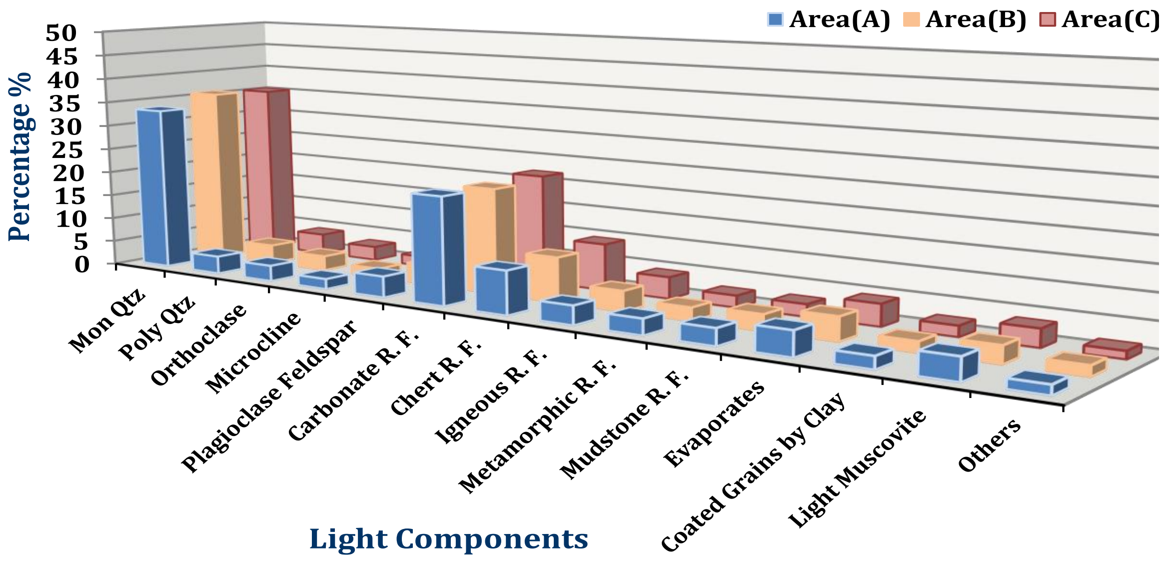


Figure 2-Bar chart showing the percentages averages of light components in studies areas (A), (B), and(C).

1) Quartz: Two types of quartz were recognized, monocrystalline and polycrystalline quartz.

A) Monocrystalline Quartz: The monocrystalline quartz grains (unitary quartz) are defined as those grains which consist of a single crystal [17]. Monocrystalline quartz represent the major quartz type that observed in all samples, the highest percentage of monocrystalline quartz was observed in (B) area has ranging between 31.8% - 37.6%, and the lowest percentage was observed in (A) area has ranging between 31.5% -36.5%, while in area(C) ranging between 31% - 39.7% Table-2.These grains show dominant straight extinction, Monocrystalline grains are angular and subrounded (Figure-3, No.1& 2).

B) Polycrystalline Quartz: The polycrystalline quartz grain (composite quartz) is that which consist of two or more quartz crystal units of different optical orientation [17], the probable source of polycrystalline quartz is metamorphic rocks such as schist, gneiss, metaquartzite, and plutonic igneous rocks [18- 20]. The highest average percentage of polycrystalline quartz was observed in area(C), and the lowest average percentage of polycrystalline quartz was observed in (A) and (B) areas has (3.56%) and (3.81%) respectively Table-2. The polycrystalline quartz in the studied dune fields is generally fine sized, subrounded in shape with slightly undulose extinction (Figure-3, No.3).

2) Feldspar:

A) Alkali Feldspar: The highest percentage of alkali feldspar (Orthoclase) was observed in (A) area ranging between 2.2% - 3.9%, and the lowest percentage observed in (C) area ranging between 2.1% - 3.7%.The Orthoclase grains observed as sub angular and sub rounded, with degrees of alteration (Figure-3,No.4). The second alkali feldspar (Microcline) in area (A) have the highest average 2.06% ,where the lowest average in area(B) have 1.88% . Grains show a cross hatching twinning, and observed as subrounded, with degrees of alteration (Figure-3, No.5). Such occurrence also suggests semi-arid paleoclimate conditions or high relief source area that has undergone rapid erosion [4].

B) Plagioclase Feldspar: Plagioclase feldspar represents the second group of feldspars that are observed in the studied samples. The highest average percentage of plagioclase was observed in area (A) 4.22% with ranging between 3.4% - 4.9%, and the lowest percentage shown in area(C) ranging between 3% -4.9% Tables-2. Plagioclase in studied samples observed as angular, subangularSome grains of plagioclase are fresh but others are altered and subdural grains (Figure-3, No. 6).The fresh feldspars may indicate a fragmentation process from igneous rocks, accompanied by a short distance of transportation [21].

3) Carbonate Rock Fragments: a Carbonate rock fragment was common in clastic sedimentary rocks and clastic sediment in Iraq due to the widespread outcrops of these rocks in many areas of Iraq. These rock fragments represent special conditions of rapid mechanical erosion rather than chemical dissolution [22]. Carbonate rock fragments were observed in all studied dune samples, the highest percentage of these grains observed in (A)area ranging between 18.8% - 24.3%, and the lowest percentages observed in area(B) ranging between 17.6% - 23.8%, while the intermediate percentages observed in (C)area ranging between 18.4% - 23.8% Table-2 and Figure-2. The identified carbonate rock fragments include several varieties which are either remanents of old formations, such as limestone subangular fragment and aragonite, shell fragment ,or fossil fragments from nearly formation carbonate these are usually sub rounded to sub angular in shape (Figure-3,No.7 , 8 ,and 9).

4) Chert Rock Fragments: The highest average percentage of chert rock fragment was observed in area(C) 9.36%, and the lowest average percentage was observed in area (A) 8.66%, while the intermediate average percentages was observed in area(B) 8.91% . The types of chert rock fragments that were identified in the studied dune samples are subrounded macrocrystalline, and microcrystalline chert rock fragments (Figure-3, No.11&12).

5) Igneous Rock Fragments: The highest percentages of igneous rock fragments was observed in area(C)4.32% and the lowest percentages was observed in area(A) 3.74%, while the intermediate percentages was observed in area(B) 4.03%. The grains of igneous rock fragments are mainly plutonic igneous rocks such as granite (Figure-3, No.12), the grains are angular to sub rounded in shape, some grains are fresh and others are altered.

6)Metamorphic Rock Fragments: The highest percentages of these grains was observed in area(A) ranging between 1.8% - 4.8%, and the lowest percentages was observed in area(C) ranging between 1.2% - 3.5%, while the intermediate percentages was observed in area(B) ranging between 1.2% - 3.6% Table-2. The metamorphic rock fragments include mainly schists. Some grains are fresh, others are altered. The shapes of these grains are subrounded (Figure-3, No.13).

7) Mudstone Rock Fragments: The highest average percentage of mudstone rock fragment was observed in area(A) 3.29% with ranging between1.6%-3.9%, and the lowest average percentage was observed in area(C) 2.46%with ranging between 1.5%-3.5%, while the intermediate average percentages was observed in area(B) 3.14%with ranging between 2.8%-3.8% . The mudstone rock fragments that were identified in the studied dune samples are subrounded and rounded grains (Figure-3, No.14). May be these grains from the old formation consist from mudstone (e.g. Injana formation).

8) Evaporites: Evaporite minerals were observed in the studied samples with the highest percentage of evaporites with an average 4.81% in area (A)with ranging 2.1%-7.5%, while the lowest average percentage in area(C) 4.33% with ranging between 2%-6.5% . Mineralogically evaporite minerals composed mainly of (Secondary gypsum) and (anhydrite). Evaporite minerals observed as sub rounded (Figure-3, No.15 &16).

The high percentage of Secondary gypsum in Najaf dune field may be caused by the presence of high gypecret soil nearly area and presence in outcrop formation. Due to the aridity of the area, the water will cause the precipitation of the evaporite minerals (e.g. secondary gypsum) which occupy the roots net of the nearby plants.

9) Coated Grains by Clay: The highest average percentage of coated grains was observed in area(A) 2.35% with ranging between1.1%-3.9%, and the lowest average percentage was observed in area(B) 2.04%with ranging between 1%-3.5%, while the intermediate average percentages was observed in area(C) 2.11%with ranging between 1.3%-2.9% . The coated grains by clay are subrounded and rounded grains (Figure-3, No.17).

10) Light Muscovite: Muscovite is the most common mineral of the mica family have 2.8-2.9 specific gravity [23- 25], light muscovite has less than specific gravity at heavy liquid (bromoform) (2.89). The highest average percentage of coated grains was observed in area(A) 4.30% with ranging between2.4%-5.9%, and the lowest average percentage was observed in area(B) 3.31%with ranging between 2.5%-3.9%, while the intermediate average percentages was observed in area(C) 3.49%with ranging between 2.5%-4.9% . Light Muscovite is colorless, basal flakes, with angular shape. Most of the observed muscovite grains are clear and fresh with some inclusions (Figure-3, No.18).

11) Other: This unidentified group includes the grains that were difficult or cannot be identified by the microscope high alteration.

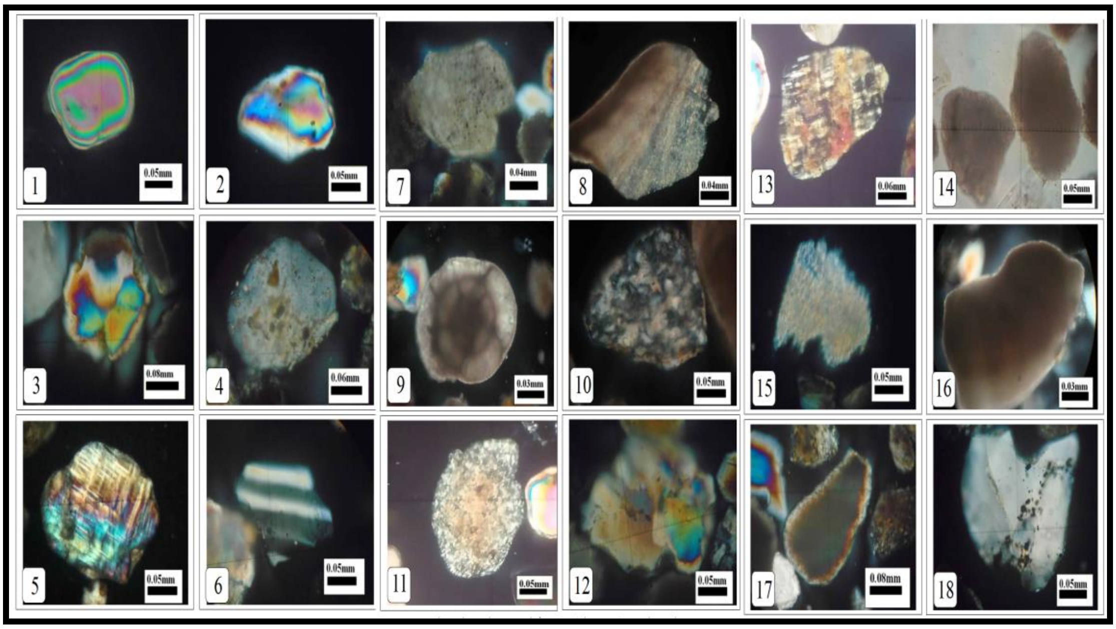


Figure 3-Light minerals component where the No.1) Rounded Monocrystalline Quartz, 2) Angular Monocrystalline Quartz, 3) Subrounded Polycrystalline Quartz, 4) Alkali Feldspar (Orthoclase) , 5)Alkali Feldspar(Microcline), 6)Angular,Polysynthetic Twined Fresh Plagioclase Feldspar, 7) Carbonate Rock Fragment (Limestone), 8) Aragonite Shell Fragment, 9) Carbonate Rock Fragment (Fossil Grain),10) Macrocrystalline Chert Rock Fragment, 11) Microcrystalline Chert Rock Fragment, 12) Igneous Rock Fragment (Granite), 13) Metamorphic rock fragment (schist), 14) Mudstone rock fragment, 15) Evaporites grain (Anhydrite), 16) Evaporite Grain (Secondary Gypsum), 17) Coated Grain By Clay, 18) Flaky Form Light Muscovite

6. 2- Heavy Minerals:

The heavy minerals of thirty samples collected from three localities in Najaf dune fields were determined in order to use them as an indicator for the source rocks and the nature of the source area. The heavy mineral fraction of sand dunes samples comprises more than (1.2%) in weight of the total mineralogy. The results are presented in Table-3 and Figure-4, these results including the average and ranges of percentages of each heavy mineral.

Heavy Minerals	Area(A)		Area(B)		Area(C)	
	Range	Average	Range	Average	Range	Average
Opaque	34.5-43.2	38.21	33-43.4	38.11	34.2-41.7	37.8
Chlorite Group	6.2-9.4	7.61	6.1-8.5	7.21	6.2-9.1	7.66
Garnet Group	3.3-7.6	5.48	3.3-7.7	5.44	4.3-7.8	5.44
Zircon	3.6-8.4	6.07	4.5-7.6	6.16	5.2-7.5	6.36
Ortho Pyroxene	2.2-3.9	2.99	2.3-3.7	3.14	2.3-3.8	3.08
Clino Pyroxene	2.8-4.9	3.7	2.5-4.7	3.67	2.7-4.3	3.52
Amphibole	3.1-6.4	4.65	3.3-6.2	4.82	3.4-6	4.48
Epidote	4.4-7	5.91	4.2-6.4	5.58	4.4-6.4	5.76
Biotite	4.3-6.1	5.22	4.4-6.7	5.21	4.8-6.5	5.49
Muscovite	4-5.6	4.95	4.3-6.6	5.46	3.1-6.6	5.2
Tourmaline	4.2-6.2	5.1	4.3-6.4	5.44	4.4-6.4	5.6
Staurolite	0.6-2.3	1.66	1.2-2.4	1.78	1.1-2.4	2.01
Kyanite	1.3-2.6	2.19	1.1-2.5	2.27	1.1-2.9	2.33
Rutile	1.3-3.6	2.32	1.2-3.7	2.72	1-4.2	2.64
Celestite	1.2-4.6	2.63	0.6-4.3	2.15	0.5-2.5	1.3
Others	0.5-2.3	1.46	0.6-2.2	1.37	0.8-2.2	1.59

Table 3- Ranges and averages of Heavy Minerals in Studies areas (A), (B), and(C)

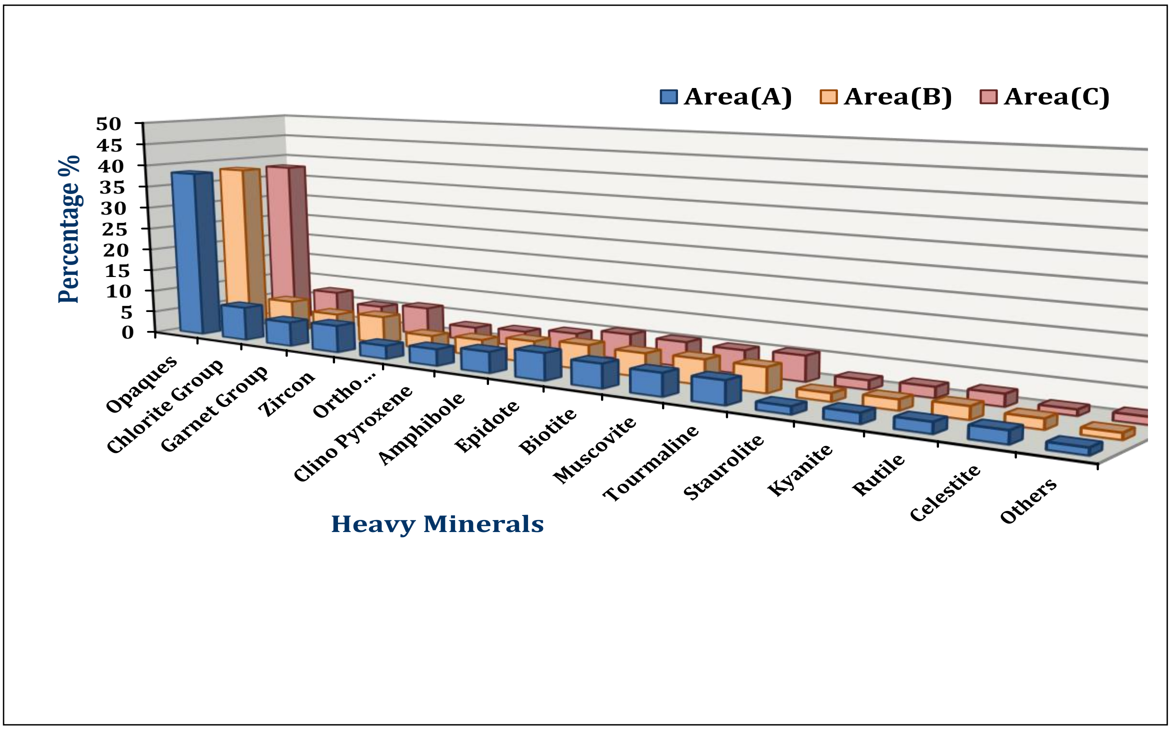


Figure 4-Bar chart showing the percentages average of the Heavy Minerals in studies areas (A), (B), and(C).

1) Opaques: The opaque minerals have the highest percentages of the heavy minerals in all studied dune samples, the highest percentages was observed in area (A) ranging between 34.5% - 43.21% and lowest percentages in area(C) ranging between 34.2% -41.7% .while the area (B) has ranging between 33%-43.4% Table-3. Opaque minerals are black, dark brown, and variable in shape from euhedral to an anhedral, and sub rounded (Figure-5, No.1)
2)Chlorite Group: Chlorites have the second highest percentages of heavy minerals. Chlorites observed in all studied samples, the percentages of chlorites observed in area(A) ranging between 6.2% - 9.4%, 6.1% - 8.5% in area(B), and 6.2% -9.1% in area(C) . Chlorites represent a group of minerals. The types of chlorite that are observed in the studied samples usually green color with no pleochroism (Figure-5, No.2) brown color (No.3). The shapes of chlorites are usually irregular flaky form and subrounded.
3) Garnet group: Two types of garnet were observed colorless garnet (Grossular), and light rose color (Almandine). The percentage of garnet was observed in area (A) ranging between 3.3% - 7.6%, and in area (B) ranging between 3.3% - 7.7%, while in area(C) ranging between 4.3% -7.8%. Garnet grains mainly show high relief, shapes are equant, to sub equant, subrounded and subhedral. Fresh garnet grains are common with some inclusions (Figure-5, No.5 & 6).
4) Zircon: The highest percentages of zircon was observed in area(C) ranging between 5.2% - 7.5%, and the lowest percentages was found in area(A) ranging between 3.6% - 8.4%, while the intermediate percentages was found in area(B) ranging between 4.5% - 7.6%. Zircon is mainly colorless with shades of black, prismatic grains are common, the crystal faces that are observed include euhedral crystals are with perfect faces and show no sign of abrasion , subhedral, and anhedral, zircon grains mostly occur with inclusions, the form of zircon from subrounded (Figure-5,No.7). The subrounded zircon refers to less sediment cycle from well-rounded shape.
5) Pyroxenes: Two types of pyroxene were observed colorless Orthopyroxene , and green Clinopyroxene.**1) OrthoPyroxene:** The highest percentages of this mineral were observed in area (B), the ranging between 2.3% - 3.7%, 2.3% - 3.8% in area(C), and 2.2% - 3.9% in area (A). orthopyroxene are usually show colorless to light green color with prismatic habit ,and subhedral (Figure-5,No.4).and **2) ClinoPyroxene:** The highest percentages of this mineral were observed in

area (A), the ranging between 2.8% - 4.9%, 2.5% - 4.7% in area (B), and 2.7% - 4.3% in area (C). clinopyroxene are usually show green color ,and subhedral (Figure-5,No.9).

6) Amphiboles: The highest percentages of amphiboles was observed in area(B) ranging between 3.3% - 6.2%, and the lowest percentages was found in area(C) ranging between 3.8% - 6%, while the intermediate percentages was found in area(A) ranging between 3.1% - 6.4%. Amphiboles in the studied dune samples are observed prismatic and cleaved grains, and showing some degree of alteration, subhedral and anhedral (Figure-5, No.11 &12).

7) Epidote: The percentages of epidote was observed in area (A) ranging between 4.4% - 7%, and in area (B) ranging between 4.2% - 6.4%, while in area(C) ranging between 4.4% - 6.4%. Epidote under the polarizing microscope show a high relief, green to pale green color, and rounded, sub rounded shape (Figure-5, No.10).

8) Biotite: The highest percentages of biotite was observed in area(C) ranging between 4.8% - 6.5%, and the lowest percentages was found in area(B) ranging between 2.58% - 4.41%, while the intermediate percentages was found in area(A) ranging between 4.3% - 6.1%. Biotite under the polarizing microscope is pleochroic brown, yellowish; mostly irregular to angular in shape, Flaky grains are common. biotite is usually fresh with some altered grains (Figure-5,No.17).

9) Heavy Muscovite: Muscovite is the most common mineral of the mica family have 2.8-2.9 specific gravity [23- 25], heavy muscovite has more than specific gravity at heavy liquid (bromoform) (2.89). The highest percentages of heavy muscovite was observed in area(B) ranging between 4.3% - 6.6%, and the lowest percentages was found in area(A)ranging between 4% - 5.6%, while the intermediate percentages was found in area(C) ranging between 3.1% - 6.6%. Muscovite is colorless, basal flakes, irregular outline. Most of the observed muscovite grains are clear and fresh (Figure-5, No.15).

10) Tourmaline: The highest percentage of Tourmaline was observed in area(C) ranging between 4.4% - 6.4%, and the lowest percentages was found in area(A) ranging between 4.2% - 6.2%, while the intermediate percentages was found in area(B) ranging between 4.3% - 6.4%. Tourmaline grains have brown to honey color with strong pleochroism, sub rounded to rounded form with inclusion these grains are mostly fresh (Figure-5, No.8 & 13).

11) Staurolite: The percentages of staurolite observed in area (A) ranging between 0.6% - 2.3%, and in area (B) ranging between 1.2-2.4, while in area(C) ranging between 1.1% -2.4%. Saurolite grains show high relief, yellowish to golden color with pleochroism, subhedral to sub rounded in form (Figure-5, No.18).

12) Kyanite: The percentages of kyanite in area(A) ranging between 1.3% - 2.6%, and in area(B) ranging between 1.1% - 2.5%, while the percentages was found in area(C) ranging between 1.1% - 2.9%. Kyanite grains are colorless, high relief, subhedral with elongated habit (Figure-5, No.21).

13) Rutile: The highest percentages of rutile was observed in area(B) ranging between 1.2% - 3.7%, and the lowest percentages was found in area(A)ranging between 1.3% - 3.6%, while the intermediate percentages was found in area(C) ranging between 1% - 4.2%. Deep red color with black shades, very high relief, Subhedral (Plate 4-8A), sub rounded shape (Figure-5, No.16&20).

14) Celestite: The highest percentages of celestite was observed in area(A) ranging between 1.2% - 4.6%, and the lowest percentages was found in area(C)ranging between 0.5% - 2.5%, while the intermediate percentages was found in area(B) ranging between 0.6% - 4.3%. The grains shape of celestite Euhedral, prismatic colorless (Figure-5, No.14 & 19). The genesis of celestite, which is the celestite is derived from the secondary gypsum covering the Dibdibba Formation. Rain water dissolves gypsum, then release Sr andSO_4^{2-}. These ions will be saturated within aqueous solution and accumulate on the Injana Formation and within Dibdibba Formation. Evaporation concentrates these ions; accordingly Sr and SO42- will be linked together as celestite (Sr SO_4^{-2}) in the pore spaces of Dibdibba Formation.This process clear in Najaf and Karbala area[26].

The heavy mineral assemblages determined for studies area dune sample, indicates a variety of probable source rock types including igneous, metamorphic, sedimentary, and pegmatite rocks .Where the Opaques minerals from sedimentary rocks, acidic igneous rocks, basic igneous rocks, and metamorphic rocks; Chlorite, Epidote, garnet, Kyanite and Staurolite minerals from metamorphic rocks; Pyroxene group from basic igneous rocks and metamorphic rocks and amphibole minerals from Acidic igneous rocks and metamorphic; Biotite, Muscovite, Tourmaline, and Rutile minerals from acidic igneous rocks and metamorphic rocks; and Celestite from sedimentary rocks[23,24,30,13,19,21,17,29,25,28,and 27].

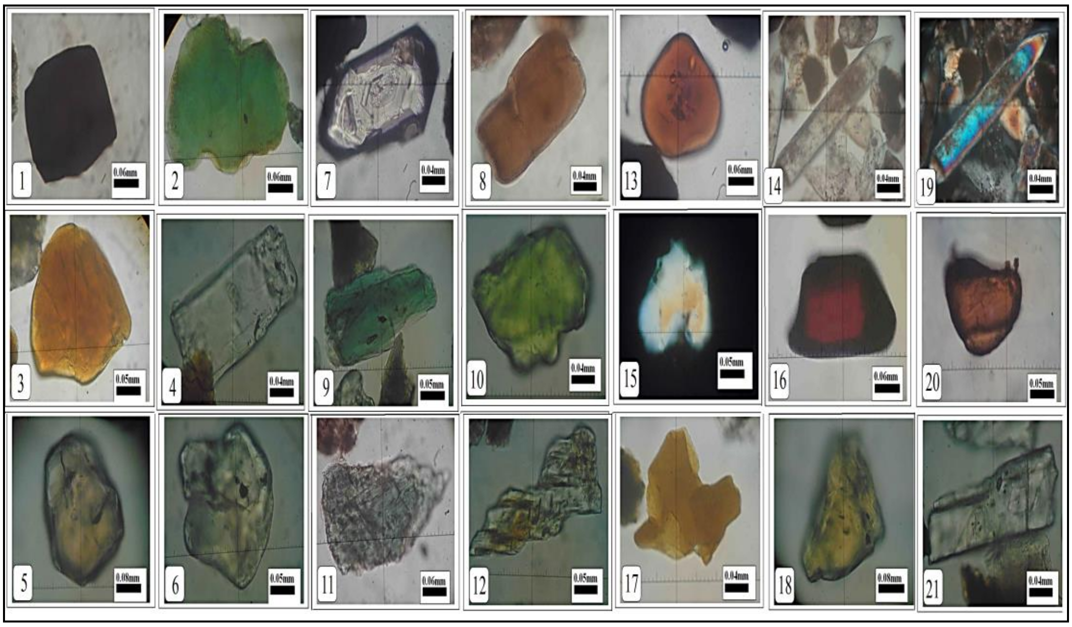


Figure 5-Images Shows the Heavy minerals where the No.1) Euhedral Opaques ,2) Flaky form, Green Chlorite , 3) Subrounded Brown Chlorite , 4) Colorless, Prismatic form, Subhedral Orthopyroxene , 5) Garnet (Almandine) , 6) Garnet (Grossular),7) Prismatic habit, High relief, Ehedral colorless, Zoning Zircon , 8) Prismatic, Honey color, Pleochroic Tourmaline , 9) Green Clinopyroxene ,10) High relief,Subhedral, light Green Epidote ,11) Slightly Pleochroic Amphibole (Hornblnde) , 12) Amphibole (Actinolite) , 13) Rounded, Honey color Pleochroic Tourmaline with inclusions ,14) prismatic colorless Celestite,PPL ,15) Anhedral fresh Muscovite , 16) Deep Red color Rutile , 17) Pleochroic Brown Biotite ,18) Yellowish Staurolite , 19) Prismatic Celestite ,XPL , 20) Red Rutile , 21) Elongated Kyanite.

6.3) Stability of Heavy Minerals:

[31]Kasper et al, (2008) work out a ternary classification for determining the heavy minerals stability contents, where the ultra-stable unstable and moderately stable groups estimate. Ternary apex diagram for heavy minerals was plotted for the dune sands data classifying unstable (pyroxenes and amphibole), moderately stable (Opaques), and ultrastable (zircon, rutile, and Tourmaline,) heavy minerals (Figure-6). Employment of the stability factor on the studied areas show that there are clear differences among the different locations indicating different sources and types of parent rocks. The dune samples from area (A) show nearly in moderately stable, while area (B) and (C) show an intermediate location in which it possesses mixed sediments of both the ultra-stable and moderately stable minerals (Figure-6).

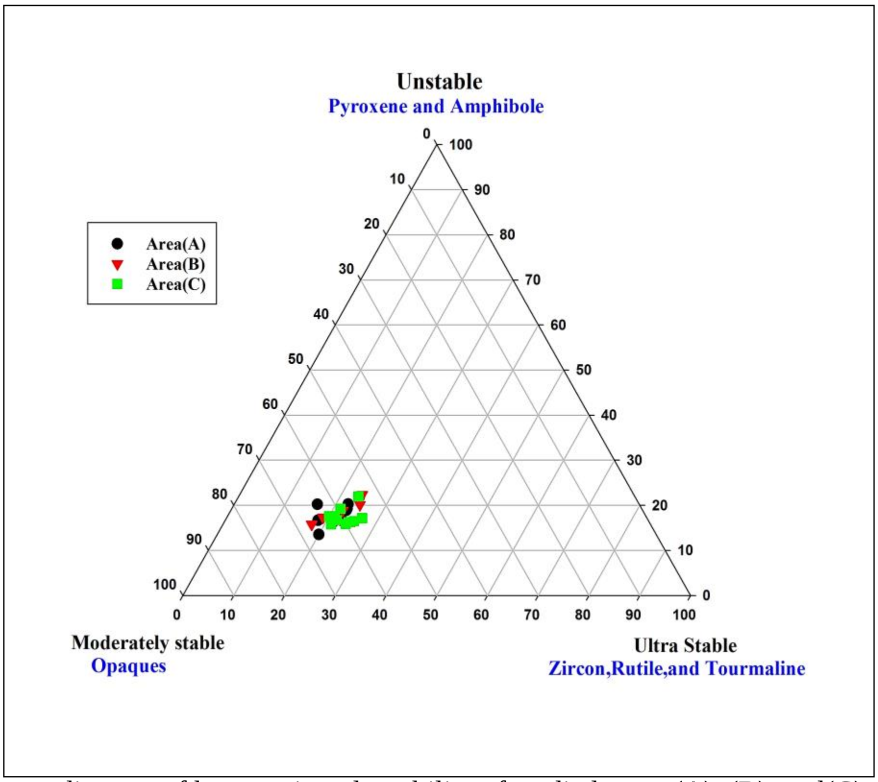


Figure 6-Ternary diagram of heavy minerals stability of studied areas (A), (B), and(C), after [31].

6.4) Carbonate Content:

The percentage of carbonate materials varies between (12.6% - 35.6%) and to confirm the result of the petrographic study, and the average of three areas about (23.35 %).The differences in the carbonate content among the samples may be caused by the differences in the grain size distribution [32]. [33] Al-Saadi (1971) mentioned that the high percentage of carbonate may indicate proximity to the source and the relatively high percentage of carbonate in the source materials, and may be from nearby the sedimentary formations (e.g. Dammam, Euphrates and Nfayil). Figure-7 Show that the highest percentage of carbonates is in area (B) dune samples (26.84 %), and lowest percentage in area (A).

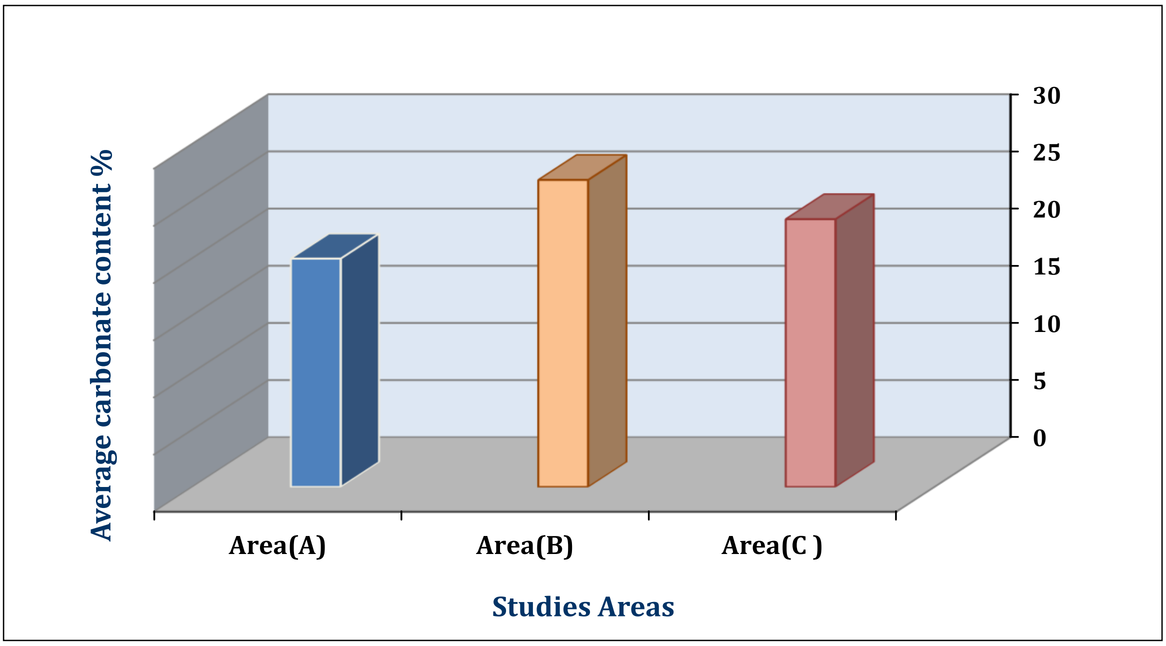


Figure 7-The average percentages of bulk carbonate content in studies areas (A), (B), and(C).

The carbonate content was related to the grain size fractions (0-1) Ø, (1-2) Ø, (2-3) Ø, (3-4) Ø, where (21) samples were used. (Table-8) and (Figure-8) show a clear relation between the carbonate percentages and the grain size, as they increase with finer sizes, the percentage average of the carbonate contents in area(A), are (15.33 %) in the (1-2 Ø) fraction, (26.73 %) in the (2-3 Ø) and (34.03 %) in the (3-4 Ø) fraction, while area(B) have the percentages (17.73%)in the (0-1Ø)fraction ,(18.48%)in the (1-2Ø)fraction ,(37.37%)in the (2-3Ø)fraction, and (43.84%)in the (3-4Ø)fraction, finally the area(C) have the average percentage are (14.5%)in the (0-1Ø)fraction,(14.33%)in the(1-2Ø)fraction,(35.90%)in the (2-3Ø)fraction ,and (41.76%)in the (3-4Ø)fraction. The changes may be related to the chemical and mechanical instability of the carbonates that facilitate size reduction processes during transportation [33]. The high percentages of the carbonate content in the studied sediments may indicate a higher erosion and contribution from the source area [34].

Table 8-The Carbonate percentages related with grain size within studies areas (A), (B), and (C).

Samples No.	Carbonates percentages with grain size			
	(0-1)Phi Coarse grains	(1-2)Phi Medium grains	(2-3)phi Fine grains	(3-4)phi Very Fine grains
A-1W	-----	17.8	25.6	33.2
A-1C	-----	17.4	28.4	33.2
A-1L	-----	14.6	25.8	35.6
A-7W	-----	14.2	26	34.4
A-7C	-----	11.8	26.6	34
A-7L	-----	16.2	28	33.8
Average		15.33	26.73	34.03
B-1ND.	20.4	25	42.8	44.2
B-1CD.	21.2	25.6	40.8	44.8
B-1SD.	25.6	27.6	42.6	47.8
B-2WF.	14	13.6	36.2	43.6
B-2C	19.4	15.4	33.2	40.8
B-2EF.	12.8	14	32	42
B-6WF.	17.4	14.8	40.4	44.4
B-6C	15.6	14.8	36.6	44.8
B-6EF.	13.2	15.6	31.8	42.2
Average	17.73	18.48	37.37	43.84
C-2WF.	10.8	12.4	32	39.8
C-2C	17.4	16.8	39	41.2
C-2EF.	10.4	11.2	36.2	41.2
C-4WF.	15	15.6	36.2	44.4
C-4C	17.8	16.2	38	43.8
C-4EF.	15.6	13.8	34	40.2
Average	14.5	14.33	35.90	41.76

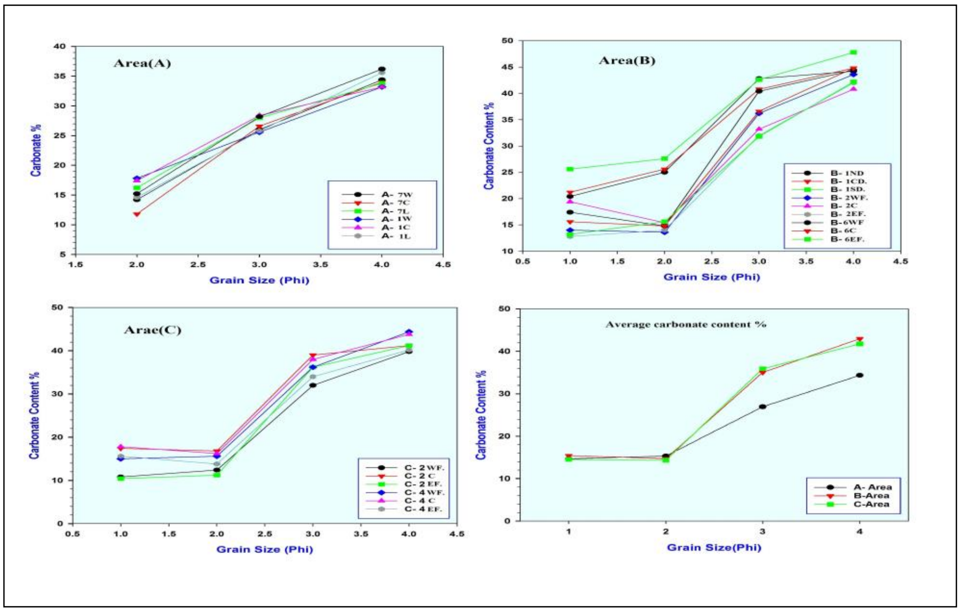


Figure 8-The carbonate percentage as related with grain size in studies areas (A), (B), and (C).

6.4) X-Ray Diffraction (XRD):

X-ray diffraction (XRD) is a basic tool in the mineralogical analysis of sediments, and in the case of fine grained sediments an essential one. It has the advantage, with modern instrumentation, that almost complete automation can be achieved to give fast, precise results [15]. The Data resulted from these analyses were treated with the ICDD, 2016 pdf2 search match software.

Twenty samples from different localities covering the three Areas of sand dunes were as a bulk sample shows in (Figure-9).The result of XRD analysis show a variation in contents of minerals with high percentage of Quartz mineral with carbonate, gypsum, feldspar, and celestite results, these are summarized as follow:

1) Quartz: The mineral quartz represents the major component in all samples exceeding 60%. The samples of area(A) ranging between (65.1%-90.1%),area(B) ranging between (53.7%-90.2%),and area(C) have ranging between (70.5%-87.3%).The higher concentration of quartz; this may be related to the nature of the source rocks formed the formation surrounded of study area.

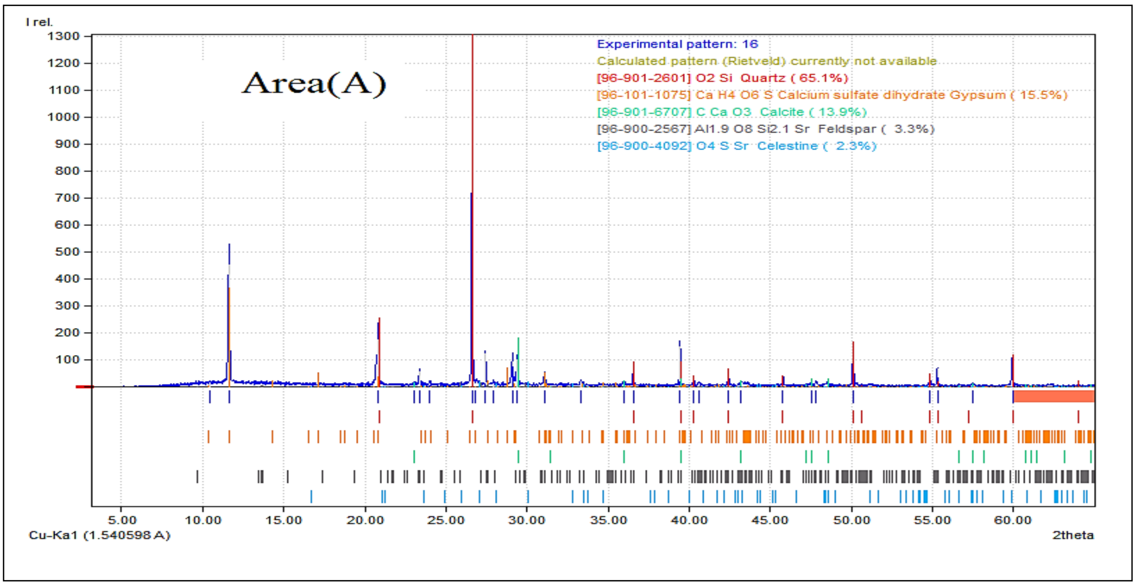
2) Carbonates: The mineral carbonates percentages in all samples exceeding 11%. The samples of area (A) ranging between (6.9%-16.5%), area (B) ranging between (7.1%-19.6%), and area(C) have ranging between (12.5%-19.7%). These percentages may be explained by the location of the dune belt within the western desert of Iraq and surrounded by carbonated older formations besides the changing nature of the wind action within this area.

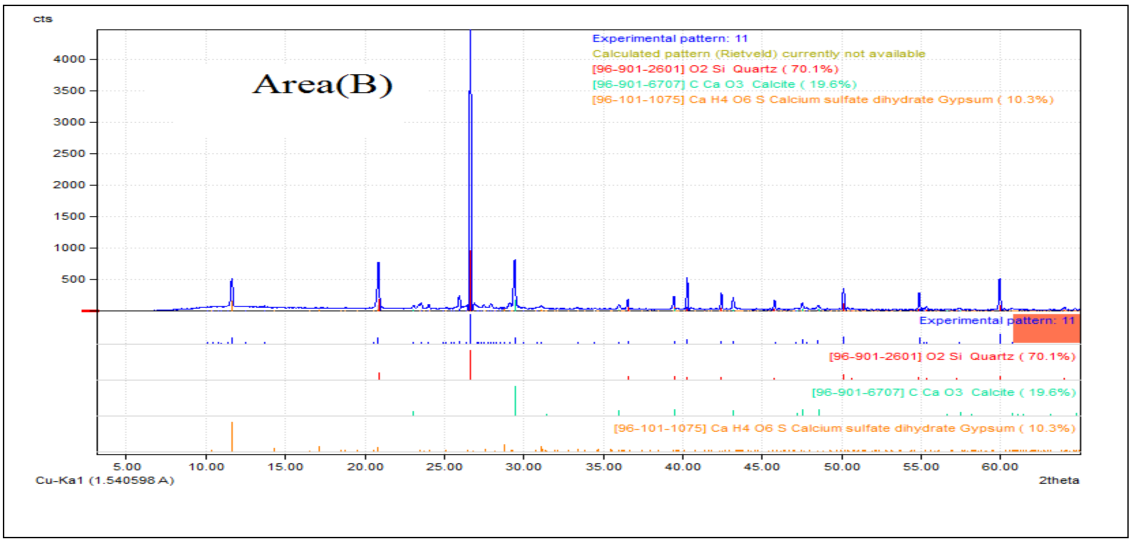
3) Gypsum: Gypsum is concentrated within area (A) have ranging between (5.1%-17.4%), while in area (B) ranging between (2.9%-26.1%), and area(C) ranging between (4.0%-20.1%). this is mainly attributed to the secondary gypsum in surrounding study area.

4) Feldspars: Feldspars show a relatively low percentage in studies area may be explained by not reading the X-Ray technique because powder of samples and covered another mineral. The percentages in area(A) ranging between (1.1%-8.6%),while area (B) ranging between (1.1%-2%),and area(C)ranging between (0.8%-3.5%). Based on the feldspar type one can explain the differences in the source rocks for the different dune areas.

5) Celestine:

Celestite show absent in some samples and presence high percentage in area (A) ranging between (0.6%-2.3%), while in area (B) ranging between(0.7%-1.0%),and in area(C) have ranging between(0.3%-1.7%). These percentages may be explained the celestite minerals formed in Dibdibba Formation and other source from evaporation minerals in near area.





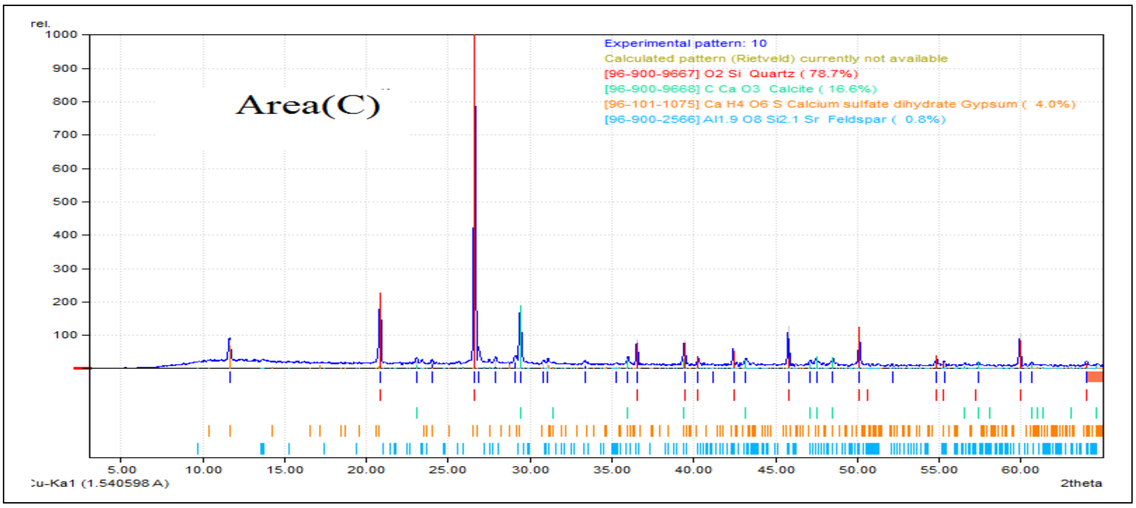


Figure 9-X-ray difractogram of bulk sample from studies areas (A), (B),and(C).

7) Conclusions

1- The mineralogy of the Najaf dunes field consisted from the light minerals and heavy minerals, where the Quartz its major component from light minerals, and the opaque minerals represent the major component from heavy minerals in all studied dune samples, because of their diverse sources and their presence in most of the rocks, followed by chlorite group, garnet group, zircon, pyroxenes, amphiboles, epidotes, biotite, muscovite, tourmaline, kyanite, staurolite, rutile, and celestite.

2-The abundance of heavy minerals indicates different source rocks such as igneous, metamorphic, and sedimentary rocks

3- A clear relation between the carbonate percentages and the grain size, as they increase with finer sizes. The high percentage of carbonate may indicate closeness to the source area and the relatively high content of carbonate in the parent rocks.

4- The stability of these dune sands as reflected from the assemblage of heavy minerals, which indicated a transition from the moderately stable to ultrastable, may be sediments derived mostly from reworked sources.

5- From the mineralogical composition, both the heavy and light fractions show that there are many sources in the areas of study.From the nearby older formation (e.g. Dibdibba Dammam, Euphrates, and Nfayil) and from quaternary sediment exposed in these areas.

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