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Mineralogy of Sand Dune Fields around Hor Al-Dalmaj Between Wasit and Al-Qadesiyah Governorates - Central Iraq

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Abstract

Vast percentage of the Hor Al-Dalmaj area is covered with sand dunes fields due to desertification .Therefore, it is vital to research these dunes to limit their bad action on the natural environment by defining the mineralogical composition of these sand dunes deposited around Hor Al-Dalmaj lake between Wast and Al-Qasisiyah Governorates to determine the provenance or the source of these dunes. Barchan and Nabkha dunes represent the main types that are recognized. The dimensions of barchan dunes are recognizing by a height range of about 0.5 to 3m, with lateral extension ranging from 2 to 15m and longitudinal extinction ranging from 3 to 15m. While the dimensions of nabkha dunes range from 10 cm to 2m in length and 15cm to 2m high. According to the major wind direction, these dunes are extended from North West to south-east. The mineralogical investigation reveals that the light minerals of studied dunes consist mainly of quartz, feldspars and various rock fragments such as carbonate, chert, mudstone, evaporate, igneous, and metamorphic rocks. The most frequent heavy minerals are opaque, chlorite, pyroxenes, amphiboles, muscovite, biotite, zircon, epidotes, garnet, tourmaline, rutile, kyanite, and staurolite. The source of these sediments is recent sediment that has formed in river terraces, flood plain and Quaternary deposits in the Mesopotamian Plain, and the outcrops of the ancient sedimentary formations in the north northwestern, west, and southwestern Iraq.

Keywords: Sand Dunes, Barchan Dunes, Heavy Minerals, Provenance

معدنية الكثبان الرملية المترسبة حول هور الدلمج بين محافظتي واسط والقادسية وسط العراق

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الخلاصة:

نسبة كبيرة من منطقة هور الدلمج مغطاة بحقول الكثبان الرملية بسبب التصحر. لذلك ، من الضروري البحث عن هذه الكثبان للحد من تأثيرها السيئ على البيئة الطبيعية من خلال تحديد التركيب المعدني لهذه الكثبان الرملية المترسبة حول بحيرة هور الدلمج بين محافظتي واسط والقادسية لتحديد مصدر هذه الكثبان. تمثل كثبان البرخان والنبخة الأنواع الرئيسية المعروفة. يتم تعيين أبعاد الكثبان الرملية من خلال مدى ارتفاع يتراوح من حوالي 0.5 إلى 3 أمتار ، مع امتداد جانبي يتراوح من 2 إلى 15 مترًا وامتدادا طوليًا يتراوح من 3 إلى 15 مترًا. بينما تتراوح أبعاد كثبان النبخة من 10 سم إلى 2 متر في الطول ومن 15 سم إلى 2 متر في

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الارتفاع. تمتد هذه الكثبان الرملية من الشمال الغربي إلى الجنوب الشرقي، وفقًا لاتجاه الرياح الرئيسي . تتكون المعادن الخفيفة للكثبان المدروسة تتكو أساسًا من الكوارتز والفلسبار وشظايا صخرية مختلفة مثل الكربونات والصوان والحجر الوحلي والمتبخرات وقطع الصخور البركانية والمتحولة. المعادن الثقيلة الأكثر شيوعًا هي المعادن المعتمة ، كلورايت ، بايروكسينات ، أمفيبولات ، موسكوفايت, بايوتايت ، زركون ، إبيدوت ، كارنت ، تورمالين, روتايل, كيانايت و شتورولايت. الصخور المصدرية لهذه الرواسب هي الرواسب الحديثة في الشرفات النهرية والسهول الفيضية ورواسب العصر الرباعي ضمن نطاق السهل الرسوبي ، فضلا عن مكاشف التكوينات الرسوبية القديمة في شمال وشمال غرب وغرب وجنوب غرب العراق.

Introduction

The Hor Al-Dalmaj area is located to the west of the Tigris River, extends from the borders of Al-Qadisiyah Governorate to the borders of Wasit Governorate and covers about 60,000 dunums, about 35km southwest of Kut [1, 2]. It is characterized by natural and environmental diversity. This diversity and the different quality of soil and plants contributed to attracting large types of birds and wild animals, creating a natural and environmental balance [3 and 4]. Geologically, Hor Al-Dalmaj area is located within the fluvial plains of the Tigris and Euphrates rivers that consist of silt, clay and very fine sand as well as aeolian sand distributed within the sand dunes fields. Gravels and hard rocks occur in river and valley channels surrounding the Mesopotamian Plain and are exposed as different stratigraphic units at the Low Folded Zone. Structurally, the site is located in the Mesopotamian Zone, without any surface structural features [5].

The water in the Hor Al-Dalmaj Lake ranges from about 0.5 m to more than 2 m in depth, considered a good breeding habitat for special colonial species, such as the Slender-billed Gull.

Several researches were conducted on the Hor Al-Dalmaj area, which dealt with the environmental situation, the hydrochemistry of water resources and the surrounding sediments of the Hor Al-Dalmaj Lake as well as the nature of the sand dunes [5 and 6]. In terms of hydrology, the surface water and shallow groundwater types are generally sulphate and bicarbonate, while the deeper groundwater are saline and chloride water type. The average depth of groundwater ranges from about 2 to 15m. During the late winter, spring, and the beginning of summer, levels rise in most areas due to the annual recharge from the rainwater [8].

The studied area represents the fields of sand dunes that were deposited around Hor Al-Dalmaj Lake between Wasit and Al-Qadesiyah Governorates, south-east of Baghdad (Figure 1). It is located between longitudes (45°:42':00" - 45°:06':00")E, and latitudes (32°:30':00" - 31°:54':00") N.

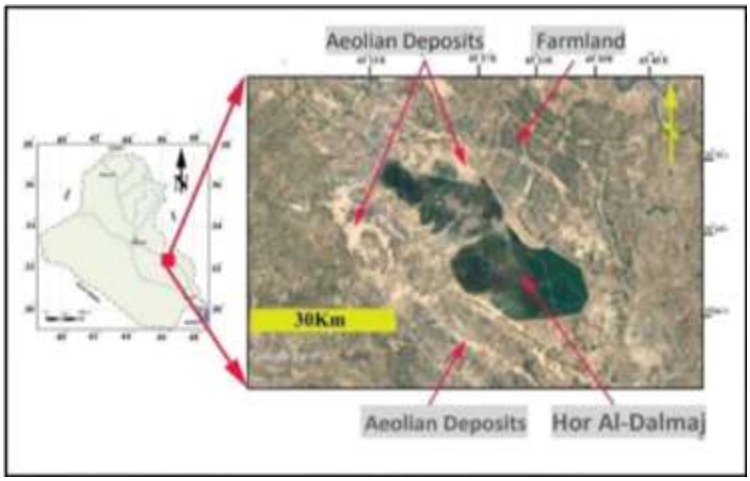

Figure 1- Location map of the study area [7]

Geologically, the study area is located within the Mesopotamian plain, mainly covered by Pleistocene and Holocene deposits derived from the Tigris and Euphrates rivers sediments of alternating sequences of sand, silt and clay, including marshes, lacustrine, flood plain, valley fill, inland sabkha and aeolian sediments as sand dunes (Figure 2). The main purpose of this research is to determine the mineralogical composition of the dune sands that are deposited around the Hor Al-Dalmij Lake, which is important in determining the source of these dunes.

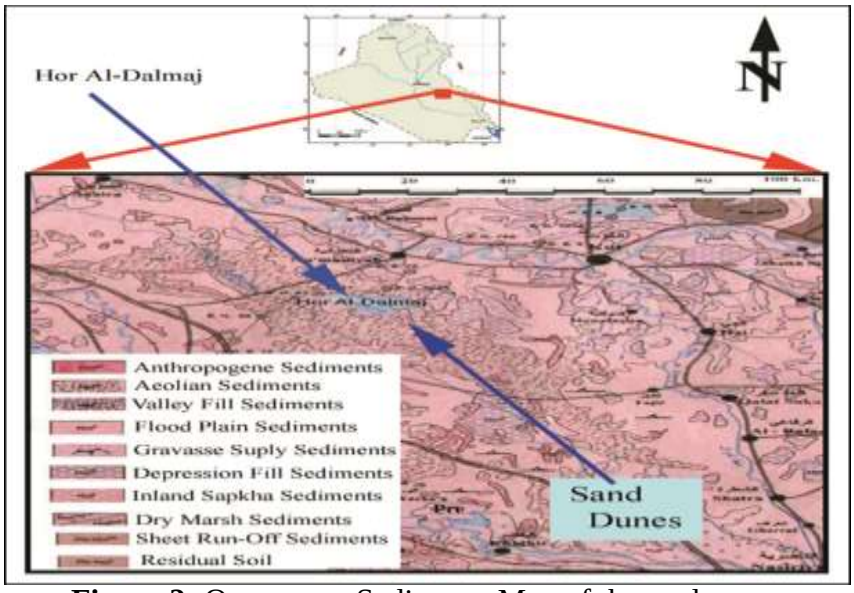

Figure 2- Quaternary Sediments Map of the study area.

Methods of Study

The Sand dunes deposited around Hor Al-Dalmaj Lake represent part of the major central dune field belt in Iraq. This field is a part of the Mesopotamian Plain (between the Tigris and Euphrates rivers). This is the largest field observed in this study, extending across Babel, Wasit, Al-Qadisiyah, East of Al-Muthana, and north of Thi-Qar Governorates [10, 11].

The field trips indicated that the barchans dunes are an important form and widely distributed in the study area. The sand dunes' shapes range from asymmetrical to symmetrical shape. These dunes range from 0.5 to 3m in height and 2 to 15m in width, while their longitudinal extinction ranges from 3 to 15m (Figure 3).

Figure 3- The Barchans dunes in the study area.

The Nabkha dunes are also observed around Hor Al-Dalmaj Lake, occurring with particular plants that act as a trap, causing sand dunes to take on their ultimate shape. Their longitudinal extinction ranges from 10cm to 2m in length, while they range from 15cm to 2m in height (Figure 4).

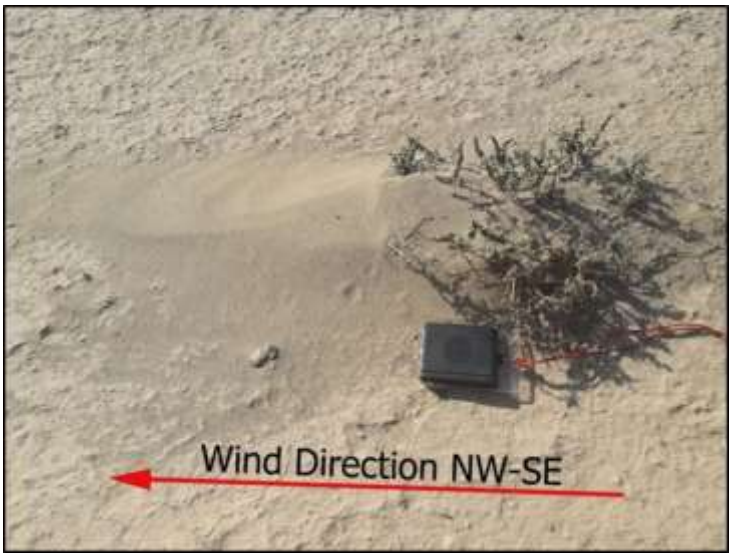

Figure 4- The Nabkha dunes in the study area.

Ten sediment samples were collected from the sand dunes fields located around Hor Al-Dalmaj Lake between December 2019 and March 2021. The dimensions of the dunes, which include the height of the dunes and their longitudinal and lateral extension, were measured using a measuring tape, and the direction of the dunes was also measured by determining the bearing of these sand dunes extinction using the Silva compass. The mineralogical composition of these dunes was determined in the petrology laboratories, Department of Geology, College of Science, University of Baghdad by applying the well-known international methods. The mineral separation was done using the Bromoform heavy liquid, with a specific gravity of (2.89). Five grams of fine and very fine sand size fractions are used for minerals separation [12, 13, 14, and 15]. A point-counting technique was applied to determine the percentages of minerals through the polarizing microscope (Table 1)[16].

Table 1- The percentages of the light minerals components of studied sand dune samples around Hor Al-Dalmaj Lake.

Light Minerals	Samples Number										Average %
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	
Monocrystalline Quartz	39.2	41.4	40.5	42.5	41.1	38.1	40.1	42.4	42.3	43.7	41.13
Polycrystalline Quartz	2.7	1.7	2.3	1.5	2.5	2.7	2.5	2.9	1.6	2.9	2.33
Potash Feldspar Microcline	1.3	2.3	1.6	1.5	2.2	3.4	2.2	1.5	1.8	1.7	1.95
Potash Feldspar Orthoclase	3.8	4.5	3.3	4.8	3.2	4.4	3.7	4.2	3.1	3.4	3.84
Plagioclase Feldspar	3.5	2.8	1.3	1.6	1.6	2.6	2.9	3.7	3.4	2.1	2.55
Carbonate Rock Fragments	17.3	21.4	27.4	25.3	26.8	20.1	19.3	22.4	19.4	20.2	21.96
Chert Rock Fragments	8.3	5.6	4.0	3.4	3.4	6.4	5.7	3.1	4.8	5.3	5.0
Igneous Rock fragment	2.9	1.7	2.4	1.7	2.5	3.1	3.3	2.4	3.9	3.7	2.76
Metamorphic Rock Fragments	2.4	2.3	1.7	2.0	3.4	3.2	3.6	2.4	3.1	2.6	2.67
Mudstone Rock Fragments	6.7	6.5	5.7	4.4	3.1	4.5	5.4	5.7	5.2	4.7	5.19
Evaporites (Gypsum)	7.1	5.3	6.1	7.3	5.4	5.5	7.1	5.2	7.4	5.1	6.15
Coated Grains by Clay	4.7	3.2	3.1	2.8	3.2	4.1	2.9	2.2	2.8	3.4	3.24
Others	0.1	1.3	0.6	1.2	1.2	1.9	1.3	1.9	1.2	1.2	1.19

Result and Discussion

Ten sediment samples were collected from the sand dune around the Hor Al-Dalmaj Lake. Hundred (100) gm from each sample were taken, and dry sieving analyses separated the sand fraction according to Folk's, 1974 method for grain size analysis [17].

Fine sand size (0.125-0.25mm) represents the main size fractions of dune with an average of more than 94%, while the rest of the analyzed sand samples is very fine sand, with silt and clay sizes of less than 6%. These differences are related to the wind energy that caused the dune accumulation. This research used fine and very fine sand size fractions for mineralogical identification [12, 13, 14, and 15]. The analyses reflected that the light mineral fraction is about 97.5%, with about 2.5 % heavy mineral fraction.

1- Light Minerals

The results of the identification of the light mineral fraction indicated that their averages are 48.46 % of silica (Quartz and Chert), 8.34% Feldspars, 38.73% mixed rock fragments and the rest is the unidentified fraction of about 4.43% (Table 1 and Figure 5).

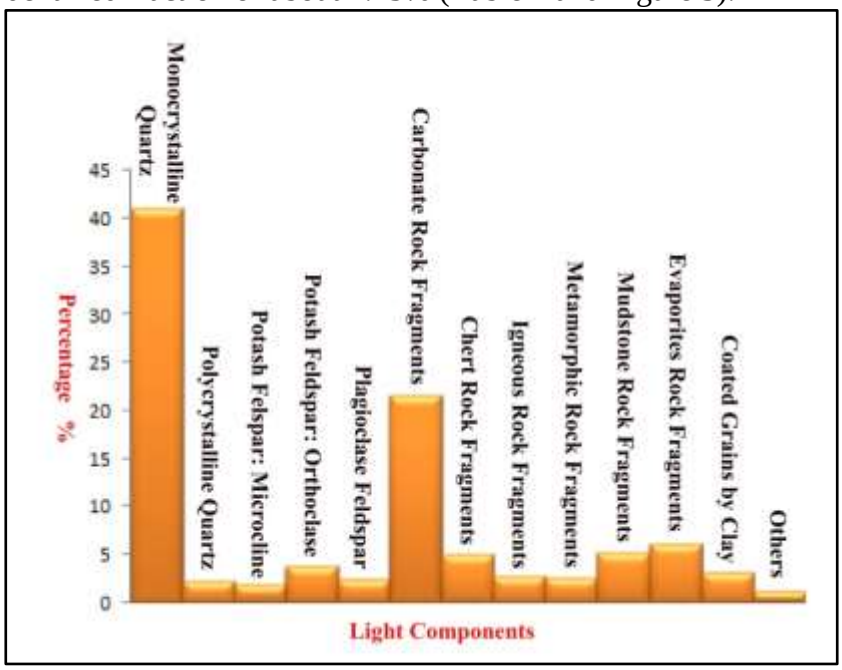

Figure 5- Bar chart represents the percentages of the light minerals components of the studied dune sand samples.

Moreover, the identified silica grains represent the majority of quartz grains (monocrystalline and polycrystalline) and, to a lesser extent, are the chert fragments. The Feldspars are represented by the plagioclase, microcline, and orthoclase, while the rock fragments (21.96%) are represented by the carbonate (calcite and dolomite). Evaporates (gypsum and anhydrite) participated by 6.15%. The percentages of igneous and metamorphic rock fragments are 5.43%. The studied samples contain about 5.19% mudstone rock fragments and about 4.24% of the unidentified grains coated by clay (Figure 6).

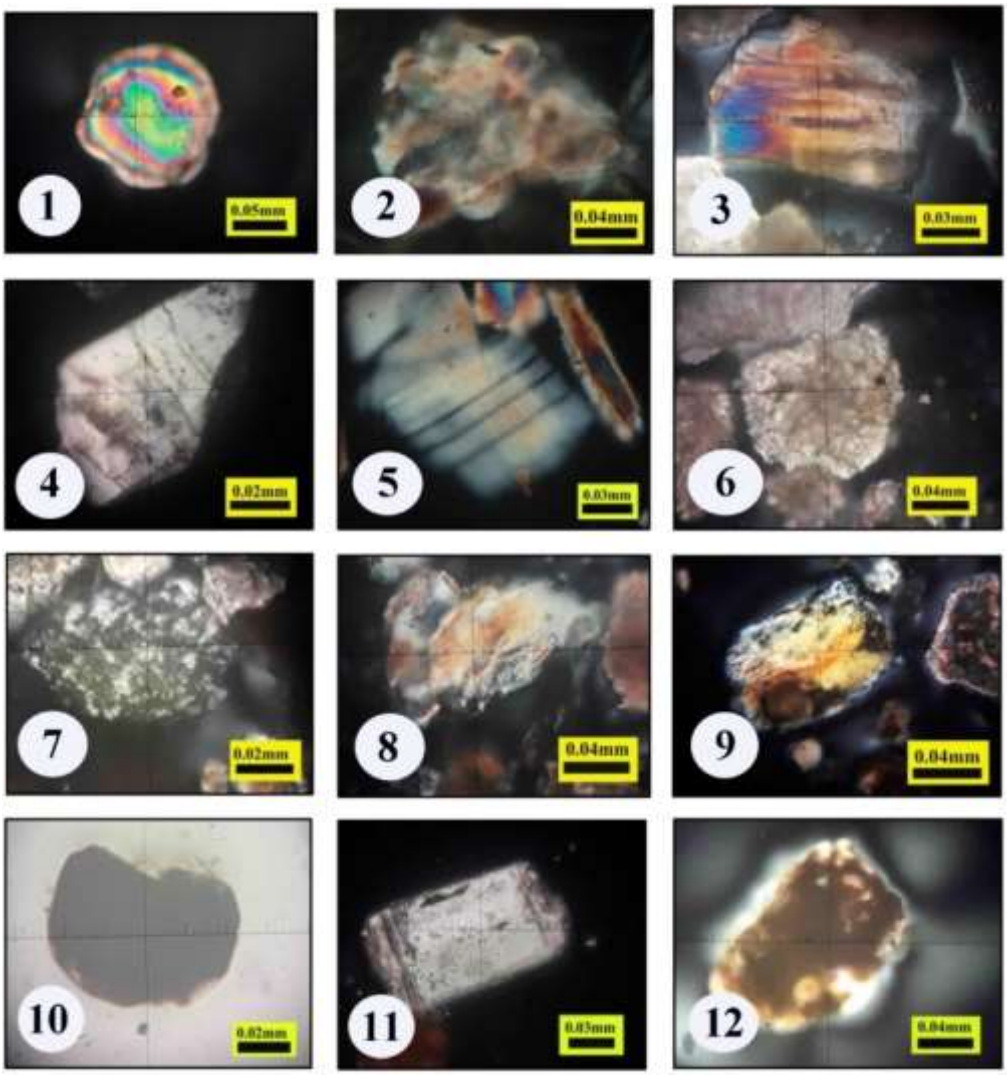

Figure 6- The identified light minerals, 1: rounded monocrystalline quartz, 2: sub-rounded polycrystalline quartz, 3: microcline potash feldspar, 4: orthoclase potash feldspar, 5: plagioclase feldspar, 6: carbonate rock fragment, 7: angular chert rock fragment, 8: igneous rock fragment, 9: metamorphic rock fragment, 10: mudstone rock fragment, 11: gypsum grain, 12: coated grain with clay.

2-Heavy Minerals

The heavy minerals are identified to determine the stability of these minerals and the nature of the source rocks area. The identification of the heavy minerals fraction indicated that their average percentages are 36.43% opaque minerals, and 62.33% non-opaque minerals.

The average percentages of the non-opaque mineral are mainly composed of 6.13% Chlorites, 7.06% Pyroxenes (both Orthopyroxene and Clininopyroxen), 7.61% Amphiboles (group of Hornblende, Glaucophane, and Tremolite), 12.58% Micas (both Biotite and Muscovite), 6.05% Zircon, 4.25% Garnet, 1.69% Celestite, 5.14% Epidote, 2.68% Rutile, 3.73% Tourmaline, 2.13% Staurolite, 2.06% Kyanite, and about 1.23% unidentified heavy minerals (Table 2 and Figures. 7 and 8).

Table 2- Percentages of heavy minerals of studied sand dune sample around Hor Al-Dalmaj Lake.

Heavy Minerals		Samples Number										Average %
		D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	
Opaques		35.6	36.9	40.1	36.2	40.4	41.5	36.5	38.6	37.3	38.7	36.43
Chlorite		5.6	6.5	7.7	5.4	6.9	5.3	7.7	4.8	6.2	5.2	6.13
Pyroxenes	Orthopyroxene	3.3	1.2	2.4	2.8	3.1	1.7	2.2	2.6	3.4	3.4	2.61
	Clynopyroxene	2.5	5.4	4.6	3.3	5.2	4.3	5.4	3.7	4.8	5.3	4.45
Amphiboles	Hornblende	6.8	5.7	4.3	5.6	4.4	5.4	4.4	5.0	4.4	5.7	5.17
	Glaucophane	1.3	1.4	1.5	1.7	0.6	0.9	1.1	1.4	1.5	0.9	1.23
	Tremolite	1.5	0.6	1.1	0.3	0.7	0.8	1.5	0.6	2.8	1.2	1.11
Mica	Biotite	6.6	5.2	4.3	6.4	3.4	5.6	6.7	7.5	6.3	6.4	5.84
	Muscovite	6.3	7.8	7.7	6.1	6.5	6.9	7.7	6.6	5.7	6.1	6.74
Zircon		5.7	4.6	6.7	8.2	6.2	6.7	6.2	6.4	4.4	5.4	6.05
Garnet		5.4	4.7	3.4	4.2	4.7	3.8	3.7	4.5	3.8	4.3	4.25
Celestite		1.7	0.9	2.5	1.9	1.6	2.1	1.5	0.9	2.2	1.6	1.69
Epidote		3.3	6.4	5.2	6.6	5.2	4.4	4.6	6.3	4.4	5.0	5.14
Rutile		3.4	2.6	3.3	2.2	2.2	2.7	2.3	1.3	3.2	3.6	2.68
Tourmaline		4.3	4.6	3.9	2.7	4.5	3.2	3.6	4.5	3.6	2.4	3.73
Staurolite		2.6	2.4	1.5	3.4	1.6	1.8	1.7	1.3	2.7	2.3	2.13
Kyanite		2.4	1.9	2.4	2.1	1.6	1.7	2.0	2.8	2.4	1.3	2.06
Others		1.7	1.5	1.3	0.9	1.2	1.2	1.2	1.2	0.9	1.2	1.23

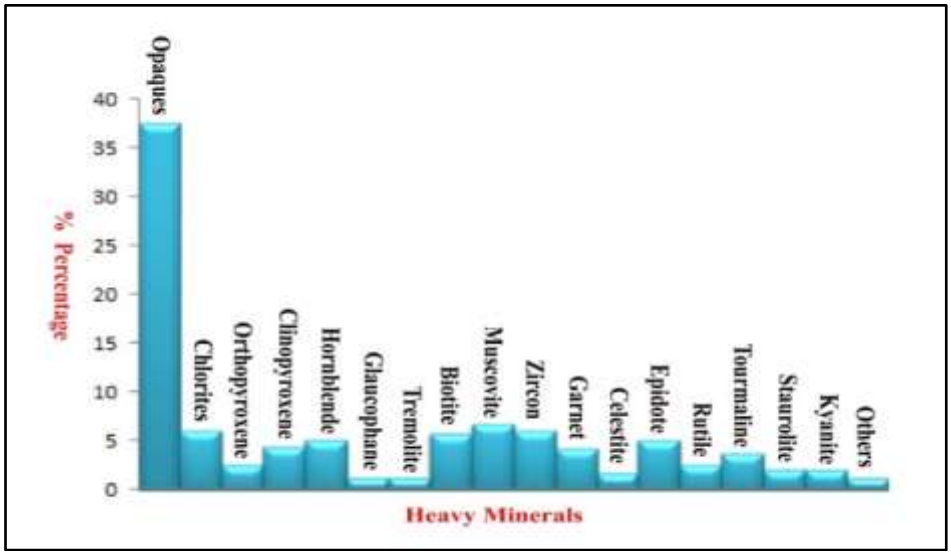

Figure 7- Bar chart represents the percentage of heavy minerals in the studied dune sands samples

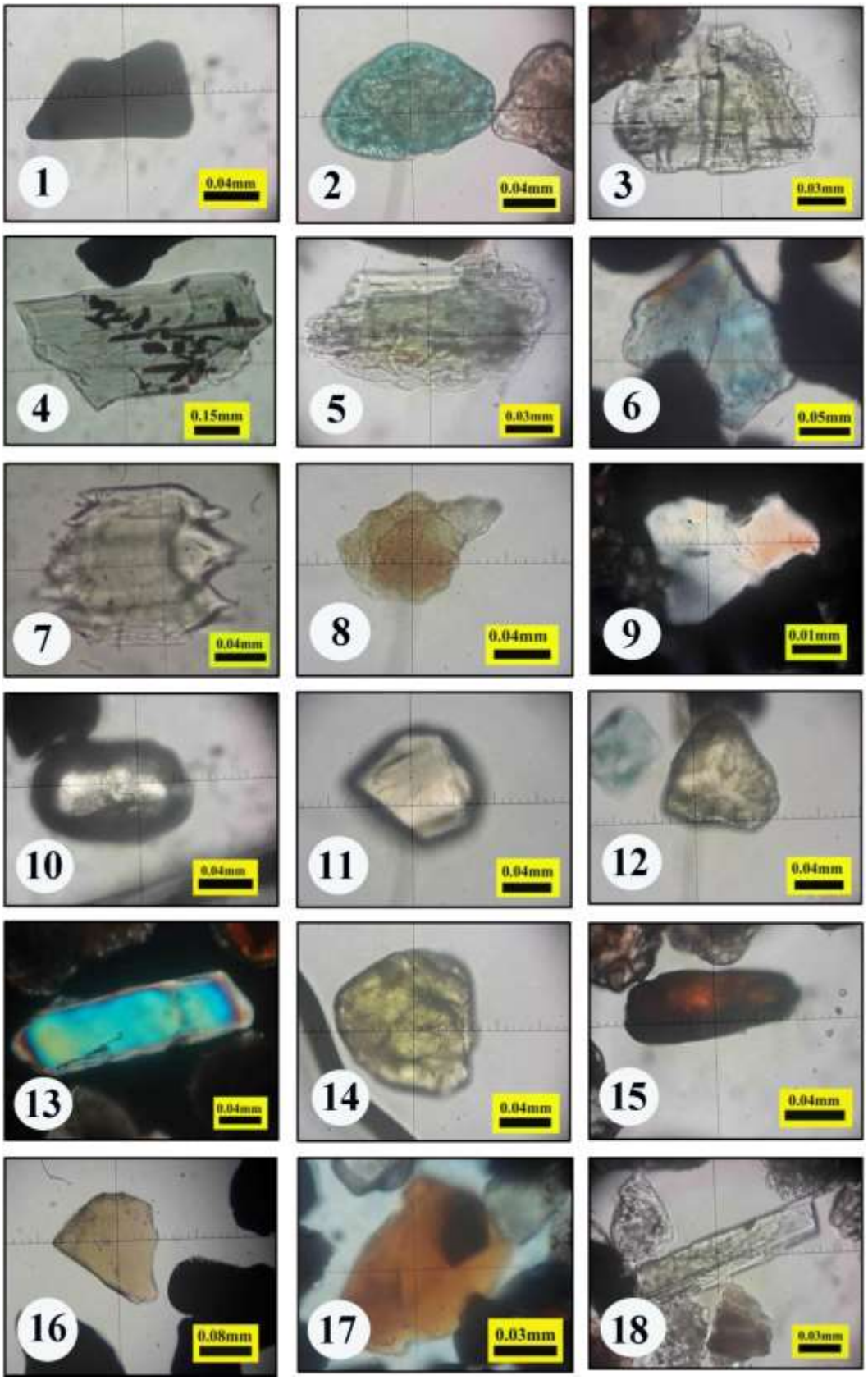

Figure 8- The identified heavy minerals, 1: Opaques, 2: Chlorite, 3: Orthopyroxene, 4: Clinopyroxene, 5: Hornblende, 6: Glaucophane, 7: Tremolite, 8: Biotite, 9: Muscovite, 10 and 11: Zircon, 12: Garnet, 13: Celestite, 14: Epidote, 15: Rutile, 16: Tourmaline, 17: Staurolite, 18: Kyanite.

Stability and Source

According to Folk, 1974 and Nesse, 2000 [17 and 18], the high percentage of opaque heavy minerals in clastic sediment refers to moderately stable clastic sediments, while the high percentage of zircon, tourmaline and rutile (ZTR) refer to ultra-stable clastic sediments. Kasper-Zubillaga, 2008 [19] created a ternary classification for determining the stability of heavy mineral concentration, in which unstable minerals, moderately stable and ultra-stable groups are used. By applying Kasper-Zubillaga, 2008 [19] methods, all samples are moderately stable, indicating different source rocks and distances from source rocks and maybe reworked (Figure 9).

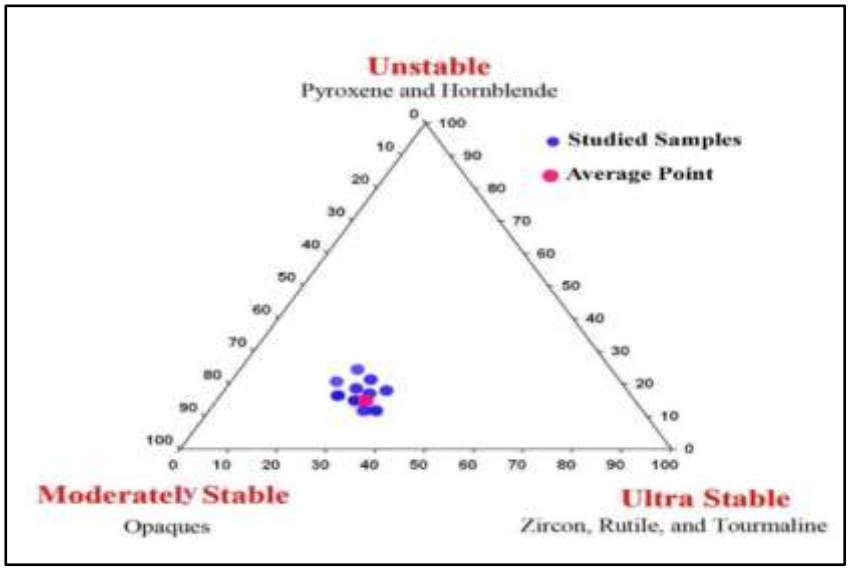

Figure 9- Ternary diagram of heavy mineral stability of studied samples [19].

The heavy minerals are widely carried out to determine the provenance of source rocks and transport signatures of certain depositional environments such as sand dunes, beaches, alluvial deposits, and rivers sediment [19, 20, 21 and 22].

Therefore, the possible source rock types are Igneous, metamorphic, and sedimentary rocks. Taking into account each mineral relative abundance and distribution.

Conclusion

1- The barchan dunes' shapes range from asymmetrical to symmetrical shape. Their size ranges from 0.5 to 3m in height, and from 2 to 15m in width, while their longitudinal extinction ranges from 3 to 15m.

2- The Nabkha dunes occur with particular plants that act as traps, causing sand dunes to take on their ultimate shape. Their longitudinal extinction ranges from 10cm to 2m in length, while they range from 15cm to 2m in height.

3- Fine sand size (0.125-0.25mm) represents the main size fractions of a dune with an average of more than 94%, while the rest of the analyzed sand samples is very fine sand, with silt and clay sizes of less than 6%.

4- The fine and very fine sand size fractions are used for the light and heavy minerals identification. The results reveal that the light mineral fraction is about 97.5%, with about 2.5 % heavy mineral fraction.

5- The composition of the light minerals is quartz grains (monocrystalline and polycrystalline), Chert, Feldspars (Plagioclase, microcline, and orthoclase) with carbonate (calcite and dolomite, Evaporates (gypsum and anhydrite), mudstone, igneous and metamorphic rock fragments.

6- The composition of the heavy minerals is chlorites pyroxenes, amphibole, mica, zircon, epidote, garnet, tourmaline, and rutile with abundant amounts of opaques heavy minerals.
7- Different source rocks are indicated by the abundance of these heavy minerals, such as igneous, metamorphic, and sedimentary rocks.
8- The maturity and stability of these dune sands are moderately stable, as evidenced by the assemblage of heavy minerals.
9- Both the heavy and light fractions reflect that the major sources for these dunes are the river terraces and flood plain of the rivers in the Mesopotamian Plain. Other sources of these dunes are the aeolian deposits derived from the outcrops of ancient sedimentary formations in the north and west of Iraq, as indicated by the presence of carbonate rock fragments, quartz, and feldspars.

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