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Provenance and Origin of the Sand Dunes Sediments in the Na'ama Area / Southeast Tikrit City Northern Iraq

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Abstract

Study of three Barchan sand dunes in Na'ama area southeast Tikrit city have been carried out for (10) samples, the investigation included petrographical, mineralogical and geochemical aspects of the sand dunes from grain size point, the sand grains are commonly sub-rounded to sub-angular forming about (98.8%) with (1.2%) of mud. Petrographically, the sand are sub-litharenite to lithic arenite and mineralogical analysis indicated that most of sand dunes are mainly consist of quartz and carbonate rock fragments in addition to rare feldspar and mica where quartz prevail the mineralogy of all sand dunes due to the selective wind sorting which concentrates more quartz grains, and to the aeolian weathering activity which has depleted the feldspar grains through subaerial collisions. Fine grained mean grain size, very well to moderately sorted, near symmetrical skewness with leptokurtic distribution are characterized the sand dunes in the study area. These statistical parameters show that the sand dunes are extremely controlled by sedimentary sources (Injana Formation sediments). Also, the rarities of organic materials within the sand dunes indicate to the rarity of coverage plant within the seasonably moved sand dunes.

Several transparent heavy minerals are identified in the sand dunes such as Tourmaline, Hornblende, Olivine, Chlorite, Ankerite and Zircon with well rounded edges due to the transportation, in addition to opaque heavy minerals of iron oxide like Magnetite, Hematite and Chromite concentrated within sand fraction. Atomic absorption analysis distinguished many types of major and trace elements in the sand dunes too. These heavy minerals and trace elements refer to that the sand dunes were derived from ancient igneous and metamorphic rocks which eroded and deposited later within Injana Formation.

Introduction

Sand dunes are mounds or ridges shapes forming by accumulations of sand grains due to the wind and the gravity influence [1]. They form when sand moves by wind with various styles like saltation of sand grains under direct wind pressure, grains coarser than one millimeter in diameter move by surface creep and smaller sand grains moves is by suspension [2]. Sand dunes classify to different types dependent on the number and slip-face resulting from the wind dominant directions [3], where single slip-face like Barchan sand dunes which have crescent shape develop with low amount of available, when more amount of sand grains are accumulate the Barchanoid ridge type is formed from merging the first type and with continuity of sand accumulation the second type grade into the Transverse sand dunes type. Two slip-faces sand dunes indicate to two different wind directions such as the Seif (Linear) sand dunes which form as narrow longitudinal dunes with steep crest form as Aeolian inland dunes. Another type of two slip-face dunes is Reversing dunes which form immediately after changing the wind direction by opposite side. Three or more slip-faces type is related to multi-directional wind is known as Star dunes. The Parabolic dune is another sand dunes type with crescent form and less mobile slips due to the vegetation [4]. The dominant sand dunes type covered the study area is Barchan sand dunes.

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Several previous studies were carried out on sand dunes in the areas neighboring Tikrit city such as study of the morphology, distribution and orientation of sand dunes in Baiji area by [5]. The early Pleistocene sediments in the area lies between the Fat'ha and Baghdad city were studied by [6] who pointed that these sediments and sand dunes were produced as fluvial fans of Tigris River. The nature and movement of sand dunes using remote sensing techniques in Baiji area indicate that the desertification and sand dunes were increased due to aridity and badly uses of earth for agriculture [7]. The role of sand dunes in recharging of ground water in Na'ama area was given by [8] who showed that the sand dunes could be as internal hydrogeological boundary of water basin control the ground water recharge. [9] pointed that the northwest-southeast direction of the sand dunes is formed under the influencing of the prevalent windward that blown from the northwest during the dry seasons where the sands are unconsolidated. On contrast, the winter season characterize by southeast windward where the sand particles are consolidated due to the moisture content and the desert plants.

The study area is located to the eastern of the Tigris river and south of Hemrin mountain near the Na'ama village about (24 km) from Tikrit city in Salah alddin governorate between (43° 57′ - 44° 03′) longitude and (34° 42′ - 34° 37′) latitude with elevation about (71-116 m) above sea level (Figure1), and tectonically it is located in Hemrin - Makhul Subzone within Foothill Zone part of the Unstable Shelf [10].

Geologically Many types of rocks are outcropped in the study area. These rocks belong to different ages extend from Miocene up to Pleistocene which overlain unconformable by the Quaternary deposits. The exposed sedimentary sequence (from older to younger) is composed as following [10]:

1- Injana Formation: This formation has widespread distribution in the study area and it overly the Fat'ha Formation by a conformable contact. This formation is composed of alternation of reddish brown, calcarea, claystone, siltstone and sandstone. This formation has been deposited in a fluvitial environment and it belongs to the Late Miocene [11].

2- Quaternary deposits: These deposits overly the Injana Formation unconformabely, and they consist of intermixed sand, clay, gravel and silt. The main types of Quaternary deposits in the study area are represented by flood plain deposits, slope sediments, valley fillings, gypseous soil and gypseous. The age of these deposits is Pleistocene-Recent [7].

The study area is characterized by Barchan dunes which have crescent shape and comprise only a small percentage of the world's dune areas and tend to develop where limited amounts of sand are available [12]. These sand dunes are extended to the northwest-southeast direction in the study area.

Ten samples from three sand dunes as well as interdunes were selected; the wind side with slope angle about (10° -16°), peak and lee side with slope angle about (33°) while the interdunes area was characterized by desert plants.

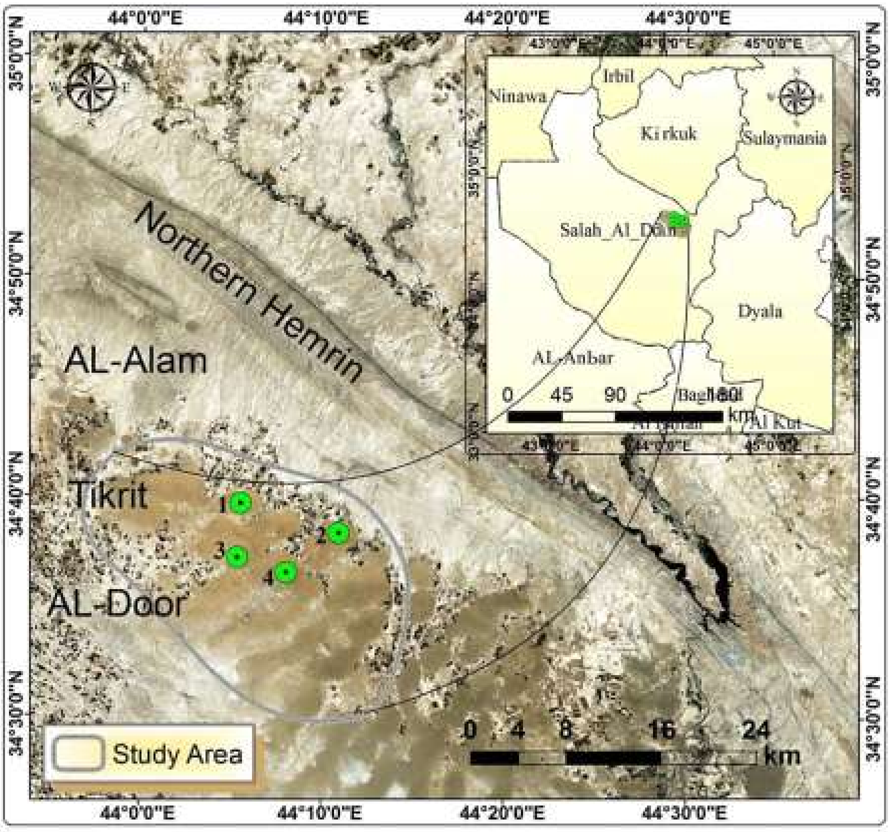

Figure (1) Location map of study area

Aims of Study

This topic aims to the following:

1. Investigate the types of sand dunes in the study area.

2. Determining the provenance of the sand dunes in the study area based on the sedimentology, modal analysis and geochemistry of major and trace elements of the sands.

3. The specific aim of this paper is to observe the grain size parameters, petrographic and geochemical data as a contribution to the origin attributes, heavy mineral concentrations in the sand dunes of the Na'ama village, to gain insight into the mineral distribution, the mineralogy and comment on the economic potential of prospecting for the heavy minerals.

Climate of the studied area:

In according to the aridity index associated with soils and vegetation information, Iraq is considered as arid to semi-arid region [13]. Rainfall, temperature and relative humidity represent the main climatic elements in the study area indeed to the wind which is considered an effective geomorphic agent. The available records in Tikrit climatic station for the period (1988-2011) indicated that the mean annual wind direction at the study area is north westerly and wind velocity is greater during the day than at night and greater in the summer than in winter [9] which is suitable to form sand dunes from climatic element [7]. The study area is recognized as rainless, hot to very hot in summer with average annual rainfall between (0-0.6mm) and maximum temperature exceed to (36°C) and lowest value of relative humidity less than (21.7%) in July. On the other hand, it is represented by a rainy winter with annual rainfall ranging (22.1-33.2 mm) and lowest temperature less than (8.7 °C) and highest value of relative humidity about (75.2%) in January. So, the climatic of the study area was identified as a semi-arid region [14 and 9].

Materials and Methods

1. The field work of the sand dunes include determination the types of sand dunes by measuring the height, orientation, the wind side, lee side slopes and sand sheets of the dunes.

2. Collecting (10) samples from the wind side, lee side and sand sheets and grain size analysis are made.

3. Four fine grained sand samples (2-3 φ) from peaks of studied sand dunes and interdunes are picked for heavy minerals separation by bromoform liquid in the laboratories of Applied Geology Department in Tikrit University using [15] method.

4. Atomic absorption for major and trace elements on (4) samples from crests of three sand dunes in addition to interdunes are made in Chemical Engineering Department laboratories in Tikrit University.

5. Petrographic and mineralogical identification are carried out in order to determination the composition and origin of sand dunes.

Petrographic and Mineralogical Study of sand dunes

Analysis of grain size distribution has been widely used by geologists to classify sedimentary environments and determine the dynamics of transportation where the grain size distribution is controlled by the type of the source rocks with the weathering and erosion processes during the transportation [16]. Long aeolian transportation produces well sorted and fine-grained sand dunes [17]. Much evidence about the origin of the sand dunes can be given by the geochemical and mineralogical studies [18]. The abundance of quartz in the sand dunes refer to the maturity which is related minerals stability such as feldspar when they are affected by either the collision in high energy aeoline environment or by the chemical weathering [19]. The grain sizes of sediments provide an indication of the shear stress that must be applied by the medium to initiate and sustain particle movement. Grain size distribution is affected by other factors such as source material, distance from the source, topography and transport mechanisms. The vegetation composition was extensively influenced by the mean particle size of the sand where the fine grained sand had high species diversity in contrast to those with medium-grained sand which were mostly unvegetated or sparsely vegetated; these differences may be accompanied by differences in chemical composition and/or substrate processes [20].

Three sand dunes were selected for this study in addition to the inter dune area, and ten loose dry samples have been sampled with (250 gm) weight and analyzed using dry sieving analysis with (-1 , 0, +1, +2, +3 and +4 phi). The samples were picked from lee ward, crest and wind ward rather than the inter dune area. The sieve analysis show that most samples are composed of sand with average weight percent more than (99.8%) ranging between (97.95-99.39 %) while rare percent of mud fractions (silt and clay) are represent the rest composition of sand dunes with average weight percent less than (1.2%) ranging between (0.61-2.05%) (Table1).

Roundness number of each grain has been calculated by Wadell's method using Krumbien's chart (1941) in [15]. The sand dunes have moderate average roundness which increases in the fine grades The weight percent of each fraction has been calculated (Tables 2, 3, 4 and 5) and the cumulative percentages were drawn versus grain size in phi unit on a logarithmic probability papers (Fig. 2) Then, the statistical parameters by [21] like median (Md Φ), mean size (Mz Φ), sorting (σ Φ) and skewness (Sk) were calculated (Table 6) according to [22] formula as below:

$$Md\,(\emptyset) = \emptyset\,50$$

$$\text{Mz}\,(\emptyset) = \frac{\emptyset 16 + \emptyset 50 + \emptyset 84}{3}$$

$$\sigma\,(\emptyset) = \frac{\emptyset\,84 - \emptyset\,16}{4} + \frac{\emptyset\,95 - \emptyset\,5}{6.6}$$

$$\text{SK}\,(\emptyset) = \frac{\emptyset\,16 + \emptyset\,84 - 2\,\emptyset\,50}{2\,(\emptyset\,95 - \emptyset\,5)} + \frac{\emptyset\,5 + \emptyset\,95 - 2\,\emptyset\,50}{2\,(\emptyset\,84 - \emptyset\,16)}$$

Table (1) Average percent of sand and mud components in the studied sand dunes

Section Grains	Wind side	Peak	Lee side	interdune	Average Weight Percent
Sand (average %)	99.20	98.85	97.95	99.39	98.8475
Mud (average %)	0.8	1.15	2.05	0.61	1.1525

Table (2) Grain size analysis of sand dunes 1

Sieves size(Ø)	Wind side			Peak			Lee side		
	Weight (gm)	Weight (%)	Accumulative weight	Weight (gm)	Weight (%)	Accumulative weight	Weight (gm)	Weight (%)	Accumulative weight
-1	–	–	–	–	–	–	–	–	–
0	–	–	–	–	–	–	–	–	–
1	5.61	2.244	2.244	1.74	0.696	0.696	0.59	0.236	0.236
2	180.0	72.00	74.244	135.66	54.264	54.96	58.85	23.54	23.776
3	49.52	19.808	94.052	90.05	36.02	90.98	140.59	56.236	80.012
4	11.42	4.568	98.62	15.64	6.256	97.236	37.65	15.06	95.072
Pan	3.43	1.372	99.99	6.88	2.752	99.988	12.32	4.928	100.00

Table (3) Grain size analysis of sand dunes 2

Sieves size(Ø)	Wind side			Peak			Lee side		
	Weight (gm)	Weight (%)	Accumulative weight	Weight (gm)	Weight (%)	Accumulative weight	Weight (gm)	Weight (%)	Accumulative weight
-1	–	–	–	–	–	–	–	–	–
0	–	–	–	–	–	–	–	–	–
1	–	–	–	–	–	–	–	–	–
2	8.0	3.2	3.2	5.11	2.044	2.044	22.5	9.0	9.0
3	182.24	72.896	76.096	217.65	87.06	89.104	190.31	76.124	85.124
4	57.67	23.068	99.164	26.38	10.552	99.656	34.39	13.756	98.88
Pan	2.09	0.836	100	0.86	0.344	100	2.79	1.116	99.996

Table (4) Grain size analysis of sand dunes 3

Sieves size(Ø)	Wind side			Peak			Lee side		
	Weight (gm)	Weight (%)	Accumulative weight	Weight (gm)	Weight (%)	Accumulative weight	Weight (gm)	Weight (%)	Accumulative weight
-1	–	–	–	–	–	–	–	–	–
0	–	–	–	–	–	–	–	–	–
1	–	–	–	–	–	–	–	–	–
2	0.80	0.32	0.32	2.44	0.976	0.976	2.5	1	1
3	226.90	90.76	91.08	228.86	91.544	92.52	238.5	95.4	96.4
4	21.85	8.74	99.82	17.81	7.124	99.644	8.75	3.5	99.9
Pan	0.45	0.18	100	0.87	0.348	99.992	0.25	0.1	100

Table (5) Grain size analysis of interdunes

Sieves size(Ø)	Inter dunes		
	Weight (gm)	Weight (%)	Accumulative weight
-1	–	–	–
0	5.38	2.152	2.152
1	111.22	44.488	46.64
2	79.0	31.6	78.24
3	44.07	17.628	95.868
4	8.82	3.528	99.396
Pan	1.5	0.6	99.996

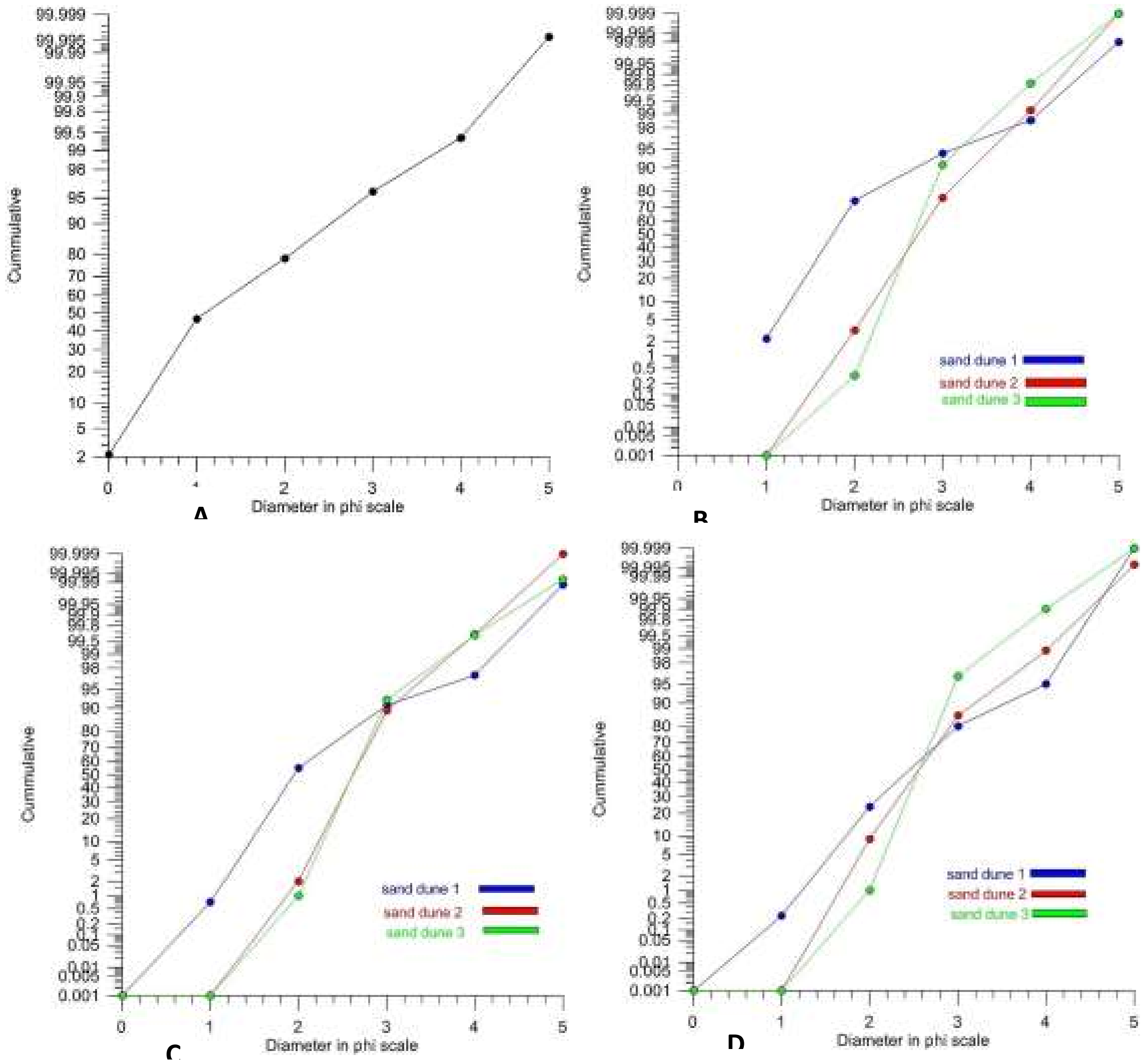

Figure (2) Cumulative curves of grain size analysis:

A- Inter dunes. B- Windward dunes C- Crest dunes D- Leeward dunes

The similar shape of inter dunes and wind direction cumulative curves indicate similarity in the source and transportation mechanism of sand dunes (Figure 2A & B), and the steepening of most cumulative curves may be resulted from the selective sorting of wind transport agent.

Table (6) Statistical parameters of grain size analysis

Static Parameters (φ)	Wind side				Crest				Lee side				Inter dune	
	Sand dune 1	Sand dune 2	Sand dune 3	Descript-ion	Sand dune 1	Sand dune 2	Sand dune 3	Description	Sand dune 1	Sand dune 2	Sand dune 3	Description		
Median (md)	1.75	2.7	2.68	Fine sand	1.95	2.62	2.62	Fine sand	2.45	2.58	2.58	Fine sand	2.62	Fine sand
Mean size (Mz)	1.83	2.72	2.67	Fine sand	2.09	2.62	2.62	Fine sand	2.48	2.57	2.57	Fine sand	2.62	Fine sand
Sorting (ð)	0.53	0.43	0.26	Very well to moderately	0.61	0.32	0.28	Very well to moderately	0.69	0.45	0.24	Very well to moderately	0.27	Very well sorted
Skewness (SK1)	0.30	0.12	0.01	Near symmetrical to fine	0.39	0.07	0.06	Near symmetrical to very fine	0.16	0.04	- 0.03	Near symmetrical to fine	0.07	Near symmetric
Kurtosis (KG)	1.48	1.24	1.20	Leptokurtic	1.14	1.09	1.14	Leptokurtic	1.11	1.17	1.05	leptokurtic	1.33	leptokurtic

The statistical parameters show that the studied sand dunes are fine grained moderately to very well sorted and they have median with little range between (1.7-2.7 φ) which indicate to low air density [23]. The mean grain size ranging (1.83-2.72 φ) as fine grained sand and the sand dunes were very well to moderately sorted with standard deviation value (0.24-0.69 φ) with fine to near symmetrical skewed where the stoss

side and the crest were fine skewed with skewness values ranging (0.01 to 3.0 φ) for the stoss side and (0.06 to 0.39 φ) for the crest, while the lee side was near symmetrical skewed with skewness values (-0.03 to + 0.16 φ) which mean that the fine grains in the lee side were less concentration from both crest and stoss side. The sediments were represented by leptokurtic kurtosis with (1.05-1.48 φ). One of the reasons dune sand is so well sorted is the narrow size range (2-3 Φ) of sand that wind can move under most conditions [24].
There are no substantial changes are shown in the values of the grain-size, sorting, skewness and kurtosis between the crest and both the leeward and the windward of the sand dunes where the grain size variations are related the height of the sand dunes [25].
In this study, the field observations show the studied sand dunes are less than (3 m) high. Therefore, they may slightly control over the homogeneity of the grain-size distribution. Nevertheless, relationships between grain-size distributions and the height of sand dune cannot be depended as a general rule because there are many factors may be control the grain size distributions in the sand dunes like aeolian transport (e.g. creep, saltation and suspension) and wind patterns [26]. The kindred values of the sorting between the crest and the flanks of the sand dunes may be refer to the fact that the dune morphology practice control over the sorting and to the grain-size distribution of the one hypothesized sediment source that generates only particles ranging (1.83-2.72 φ); hence, dunes have better sorted sands. It could also refer to the long distance from the source, which allows for longer aeolian transport and better sorting of the sands. The skewness and kurtosis values are characterized as unimodal character of curves which indicate that the sands are produced by only one sediment source [27].
The petrographic study show that quartz represents most of mineralogical composition of the light minerals of sand dunes with average of (70%), rock fragments of carbonates and gypsum particles (20%), feldspar (8%) with other particles about (2%). Heavy mineral fraction from four samples from the crest of each sand dunes rather than to the inter dunes with (59 gm) weight of fine to very fine grained size sand restricted between (2-3 φ) have been separated by using bromoform liquid [20] and examined under microscope and it was found that the heavy minerals form about (1.1-3.4%) of the total percent weight of the mineralogy of sand dunes where the opaque minerals form (16%) of the total percent weight of heavy minerals and they are represented by Magnetite, Hematite, Chromite whereas the non-opaque minerals form (84%) and include Tourmaline, Hornblende, Olivine, Chlorite, Ankerite and Zircon (Table 7) and (Fig.3).

Table (7) Heavy minerals in the studied sand dune

Samples	Magnetic minerals (Opaque)			Non-magnetic minerals (Transparent)			Total	
	Gm	%	Magnetite, Hematite, Chromite	Gm	%	Tourmaline, Hornblende, Olivine, Chlorite, Ankerie and Zircon	gm	%
Sand dune (1)	0.182	0.3		1.840	3.1		2.022	3.4
Sand dune (2)	0.218	0.3		0.954	1.6		1.172	1.9
Sand dune (3)	0.426	0.7		1.323	2.2		1.749	2.9
Inter dunes	0.068	0.1		0.594	1.0		0.662	1.1

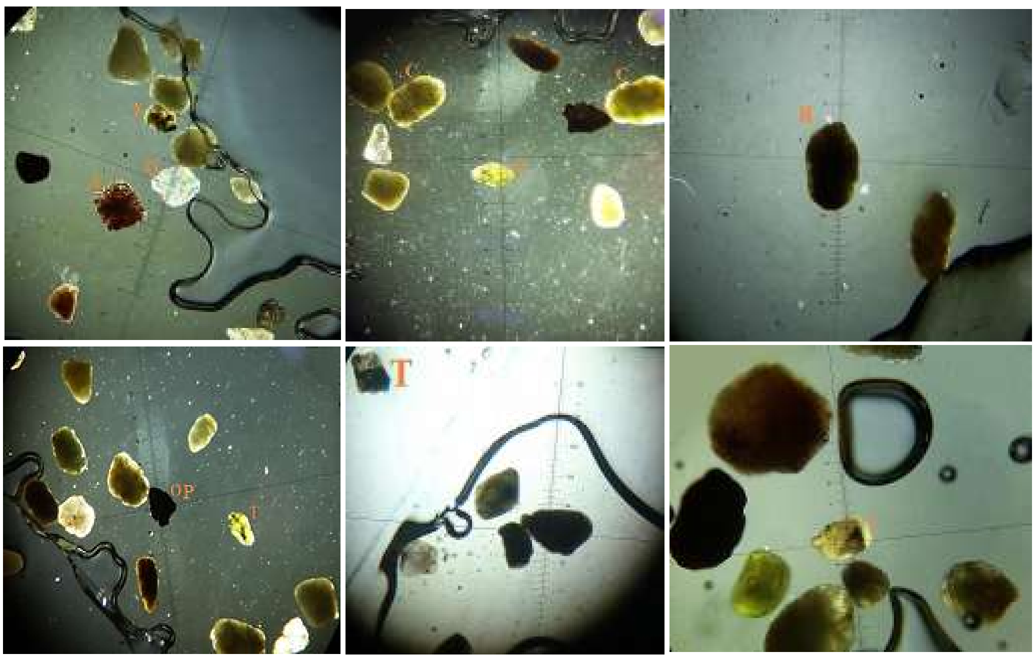

Figure (3) Heavy minerals of studied sand dunes include Tourmaline (T), Olivine (O), Hornblende (H), Chlorite (C), Ankerite (A) and Opaque mineral (OP)

Because sorption properties of the mineral are associated with the clay and silt-size fractions [28], four samples of sand dunes with fine grained size (4 φ) are analyzed using the atomic absorption technique in order to determining the trace elements (Table 8) that can be useful in concluding the origin of the parent rocks provide sand dunes sediments. The trace elements that are determined in this study include: Cd, Pb, Ni, Cu, Zn, Fe, Cr, Co, Mn, Se, and Ag in addition to Mg, K, Ca and Na.

Table (8) Trace elements of studied sand dunes (measured with ppm unit)

Samples	Cd	Pb	Ni	Cu	Zn	Fe	Cr	Mg	Co	K	Mn	Se	Ag	Ca	Na
Dune(2)	<0.1	0.12	18	14.3	29	729	0.2	2400	0.1	2160	9.2	0.31	0.1	1122	2820
Dune(3)	0.13	<0.1	22	12.1	32	816	0.5	2380	0.21	2180	8.6	0.41	0.11	1032	2760
Dune(4)	0.23	0.13	19	9.3	28	780	0.3	2420	0.15	2120	7.8	0.21	0.11	1060	2612
Inter dune	0.21	0.11	32	7.8	31	754	0.3	2370	0.14	2009	6.69	0.19	0.12	1112	2709

Among the rife primary minerals in sediments derived from the source rocks plagioclases (Na ≈ Ca) are considered more susceptibility to weathering processes than K-feldspar and muscovite while quartz is more stable [28] therefore, the enrichment of quartz in studied sand dune probably could be resulted either from its stability during the weathering or the maturity process, where the source rocks might provide quartz-rich sediments. This interpretation is supported by the high content of sedimentary lithic probably derived from sedimentary outcrops of the Injana Formation in the study area. The low percent of feldspars may be imputing to low relative resistance to weathering and their alterations provide materials for clay mineral formation. Carbonates (calcite, dolomite) and metal oxides are usually accessory minerals in soils of humid climatic zones, while they may be significant soil constituents in soils of arid climatic zones [28].

On the other hand, used the heavy-minerals are suit to conclude that the sand derived mostly from the older igneous and metamorphic rocks. Independent on [29], Tourmaline is widespread in detrital sediments and it is inherited from metamorphic and basic igneous rocks and it seems to be rounded edges which associated with Zircon as mature sediments, Olivine has spherical shape with rounded edges may be derived from older basic igneous rocks and because of the unstable nature it may be found only in quaternary and recent sediments, Hornblende is derived from the older igneous and regional metamorphic rocks where it is characterized by cylindrical shape with rounded edges which indicate to aeolian sediments in studied dunes, Chlorite is spread out in both metamorphic rocks with low grade metamorphism and igneous rocks rather than it can forms due to weathering and diagenesis processes on sedimentary rocks, Ankerite perhaps occur as cement in iron rich sediments and Zircon is derived from the intermediate igneous rocks and it is characterized by rounded edges which may indicate to the detrital origin with long distance transport.

In accordance to [30] and [28], Cu is inherited from mafic and intermediate rocks with mean levels for Cu vary from (13 to 24 ppm) in the Earth's crust where it is found with normal level in the studied sand dunes ranging between (7.8- 14.3 ppm). The lowest value is determined within the inter dunes. The common range of Ag in sediments is (0.03 to 0.4 ppm) and the range of its concentration in studied dunes is ranging between (0.1-0.12 ppm). Zn distribute in the magmatic rocks, mafic rocks, acid rocks (40-120 ppm) and argillaceous sediments (80-120 ppm) while the concentration of this metal element decrease in sandstones and carboniferous rocks to be (10-30 ppm) and it found with concentration range between (28-31 ppm) in studied sand dunes. Cd occur in argillaceous and shale deposits, magmatic rocks and sedimentary rocks abundance less than (0.3 ppm) independent on the source rocks where its content in the studied sand dunes ranging (less than 0.1–0.23 ppm). Pb has terrestrial abundance within Earth's crust about (15 ppm) where it concentrate in the acid series of magmatic rocks and argillaceous sediments with less abundance in ultramafic rocks and calcareous sediments range from (0.1 to 10 ppm) where it is found with concentration range (less than 0.1-0.13 ppm) in studied sand dunes. Likewise Cr has terrestrial abundance associated mainly with ultramafic and mafic rocks whereas it has low abundance in both acid igneous and sedimentary rocks where its content is depended on parent rocks in which it increase in both mafic and volcanic rocks while the sand sediments are poorest in Cr where it found with low values ranging between (0.2-0.5 ppm) in the studied sand dunes. Se occurs in magmatic rocks and it is associated with the clay fraction therefore, it has small values in sandstones and limestones with an average of (0.33ppm) where it where it found in studied sand dunes with concentration range (0.19-0.41 ppm). Mn also has high abundant within the lithosphere associated with mafic rocks and it has concentration range from (6.69 to 9.2 ppm) in the studied samples. Fe has wide distribution within lithosphere and mostly inherited from the mafic series of magmatic rocks and it occur concentration ranging between (729-816 ppm) in the studied sand dunes where it could be associated with Hematite and Magnetite heavy minerals. Fe and Mg occur with heavy minerals associated with plutonic and sedimentary source [31]. Co has wide spread in ultramafic rocks (100-200 ppm) while it has lesser concentration within sedimentary rocks (0.1-20 ppm) and it may be related with clay minerals or organic matter and it is found in studied sand dunes with concentration ranging between (0.1–0.21 ppm). Ni is abundant in ultramafic rocks with lesser content in acidic rocks while its concentration within sedimentary rocks ranging from (5 to 90 ppm) where the value increase in argillaceous rocks and it decrease with sandstone and it concentrate in studied sand dunes in range (18-32 ppm) where the highest content is found interdunes. Ca content within studied sand dunes is ranging between (1032-1122 ppm) and it may be derived from carbonate rocks.

Conclusions

The main conclusions that have been deduced from the current study of the sand dunes can be summarizing as the following:

1. Burchan is predominant morphological types in the active belt of sand dune in the study area due to unidirectional wind.
2. The grain size analyses show that the studied sand dunes are consisted of well sorted fine grade which could be resulted by wind selectiveness and long distance transportation from the source.
3. In the study area sand dunes have low height not exceed (3.5 m) therefore, there are no significant control have been exerted over the grain size distributions of the studied dunes.
4. The mineralogical study indicates that sand dunes are composed of different components such as quartz, rock fragments of carbonate gypsum particles and rare feldspar in addition to different types of heavy minerals like Tourmaline, Hornblende, Olivine, Chlorite, Ankerite, Zircon, Magnetite, Hematite and Chromite.
5. Quartz enrichment of the studied sand dunes may be inherited from quartz-rich parent rock which is represented by Injana Formation that enriched with quartz and sedimentary lithics, and due to the aeolian activity, which exhaust the feldspar grains by subaerial collisions.
6. Heavy minerals in the studied sand dunes indicate that most of them have been derived from older mafic and ultramafic igneous rocks and metamorphic rocks which suffered from long distance of transportation and redeposited within sedimentary source.
7. Trace elements demonstrate that they are imparted with heavy minerals which seem to be from sedimentary source presented by Injana Formation.

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مصدر واصل الكثبان الرملية في منطقة الناعمة / جنوب شرق مدينة تكريت شمالي العراق

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الملخص

نمذجت (10) نماذج من ثلاث كثبان رملية هلالية الشكل (برخان) في منطقة الناعمة جنوب شرق مدينة تكريت شمالي العراق ودراستها بتروغرافيا ومعدنيا وجيوكيميائيا بعد اجراء التحليل الحجمي عليها، وبشكل عام فإن الكثبان الرملية تتألف من الرمل بنسبة اكثرمن (98.8 %) بينما يشكل الطين نسبة لا تزيد عن (1.2 %)، وقد تمثلت الحبيبات في الكثبان بكونها شبه مستديرة الى شبه زاوية الحواف، وقد بين الوصف البتروغرافي والتحاليل المعدنية ان رواسب الكثبان هي رمال شبه لث ارينايت ولث ارينايت حيث تتكون بشكل رئيس من معدن الكوارتز تليه قطع صخرية كربوناتية اضافة الى تواجد نادر للفلدسبار والمايكا. يمثل الكوارتز المعدن السائد والأكثر شيوعا في ترسبات الكثبان نتيجة الفرز الإنتقائي للرياح التي تعمل على تركز الكثير حبيبات الكوارتز وكذلك نتيجة فعالية التجوية الهوائية التي تعمل على استنزاف حبيبات الفلدسبار نتيجة التصادم شبه الهوائي. تمثلت الكثبان الرملية في منطقة الدراسة بكونها ذات حجم حبيبي ناعم وفرز متوسط الى جيد جدا والتواء شبه متناظر وتفرطح مدبب مما يعني ان هناك مصادر رسوبية تتحكم بشدة في تشكل هذه الكثبان (مثل ترسبات تكوين انجانة المنكشف على السطح) كما تدل ندرة المواد العضوية في الكثبان قيد الدراسة على ندرة الغطاء النباتي في الكثبان الرملية موسمية الحركة.

شخصت عدة انواع من المعادن الثقيلة الشفافة كالتورمالين والهورنبلند والأوليفين والكلورايت والانكرايت والزركون وقد امتاز معظمها بحواف مستديرة بشكل جيد، كما تواجدت اكاسيد الحديد كمعادن ثقيلة معتمة مثل الماكنيتايت والهيماتايت والكرومايت ضمن الحبيبات الرملية، وقد اوضحت تحاليل الإمتصاص الذري وجود عدة انواع من العناصر الرئيسة والعناصر النادرة ضمن الكثبان الرملية قيد الدراسة، وقد دلت المعادن الثقيلة المشخصة وكذلك العناصر النادرة الى ان هذه الكثبان قد اشتقت من صخور نارية ومتحولة قديمة تعرضت للتعرية ثم الترسيب لاحقا ضمن ترسبات تكوين انجانة.