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Mineralogy of Duné s Sand of Missan Dune Fields Southeastern Iraq

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Abstract

The aim of this study is to define the mineralogical composition of Missan dune fields South Eastern of Iraq, and try to determine the origin or the source of these dunes .

Three main types of dunes were recognized in the studied area, these are: barchanoid ridge, barchans and nabkha dunes. The direction of these dunes is northwest to southeast .

The dunes in Missan dune fields were divided into three fields according to the varieties in the composition and geographical position in the studied area, these three fields are: Al-Manziliyah, Middle Chailat, and Said Subair dune fields .

9 samples were collected from these fields, the samples were separated into light and heavy fraction by heavy liquids. The light fraction composed from quartz, feldspar, and rock fragments, the rock fragments composed mainly of carbonate, chert, igneous, and metamorphic rock fragments .

The heavy minerals are mostly opaques, chlorite, pyroxenes, amphiboles, epidotes, zircon, garnet, muscovite, biotite, kyanite, staurolite, and rutile .

The percentages of heavy minerals fraction to light minerals fraction was very variable in which the percentage of heavy minerals in Sayid Subair field are higher than the percentage in Al-Manziliyah field.The source area of these sediments is the recent sediment that deposited in the flood plain and traces of the Tigris river and the outcrops of upper Miocene-Pliocene rocks in the eastern of studied area (Himreen Anticline and Zagros Mountain).

Keyword: Heavy Minerals, Sand Dunes, Barchan dunes.

الخلاصة

تهدف الدراسة الحالية لمعرفة المحتوى المعدني لحقل الكثبان الرملية في منطقة جلات ضمن محافظة ميسان جنوب شرقي العراق ومحاولة تحديد اصل ومنطقة المصدر لرمال هذه الكثبان.

تم تحديد ثلاثة أنواع من الكثبان في منطقة الدراسة وهي الحواجز الهلالية وكثبان البرخان وكثبان النبخة وكان الاتجاه العام لهذه الكثبان هو شمال غرب – جنوب شرق تم تقسيم حقول كثبان ميسان الى ثلاثة حقول ثانوية وهذا التقسيم تم بالاعتماد على التغير في التركيب المعدني وكذلك التجمع الجغرافي وهذه الحقول الثلاثة هي حقل المنزلية وحقل جلات الوسطي وحقل سيد صبير.

تم جمع ٩ نماذج من رمال الكثبان الرملية وتم فصل المعادن الخفيفة عن المعادن الثقيلة بواسطة استعمال السوائل الثقيلة.

الجزء الخفيف مكون بصورة رئيسية من الكوارتز والفلدسبارات والقطع الصخرية. القطع الصخرية مكونه بصورة رئيسية من الكربونات والصوان وقطع الصخور النارية والمتحولة.

المعادن الثقيلة مكونه بصورة رئيسية من المعادن المعتمة والكلورايت والبايروكسينات والامفيبولات والابيدوت والزركون والكارنت والمسكوفايت والبايوتايت وبصورة اقل من الكيانايت والشترولايت والروتايل.ان نسبة المعادن الثقيلة الى الخفيفة كانت اعلى نسبيا في حقل سيدصبير منها في حقل المنزلية وجلات الوسطي .

ان مصدر رواسب الكثبان الرملية في حقل كثبان جلات هو السهول الفيضية والمصاطب النهرية لنهر دجلة وكذلك المكاشف الصخرية القديمة العائدة للمايوسين الاعلى – البلايوسين التي تتكشف في الجزء الشرقي لحقل كثبان جلات ضمن تلال حمرين وجبال زاكروس.

الكلمات المفتاحية: المعادن الثقيلة, ألكثبان الرملية, الكثبان الهلالية .

1- Introduction

Sand dunes are the results of complex physical interactions between wind flow and sand bed in desert area. Schematically, the wind is able to set sand grains into motion, and by this mean, to change the shape of the dune. Reciprocally, the dune is large enough to modify the flow pattern of the wind. The equilibrium between the two leads to the selection of shape and dynamics of dunes. The results have been studied in deserts for 50 years by geologists and geographers [1], [2], [3].

The mineralogy of clastic sediment found in sand or sandstone provides important clues about its origin, including source rock lithologies and transportation history. In addition to the major constituents of sand or sandstones (quartz, feldspars, and lithic fragments), sandstones contain minor abundances of other mineral grains, including heavy minerals (densities greater than 2.85 g/cm3). Heavy minerals reflect the source area because different rock types contain different heavy mineral assemblages [4].

Identification of mineralogical specifications of sand dunes have been performed to determine the sand source of dunes, description of their properties, stabilizing the dunes, study of sand dunes activity and Their economical importance [5] [6] [7]

Heavy minerals are defined as minerals having a higher density than quartz, the most common rock-forming mineral with a density of 2.65 g/cm^3. In practice, only those minerals that are heavier than the dense media most commonly used in the lab-bromoform (2.89 g/cm^3) or tetrabromomethane (2.94 g/cm^3) – i.e. that sink in these media, are included in the group of heavy minerals. In contrast, minerals with a lower density than heavy minerals, e.g. Quartz, Feldspars, calcite, dolomite, aragonite, and evaporites, are called light minerals [8] (Elsner, 2010). Heavy minerals can be very useful, particularly when interpretation of the major constituent grains is ambiguous [9].

Heavy mineral analysis begins with disaggregation of grains and sieving to obtain a particular size range, typically in the fine to medium sand size range. Heavy minerals are separated using a heavy liquid with a density of 2.85 g/cm^3. In traditional analysis, the separated heavy mineral grains are mounted on a glass slide and then identified and counted using transmitted light microscopy [10] [11].

Heavy mineral analysis is one of the most sensitive and widely used techniques in the determination of sand and sandstone provenance. The heavy mineral assemblage is not only controlled by the mineralogical composition of the source region but is also modified by several other processes that operate during the sedimentation cycle [12].

2-Location of Study Area

The area of study include the sand dunes fields that are located in Missan Governorate (Figure.1).

This field represents the south eastern part of the north east belt in Iraq (Baiji – Badra-Altib). This Field is located in Missan Governorate, east of Ali Al-Gharbi Town, between latitude (32° 28′ 00″)N and (32° 39′ 00″)N, and longitude (46° 39′ 00″)E and (47° 03′ 00″)E, The dimensions of this field occupy about (75) Km^2.

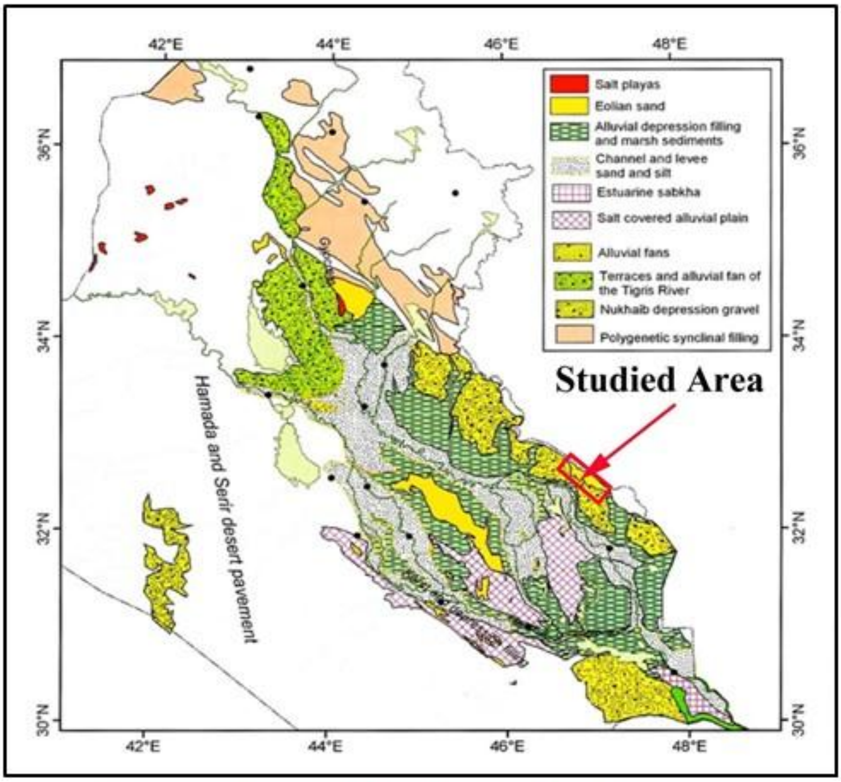

Figure.1: Location Map of study dune fields (13)

3- Geology of Study Area

The area of study located to the east of Ali Al-Gharbi Town in Missan Governorate (Chailat sand dune field) is bordered in east by the outcrops of Upper Miocen-Pliocene formations (Injana and Muqdadiya formations that extend from Al-Teeb east of Amarah city [14] [15] [16]. Missan dune fields represents one of the active dune fields in the eastern belt and it lies within the Mesopotamian plain to the west of the western flank of the asymmetrical Himreen anti- cline (Figure 2). The flood plain of Tigris River occupies the western part of this field [17].

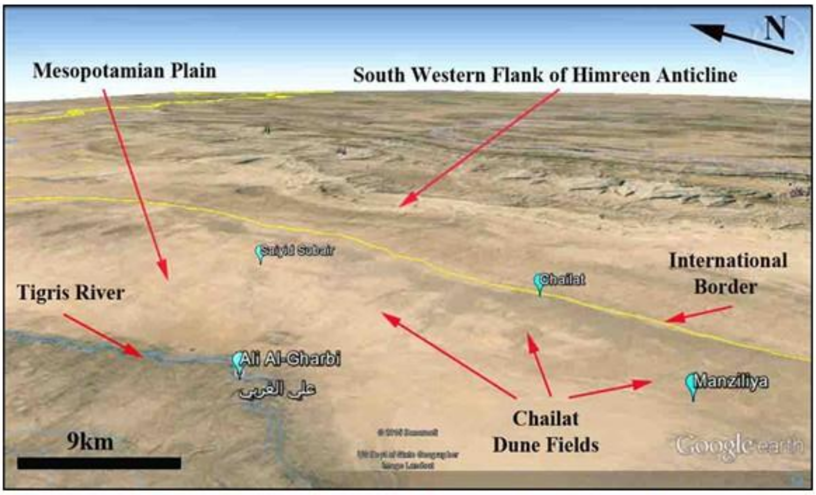

Figure.2: Inclined Google view showing the Missan dune fields (18).

These fields are divided into three smaller fields depending on the previously mentioned factors these are: Sayid Subair dune field, Middle Chailat dune field, and Al-Manziliyah dune field (figure 3).

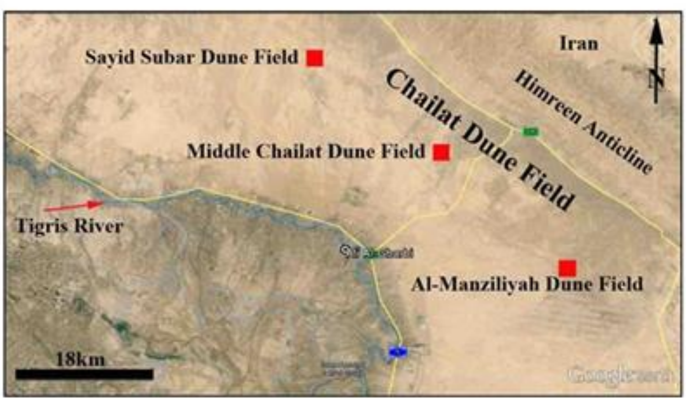

Figure.3: Google view shows the three divisions of Missan dune field (18).

Morphologically barchans dunes represent the major type in both size and shape observed in Missan dune fields.

Barchans dunes in Missan dune fields concentrated in Al-Manziliyah, Sayid Subair, and Middle Chailat dune fields in decreasing order .

The dimension of these dunes ranges from 2-10m in height, 15-70m in width, and 15-75m in length, the shape of these dunes range between symmetrical to asymmetrical (Figure. 4).

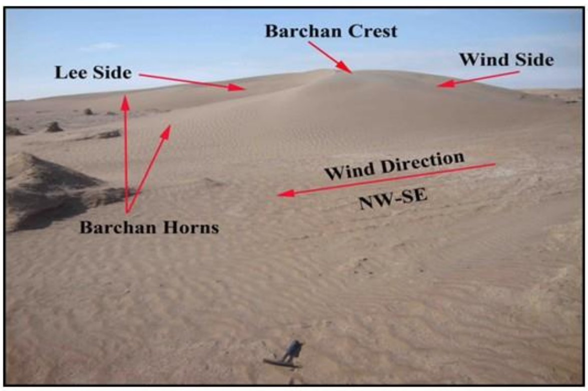

Figure.4: Barchan dune, Al-Manziliyah dune field, Missan Governorate.

The barchanoid ridges were observed in many areas of the studied dune fields, the distribution and density of barchanoid ridges varies from one area to another. These dunes represent a late stage of dune formation in which the movement and migration of many barchans that have different velocities are coalesced and accumulation. The main axis of the barchanoid show perpendicularity to the main wind direction (Figure. 5)

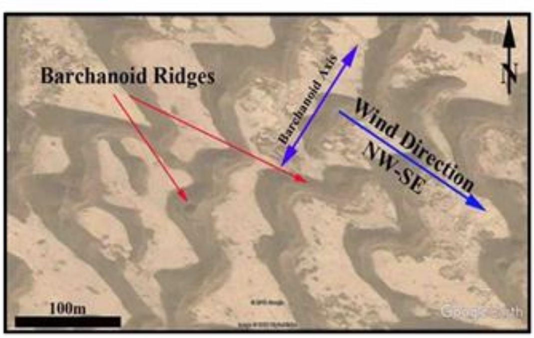

Figure.5: Google View showing the barchanoid ridge in Al-Manziliyah dune field, Missan governorate (18).

Nabkha types were observed in large concentration in Missan, dune fields. The dimensions of these dunes range between 50cm-15m in length, and 15cm-2.5m high (Figure. 6). These dunes are controlled by the presence of certain plants as a trap forming the final shape of these dunes.

Figure.6: Nabkha dunes (shadow sand), Al-Manziliyah dune field, Missan Governorate.

4- Methods of Study

9 samples from Missan dune fields are collected during two field surveys, (November. 2015 and March, 2016). This study is to cover the fine size fractions which include fine sand, and very fine sand, were separated into light and heavy mineral fractions using the standard bromoform method. The mineral composition of both light and heavy fractions was determined using the standard counting technique by using Leitz research polarizing microscope .

5- Result and Discussion

5.1- Light Components

The light mineral fraction of Missan dunes samples comprises more than (98%) of the total mineralogy , with an average of 68.07 % quartz (including chert fragments), 9.09% feldspar, 18.61% carbonates, 3.05% igneous, and metamorphic rock fragments, and 1.26% evaporates, the results of this analysis are summarized in (Tables 1).

Table 1- Percentage of light minerals of Missan dune field sands.

Missan Dune Fields										
Light Components		Samples Number								
		Sayid Subair Field			Middle Chailat Field			Al-Manziliyah Field		
		ChS1	ChS2	ChS3	Ch1	Ch2	Ch3	ChM1	ChM2	ChM3
Monocrystalline Quartz		53.6	50.1	51.3	52.0	50.8	52.3	51.4	50.3	50.1
Polycrystalline Quartz		2.5	2.2	1.9	1.9	2.1	1.7	2.3	1.7	1.9
Alkali Feldspar	Orthoclase	2.8	3.1	2.1	2.1	2.4	2.5	3.2	2.8	2.6
	Microcline	1.3	2.4	2.3	2.3	2.8	2.3	2.3	2.3	1.8
Plagioclase Feldspar		3.0	4.5	5.0	4.8	4.5	4.0	4.2	4.2	4.5
Evaporites		1.2	1.1	1.4	1.5	2.0	1.0	0.8	1.2	1.2
Carbonate Rock Fragments		18.7	19.3	18.6	17.3	18.3	17.6	19.2	19.4	19.1
Chert Rock Fragments		14.8	15.3	14.5	14.6	14.8	15.3	14.5	13.6	14.8
Igneous Rock Fragments		1.5	2.0	1.5	2.1	1.9	1.7	1.7	1.5	1.8
Metamorphic Rock Fragments		1.2	1.4	1.3	1.4	1.2	1.2	1.1	1.5	1.5

The majority of the quartz grains are monocrystalline , with dominant straight extinction and noinclusions. Subordinate amounts of polycrystalline and chert fragments making the silica content more than 68.07% of the light fraction. Feldspars range between 7.1- 10.2% of the light fraction and includes sodic-plagioclase, microcline and orthoclase, many of these grains show different degrees of alteration.

Carbonates make up between 17.3-19.4%, and constitute mainly of calcite occurring as rock fragments of the older formations that show their distinct micritic and recrystallized components, and to a lesser extent as clear crystals or biogenic shell fragments. Evaporites range in abun- dance between 1-2% of the light fraction, they mainly composed of gypsum. The clay coated grains could be either intensely altered feldspar grains or clay mineral coatings that are very fragile and are easily abraded away during aeolian transport which will re- sult in decreasing the mean particle size of the sand grains. These minerals are shown in (Figure. 7)

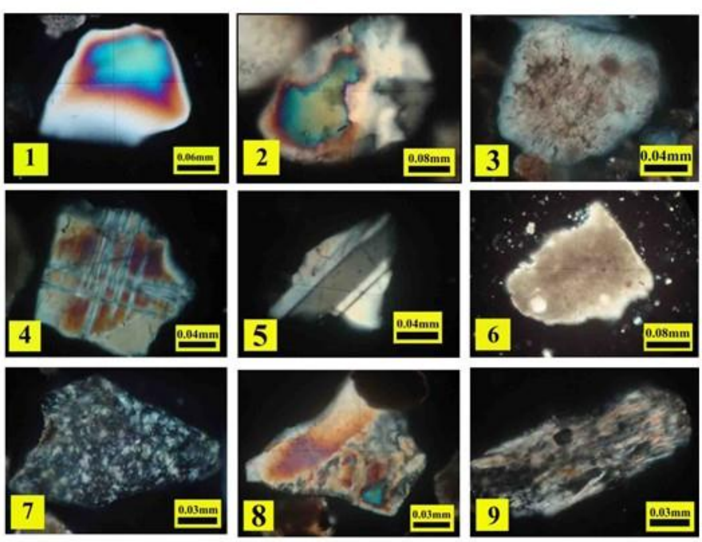

Figure.7: Light minerals and components whereby 1: Monocrystalline quartz, 2: Polycrystalline quartz, 3: Alkali feldspar orthoclase, 4: alkali feldspar microcline, 5: plagioclase feldspar, 6: carbonate rock fragment, 7: chert rock fragment, 8: igneous rock fragment, 9: metamorphic rock fragment.

5.1.1 Heavy Minerals

The heavy minerals of 9 samples collected from Missan dune fields were determined in order to use them as an indicator for the source rocks and the nature of the source area. The procedure for heavy mineral analysis separation was followed after [19], [4] , [20] , and [21] .

The heavy minerals recognized in the studied samples were estimated by using point counter mechanical stage following the method of [22] [20].

The heavy mineral residue of the studied samples is composed of opaque mineralsas a main component with an average 46.17% and non-opaque minerals with an average 53.83%. The non-opaque mineral assemblage is mainly composed of chlorite 15.48%, (mica muscovite and biotite) 9.88%, epidote 8.42 %, garnet 6.76%, pyroxenes 4.79%, amphiboles 4.28%, zircon tourmaline 1.05%, and rutile 0.45% arranged in a decreasing order of their average content (Table 2). The minerals grains vary in shape from prismatic to spherical and are mainly subrounded to rounded (figure8).

Table 2- Percentage of heavy minerals of Missan dune fields.

Heavy Minerals	*Missan Dune Fields*								
	Samples Number								
	Sayid Subair Dune Field			Middle Chailat Dune Field			Al-Manziliyah Dune Field		
	ChS1	ChS2	ChS4	Ch1	Ch2	Ch3	ChM1	ChM2	ChM3
Opaques	56.3	57.7	55.2	53.2	52.9	52.0	51.2	49.2	49.7
Chlorite	10.2	9.6	9.6	11.5	9.7	11.8	8.5	11.3	10.3
Pyroxene	4.5	3.9	4.5	4.8	4.9	4.6	5.3	4.8	4.8
Amphibole	4.3	4.4	5.6	4.5	5.2	4.9	5.5	5.3	4.7
Muscovite	3.0	4.0	4.2	3.4	3.6	3.9	4.5	5.9	5.6
Biotite	2.6	2.5	2.8	3.2	2.9	3.5	4.5	4.2	4.5
Epidote	5.6	4.9	5.3	5.0	5.3	5.0	5.8	5.2	4.7
Zircon	2.6	2.5	2.6	3.2	3.5	3.2	4.6	5.1	5.3
Garnet	4.7	4.8	4.0	4.9	4.7	5.0	4.2	4.9	5.2
Tourmaline	2.2	2.7	3.0	2.7	2.1	1.9	2.8	2.6	2.2
Rutile	1.2	0.8	1.2	1.5	1.8	1.9	-	1.4	1.5
Staurolite	0.8	1.0	0.8	1.0	1.0	1.1	0.8	-	-
Kyanite	0.8	-	-	-	0.9	-	0.9	1.1	0.8
Unidentified	1.2	1.2	1.2	1.3	1.5	1.2	1.4	-	0.6

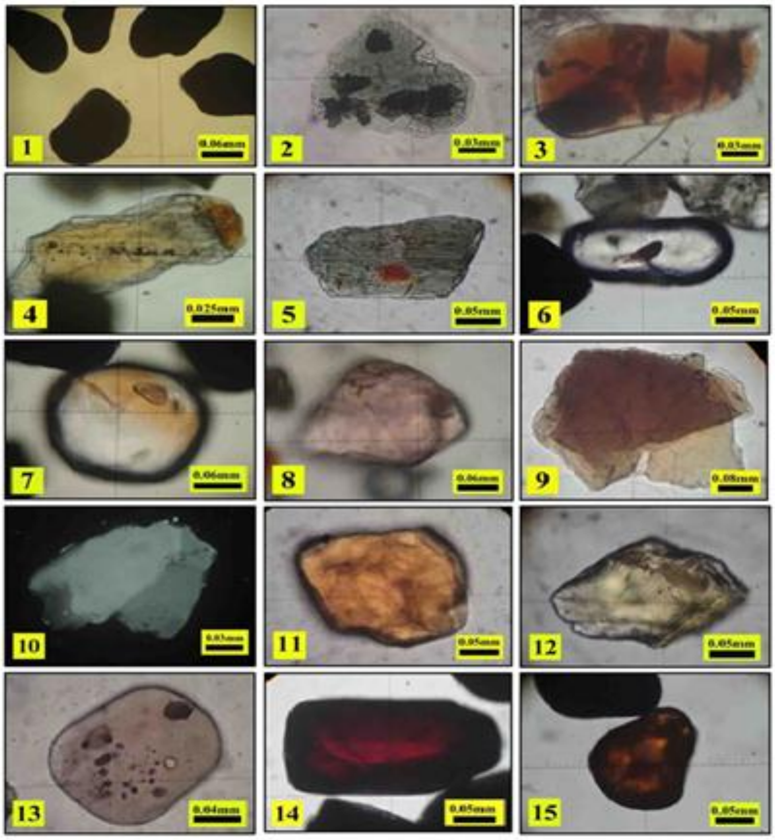

Figure.8: Images of heavy minerals of Missan dune fields whereby: 1- Opaqures, 2- Chlorite, 3- Chlorite, 4- Pyroxene, 5- Hornblende, 6- Zircon, 7- Zircon, 8- Garnet, 9- Biotite, 10- Muscovite, 11- Staurolite, 12- Epidote, 13- Tourmaline, 14- Rutile, 15- Rutile.

6-Stability of Sediment

[23] formulated a ternary classification for determines the stability of heavy mineral content, in which unstable, moderately stable and ultra-stable groups are considered. Application of the stability factor in the studied areas, show that there are marked differences among the different locations indicating different sources and types of parent rocks (Figure. 9).

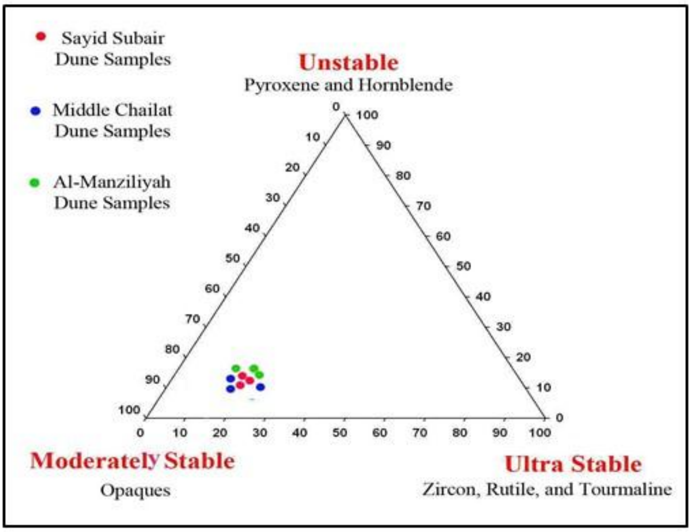

Figure.9: Ternary diagram of heavy mineral stability of Missan dune samples (23)

Missan dune fields which in nearer to the Zagros and Himreen mountain chains show less stability (moderately stable) indicating the high percentage of opaques minerals.

7- Source of Sediments

Heavy minerals have been widely used to determine transport and provenancé s signa- ture in several depositional environments such as dunes, beach, alluvial deposits, and rivers [23]. Heavy mineral are usually used for source rocks determi- nation [24]. Heavy minerals data provide constraints on the mineralogical nature of the source terrains [25].

The heavy minerals of detrital sediment and sedimentary rocks are diverse and non-genetic mineral group. The minerals are not necessarily related to each other in any way; it’s the operational procedure in separating them that defines them as a group. Heavy minerals are minerals of parent rock surviving destruction by weathering [26].

The heavy mineral assemblages determined for Missan samples (figures 10), indicates a variety of probable source rock types including igneous, metamorphic, sedimentary, and pegmatite rocks. Taking into account the relative abundance and distribution of each mineral, it may be suggested that the studied heavy mineral assemblages, are primarily derived from sedimentary rocks (single or multi cycles), low and high rank metamorphic rocks, acidic and basic igneous rocks, and pegmatite rocks.

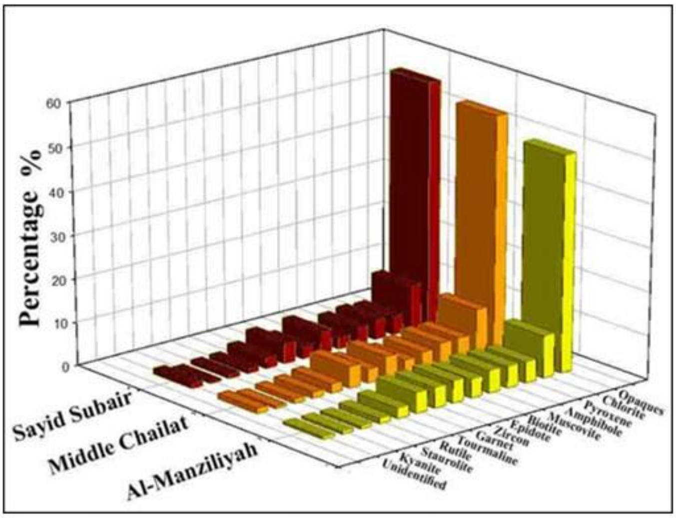

Figure.10: Average distribution of the heavy minerals in the Missan dune samples.

The linkage between tectonic setting and sediment composition has been long recognized [27]. [28] Suggested a plate tectonic interpretation of heavy mineral data by comparing the assemblage configuration with the possible sources of clastic sediments resulting from different stages of the plate tectonic cycle.

[28] Constructed the right angle triangle diagram (MF, GM, and MT) linking plate tectonic setting and the heavy mineral assemblage where :

1 -MF: Common constituents of mafic magmatic rocks = total contents of pyroxene, hornblende, and olivine .

2- MT: Common constituents of basic metamorphic rocks = total contents of pale-colored and blue green amphibole, epidote, and garnet .

3- MG: Accessory minerals of granites and sialic metamorphic rocks = total content of zircon, tourmaline, staurolite, kyanite, andalusite, monazite, and sillimanite.

4-

Missan dune samples fill within the field of active continental margins, which are characterized by a relatively high percentage of minerals derived from Basic and intermediate igneous rocks, these source rocks are represented by Himreen and Zagros Mountains and their derived formations such as aTertiary exposed formation (Injana, Mukdadiya, and Bai-Hassan Formations), (Figure. 11).

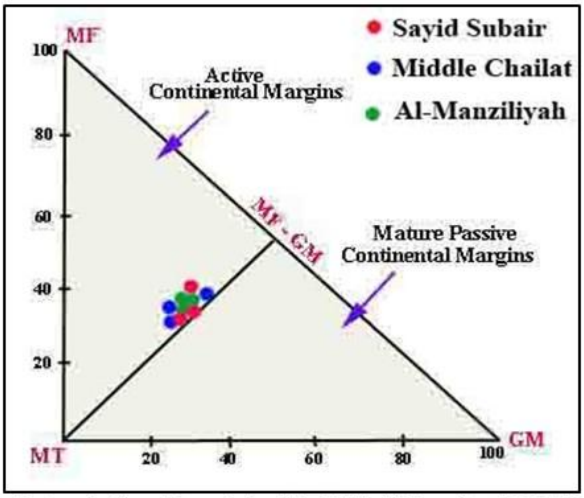

Figure.11: Interrelationship of the MF-MT-GM suits of Al-Muthana, Missan, and Thi-Qar dune samples (28). Where by MF: Pyroxene, Amphibole, Olivine. GM: Zircon, Tourmaline, Staurolite, Kyanite, Andalusite, Monazite, Silimanite. MT: Epidote, Garnet.

8- Conclusions

A- Opaque heavy minerals represent the major component in all studied dune samples followed by chlorites, amphiboles, and pyroxenes in the eastern belt, and total zircon and tourmaline in south western belt.

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

C- The maturity and stability of these dune sands as reflected from the assemblage of heavy minerals, which indicated a transition from the moderately stable in Missan dune fields.

D- From the mineralogical composition both the heavy and light fractions show that these are two major sources in the areas of study. The Missan dune fields have their source from Zagros Mountains and Himreen Anticline and to lesser extends the Mesopotamian Plain sediments as indicated by the presence of the carbonate rock fragments, chert rock fragments, Pyroxenes, Amphiboles, and Opaques.

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