Heavy Minerals Distribution and Provenance in Palinurus Shoal, Northwest of the Arabian Gulf

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Doi 10.29072/basjs.20190109, Article inf., Received: 1/3/2019 Accepted: 18/4/2019 Published: 30/4/2019

Abstract

Twelve stations were selected from Palinurus shoal area and one sample from each station where dredged. The heavy and light minerals of a sandy fraction in size 0.125mm were separated by Bromoform liquid and identified. After the petrographic study of twenty-four thin sections under the polarized microscope, mineral identification showed different types, dominated by opaque as 41.8% with some transparent minerals, which indicate multiple source rocks as sedimentary, igneous, and metamorphic rocks. The main components of the studied sand fraction are opaque minerals followed by transparent minerals as pyroxene, hornblende, zircon, tourmaline, and rutile. This assemblage discerns that the sand deposits are of a moderate type. The triangular clarifies that the values are located near the stable medium range, the Palinurus Shoal region has moderate stability of the mineral deposits and this confirms the increase in the percentage of opaque minerals percentage, which could be attributed to the drop in sea level during the sedimentation period.

Keywords: Petrography, Provenance sediment, Palinurus Shoal, Opaque, North –West of Arabian Gulf.

1. **Introduction**

Palinurus shoal is a rocky area located southwest of the Khor Abdullah entrance, recently, discovered that these rocks are covered by corals. Most of the coral reef communities in the Arabian Gulf live within shallow coastal waters where the [1] stated that 30-40% of the coral cover in Oman is at a depth of 4-12 m, while the coral communities in Bahrain are surrounded by the areas of 40 m deep sea water. And the Iranian coasts where the reef pools are distributed at depths ranging from 3 to 15 m; and cover the total area of coral reefs in the UAE at a rate of less than 20 m [2]. The map of [3] shows the distribution of the coral reefs in all waters and coasts of the Arabian Gulf, including the Iraqi coastline. Coral reefs were recorded in the northwestern part of the Arabian Gulf in southern

Iraq in 2014 and for the first time, coral reefs were found to be alive and with an area of 28 km2 of large coral reefs [4]. This is contrary to the previous belief that there are no such areas of life and sedimentation in the waters of Iraq. That the discovery of coral reefs in the turbid coastal waters of Iraq has stimulated the interest of government agencies and environmental organizations, as well as the international scientific community, which is working on the basic understanding of coral reef ecosystems and the global climate today. This discovery is very important especially for Iraq because it is of great importance for monitoring climate change in the Iraqi marine environment, particularly in the northwestern part of southern Basrah, and there are likely to be many groups in the Iraqi maritime border.

Mineralogical study is providing an evidence for sediment provenance and paleo-history. The mineral analysis is one of the most sensitive and widely used techniques for this purpose. Heavy minerals are present in small quantities, are resistant to weathering and abrasion. Identification of mineralogical specifications of the sand fraction has been performed to determine the minerals assemblages and description of their properties. Heavy minerals reflect the source area which explains the rock types of different heavy mineral assemblages [5]. Heavy minerals can be very useful, particularly when an interpretation of the major constituent grains is ambiguous [6]. 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 as the diagenesis and alterations [7].

This study is an attempt to give a detailed petrographic description of the sand unit at Palinurus Shoal, and to interpret the provenance and tectonic environment.

2. Materials and Methods

The study area represents one of the shoal sites in the Iraqi regional waters which have many shoal site" under water island", in the extreme southern part of Basrah Governorate, North-West of the Arabian Gulf. It is located about 42 km southwest of the Shatt Al-Arab Estuary and 40.3 km south of the Khor Abdullah entrance. It was named a Palinurus Shoal in the Admiralty chart. It is bounded by latitudes 29° 35′ 22.3″- 29 ° 38′ 22.4″ E and longitudes 48° 47′ 7.5″- 48° 48′ 52.8″ N, covering an area of about 16.38 km² (Fig .1).

Twelve sand samples were collected from the study area. 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 as heavy liquid. The procedure for heavy mineral analysis separation was followed after [5, 8, 9, and 10]. Twenty-four slides, 12 slides for each of heavy and light minerals, were used in this study for the identification and standard counting technique by using point counter mechanical stage following the method of [8, and 9] for both heavy and light minerals by using Leitz research polarizing microscope.

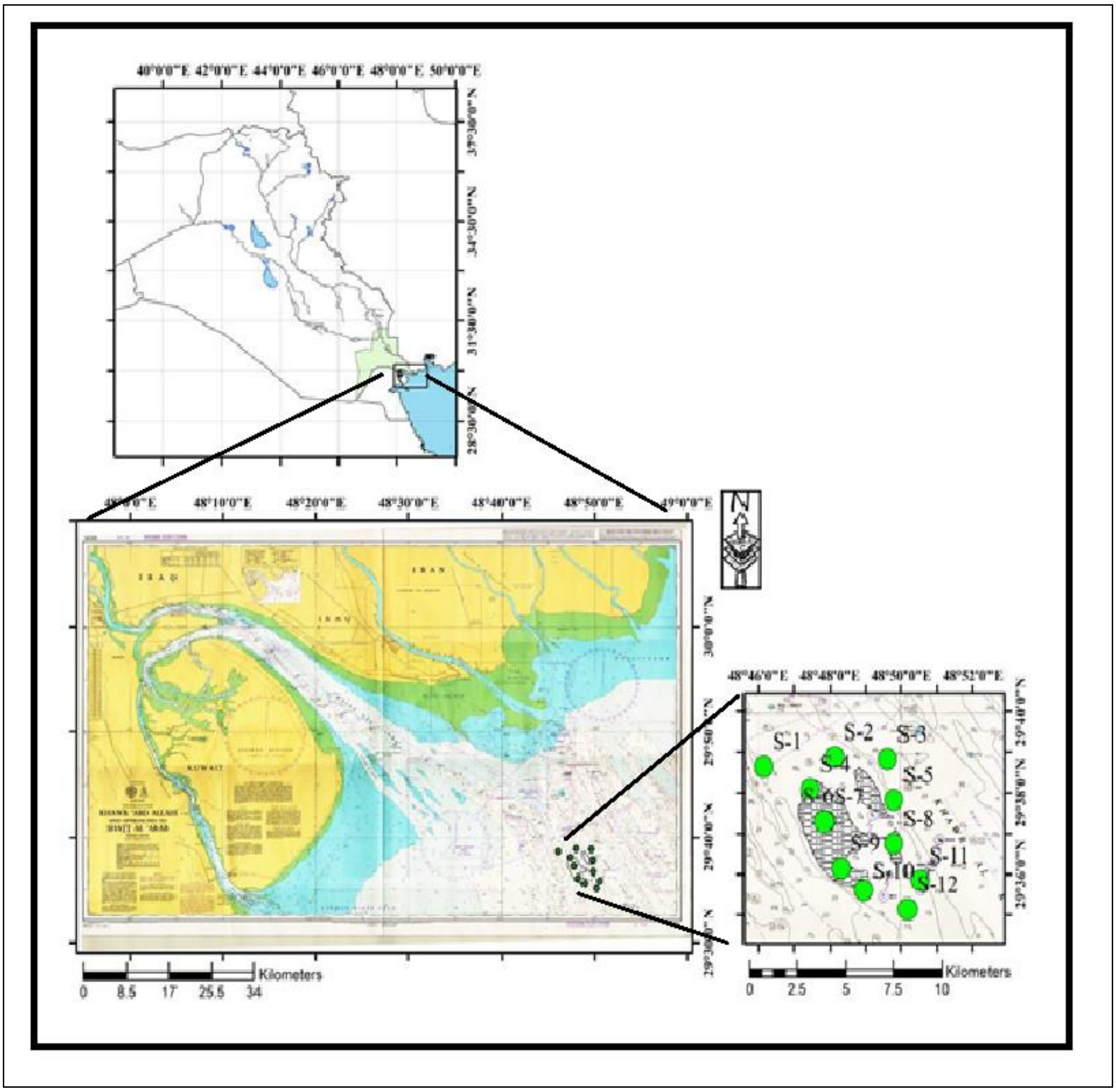


Fig.1: Location Map of the study area.

3. Results

Heavy Minerals

The heavy minerals that diagnosed in the sediments of study area are represented in table (1) and plate 1. These minerals are divided for two types; Opaque and transparent.

Opaques

The opaque heavy minerals comprise the highest percentage with an average of %41.8 (Table 1) (Plate 1). The identification of Opaque minerals depends on the dark colour and the form of the grains [11].

Transparent Heavy Minerals

These heavy minerals can be classified according to their stability into three subgroups: Ultra-stable, Unstable and Metastable heavy minerals and additional group called Mica group [12].

Table 1 percentage and average of heavy minerals in study area.

Heavy Minerals		Sample Numbers												
		S-1	**S-2**	**S-3**	**S-4**	**S-5**	**S-6**	**S-7**	**S-8**	**S-9**	**S-10**	**S-11**	**S-12**	**A V %**
Opaques (Iron Oxides)		38.7	41.6	42.5	43.2	45.3	38.4	40.6	42.2	42.1	38.7	43.5	44.2	41.8
Ultra-Stable	Tourmaline	8.8	12.0	7.8	10.0	12.2	10.1	9.9	11.7	10.4	11.4	9.1	10.6	10.3
	Zircon	11.3	9.3	10.5	8.2	8.9	7.7	8.9	8.2	9.1	11.5	10.8	7.5	9.3
	Rutile	3.6	4.3	3.7	2.7	3.0	5.1	4.4	3.4	4.4	4.5	2.2	2.6	3.7
Unstable	Amphibole	5.2	4.5	3.3	6.1	2.9	5.4	4.1	5.3	5.2	5.1	5.8	6.3	4.9
	Pyroxene	3.6	4.4	5.3	3.2	3.3	4.7	5.2	3.5	4.9	4.2	4.7	3.2	4.2
Meta-Stable	Group Garnet	4.0	2.4	2.7	3.7	4.2	3.8	3.3	2.3	4.2	3.2	3.6	5.2	3.5
	Epidote	2.3	2.0	1.4	2.4	1.5	1.9	2.7	2.3	1.2	2.1	5.7	2.1	2.3
	Staurolite	2.3	1.6	0.7	-	-	2.2	2.7	2.0	0.7	-	2.3	0.2	1.4
	Kyanite	1.7	1.4	1.1	1.8	1.3	1.5	1.2	1.1	1.6	1.2	1.1	1.4	1.2
Mica	Muscovite	6.5	7.4	8.7	7.6	5.3	7.8	5.7	6.1	6.8	7.1	3.8	7.6	6.7
	Biotite	5.5	4.2	6.4	4.7	6.1	5.4	5.5	6.4	4.7	6.5	2.3	4.4	5.2
	Chlorite	4.9	3.1	4.0	5.7	4.8	4.2	4.2	3.5	3.4	4.0	4.1	3.4	4.1
	Others	1.6	1.8	1.8	0.5	1.0	1.8	1.6	2.0	1.4	0.5	1.2	1.3	1.4

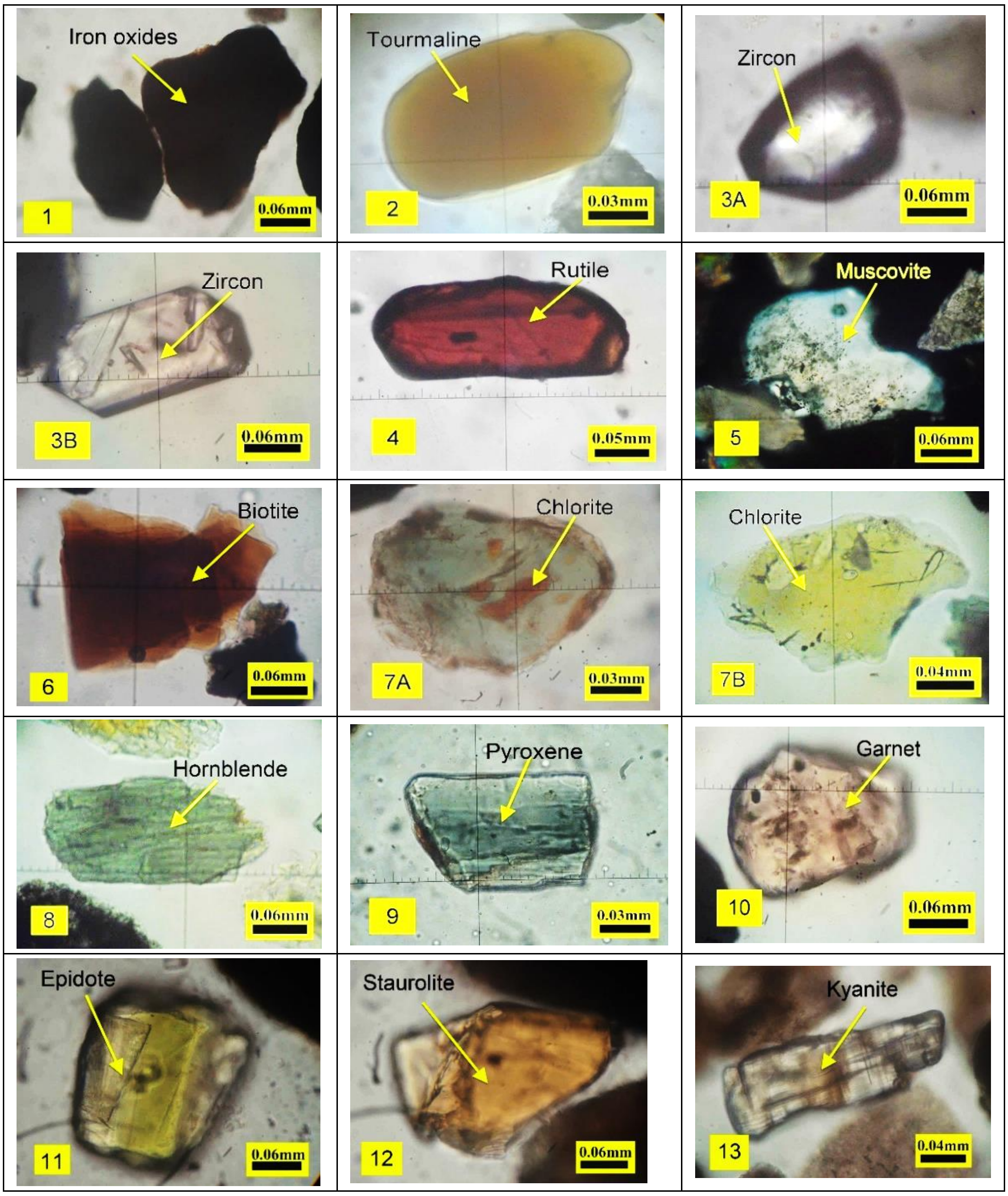
a. Ultra-Stable Heavy Minerals

This group is characterized by its high resistance to erosion and weathering. In the study area, it was found to have three minerals: Tourmaline, Zircon and Rutile. The average percentage of these minerals in the region was 23.3% of the total percentage of heavy minerals (Table 1). The percentage of Tourmaline is between 7.8-12.2 % with an average of 10.3 % (Table 1). Its crystalline surfaces have a glass glitter, and in this study, it appears with round crystals and hazel colors (Plate 1). Zircon is characterized by many colors, including gray, yellow, and red; with a metallic luster (Plate 1), its percentage is between7.5 and 11.5% with an average of 9.3% (Table1). Rutile mineral is one of the most stable heavy minerals in the sedimentary cycle and has a wide spread in ancient and modern sedimentary sediments [13]. Its percentage is between 2.2 and 5.1% with an average of 3.7% (Table1). It is often painted with a red-brown color [14](Plate 1).

b- **Unstable Heavy Minerals**

This group contains an amphibole and pyroxene minerals, it is characterized by instability in the face of weathering. Its percentage is between 6.3 and 10.5% with an average of 9.1% of the total average of heavy minerals in the study area (Table1). Amphibole group includes a number of common and important minerals, the most important mineral is hornblende, its grain is prismatic, sub rounded forms, and green color (Plate 1). Its percentage is between 2.9 and 6.3% with an average of 4.9% (Table1).

Plate 1



1-Iron oxides, 2-Tourmaline, 3- Zircon, 4-Rutile, 5-Muscovite, 6-Biotite, 7A-Chlorite, 7B-Chlorite, 8-Hornblende, 9-Pyroxene, 10-Garnet, 11-Epidote, 12-Staurolite, 13-Kyanite.

The amount of pyroxenes is between 3.2 and 5.3% with an average of 4.2% (Table 1). Pyroxene was observed under a polarized microscope, forming anhedral of light green color (Plate 1).

c- Metastable Heavy Minerals

This subgroup includes Garnet, Epidote, Staurolite and Kyanite, which were recognized in the studied sand fractions. The percentage is between 6.0 and 12.7 % with an average of 8.4% of the total average of heavy minerals in the study area (Table1). Garnet is characterized by distinct optical properties such as high relief, sub rounded form and pale brown to dark brown color (Plate 1). The percentage was from 2.3 to 5.2% with an average of 3.5 % (Table 1). The Epidote is semi-circular, prismatic, or semi-circular crystalline, colorless in thin sections. The iron-rich Epidote is pale yellow, greenish (Plate 1). The percentage was from 1.2 to 5.7% with an average of 2.3 % (Table 1). The Staurolite has clear crystals and is mostly twin, it has a brown color and is often reddish or black and grayish. It is found in the sandy part of the study area in golden color (Plate 1). The percentage was from 0.7 to 2.7% with an average of 1.4% (Table 1). Kyanite appears under the polarized microscope as semi-transparent. The percentage was from 1.1 to1.8% with an average of 1.2 % (Table 1). It is crystallized in crystal forms of flat shapes and protruding, long vertical or possibly curved crystals.

d- Mica Group

This group is divided into three minerals: Muscovite, Biotite, and Chlorite. The percentage of this group was 16.0% of the total heavy minerals in the study area (Table 1). Muscovite is under polarized microscope, thin plates colorless, yellowish, or greenish, depending on the impurities, and their crystals are rectangular or cylindrical, and with glass luster (Plate 1) .The percentage was between 3.8 and 8.7% with an average of 6.7 % (Table 1). The Biotite has a clear color contrast and is dark brown to yellow or green (Plate 1). The percentage was between 2.3 and 6.5% and with an average of 5.2 % (Table 1). In this study, chlorite was found in green color and yellowish green (Plate 1) with a percentage of 3.1 to 5.7% and an average 4.1% (Table 1).

4. Discussion

Heavy minerals data provide constraints on the mineralogical nature of the source terrains [15]. There are minerals of parent rock surviving destruction by weathering [16]. The heavy mineral assemblages determined for Shoal (Plate 1), indicate 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.

The links between tectonic setting and sediment composition has been long recognized, tectonic setting and sediment composition can be used as evidence of tectonic environments [17]. Tectonics not only controls the total minerals and sandy texture but also determine the composition of heavy metal assemblages. [18] proposed an explanation of the tectonic plate of heavy minerals data by comparing the assemblages of detrital sediments from the various phases of the plate tectonic cycle. Accordingly, they designed a diagram linking the tectonic plate system to heavy mineral assemblages, in the form of a triangle where the head of each side of the triangle represents one of the three symbols (GM, MT, MF), which represents a certain set of heavy minerals concentration data for the study area. After processing the data as shown in (Table 2), It was found that the sedimentary deposits of the study area fall within the field of maturation of the passive continental margin (Fig. 2), characterized by a relatively high proportion of minerals derived from granite and metamorphic rocks as a result of variable degree sediment reworking and weathering in areas lacking active tectonic events.

Table 2 - Heavy mineral data of clasts sediments of Palinurus shoal. [MF *(common constituents of mafic magmatic rocks) = total contents of pyroxene, hornblende.* MT *(common constituents of basic metamorphic rocks) = total content of epidote and garnet.* GM *(accessory minerals of granites and metamorphic rocks) = total content of zircon, tourmaline, Staurolite, and Kyanite]*.

Station No.	MF%	MT%	GM%
S-1	22.5	15.9	61.5
S-2	23.7	11.7	64.6
S-3	26.2	12.6	61.2
S-4	26.2	17.3	56.5
S-5	18.2	16.5	65.3
S-6	27.1	15.3	57.6
S-7	24.5	15.8	59.7
S-8	24.2	12.6	63.2
S-9	27.1	14.5	58.4
S-10	24.0	13.7	62.3
S-11	24.4	21.6	54.0
S-12	26.0	20.0	54.0

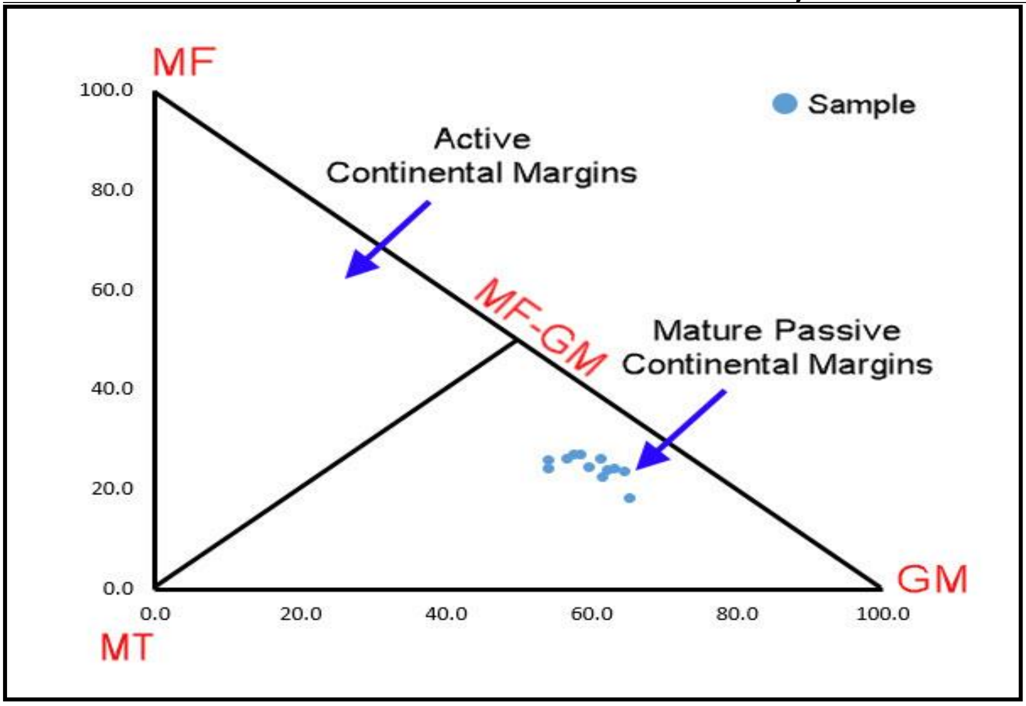


Fig. 2: Interrelationship of the MF-MT-GM [18].

Heavy minerals assemblages are often used in provenance studies due to their great number of varieties used to determine transport and provenances sign- true in several depositional environments [15]. [19] formulated a ternary classification for determines the stability of heavy mineral content, which is Unstable, Moderately Stable, Ultra Stable, are considered and the application of the Stability Factor in the studied area as shown in(Table 3), It is clear that the heavy minerals of the Palinurus Shoal region have a moderately stable opaque minerals (Fig. 3).

Table 3- Assemblages of Heavy Minerals in Palinurus Shoal, according to [19].

Station NO.	Unstable (Pyroxene &Hornblende)	Moderately Stable (Opaques)	Ultra-Stable (Zircon, Rutile, & Tourmaline)
S-1	12.36	54.35	33.29
S-2	11.70	54.66	33.64
S-3	11.76	58.14	30.10
S-4	12.67	58.86	28.47
S-5	8.20	59.92	31.88
S-6	14.15	53.78	32.07
S-7	12.72	55.54	31.74
S-8	11.84	56.80	31.36
S-9	13.27	55.32	31.41
S-10	12.33	51.33	36.34
S-11	13.80	57.16	29.04

S-12	12.77	59.41	27.82

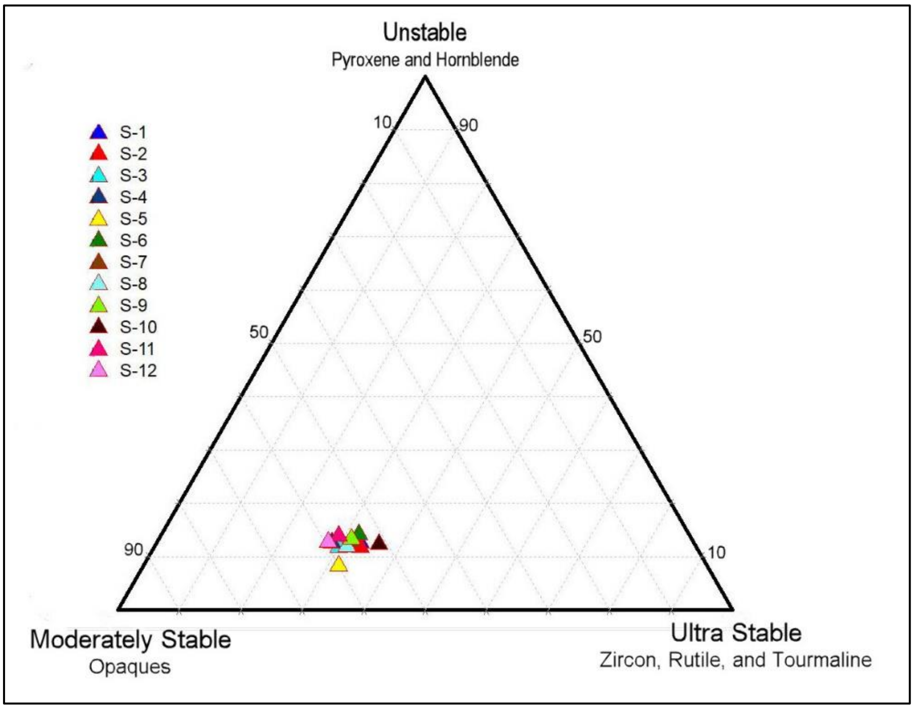


Fig. 3: Ternary diagram of heavy Mineral stability of Palinurus Shoal [19].

Because mineral maturity is associated with the prevailing climate factor with complex and overlapping relationships, its effect on the sediment components appears, the relation of [20](Fig.4) which act as a distinct characteristic of the sedimentary deposits, were used in different climatic legacies to represent sand sediments in all the studied stations in the region, The prevailing climatic background during deposition of sediments and the identification of the old climatic conditions that affected the area of Palinurus shoal.

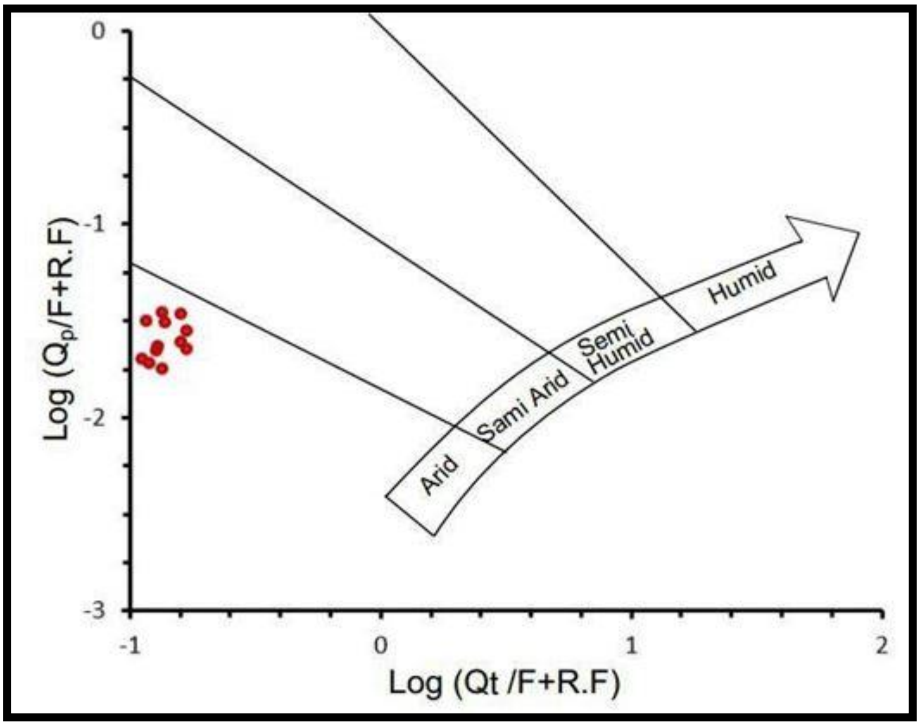


Fig. 4: A relationship that represents the old climate of Palinurus Shoal

Mineral components [20].

The abundance of Tourmaline, Zircon and Rutile minerals, which were concentrated in the eastern part of the region towards the open water area indicate that the weather resistance of the round shapes is believed to be part of the sediments carried by wind load from nearby areas adjacent to the study area [21] that the composition of Dibdibba Formation characterized by high concentrations of these minerals and the fact that these minerals come from the erosion of the old rocks, which can remain for several sedimentary cycles and the possibility of the emergence of modern deposits in the process of reworking of the old sediments. The unstable mineral group, amphibole and pyroxene, was found in the north and south of the study area, which is a major component of heavy metals, can provide a good indication of the proximity of sediment processing sources. The presence of these minerals indicates rapid erosion and mechanical erosion and low incidence of chemical degradation [12]. The meta-stable mineral group represented by Garnet, Epidote, Staurolite and Kyanite was concentrated in the north of the study area, i.e., in the direction of the Shatt al-Arab River, except Epidote, which was found in semi-circular yellowish green grains and concentrated in the south of the study area with the major heavy mineral assemblages reported by [22] in the Shatt al-Arab region. This congruence in heavy mineral assemblages indicates the possibility of the transport of sediments to this region by the effect of river processes and tides. [11] in which he mentioned that Epidote is found in high percentages in the old sediments more than modern to the Tigris and Euphrates Rivers, it is possible to say that these sediments moved to the region from the impact of the Shatt al-Arab River by the saltation and rolling due to the impact of tidal currents and the drainage of the Tigris and Euphrates Rivers, during the decrease in sea-level at mid-Holocene [15]. This is further evidence that the source of the sediments is transported sediments.

As for mineralogical study of light minerals, the results of mineral analysis showed a predominance of the components of rock fragments, followed by the group of quartz minerals, Feldspar minerals, evaporated minerals and coated grains, and low percentages of unknown minerals. The analysis of these minerals found a variety of rock fragments, consisting of sedimentary, metamorphic and igneous rocks, and sedimentary rocks that dominated the sediments with a rate of 72.9%. These forms are good evidence of sedimentation and transport distances. The sedimentary rocks fragments included four types, the first of which was the carbonate fragments, which dominated the rest of the rock minerals, were the minerals of the shells of the Aragonite, and the limestone minerals, which led the group of other rock components and other light minerals in the region at a rate of 48.5%. These minerals appear in irregular, sharp, sharp, and sometimes sharp crystalline shapes that indicate the proximity of sources and originate from within the sedimentary basin by erosion and re-sedimentation of carbonate sediments. These are obtained in coastal environments and Tidal Flat environments [23]. The presence of these sediments of chert and mudstone rock fragments in the shallow environments, which confirms our belief that the environment coastal shallow beach.

It can be said that the results of the current study show the source of sediments through the river load of Shatt al-Arab River and the lateral deviations of the surrounding formations of the region as well as through the transport of wind sediment composition of Dibdibba Formation noting the relative differences and mineral abundance of deposits of heavy minerals and light in all sites of the study area. The petrographic history suggests a classification of deposits as lithic rocks, the sediments of the region is characterized by the increase of the rock fragments in relation to the quartz and the Feldspar. The presence of this type of sediment indicates that the source rocks are sedimentary, metamorphic and plutonic rocks, and the sediments are local. In other words, the sediments are transported in short distances and this type of sand is within the river environments [17]. The mineral assemblages of this study are identical to the mineral assemblages of [22], it could conclude that these sediments were transported from the Shatt Al-Arab River by tide currents or the Shatt Al-Arab River course was extended to the area during the decreasing of the sea-level in the mid-Holocene.

Conclusion

Opaque heavy minerals of mafic igneous source rocks represent the major component in all studied area samples followed by Tourmaline, Zircon, Muscovite, Biotite amphiboles, and pyroxenes. The Ultra stable heavy minerals indicate that the source rock is not proximity and they have high resistant of weathering processes. The presence of different kinds of heavy minerals indicates multiple source rocks; sedimentary, igneous and metamorphic. The tectonic setting mainly is a passive continental margin. The minerals assemblages provide evidence of deposition in a shallow area during the decreasing of sea-level in the Mid-Holocene.

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توزيع ومصدر المعادن الثقيلة في ضحضاحة البالينورس، شمال غرب الخليج العربي

ندى صالح عباس[1] و بدر نعمة البدران[2] و أوسامة قاسم الوحيلي[1]

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المستخلص

تم أختيار 12 محطة في المنطقة الضحضاحية بالينورس واخذت عينة واحدة من كل محطة، شخصت المعادن الثقيلة والخفيفة في الجزء الرملي حجم 0.125 ملم وبعد الدراسة البتروغرافية لاربع وعشرين شريحة رقيقة تحت المجهر المستقطب تم تحديد وتشخيص أنواع

ونسب هذه المعادن. أظهرت نتائج تحاليل المعادن الثقيلة أنواعاً مختلفة، حيث هيمنت المعادن المعتمة بنسبة 41.8% وتليها المعادن الشفافة، بيروكسين ، هورنبلند، الزركون، التورمالين، والروتايل كدليل إضافي على تعدد صخور المصدر كصخور رسوبية ونارية ومتحولة. تستخدم المكونات المعدنية الأساسية للرمل في تصنيفها الذي يبين أن الرواسب الرملية ذات نوع معتدل. يشير المخطط الثلاثي الى أن القيم تقع بالقرب من المدى المتوسط المستقر، وبالتالي فإن ضحضاحات البالينوروس تتمتع باستقرار معتدل للرواسب المعدنية وهذا يؤكد على الزيادة في نسب تراكيز المعادن المعتمة. يمكن ان يعزى هذا الى طبيعة الانخفاض في مستوى سطح البحر اثناء فترة الترسيب.