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Mineralogy of Lower Diyala River Sediments Northeastern Baghdad

Mustafa Najm Al-Shamary*, Mazin Yousif Tamar-Agha

Department of Geology, College of Science, University of Baghdad, Baghdad, Iraq

Abstract

The purpose of this study is to determine the mineralogical composition of Lower Diyala River, northeastern of Baghdad, and attempt to define the sources of sediments. 10 samples were collected from Lower Diyala River from the area between Himreen Dam to south Baghdad, where these samples are dealings by the heavy liquid to separated into light and heavy minerals. The light minerals contents are composed mainly of quartz, feldspars, and rock fragments. The main rocks fragments consist of; igneous, metamorphic, carbonate, chert rock fragments, and evaporites. The heavy minerals contents are opaques minerals, chlorite, amphiboles, pyroxenes, epidote, zircon, garnet, muscovite, biotite, kyanite, tourmaline, staurolite, and rutile. The source area of these sediments is the outcrops of Upper Miocene-Pliocene rocks at the northeastern part of the studied area, igneous, and metamorphic rocks in the northeastern Iraq and Iran.

Keywords: Heavy Minerals, Light Minerals, Source Rocks, Diyala River.

معدنية رواسب نهر ديارلى الاسفل شمال شرقي بغداد

مصطفى نجم الشمري*, مازن يوسف اغا

قسم الجيولوجي، كلية العلوم، جامعة بغداد، بغداد، العراق

الخلاصة

تهدف الدراسة الحالية الى التعرف على التركيب المعدني لرواسب نهر ديارلى الاسفل الذي يقع شمال شرق بغداد , ومحاولة التعرف على صخور المصدر لهذه الرواسب . تم جمع عشرة عينات على طول قناة نهر ديارلى الاسفل من منطقة سد حميرين الى جنوب بغداد , تم فصل الرواسب الى جزئين , الجزء الخفيف والجزء الثقيل بواسطة السوائل الثقيلة. يتألف الجزء الخفيف من الكوارتز والفلدسبارات , والقطع الصخرية . تالفت القطع الصخرية من قطع الكربونات والصوان والقطع الصخرية النارية والمتحولة والوحلية وقطع المتبخرات . الجزء الثقيل تالفت من المعادن الثقيلة المعتمدة بصورة اساسية وكذلك الكلورايت والبايروكسينات والامفيبولات والمايكا والابيدوت والزركون والتورمالين والكياناييت والشترولايت والروتايل. ان المصدر الاساسي لرواسب نهر ديارلى هي المكاشف الصخرية للتكاوين الرسوبية التي يجري خلالها النهر وخاصة مكاشف الدورة الترسيبية المايوسين المتأخر - البلايوسين , وكذلك الصخور النارية والمتحولة في شمال شرق العراق وايران.

1. Introduction

The mineralogy of modern sediments found in sand or sandstone gives essential clues about its origin, which includes supply rock, lithologies, and transportation history. In addition to the principal components of sand or sandstone (quartz, feldspars, and rock fragments), the secondary contains of

*Email: Mustafanajjim768@gmail.com

other minerals grains, consisting of heavy minerals (densities greater than 2.85 g/cm^3). Heavy minerals replicate the source region due to the fact unique rock types include specific heavy mineral assemblages [1].

Heavy minerals are described as minerals having a higher density than quartz, the most frequent rock-forming mineral with a density of 2.65 g/cm^3 . In workout, solely these minerals that are heavier than the dense liquid most commonly used in the lab-bromoform (2.89 g/cm^3) or tetrabromomethane (2.94 g/cm^3), i.e. that immersion in these liquid, are included in the group. minerals group. The light minerals have a lower density than heavy minerals, e.g. quartz, feldspars, calcite, dolomite, aragonite, and evaporites. [2]. Analysis of heavy minerals is one of the most sensitive and most commonly used techniques in determining the origin of sand and sandstone. The heavy mineral accumulation is not only managed by the mineralogical component of the source area but is also by many other processes that influence throughout the sedimentation cycle [3]. Heavy minerals can be very Important better, especially when the interpretation of the main constituents is unclear [4]. Mineralogy analyses of sediments start with sieving to obtain a specific size range, mostly from fine to medium sand-size ranges, and heavy minerals are separated by heavy liquid as bromoform (density of 2.85 g/cm^3). In the classical analysis, the separated heavy mineral grains are mounted on a glass slide, then identified and counted using transmitted polarized light microscopy [5] and [6].

The area of study is the Lower Diyala River located in Diyala and Baghdad Governorates (Figure-1) (Longitudes $45^{\circ}:06':00'' \text{ E}$ and $44^{\circ}:18':00'' \text{ E}$ and Latitudes $33^{\circ}:06':00'' \text{ N}$ and $34^{\circ}:06':00'' \text{ N}$ covering more than 40 km^2).

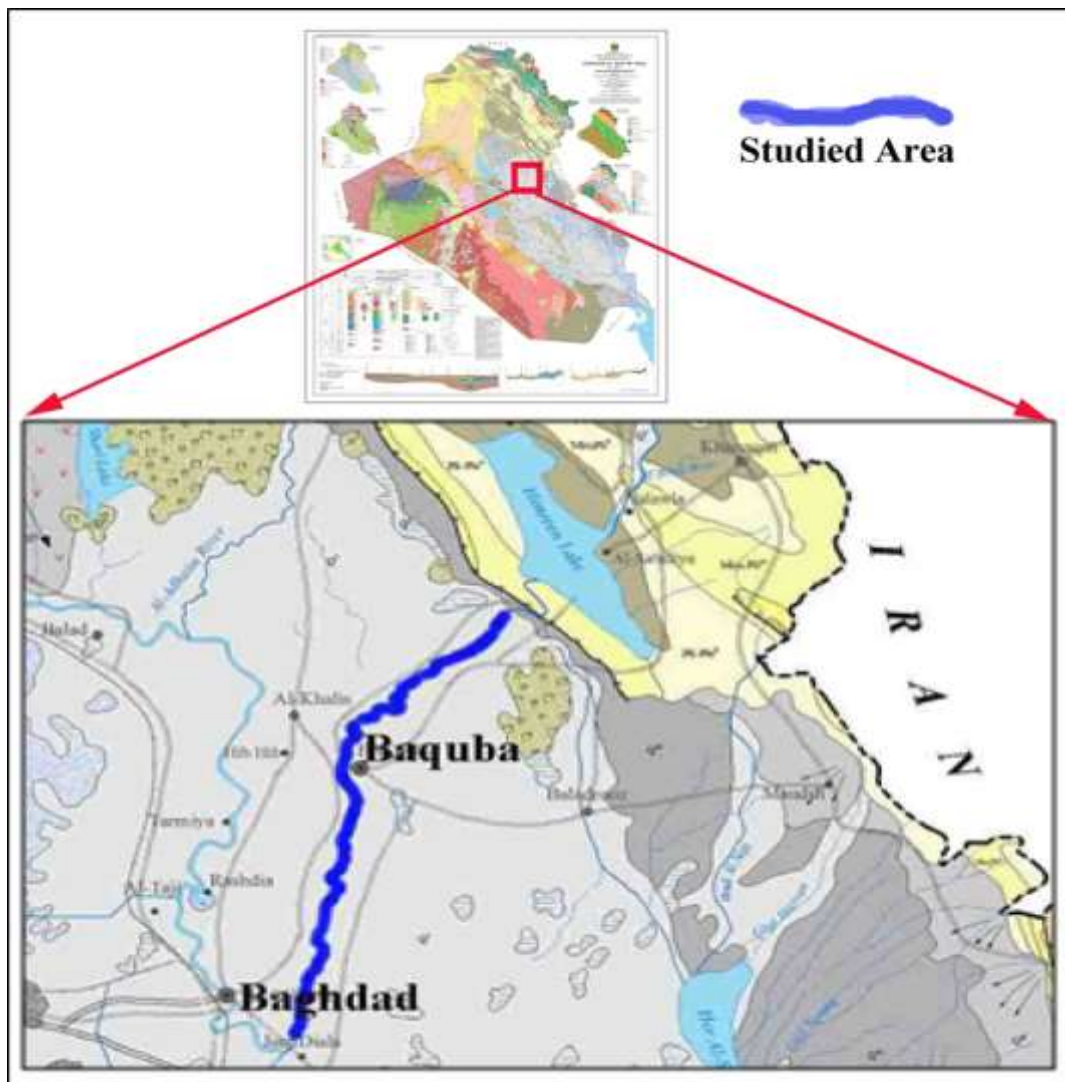


Figure 1- Location Map of the study area [7]

2. Geology of the studied area

Diyala River is the second and the biggest tributary of the Tigris River within the Mesopotamian Plain. Its flood plain is generally flat terrain, very gently sloping towards south and southwest, from its outlet from Himreen Range, with micro-relief caused by silted up irrigation canals (both ancient and active). The river flows towards the southwest from its outlet to Baquba city, following the main foothills gradient, and then it changes to the south and flows parallel to the Tigris River, following the main trend of the axis of the Mesopotamian flood basin [8]

The floodplain is densely cultivated and vegetated; particularly those parts located near the river course and irrigation canals whereas the distal parts are almost totally barren. Two stages of flood plains are developed by the Diyala River, the surface of the higher one, which is the most extensive is around 5 m, whereas the second is around 3 m, above the present river level. Diyala river basin splits into three parts [8].

- 1- Thrust Zone.
- 2- Folded Zone.
- 3- Unfolded Zone.

Diyala River intersects the folds and outcrops of rocks formations during its flow and is surrounded by river terraces. The erosion of the river plays a major role in formatting these terraces (Figure-2).

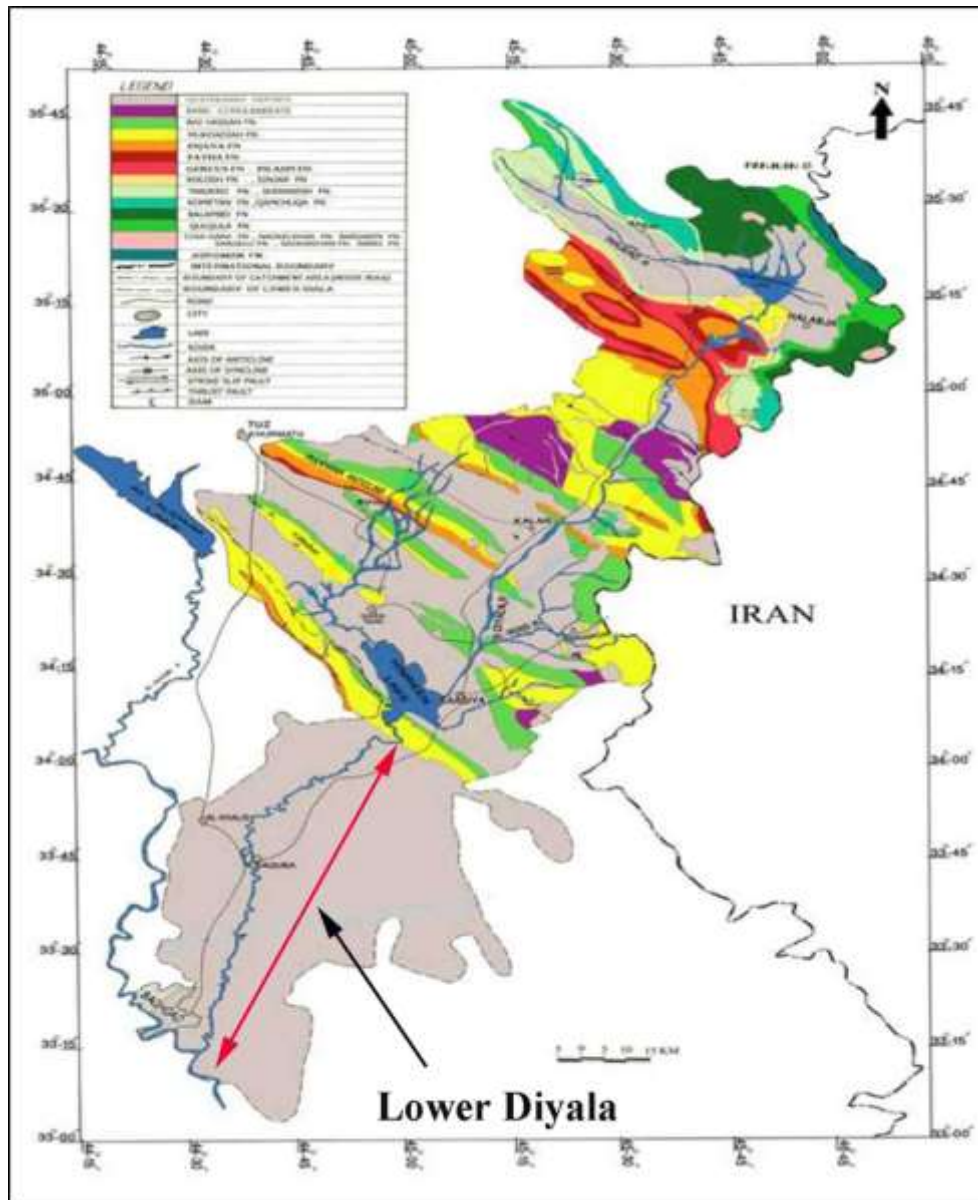


Figure 2- Geological map of Diyala River basin [9]

3. Methods of Study

Ten samples are collected from the Lower Diyala River, dry sieved into two fractions, fine sand (3 Phi) and very fine sand (4Phi). The sieved fractions are separated by the standard bromoform method into the light and heavy minerals ([10], [11], [5], and [12]). The result of the mineral separation of light and heavy minerals is determined using by polarizing microscope and using point counter mechanical-stage to numerical counted fractions [13, 14].

4. Result and Discussion

1- Light Minerals

The components of light minerals of Lower Diyala River samples consist more than 97.5% of the whole mineralogical contents with an average of quartz minerals have 20.5 % from (both mono and poly crystalline), 8.4% feldspars, 39.3% carbonates, 9.7 chert, 3.5% evaporites, 4.7 mudstone fragments, 7.9% igneous and metamorphic rock fragments (Table-1).

Table 1- Percentages and averages of light Components of the Lower Diyala River sediments

Light Components		Samples Number									
		DD1	DH1	DD3	DH3	DD5	DH5	DD7	DH7	DD9	DH9
Monocrystalline Quartz		17.7	15.8	17.6	19.8	19.3	18.6	15.1	18.3	13.0	15.5
Polycrystalline Quartz		3.3	3.2	3.4	3.5	3.9	2.4	3.9	3.7	3.1	3.5
Potash Feldspar	Orthoclase	2.1	2.6	2.4	2.6	2.6	2.1	2.4	2.1	2.1	2.4
	Microcline	2.7	2.5	2.5	2.4	2.2	2.3	2.4	2.8	2.8	2.4
Plagioclase Feldspar		3.9	3.8	3.5	3.4	3.2	3.8	3.7	3.3	3.7	3.6
Carbonate Rock Fragments		37.6	38.7	36.4	40.6	35.8	37.6	41.3	40.3	44.2	39.4
Chert Rock Fragments		10.8	8.5	11.7	9.4	9.2	11.8	8.2	9.2	8.0	10.2
Igneous Rock Fragments		3.1	4.4	3.2	3.5	3.2	3.1	3.6	3.2	3.4	3.7
Metamorphic Rock Fragments		4.5	3.2	4.9	4.6	4.7	4.9	4.5	4.6	4.5	4.4
Mudstone Rock Fragments		4.4	5.7	4.5	5.3	4.5	4.2	4.5	4.6	4.6	4.5
Evaporites		3.6	3.4	3.6	3.8	3.5	3.9	3.2	3.5	3.5	3.3
Coated Grains by Clay		3.7	4.9	3.2	3.6	3.9	4.6	3.9	4.9	3.7	3.8
Others		2.6	1.6	2.9	2.5	2.2	1.5	2.8	1.2	2.8	2.8

The main quartz grains are composed of mono -crystal, with predominant of straight extinction, and low amounts of poly-crystals and chert rock fragments ,these content more than 28.2% of the light minerals. The feldspars contents are ranging between 8.0 and 8.9% from light fraction include orthoclase, microcline and plagioclase; most of these grains explain more and clarify that have alteration. The carbonate contents ranging between 35.8-44.2%, these composed mainly of calcite minerals represent as rock fragments from geological formations that show their clear recrystallized and micritic components. Evaporates minerals, mostly gypsum have ranged between 3.2 and 3.9%. The coated grains by clay can be either heavily modified feldspar pellets or clay minerals coatings that are very soft and easily corroded during transport, reducing the average particle size of sand grains. The light minerals show in Figure-3.

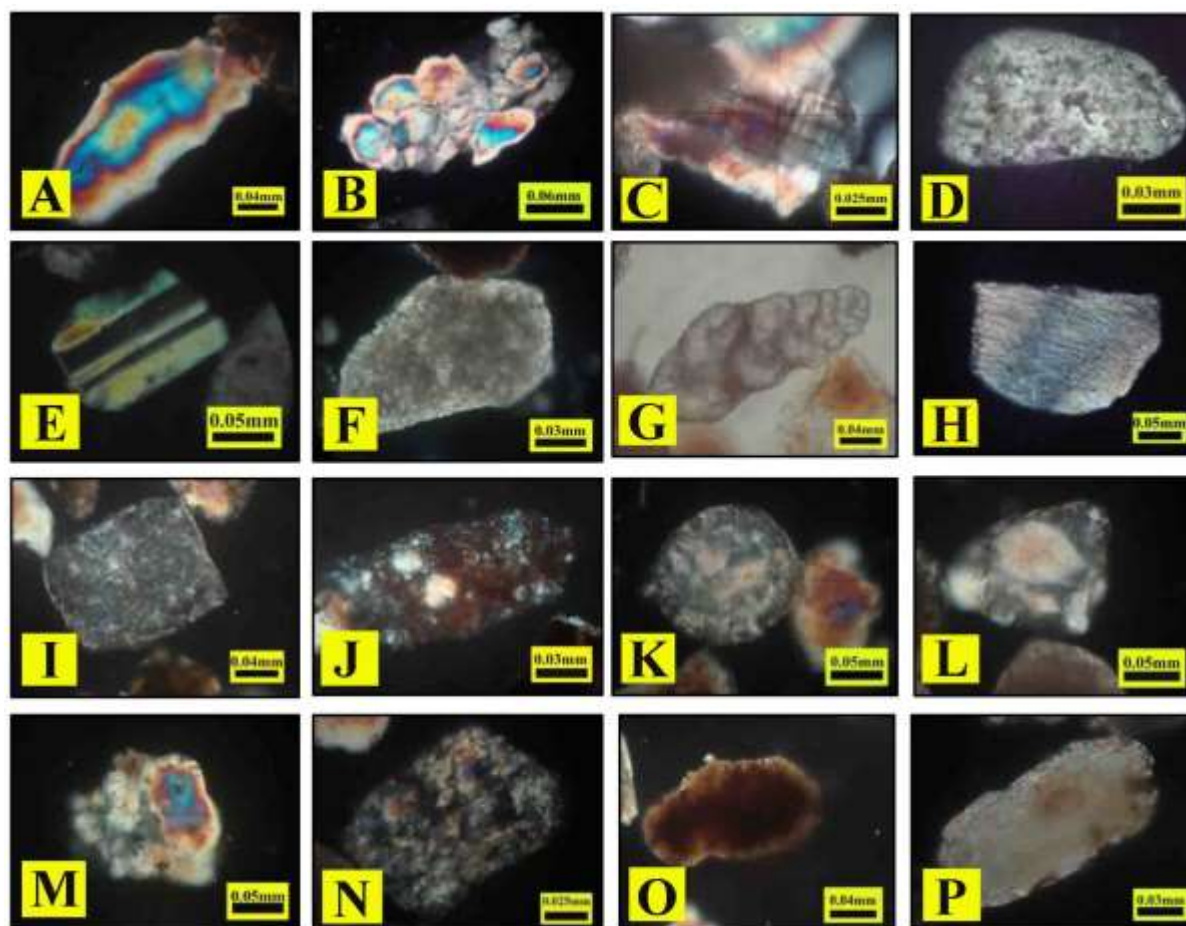


Figure 3- Light minerals components; (A) Monocrystalline quartz, (B) Polycrystalline quartz, (C) Potash feldspar microcline, (D) Potash feldspar orthoclase, (E) plagioclase feldspar, (F) Carbonate rock fragment, (G) Fossil fragment, (H) Aragonite complete shell fragment, (I) Chert rock fragment, (J) Jasperoid chert rock fragment, (K) Radiolarian chert rock fragment, (L) Volcanic igneous rock fragment, (M) Plutonic igneous rock fragment, (N) Metamorphic rock fragment, (O) Mudstone rock fragment, and (P) Evaporites fragment.

2- Heavy Minerals

In the study areas samples consist of opaque minerals as a major component 36.1%, while having 63.9% from non-opaque minerals. The heavy minerals mainly consist of Mica (Muscovite and Biotite) 10.4%, chlorite 8.8%, epidote 6.4 %, garnet 4.7%, pyroxenes 7.0%, amphiboles 9.6%, zircon 6.0 %, tourmaline 3.3%, staurolite 2.0%, Kyanite 2.7% and rutile 2.0%. The average contents of heavy minerals are ordering in Table-2. Many of minerals grains variation in shape from angular to subangular, rounded to subrounded, and prismatic or flaky shape (Figure-4).

Table 2- Percentage and averages of heavy minerals of Lower Diyala River.

Heavy Minerals	Samples Number									
	DD1	DH1	DD3	DH3	DD5	DH5	DD7	DH7	DD9	DH9
Opagues	34.7	37.2	35.1	34.1	37.8	36.4	35.4	36.1	39.2	34.7
Chlorites	9.2	8.5	8.7	8.7	8.7	9.2	9.1	9.2	7.4	9.0
Orthopyroxene	2.1	2.8	2.3	3.5	3.1	2.2	1.2	2.2	3.2	2.4
Clinopyroxene	3.5	4.2	5.7	5.5	5.4	4.8	3.0	4.8	3.0	4.7
Hornblende	5.3	5.6	5.8	5.2	4.4	5.4	5.1	5.4	5.4	4.6
Actinolite	3.2	2.5	3.6	2.9	3.5	2.7	3.4	2.2	3.7	2.4
Glaucophane	1.5	1.2	1.7	2.1	-	1.3	0.5	1.2	1.6	2.1

Muscovite	6.1	5.3	4.3	5.2	4.3	5.9	6.6	5.4	5.0	6.4
Biotite	5.4	4.5	4.0	4.6	4.4	5.4	5.4	5.3	5.4	5.3
Zircon	7.5	5.2	6.2	6.1	6.1	4.7	7.6	6.5	4.1	5.6
Garnet	3.8	4.9	4.9	4.7	4.6	5.4	3.5	5.4	5.4	4.6
Epidote	7.7	6.3	6.3	6.5	6.5	5.7	7.4	5.7	5.7	6.6
Tourmaline	3.7	3.6	3.3	3.7	3.9	2.7	3.3	2.7	2.3	4.2
Kyanite	2.6	2.9	2.7	2.8	2.6	2.6	2.2	2.8	2.6	2.8
Rutile	1.4	1.9	1.5	1.9	1.2	2.6	3.4	2.4	2.4	1.6
Staurolite	2.5	2.2	2.5	1.3	2.4	2.0	1.4	1.5	2.0	1.9
Others	1.0	1.2	1.4	1.2	1.1	1.0	1.5	1.2	1.6	1.1

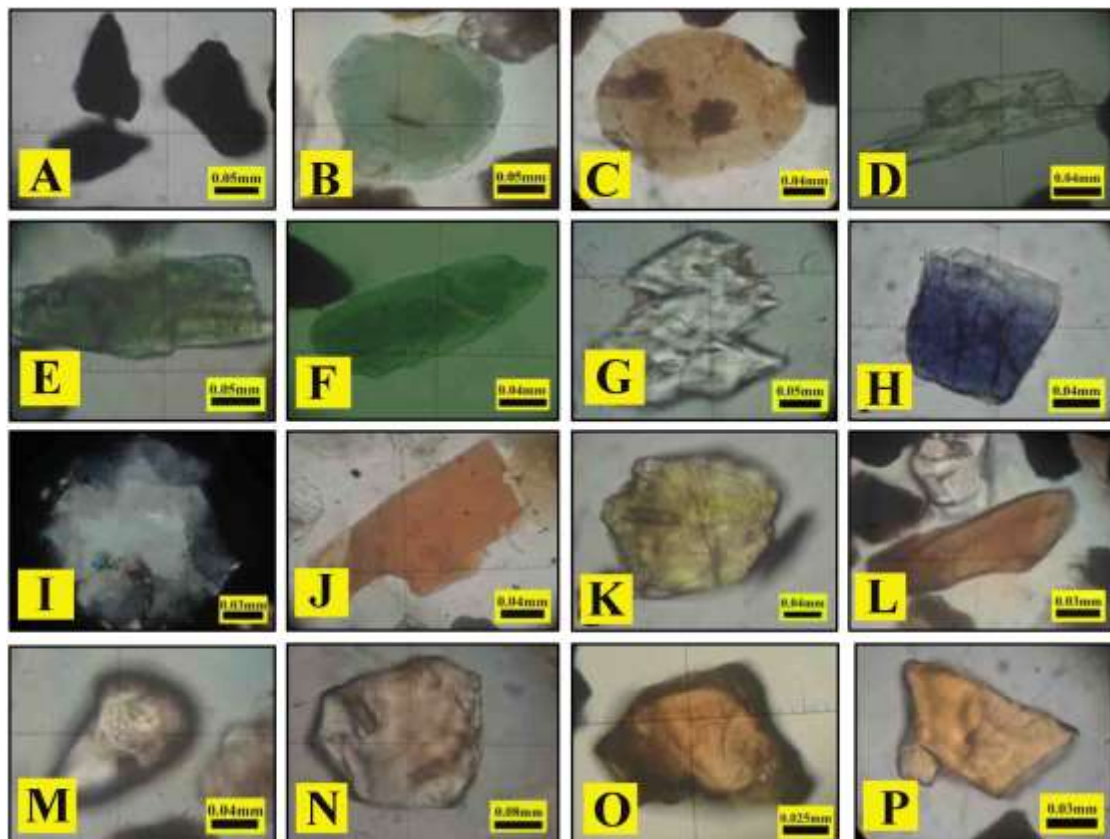


Figure 4- Images of heavy minerals of Lower Diyala river, (A) Opaques, (B) Green chlorite, (C) Brown chlorite, (D) Orthopyroxene, (E) Clinopyroxene, (F) Hornblende, (G) Actinolite, (H) Glaucofanite, (I) Muscovite, (J) Biotite, (K) Epidote, (L) Tourmaline, (M) Zircon, (N) Garnet, (O) Rutile, and (P) Staurolite.

5. Stability

Kasper et al., 2008 [13] suggested a ternary diagram for determining the stability of heavy minerals constituent, in that classifying unstable (pyroxenes and amphiboles), moderately stable (opaques) and ultrastable. heavy minerals associated with the source rocks and transport distance, where employment of the factor of stability on the study areas shows that there are no variations in among the different areas, thus indicated that nearly same sources and the origin of type rocks (Figure-5). They are in the field of moderately stable.

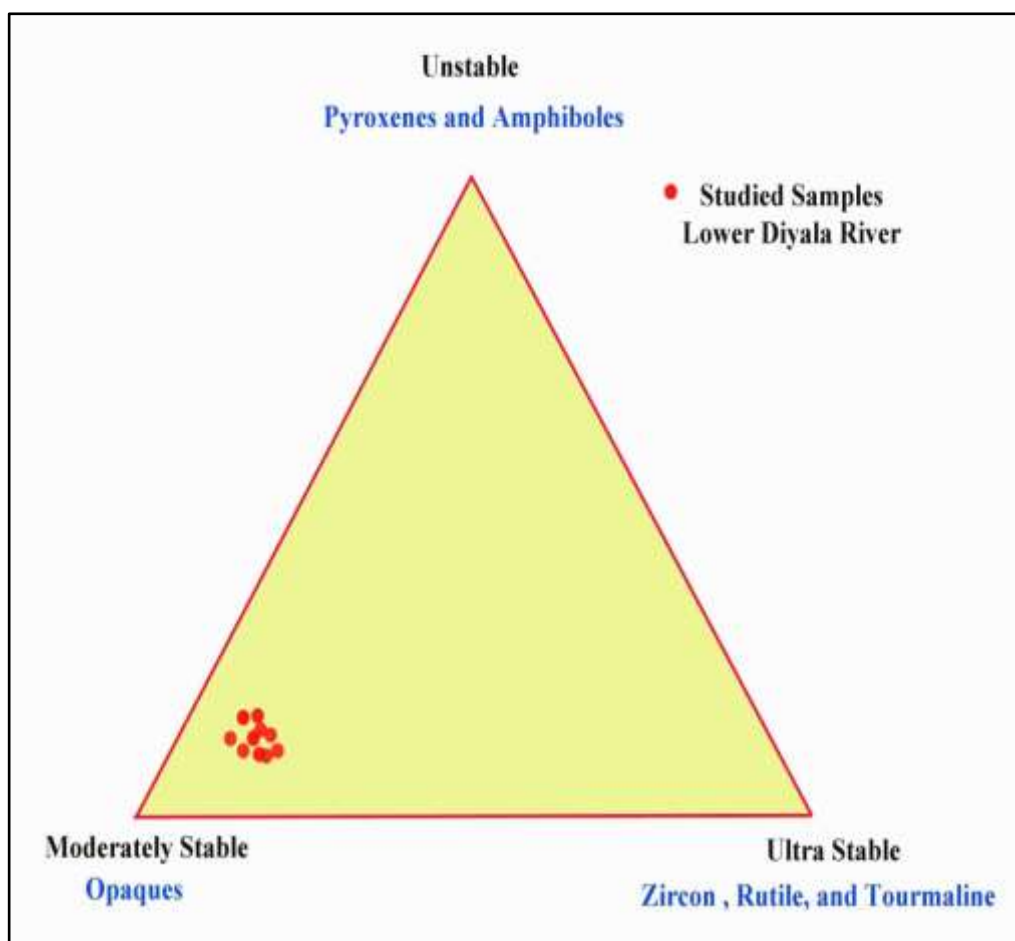


Figure 5- Ternary diagram of heavy mineral stability of Lower Diyala River samples [using the Kasper *et al.*, 2008 triangular diagram].

6. Provenance

Heavy minerals are quite used to define transportation and origin in diverse depositional environments like alluvial deposits, dune, beach, and rivers [13]. Heavy minerals are commonly applied for reason sources rocks determination ([14], where these minerals data supply of the mineralogical nature of the source region [15].

The heavy minerals of classics rocks and detrital sediment were the various and nongenetic mineral group. The minerals were not inherently in any other way linked to one another; because they just are categorized as a group by the fully operational type of procedure in dividing them, these minerals of origin rock remaining destruction by erosion [16].

Average distribution of the heavy minerals in Lower Diyala River area (Figure-6), specifies a variation of likely rock original source kinds such as igneous, metamorphic, and sedimentary rocks. Considering the abundances and availability from each mineral, it may be mentioned that the heavy mineral assemblages studied are extracted principally from sedimentary rocks two types of one or more than cycles, metamorphic rocks, acidic and basic igneous rocks, and as well as pegmatites.

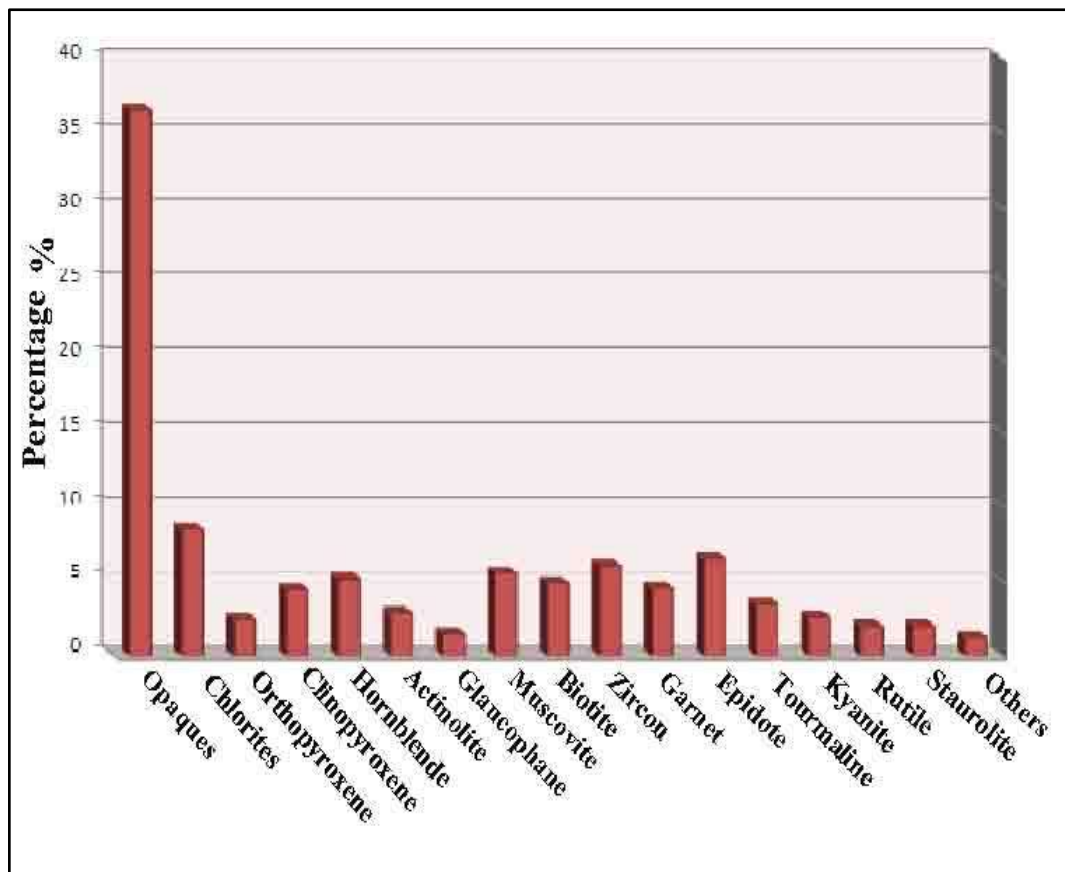


Figure 6- Average distribution of the heavy minerals in Lower Diyala River samples.

7. Conclusions

Carbonate rock fragment represents the major components in all studied samples. This high percentage is due to the nature of source rocks as they have composed of old carbonate formation in northeastern of Iraq and clastic formation rich in carbonate rock fragment, especially Tertiary Formations.

The Opaque's component is the main content of heavy minerals in all samples of the study area, while the second component is the chlorite group, amphibole group, and pyroxenes group, zircon and tourmaline. These minerals amount clearly indicates various source rocks such as igneous, metamorphic and sedimentary rocks. The stability of river sediments indicates moderately stable assemblage.

The heavy and light minerals display that the main sources of study areas are from Zagros and Himreen mountains and to least spread the Mesopotamian sediments as set by the appearance of the carbonate contents of rock fragments and chert rock fragments.

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