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Petrographical study of sandstone of Injana Formation in Bazian (Northern Iraq) and Zurbatya (Eastern Iraq)

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Abstract

The present study focused on petrography of sandstone in Injana Formation in Sulymaniyah(Northern Iraq) namly ; Bazian (Bz) and the other in Wasit(eastern Iraq) namly Zurbatiya(Zu) . Twenty samples were selected, nine of which represent Bazian (Bz) samples and eleven samples representing Zurbatiya(Zu) samples in term of petrography study . The study revealed that monocrystalline quartz represents the major quartz type and its lowest percentage was observed in Bazian (Bz) while the highest percentage was observed in Zurbatiyah (Zu) that related with increasing distance from probably source from north east Iraq because high stability of quartz in the long distance of transportation. Polycrystalline quartz is a function of grain size and it increase with increasing grain size, therefor, the highest average record in Bazian compared to Samples of Zurbatyah . These grains (monocrystalline and polycrystalline quartz) showed dominant straight and wavy extinction which resulted from the stress on quartz grains that suggested they derived from plutonic igneous rock or metamorphic rock. These grains are angular, sub-angular and sub- rounded and these criteria are characteristic of immature sandstone.

Orthoclase and microcline are sub- angular to sub -rounded with a slight difference in percentages were observed in sample of Bazian(Ba) and Zurbatiyah (Zu). Plagioclase is very angular to sub-angular. However, Orthoclase and plagioclase may be derived from plutonic igneous rock or metamorphic rocks .Microcline is commonly found in the plutonic igneous rocks .

The highest average of carbonate rock fragments was record in Zurbatiyah (Zu) in compression with Bazian, , while the highest average of metamorphic and igneous rock fragments was in Bazian (Ba) compared to Zurbatiyah (Zu). Petrographic classification indicated that the samples of Bazian and Zurbatiyah (Zu) are Calclithite , moreover Litharenite, but the samples of Bazian are Lithic arenite to Calci Lithic arenite, wheareas Zurbatiyah (Zu) are Calci Lithic arenite , This reflects the effect of the increase of carbonate rock fragments in Zurbatiyah (Zu) . Provenance ,the studied samples indicated that the recycled orogen (Undissected Arc) and Lithic Recycled sediments.

Key words : Injana Fn., sandstone, Petrography, Bazian, Zurbatiyah ,Iraq

1. Aim of study

The current study deals with petrography of clastic deposits of injana formation in the two studied areas in Sulaymaniyah (northern Iraq) and Wasit (eastern Iraq) . the study were carried out on the sandstone sediments , in order determine their mineralogical composition and Comparison between two different areas Sulaymaniyah and Wasit to expect the provenance and origin of injana formation.

2.Previous studies

-[1] studied the formation in north Iraq and mentioned that the formation consists of braded and meandering rivers environments based on sedimentary facies study.

-[2] studied Injana Formation in Kand Anticline, about 33km north of Mosul city. The sequence consist of cyclic alternation of sandstones, siltstones and claystones .

-[3] studied Injana Formation of Iraq , Petrographic of the sandstone suggest the derivation of the Injana Formation from a nearby sources with contribution from igneous metamorphic and sedimentary provenance mainly from the high lands in the northeastern parts of Iraq .

-[4] studied Injana Formation in . Zawita, Tikrit and Tar Al-Najaf and pointed in his petrographic study the effect of Zagros-Taurus in provenance of Injana sediments.

-[5] studied the Miocene succession (Serikagni, Dhiban, Jeribe, Fatha and Injana Formations)in Zurbatiya area . The clastic rocks repointed that of injana in studied sections are represented by Sand dominated - mud dominated rocks which characterized by

high percentage of rock fragments and low percentages of quartz and feldspar The majority of the studied sandstones plot in arid field with low maturity . sandstones are indicated also from thin section study by prevailing of angular to subangular grains and common presence of lithic components composed mainly of carbonates.

-[6] point out the sandstone of the Injana and Mukdadiya Formations in Zurbatiya area, are classified as Litharinite, Sedarinite and Calclithite. The tectonic provenance a lithic recycled .

3. Introduction

Injana Formation(upper Miocene) comprises fine grained mollase sediments deposited initially in coastal area , and later in fluviolacustrine system[7]. The type section is near Injana area at southern Hemrin mountain (120 km NE of Baghdad) with a thickness of 620m [8].The thickness of the formation is very variable , due to subsequence erosion over major folds .A maximum thickness of 2000 m in central depositional area in the Foothill Zone [9]

The major unit includes sandstone bedded with red to brown mudstone and thin gypsum bed in addition to calcareous sandstone and rare limestone.They deposited in sedimentary cycles of sandstone , siltstone and mudstone.These cycles consist principally of repeated fining upwards succession nested above each other in general coarsening upwards in the sand . The lower contact of Injana Formation with Fatha

formation is gradational (marly limestone to marl) ,the upper contact with Mukdadiya formation is also gradational (pebbly sandstone) .

In the current study area , the Mukdadiya, Injana ,and Fatha formation are appeared as outcrops along with the ridges. The lower contact of the Injana formation with Fatha Formation is deducted of appearance of green marl bed while the upper contact with

Mukdadya Formation is marked by the first bed of pebbly sandstone.

4. General Description of Study Area

4.1 Location of Study Area

Two outcrops of Injana formation were chosen, the first in Sulaymaniyah (Bazian) (N 35° 39' 49" & E 45° 05' 30") and the second in Wasit governorate (Zurbatiyah) (N 33° 13' 18" &E 46° 05' 24") Figure 1.

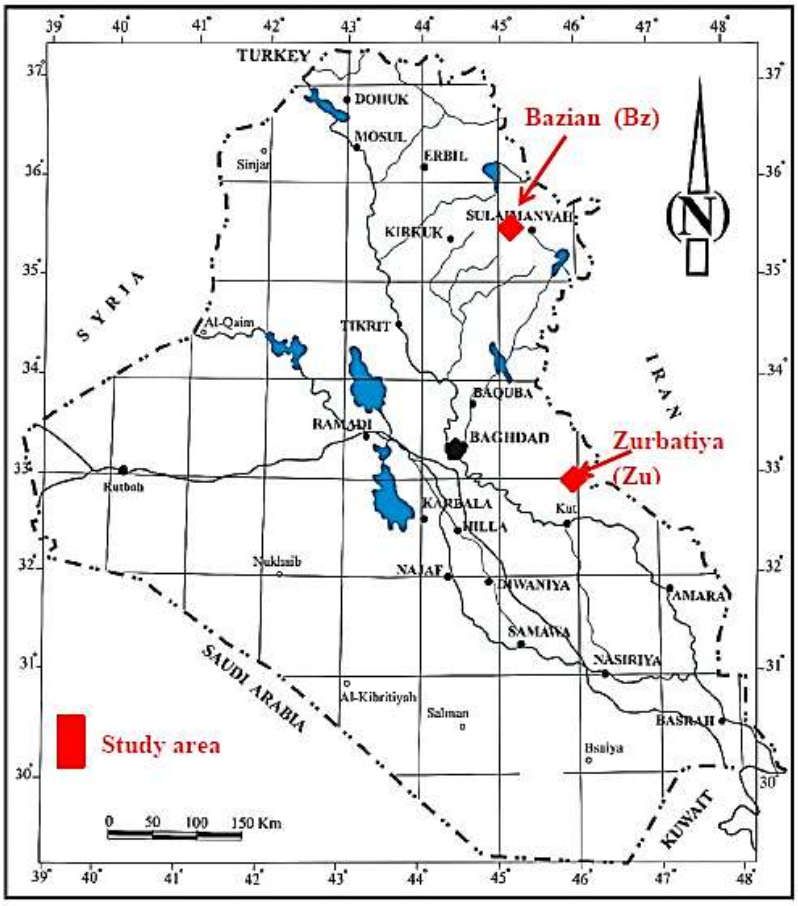

Figure 1. Location map of the study areas

4.2 Tectonic Setting

Bazian represents part of Unstable Shelf (High Folded Zone) according to [7], On the Other hand, it represents part of Forland Basin according [10,11] which suggest division of Iraq based on plate tectonic movements. ; and it is part of Arabian Platform,outer plat form,Westren Zagros fold-thrust zone in High folded zone [12,13]. While Zurbatya Zurbatiya represents part of Unstable Shelf (Low Folded Zone) , Foothill zone, Hemrine sub Zone according to [7], On the Other hand, it represente apart of Forland quasiplat according to [10, 11] and a part of Arabian platform, Outer plat form,Westren Zagros Fold-thrust Zone in Low folded zone [12,13]

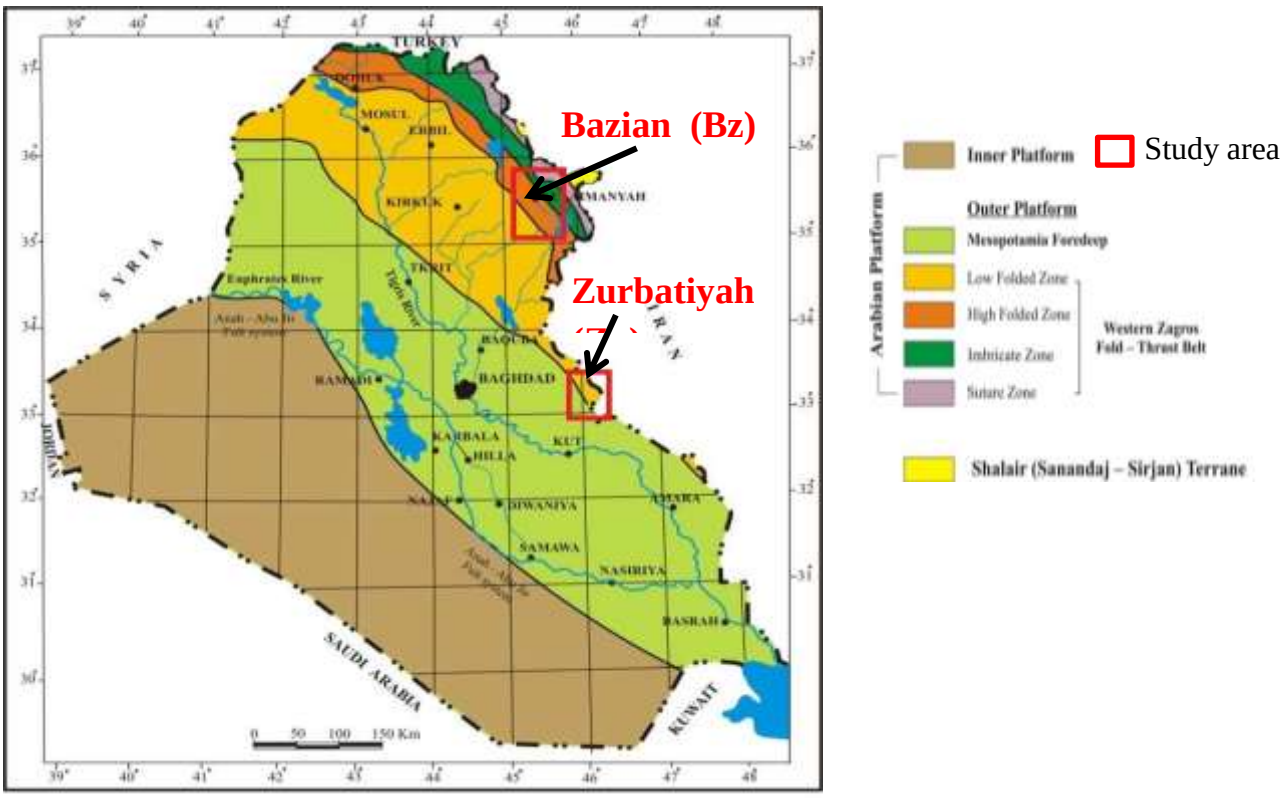

Figure 2 . Tectonic map showing studied area after Sissakian and Fouad,(2012).

5. Field work

5.1 Bazian (Bz) section

The section is located in the northwestern part of Sulaymaniyah at. The total thickness of the outcrop of Injana formation is about 204 m ,the upper contact of Injana with Mukdadiya formations was characterized by 1-2 m of pebbly sandstone bed, while the lower contact with Fatha Formation was marked by 2 m of green marl bed, Figure 3.

This section consists of the following lithofacies:

1- Sandstone Facies

These rocks are gray, dark gray and greenish gray,with about 66m in thickness most of these rocks are friable and the other are hard and massive rock.

2- Siltstone Facies

Appeared as light brown to reddish brown and thickness of about 107 m in all parts of the section.

3- Mudstone Facies

Mudstone were observed in the lower part of the section and characterized by light brown and with a relatively low thickness of about 9 m

4- Calcareous sandstone

These rocks were observed in the lower part of the section and were characterized by gray to white colours with a thickness of about 18m . This type of rock is characterized by being hard and massive or blocky due to carbonate cement content. This type of cementation is common in fine grained sediment such as sand and silt , especially in deep and quiet environments fold-thrust zone in Low Folded Zone [14].

5.2 Zurbatiyah (Zu) section

The section is located in the northeast part of Wasit . The total thickness of the formation is about 137 m ,the upper contact of injana with Mukdadiya formation were detected by appearance 1m thickness of pebbly sandstone bed , while the lower contact with Fatha formation were marked by 1.5 m thickness of green marl bed. This section consists of the following lithofacies:

1-Sandstone Facies were charchaterized by a thickness of 68 m. These rocks are gray, greenish gray and brown grey , Sand sediments are characterized by low cohesion and friable at all parts of the section.

2- Siltstone lithofacies

Siltstone Facies appeare as light brown to reddish brown and thickness of about 9 m in all parts of the section.

3- Mudstone facies were observed in all part of the section and characterized by light brown and relatively high thickness of about 48 m .

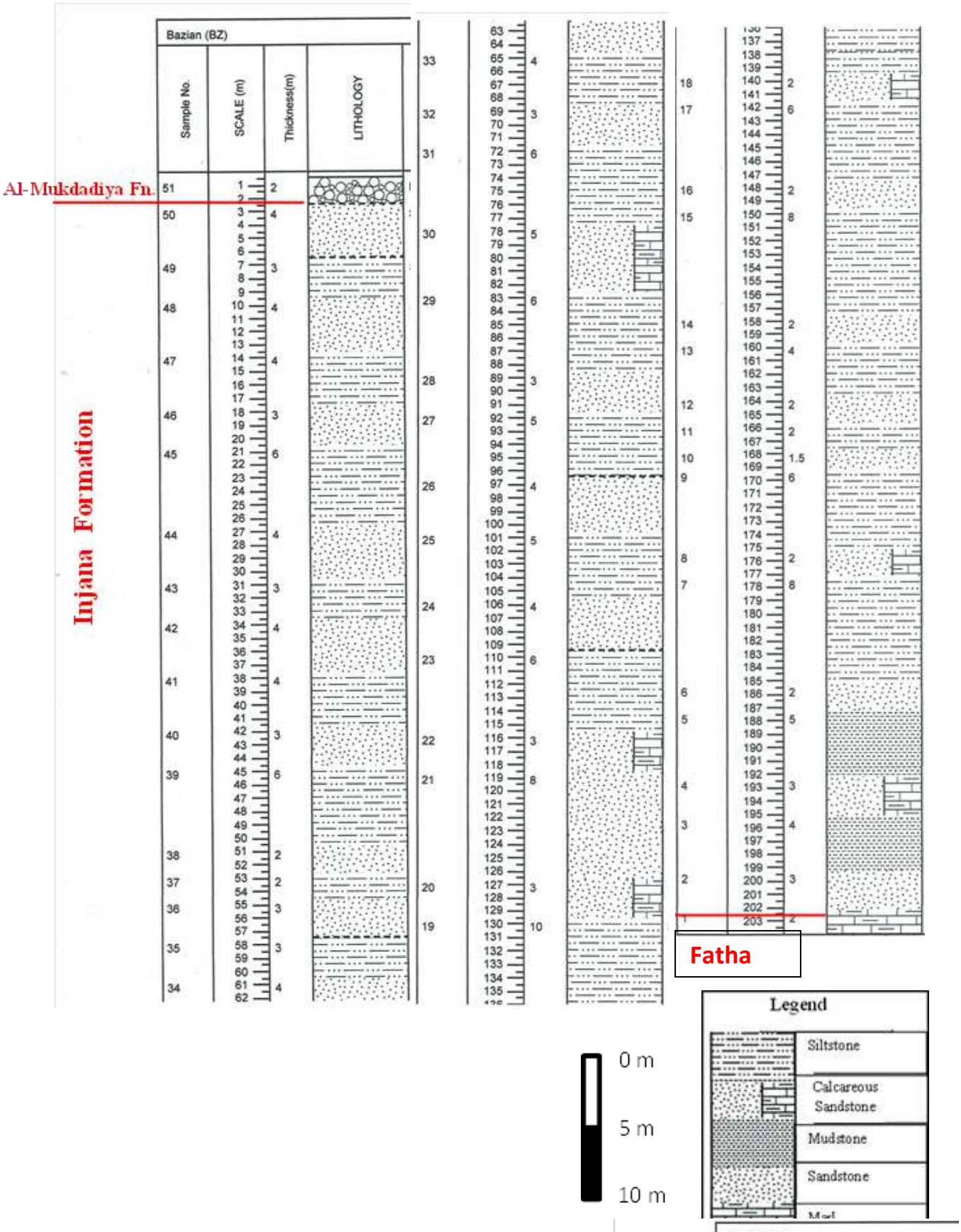

Figure. 3 Stratigraphic section of Injana Formation in Bazian

Table 1 sandstone components percentage (%) of Injana Formation in Bazian(Bz)

	Sample	BZ 50	42	36	34	26	14	8	6	2	min	max	Av
	Lithology	Sand stone	Sand stone	Sand stone	Sand stone	Sand stone	Sand stone	Silty sand	Sand stone	Sand stone			
QUARTZ	Mono. Qz.	8.8	8.5	11.6	6.8	7.9	12.7	9.6	6.7	14.6	6.7	14.6	9.69
QUARTZ	Poly.QZ.	3.7	4.6	2.7	3.9	3.8	2.5	1.7	2.6	1.7	1.7	4.6	3.02
QUARTZ	Total QZ.	12.5	13.1	14.3	10.7	11.7	15.2	11.3	9.3	16.3	9.3	16.3	12.71
FELDSPAR	Orthoclase	2.9	3.7	2.5	2.7	2.9	3.8	3.5	2.5	2.5	2.5	3.8	3
FELDSPAR	Microcline	0	0.5	1.8	0	0.8	0.9	1.2	0	0.6	0	1.8	0.64
FELDSPAR	Plagioclase	2.6	2.6	3.5	1.6	4.6	2.8	2.3	1.7	1.8	1.6	4.6	2.61
FELDSPAR	Total Fld.	5.5	6.8	7.8	4.3	8.3	7.5	7	4.2	4.9	4.2	8.3	6.26
ROCK FRAGMENTS	Carbonate	16.9	12.5	16.7	7.8	7.7	23.6	20.25	32.9	22.7	7.7	32.9	17.89
ROCK FRAGMENTS	chert	11.8	7.4	10.6	14.8	16.9	7.5	8.2	7.4	9.4	7.4	16.9	10.44
ROCK FRAGMENTS	Argillaceous	4.7	5.8	5.4	2.7	3.8	2.7	6.6	6.3	4.3	2.7	6.6	4.7
ROCK FRAGMENTS	Sandstone	4.6	2.9	3.8	3.8	3.6	2.9	2.3	2.8	2.5	2.3	4.6	3.24
ROCK FRAGMENTS	Metamorphic	10.8	15.9	6.3	18.8	20.4	4.8	3.1	4.6	5.7	3.1	20.4	10.04
ROCK FRAGMENTS	Igneous	6.7	6.2	4.2	8.7	5.6	3.6	2.4	2.7	3.9	2.4	8.7	4.89
ROCK FRAGMENTS	Total R.F	55.5	50.7	47	56.6	58	45.1	42.85	56.7	48.5	42.85	58	51.22
CEMENT	carbonate	9.5	14.3	12.8	16.5	8.5	10.5	8.9	10.5	11.8	8.5	16.5	11.48
CEMENT	Evaporates	0	0	0	0	0	0	0	0	0	0	0	0
CEMENT	Iron oxides	0	0	2.5	0	0	2.7	8.8	2.8	2.6	0	8.8	2.16
	opaque grains	3.6	4.8	3.6	2.4	2.6	3.3	4.6	4.7	2.7	2.4	4.8	3.59
	Matrix	8.9	7.6	8.4	6.2	7.8	10.8	11.2	6.9	10.5	6.2	11.2	8.7

Table 2 sandstone components percentage (%) of Injana Formation in Zurbatiyah (Zu)

	Sample	ZU 46	26	24	22	18	16	14	12	10	6	2	min	max	Av.
	Lithology	Sandy mud	Silty sand	Silty sand	Silty sand	Silty sand	Silty sand	sand stone	Silty sand	Silty sand	Silty sand	sand stone			
QUARTZ	Mono. Qz.	16.5	15.3	16.4	14.5	11.1	11.5	12.7	10	10.2	10.3	13.8	10	16.5	12.94
QUARTZ	Poly.QZ.	1.3	2.4	2.9	1.3	2.6	1.9	2.5	1.9	2.6	2.5	2.9	1.3	2.9	2.25
QUARTZ	Total QZ.	17.8	17.7	19.3	15.8	13.7	13.4	15.2	11.9	12.8	12.8	16.7	11.9	19.3	15.19
FELDSPAR	Orthoclase	2.4	3.8	2.8	1.2	3.8	3.8	3.5	2.8	3.8	3.6	3.6	1.2	3.8	3.19
FELDSPAR	Microcline	0.6	1.5	0.9	0.8	0.6	0.9	0	0.6	1.5	0	0.8	0	1.5	0.75
FELDSPAR	Plagioclase	2.6	3.4	3.6	2.8	2.9	2.7	1.6	3.7	2.4	2.7	3.6	1.6	3.7	2.91
ROCK FRAGMENTS	Total Fld.	5.6	8.7	7.3	4.8	7.3	7.4	5.1	7.1	7.7	6.3	8	4.8	8.7	6.85
ROCK FRAGMENTS	Carbonate	29.3	14.8	21.7	27.7	26.7	28.6	22.4	28.9	30.7	23.2	17.9	14.8	30.7	24.72
ROCK FRAGMENTS	chert	5.22	9.9	8.9	9.6	9.6	9.5	8.8	6.7	6.8	13.4	11.8	5.22	13.4	9.11
ROCK FRAGMENTS	Argillaceous	5.5	4.7	4.7	4.5	4.5	4.3	3.8	6.5	6.9	5.6	3.7	3.7	6.9	4.97
ROCK FRAGMENTS	Sandstone	1.4	1.5	2.6	2.3	1.7	2.8	0.9	1.8	1.7	1.7	3.6	0.9	3.6	2
ROCK FRAGMENTS	Metamorphic	4.5	7.8	6.7	4.6	7.8	5.9	4.2	5.7	4.5	3.3	4.9	3.3	7.8	5.45
ROCK FRAGMENTS	Igneous	2.3	4.6	3.8	2.8	4.9	2.6	2.5	3.9	2.4	2.8	6.6	2.3	6.6	3.56
ROCK FRAGMENTS	Total R.F	48.22	43.3	48.4	51.5	55.2	53.7	42.6	53.5	53	50	48.5	42.6	55.2	49.81
CEMENT	carbonate	9.6	9.7	8.7	10.5	8.7	8.5	3.5	9.3	9.6	11.6	11.7	3.5	11.7	9.22
CEMENT	Evaporates	2.5	0	0	0	0	0	16.6	0	0	0	0	0	16.6	1.74
CEMENT	Iron oxides	2.3	2.6	1.6	2.1	2.6	1.7	3.3	2.7	2.5	2.4	0	0	3.3	2.16
	opaque grains	4.3	1.5	4.9	4.8	2.8	4.6	3.8	3.6	5.5	6.2	2.8	1.5	6.2	4.07
	Matrix	7.5	10.9	7.8	9.1	7.5	8.3	6.9	9.5	7.8	8.4	7.9	6.9	10.9	8.33

6- Petrography

The petrographic study of sandstone is one of the most important evidence to determine the origin of these rocks and explain the tectonic setting of the ancient sedimentary regions [15] .Tectonic setting is one of the most important factors controlling the components of source rocks, and this is reflected in the components of sandstone [16];[11] . The components of the source rocks from which the sediments derived control the components of the resulting sandstone [18], as well as the effect of the climate on the components of the sandstone and the transformative processes [19]. Sandstone grains are a record of processes of Orogenic Belts and tectonic movements [20]. The Petrographic studies focused on the mineralogical study of the main components of sand stone (all types of quartz, feldspar and rock fragments). The components of thin section were counted according to the method of Gazzi-Dickinson [21]which is the most common method of counting point, using the Point Counter after treating the slides with the red alizarin dye [22] to distinguish the calcite grains.

6.1 Monocrystalline quartz

Monocrystalline quartz grain is that grain which consists of a single crystal [23] Monocrystalline quartz represents the major quartz type that observed in all the studied samples, In Bazian (Bz) section, monocrystalline quartz ranging between. (6.7-14.6%) with an average of (9.69%) while in Zurbatiyah section ranging between (10.0% - 16.5%) with an average (12.9 %) the lowest percentage of monocrystalline quartz was observed in Bazian (Bz), while the highest percentage of it was observed in Zurbatiyah (Zu) which related to increasing related with increasing distance from probably the source rocks from north east Iraq because high stability of quartz in the long distance of transportation. The grains show dominant straight and wavy extinction, the type of source rocks is the one of major factor that affects the undulotry of quartz [24] . wavy extinction resulted from the stress that the quartz grain suggested that they derived from plutonic igneous rock or metamorphic igneous rock .[18, 25] suggested that the occurrence of inclusions in monocrystalline quartz may be reflected derivation from plutonic igneous rock. These grains are angular , sub - angular and sub – rounded(plate 1-A,1-B**).**

6.2 Polycrystalline Quartz

Polycrystalline quartz grain is that grain which consists of two or more quartz crystal of different optical orientation [26] . polycrystalline quartz in Bazian (Bz) section ranging between (1.7- 4.6%) with an average of (3.02%) while in Zurbatiyah (Zu) section ranging between (1.3% -2.9%) with an average of (2.25 %) . The boundaries between the crystals are semi-straight. This indicates that the origin of the quartz is plutonic igneous rock , sometimes the boundaries between the crystals is curvature or unclear[25]. The shape of the grains ranges from semi-rounded to semi-equal and has straight and wavy extinction, the crystals inside the grain take irregular shapes because of the pressure between them, therefore the probable source of polycrystalline quartz is metamorphic rocks such as schist, gneiss, metaquartzite, and plutonic igneous rocks [15,25]. the amount of polycrystalline quartz present in sandstones as a function of grain size shows a positive correlation, it increases as the grain size increases [18](Plate 1-C,1-D,1-E,1-F).

6.3 Feldspar

Feldspar is a common group of minerals in sedimentary, igneous and metamorphic rocks. It

is less stable under the influence of surface conditions especially in sedimentary environments. Mechanically ,the stability of feldspar mineral is less than quartz during erosion processes and also can be altered to clay minerals. Thus, feldspar minerals refer to a short distance of transportation [27]

.6.3.1 Alkali feldspar

The occurrence of alkali feldspar (Potassium feldspars, k-Feldspar) including orthoclase and microcline suggests semi-arid paleoclimate conditions or high relief source area subjected to rapid erosion [28]. Alkali feldspar in Bazian (Bz) section ranging between (2.5 – 4.7%) with an average of (3.6%). while in Zurbatiyah (Zu) section ranging between (2.0% -5.3%) with an average (3.94 %)in Zurbatiyah (Zu) . Orthoclase grains are sub angular to sub - rounded and dusty color due to its decomposition into clay minerals while Microcline grains show a cross hatching twinning, and observed as sub angular, with degrees of alteration . A slight difference in plagioclase percentages were observed between Bazian (Bz) and Zurbatiyah(plate 2-A,2-B,2-C,2-D,2-E).

6.4 Rock fragments

Rock fragments include pieces of old source rocks that have been broken down and are indivisible into individual mineral particles. , it is importante in the study of the origin of rocks because they are easy to distinguish and are a good indicator to identify the source , the type of source rocks compared to individual minerals such as quartz and feldspar, [29]. The three rock types igneous, metamorphic and sedimentary rock fragments were identified in this study, and sedimentary rock fragments are the most common type compared to the other types of rock fragments. Rock fragments are considered a material that indicates the clastic source. Location of the source rocks affects at the percentage of rock fragments with in the sandstone. This percentage increases when the source rock area was near the sedimentary basin or has high topography [30].

6.4.1Carbonate rock fragments

Carbonate rock fragments was common in clastic sedimentary rocks and clastic sediments in Iraq due to the widespread outcrops of these rocks in many areas of Iraq, these rock fragments represent special conditions of rapid mechanical erosion rather than chemical dissolution [31]. Carbonate rock fragments in (Bazian (Bz) section ranging between (7.7 – 32.9%)with an average of (17.8 %). while in Zurbatiyah (Zu) section ranging between (14.8%) with an average of (24.7 %)(Plate 3-4).

6.4.2Argillaceous and Sandstone rock fragments

Argillaceous ` rock fragments in (Bazian (Bz) section ranging between (2.7 – 6.6%) with an average (4.7 %). In Zurbatiyah (Zu) section ranging between (3.7% -6.9%) with an average of (4.97%). Sandstone rock fragments in Bazian sections ranging between (2.3 – 4.6%) with an average (3.24 %). while Zurbatiyah (Zu) sections ranging between (0.9% -3.6%) with an average (2%).

4.4.3 Igneous Rock Fragments

In Bazian ranging between (2.4 – 8.7%) with an average of (4.89 %) . while in Zurbatiyah (Zu) section ranging between (2.3% -6.6%) with an average of (3.56%) They are generally unstable in the sedimentary environment and, and when it occurs in sandstone, provides a good and direct evidence of the rock origin [29]. It is clear that the sedimentary rock fragments is the most present in the studied samples, especially the carbonate rocks fragment. This indicates that they derived from older formations with high carbonate content, which were exposed to the surface by tectonic movement such as folding and faulting [32,33,20].

6.4.4 Chert

The presence of chert is attributed to the sediments of the chert that were subjected to the folding process or from the Chert nodules contract located in the layers of carbonate rocks that were exposed [12] . [15] pointed out that the rocks of some Mesozoic formation in the thrust zone , possibly the Qulqula series, may be a source of chert. This suggests that the rocks of the Injana formation may be derived mainly from the formation of sedimentary rocks, While the metamorphic and igneous rocks represented the secondary source of the rocks of this formation . The variability in the mineral components reflects the diversity of the source rocks [34].

6.5 Cement

6.5.1 Carbonate cement

Carbonate cement in Bazian (Bz) section ranging between (8.5 – 16.5%) with an average (11.4 %). while in (Zurbatiyah (Zu) section ranging between (3.5% -11.7%) with an average (9.22%) (plate 4-1).

6.5.2 Iron oxides cement

Iron oxides cement in Bazian (Bz) sections ranging between (zero – 8.8%) with an average (2.16 %) . while in Zurbatiyah (Zu) section ranging between (zero % -3.3%) with an average (2.16%) .

6.6 Opaque minerals

Opaque minerals in Bazian (Bz) section ranging between (2.4 – 4.8%) with an average of (3.59 %). while in Zurbatiyah (Zu) sections ranging between (1.6% -6.2%) with an average (4.07%) (plate 4-2).

6.7 Matrix

Matrix in Bazian (Bz) section ranging between (6.2 – 11.2%) with an average of (8.7 %). while in Zurbatiyah (Zu) section ranging between (6.9%) with an average of (8.3%).

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Plate

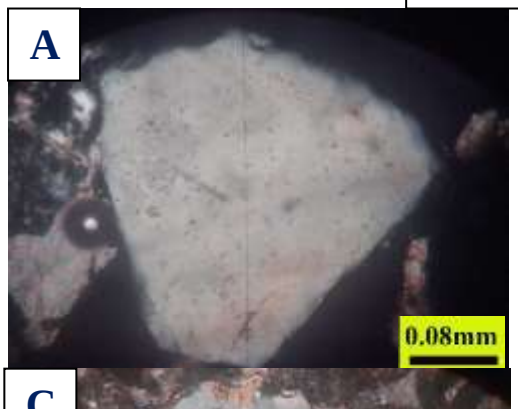

Plate 2

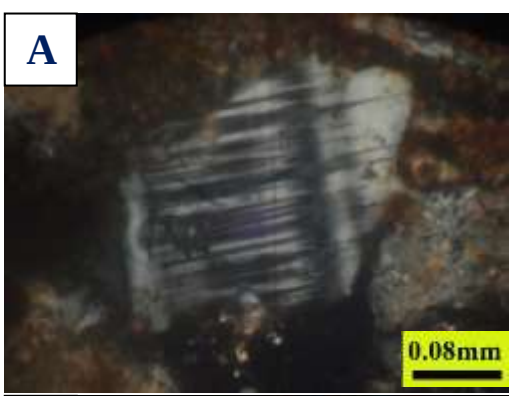

Plate 3

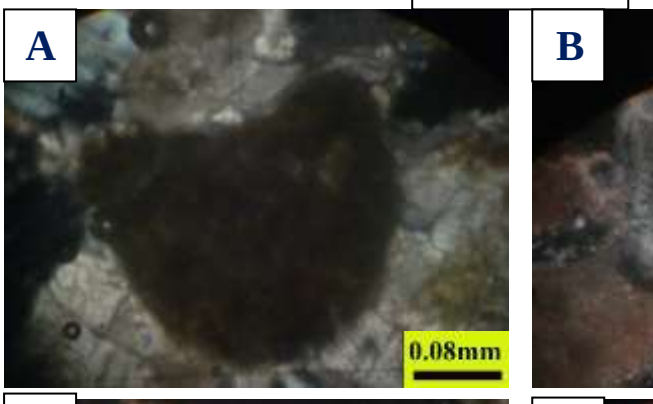

Plate 4

7. Sandstones classification

Sandstone classification suggested by [29] that depends on three types of components (Quartz, feldspar and rock fragments) , was used in order to classify sandstone . According to this classification, most of the study samples were Classified as carbonate-rich sandstone was adopted in order to classify sandstone that contains a high percentage of carbonate and carbonate cement .This classification gives an idea of rock origin, transport distance and tectonic setting. samples of Bazian (Bz) are Lithicarenite or Calcilithic arenite while the samples of Zurbatiyah (Zu) are Carbonate arenite due to increasing of carbonate rock fragments in Zurbatiyah (Zu) compared to samples Bazian. [35] pointed out that sandstone-type Litharenite rocks formed when erosion rate was predominant on the rate of chemical decomposition due to the low resistance of carbonate rock fragments and he also noted that accumulated in the field of litharenite, According to Folk classification (1974) [25], Injana sandstone are Sedarenite, and specially are calcithite.

tectonic lifting is the common process associated with the deposition of this type of sandstone. The conservation of large amounts of carbonate rock also indicates that the rocks were deposited near the source with no long distance, this type of rock is present in fluviatile sediments and continental delta (molasse) [23] therefore , Injana Litharenite sandstone are immature composition Carbonate-rich sandstone indicted that carbonate source is the main source , short distance of transportation and the deposition was in the early stage of tectonic uplift . [36] noted that the dry and semi-dry climate preserves carbonate rocks, and in contrast, depletes these rock particles in wet climates [37].

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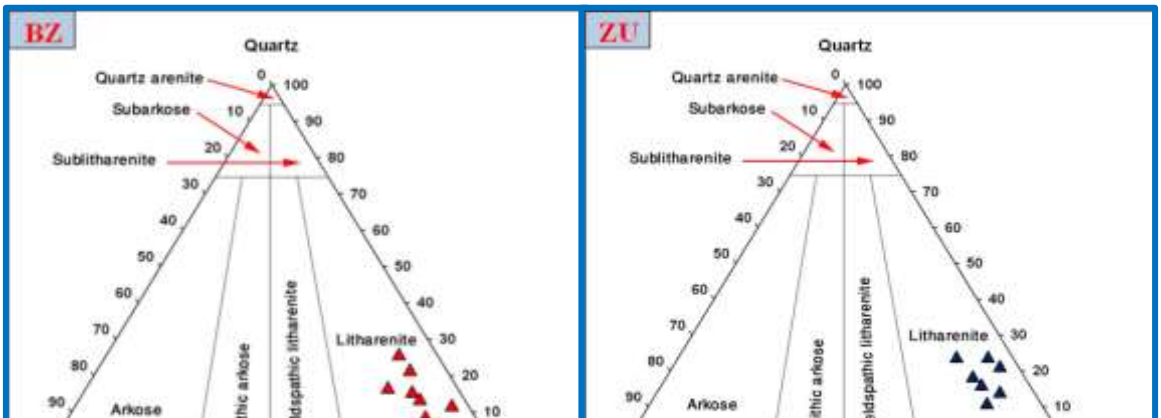

Ternary diagram of Ingersoll and Suczek (1979) was used in order to explain the provenance of Injana sandstone. In this diagram the studied samples plotting in Recycled orogen (Undissected Arc) and Lithic Recycled**.** The source of orogenic province sediments its believed of uplifted terranes of folded and faulted strata, this strata consists mainly of

sedimentary and metamorphic rock, on the other hand , igneous rock may be exposed [16].

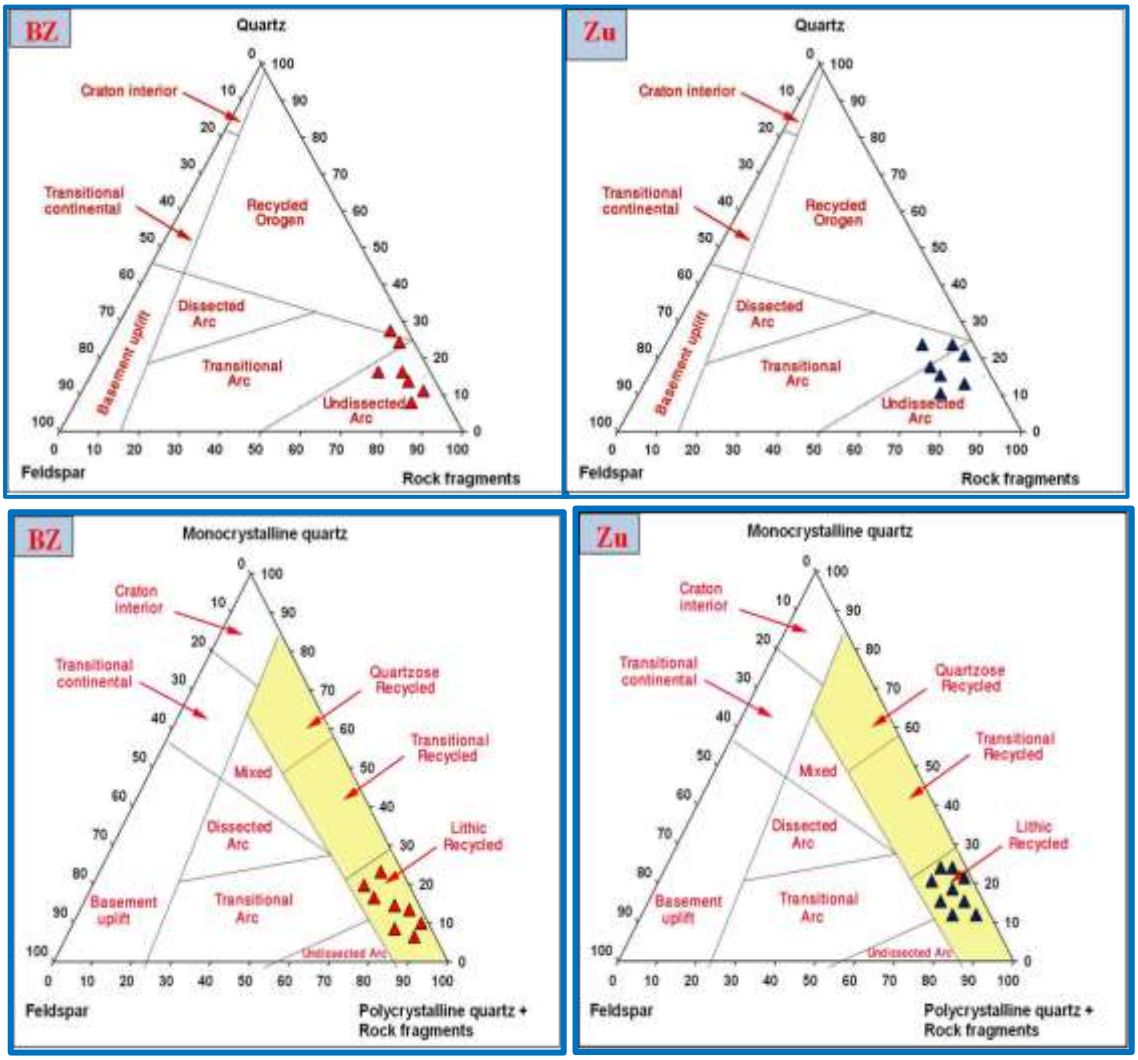

Fig.6Tectonic Provenance Classification Dickinson and Suczek,(1979) showing studied sample in Bazian (Bz) & Zurbatiyah (Zu) .

8. Conclusions

Monocrystalline quartz represent the major quartz type that observed in studied samples, the lowest percentage was observed in Bazian (Bz) while the highest percentage was observed in Zurbatiyah (Zu), that related with increasing distance from probable source from north east Iraq because high stability of quartz in the long distance of transportation. These grains show dominant straight and wavy extinction, the

type of source rocks is the one of major factors that affect the undulotry of quartz, wavy extinction resulted from the stress that subjected on the quartz grain that suggested they derived from metamorphic igneous rock. These grains are angular , sub angular and sub rounded and these criteria are characteristic of immature sandstone , moreover ,most of these grain were fresh but the others contain grains of different minerals .

Petrographic study of Polycrystalline quartz shows that the shape of the grains ranges from semi-rounded to semi-equal and has straight and wavy extinction, the crystals inside the grain take irregular shapes because of the pressure between them, moreover, the boundaries between the crystals are semi-straight. This indicates that the origin of the quartz is plutonic igneous rock, metamorphic rocks such as schist, gneiss, quartzite , sometimes the boundary between the crystals is curvature or unclear . the amount of polycrystalline quartz present in sandstones is a function of grain size and increase with increasing in grain size ,therefor , the highest average was observed in Bazian in comparison with the Samples of Zurbatyh.

Alkali feldspar (Orthoclase and Microcline) grains are sub angular to sub rounded and dusty color due to decomposition into clay minerals while Microcline grains show a cross hatching twinning, and observed as sub angular, with degrees of alteration . Plagioclase observed as very angular to sub- angular With fresh feldspars that indicate a fragmentation process from igneous rocks,Plagioclase were characterized by Albite twinning and the angular to sub angular shape of grains. A slight difference in percentages were observed in sample of Bazian (Bz)and Zurbatiyah (Zu).

However, Orthoclase and plagioclase may be derived from plutonic igneous rock or metamorphic rocks .Microcline and perthite are more commonly found in the plutonic igneous rocks of metamorphic rocks and found to be rare in rocks formation of Volcanic. It can be conclude that the origin of the Feldspar in the sand rocks for the Injana formation is the plutonic igneous rocks and metamorphic rocks.

Three main rock fragments including carbonate R.F, metamorphic R.F and igneous R.F respectively were observed in petrographic study.

The highest an average of carbonate R.F were record in Zurbatyh in comparison with the Samples of Bazia, whereas the highest averages of metamorphic and igneous R.F. were observed in Bazian formation compared to Zurbatiyah formation.

The mineral percentages were determined and used to produce ternary diagrams including (Q, F, R.F) , (Q+F, R.F excluding C.R.F, C.R.F+C.C), (Sed.R.F, Ign.R.F, Met.R.F) and (Sand R.F +Shale R.F, Carbonate R.F, Chert R.F),the sandstones samples of Bazian and Zurbatyah) are Sedarenite (Calclithite) , in addition to (Litharenite) , but the sandstones samples of Bazian are Lithic arenite to Calci Lithic arenite, wheareas Zurbatyh are Calci Lithic arenite , This reflects the effect of the increase of carbonate rock fragments in Zurbatyh area on the sediment type to be more calcareous than Bazian section .

Ternary diagram of Ingersoll and Suczek (1979) were used in order to explain the provenance of injana sandstone.In this diagram the studied samples plotting in Recycled orogen (Undissected Arc) and Lithic Recycled. The source of orogenic provenance sediments are uplifted terranes of folded and faulted strata, this strata consists mainly of sedimentary and metamorphic rock, on the other hand , igneous rock may be exposed partly. The Occurrence of a variety of rock fragments in the same strata probably indicates low

intensity weathering and sorting during their transportation from the source area to the sedimentary basin which means that the path from the source area to the sedimentary basin of Injana Formation was short and high relief.

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المستخلص

ركزت الدراسة الحالية على بتروغرافية الصخور الرملية لتكوين انجانة في مناطق بازيان وزرباطية. .يشكل المرو احادي التبلور النوع الاساس لانواع المرو وسجلت نماذج زرباطية معدلات مرو احادي التبلور اقل من نماذج بازيان بنما يلاحظ زيادة المرو متعدد التبلور في نماذج بازيان مقارنة بنماذج زرباطية والذي يعد دالة للحجم الحبيبي اذ يزداد في حجوم الرمل الخشنة في بالزيان مقارنة بالحجوم الرمل الناعمة في زرباطية.

يظهر كلا نوعي المرو احادي التبلور ومتعدد التبلور ظاهرة الانطفاء المستقيم والمتموج والذي يعد مؤشرا" لتعرض المرو لاجهادات ممايعد دليلا على الاصل الناري والمتحول. ويشير الشكل الزاوي وشبه الزاوي الى عدم نضوج الحبيبات وقربها من المصدر.

تتخذ حبيبات الاورثوكليز والمايكروكلاين شكلا شبه زاوي الى شبه مستدير مع وجود اختلافات بسيطة في معدلات الاورثوكليز والمايكروكلاين وتم تمييز معادن البلاجيوكليز بالشكل الزاوي وشبه الزاوي مع ظاهرة التؤمة المتكررة ويعتبر وجود الفلدسبار دليلا على الاصل الناري للرسوبيات .

تميزت رمال تكوين انجانة بانها ذات محتوى عالي من القطع الصخرية وسجلت نماذج زرباطية معدلات عالية من القطع الصخرية الكاربوناتية مقارنة بنماذج بازيان بينما نماذج بازيان تسجل معدلات اعلى من القطع الصخرية المتحولة والنارية مقارنة بنماذج زرباطية .يمكن تصنيف الصخور الرملية لتكوين انجانة بانها رسوبية ذات قطع صخرية كاربوناتية ونوع اخر من الارينايت الصخري .

تراوحت رمال انجانة بين الارنايت الصخري والارينايت الصخري الكلسي بينما رمال زرباطية صنفت على انها ارينايت صخري كلسي .

ان الصخور المصدرية لنماذج زرباطية وبازيان تمثلت برسوبيات معادة التدوير من المناطق الاورجينية في مناطق اقواس الجزر المتقطعة ورسوبيات صخرية معادة التبلور .

الكلمات المفتاحية : تكوين انجانة ، الصخور الرملية ،بتروغرافي ، بازيان، زرباطية ، العراق