Available online www.jsaer.com

Journal of Scientific and Engineering Research, **2019, 6(8):206-213**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Heavy Mineral Study of Injana Formation in Selected Area in Northern Iraq and Eastern Iraq

Nael Abdulimam K. Al-Najjari, Sattar Jabbar Al-Khafaji

University of Basrah-College of Science-Dept. of Geology
Corresponding author: Nael Abdulimam K. Al-Najjari, Email geonael@yahoo.com

Abstract The present study focused on heavy minerals study of sandstone sediments of Injana Formation in northern Iraq and eastern Iraq. Eighteen samples of sand in term of determine their mineralogical composition. The heavy minerals study show that the opaque mineral record the highest percentage in compression with other heavy mineral .Morevere, transparent minerals including un stable minerals (Amphibole including Hornblend, Trimolite-Actinolite and Glocophen as tabular, prismatic and cleaved grains, mostly fresh with some showing some degree of alteration, euhedral to subhedral) and (pyroxen as prismatic habit, two set of cleavage, and subhedral), Metastable minerals including (Epidote, staurolite, Garnet, Kyanite) indicated metamorphic source, Ultrastable minerals (Zircon and Tourmaline), Mica group (chlorite, biotite and muscovite) and Magnsite that forms during the alteration of magnesium-rich rocks such as peridotite or serpentinite during regional, contact, or hydrothermal metamorphism or alteration of limestone, marble, or other carbonate-rich rocks by magnesium-rich solutions during regional, contact, or hydrothermal metamorphism, therefore, can be an indicator of the type of rocks of the source because this type of rock is located in the complexes of ophiolite in northern Iraq, which can be a source of sediments composition of Injana. Ternary diagram of the heavy mineral stability after Kasper et al, (2008) (Unsatable pyroxene and hornblende, Moderately Opaque, and Ultrastable Zircone and Tourmalline) were show the heavy mineral are Moderately stable due to the effect of opaque mineral that have highest concentration.

Keywords sandstone, heavy minerals, Injana, Iraq

Introduction

Injana Formation (upper Miocene) comprises fine grained mollase sediments deposited initially in coastal area, and later in fluviolacustrine system [1]. The type section is near Injana area at southern Hemrin mountain (120 km NE of Baghdad) with a thickness of 620m [2]. 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 [3]. 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.

Heavy minerals represent the most resistant metals to weathering factors and constitute very little of the components of sandy rocks but are of great importance in their study [4]. Heavy minerals are of great importance in determining the rock Provenance [5], as well as indictor to sedimentation and transformational processes [6]. Four outcrops of Injana formation were chosen, Two of which were located in Sulaymaniyah in northern Iraq include Bazian (Bz) and Darbandikhan (Da) which have the coordinate (N 35° 39' 49" & E 45° 05' 30" and N 33° 13' 18"& E 45° 39' 10") respectively. and two in Wasit are in eastern Iraq include Zurbatiyah (Zu) (N 33° 13' 18" &E 46° 05' 24") and the second section located in Badra (Ba) (N 33° 01' 10" & E 46° 04' 02") near the Iraq- Iran border (Figure1). The current study deals with heavy mineral study of injana formation in these four studied areas in order determine their petrographic description and to expect the provenance and origin of injana formation.

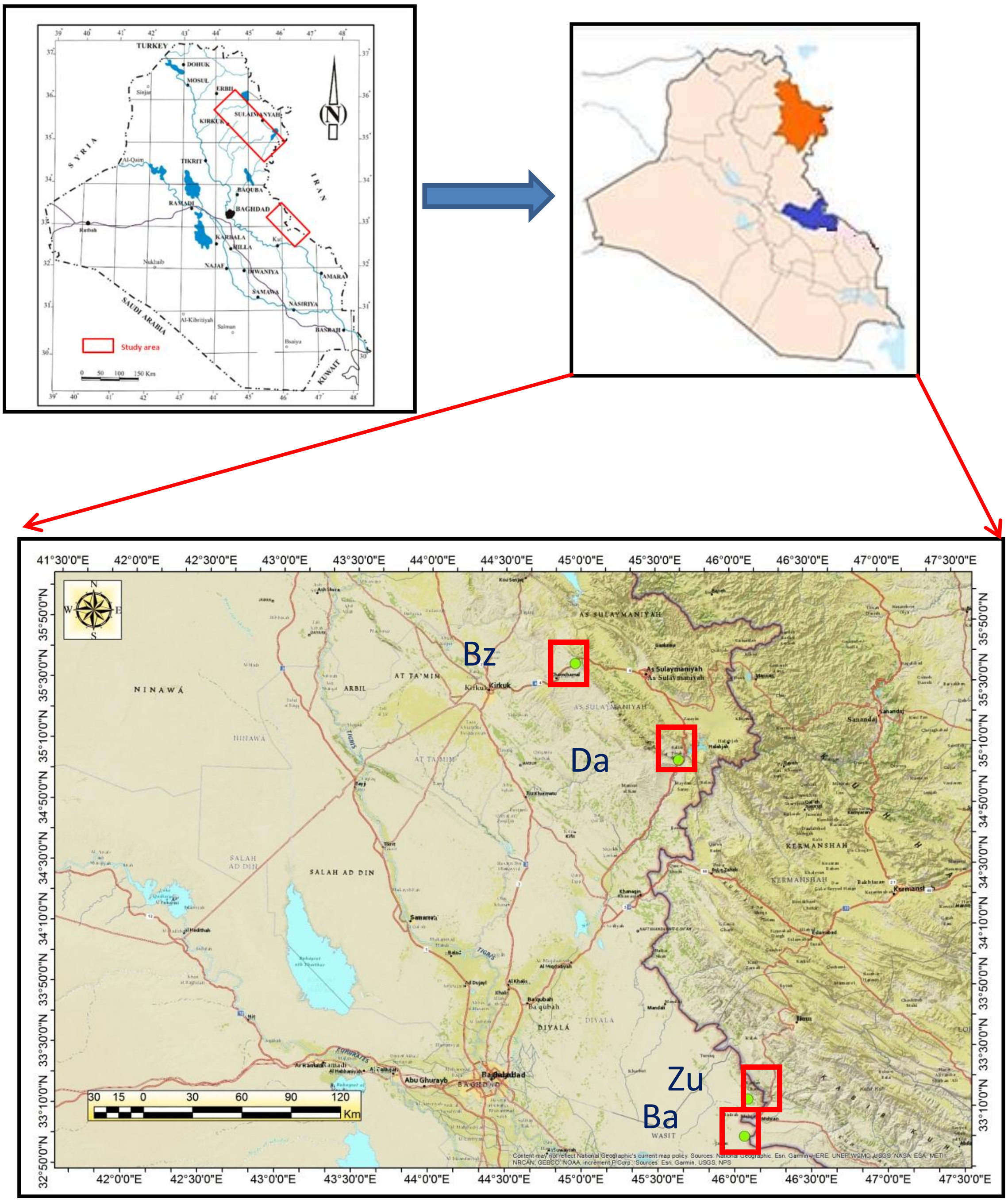


Figure 1: Study area, Bazian (Bz), Darbandikhan *(Da), Zurbatiyah (Zu) and Badra (Ba)*

Material and Methods

Eighteen samples of sandstone were chosen in order to identify the heavy minerals by Polarized microscope. The procedure for minerals separation was followed after [7-9], Sand fractions were separated using sieves size fractions 1mm, 0.5mm, 0.25mm, 0.125mm, and 0.063mm. The 3Ø (0.125mm), and 4Ø (0.063mm) which were obtained by dry sieving were mixed together, Five grams of these sizes were used for minerals separation, using heavy liquid (bromoform) with a specific gravity of 2.89.

Results

Two sets of heavy minerals have been identified and described in the current studied samples:
A- Opaque Minerals: The minerals, of iron oxides are found on two types, dark brown and black opaque, and dark brown minerals predominate in the studied samples including limonite, hematite and goethite and take different shapes. Opaque Minerals in the Sulaimaniyah samples have an average 61.3 % and 65.7 % in Bazian (Bz) and Darbandikhan (Da) respectively. While in Wasit sections indicated an average 64.2 %, and 63.5 % in Zurbatiyah (Zu) and Badra (Ba) respectively (Table 1), (plate 1, A & B).

B- Transparent minerals. According to the division of [4], depending on the stability of heavy minerals, the heavy minerals can be divided into the following groups

Table 1: Heavy minerals percentage (%) in studied samples

Sample	Opaques	Amphibole	Pyx.	Epidote	Staurolite	Garnet	Kyanite	Zircon	Tourmaline	chlorite	Biotite	Muscovite	Magnesite	Chromite spinel
BZ 50	51.6	4.4	5.6	6.7	0	4.6	0	3.2	0	5.8	2	2.1	10.6	2.2
BZ 2	62.7	2.8	3.5	3	0.9	3.7	0	2.8	0	7.9	2.6	2.4	4.9	1.2
BZ 34	65.8	2.9	4.2	4.5	0	3	0	3.21	0	3.2	1.6	1.61	6.7	1.2
BZ 2	58.5	2.5	3.5	3.6	0.9	2.6	0	2.5	0	7.4	0.9	1.8	10.7	2.5
BZ 16	67.9	2.8	2.3	3.5	0	3.9	0	3.5	0	5.8	0.9	1.5	3.8	1.5
min	51.6	2.5	2.1	3	0	2.6	0	2.5	0	3.2	0.9	1.5	3.8	1.2
max	67.9	4.4	5.6	6.7	0.9	4.6	0	3.5	0	7.9	2.6	2.4	10.7	2.5
av.	61.3	3.08	3.82	4.26	0.36	3.56	0	3.042	0	6.02	1.6	1.882	7.34	1.72
Da 35	68.6	3	2.4	3.8	0	3.6	0	3.2	0	6.5	1.2	1.6	3.8	0
Da 33	62.7	2.8	3.5	3	0.8	3.7	0	2.8	0	7.9	2.6	2.4	5.3	1
Da 31	67.9	2.8	2.6	3.5	0	3.5	0	3.8	0	5.7	0.9	1.5	2.9	1.5
Da 2	63.8	3.2	4.2	2	0	4.2	0.5	3.5	0	5.3	2.5	2	3.6	0.5
min	62.7	2.8	2.3	2	0	3.5	0	2.8	0	5.3	0.9	1.5	2.9	0
max	68.6	3.2	5	3.8	0.8	4.2	0.5	3.8	0	7.9	2.6	2.4	5.3	1.5
av.	65.75	2.95	3.175	3.075	0.2	3.75	0.125	3.325	0	6.35	1.8	1.875	3.9	0.75
ZU 25	48.7	4.8	5.2	4.6	1.7	3.9	0	3.8	1.3	9.6	6.7	3.5	4.5	0
ZU 18	54.5	4.7	4.6	4.3	1.4	4.6	0.9	4.3	1.3	5.7	2.6	2.5	3.8	2.8
ZU 14	53.9	4.3	5.2	4.5	1.5	4.3	0	3.7	1.4	8.7	4.8	2.4	3.7	0
ZU 12	60	2	2.1	2.2	0.6	2.8	0.9	2.4	0	4.5	3.5	2.4	12.6	2.4
ZU 2	64.2	3	4.1	4.6	0.9	3.6	0	2.6	1.8	4.7	1.2	1.2	4.5	1.6
min	48.7	2	2.1	2.2	0.6	2.8	0	2.4	0	4.5	1.2	1.2	3.7	0
max	64.2	4.8	5.5	4.6	1.7	4.6	0.9	4.3	1.8	9.6	6.7	3.5	12.6	2.8
av.	56.26	3.76	4.24	4.04	1.22	3.84	0.36	3.36	1.16	6.64	3.76	2.4	5.82	1.36
Ba 43	59.7	2.9	4.2	5.8	1.2	5.6	0	3.3	0.9	5.3	2.8	2.9	0	1
Ba 37	66.8	3.2	3	4.5	0.6	3	0	3.5	0	4.9	2.8	1.5	4.6	0
Ba 33	65.8	2.4	1.5	3.8	0.91	3.8	0	3.2	0.9	6.6	2.4	1.2	4.2	1.2
Ba 2	61.7	3.6	4.2	2.9	1.2	3.2	0	2.9	0.9	5.3	2.1	1.8	5.5	1.5
min	59.7	2.4	1.5	2.9	0.6	3	0	2.9	0	4.9	2.1	1.2	0	0
max	66.8	3.6	4.2	5.8	1.2	5.6	0	3.5	0.9	6.6	2.8	2.9	5.5	1.5
av.	63.5	3.025	3.225	4.25	0.9775	3.9	0	3.225	0.675	5.525	2.525	1.85	3.575	0.925

1- un Stable minerals

It includes the following minerals

a- Amphibole Group: include Hornblend, Trimolite-Actinolite and Gloghophen.

Amphibole in the Sulaimaniyah samples have an average (3.08 % and 3.2%) in (Bazian (Bz) and Darbandikhan (Da) respectively. while in Wasit sections indicated an average (3.7 %, and 3.3%) in (Zurbatiyah (Zu) and Badra (Ba) respectively.

Amphiboles in samples are observed as tabular, prismatic and cleaved grains, mostly fresh with some showing some degree of alteration, euhedral to subhedral (plate 1, C).

b-Pyroxene

Pyroxene in the Sulaimaniyah samples have an average (3.82 % and 3.17%) in (Bazian (Bz) and Darbandikhan (Da) respectively. while in Wasit sections indicated an average (4.24 %, and 3.22 %) in Zurbatiyah (Zu) and Badra (Ba) respectively both orthopyroxene and clinopyroxene sub group were observed. Pyroxenes are usually show green to light green color with prismatic habit, two set of cleavage, and subhedral (plate 1, D, E).

2- Semi-stable metal group Metastable minerals

This group includes Epidote, staurolite, Garnet and kyanite metals:

a -Epidote

Epidote in the Sulaimaniyah samples have an average 4.26 % and 3.07 % in (Bazian (Bz) and Darbandikhan (Da) respectively. While in Wasit sections indicated an average 4.04 %, and 4.25% in Zurbatiyah (Zu) and Badra (Ba) respectively. Epidotein polarizing microscope show a high relief, green to pale green color, and rounded, sub angular, and angular shape (plate 1,F).

b-Staurolite

StauroliteIn the Sulaimaniyah samples have an average (0.36 % and 0.2%) in Bazian (Bz) and Darbandikhan (Da) respectively. While in Wasit sections indicated an average 1.22 %, and 0.97 % in (Zurbatiyah (Zu) and Badra (Ba) respectively. Saurolite grains show high relief, yellowish to golden color with pleochroism, sub angular to sub rounded in form.

c- Garnet

Garnet in the Sulaimaniyah samples an average were observed (3.56 % and 3.75 %) in (Bazian (Bz) and Darbandikhan (Da) respectively. While in Wasit sections indicated an average (3.84 %, and 3.9%) in Zurbatiyah (Zu) and Badra (Ba) respectively. Two types of garnet were observed colorless garnet (Grossularite), and light rose color (Almandine).

Garnet grains mainly show high relief, shapes are equant, to sub equant, occasionally sub angular to sub rounded. It is characterized by being colorless, pinkish or brown, and high relief, and there is no paleochrosim phenomenon, which is isotropic mineral, giving black color under the polarized microscope and irregular granules (plate 1, F).

D- Kyanite

Kyanite in the Sulaimaniyah samples have an average (0.125 %) in Darbandikhan (Da). While in Wasit sections indicated an average (0.3 %, and 0.0 %) in (Zurbatiyah (Zu) and Badra (Ba) respectively. The mineral is characterized by its colorless color and high interference colors, 1set. Cleavage and granules irregular shape prismatic form, subhedral with elongated habit.

3- Ultra stable minerals

This group includes zircon and tourmaline metals

A- Zircon

Zircon in the Sulaimaniyah samples have an average (3.04 % and 3.32 %) in (Bazian (Bz) and Darbandikhan (Da) respectively. While in Wasit sections indicated an average (3.36 %, and 3.22 %) in (Zurbatiyah (Zu) and Badra (Ba) respectively.

Zircon is mainly colorless with shades of deep blue to black, prismatic grains are common, the crystal faces that are observed include euhedral, subhedral, and anhedral, zircon grains mostly occur with inclusions, the form of zircon ranging from subangular to well-rounded (plate 1, H, I).

B- Tourmaline

Tourmaline in Wasit sections indicated an average (1.16 %, and 0.65 %) in (Zurbatiyah (Zu) and Badra (Ba) respectively characterized by being colorless to yellowish brown and medium overlapping colors, and the phenomenon of multicolor is clear and protruding high and extinguishing parallel and longitudinal body.

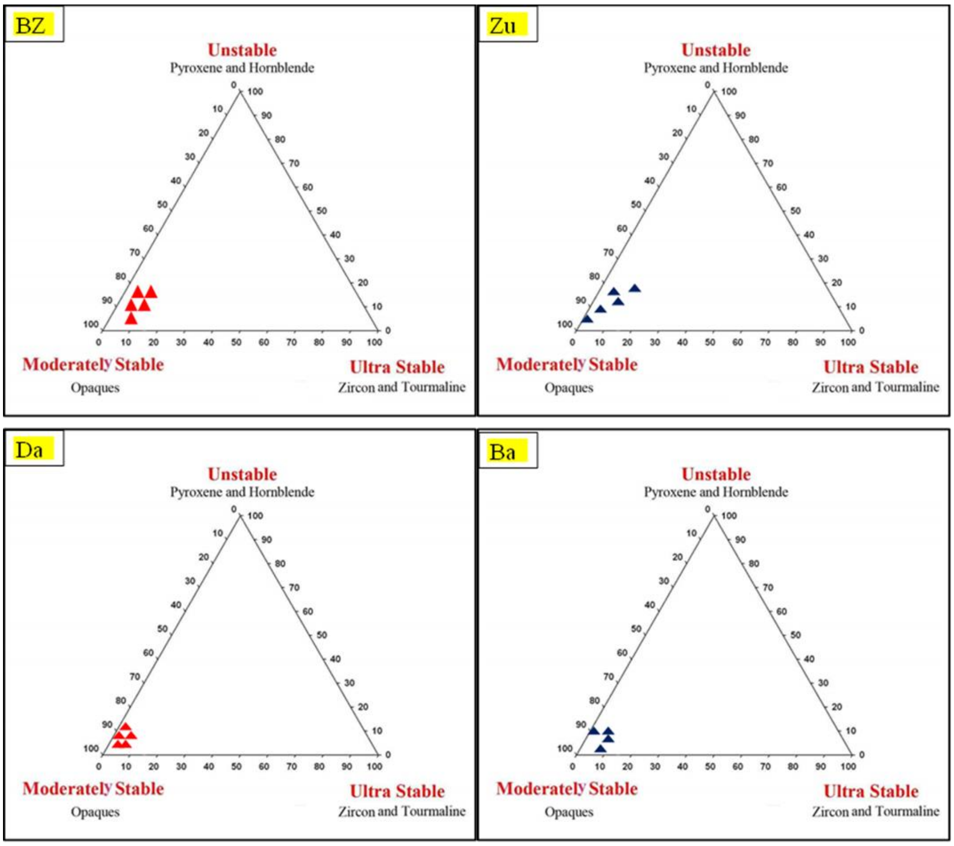


Figure 1: Ternary diagram of heavy mineral stability after [10] of studied sample in Bazian (Bz), Quradagh (Qd), Darbandikhan (Da), Zurbatiyah (Zu) and Badra (Ba)

4- Flaky minerals or Mica group: include on biotite, chlorite and muscovite minerals

a- Chlorite

Chlorite in the Sulaimaniyah samples have an average (6.02 % and 6.35 %) in (Bazian (Bz) and Darbandikhan (Da) respectively. While in Wasit sections indicated an average (6.64 % and 5.52 %) in (Zurbatiyah (Zu) and Badra (Ba) respectively (table 3-16).

It is characterized by its brown and pale green colors, and it has a tendency and is characterized by the cracking of the groups of mica, which is a uniformly homogeneous metal and its granules irregular (plate 1, J, K).

b- Biotite

Biotite in the Sulaimaniyah samples have an average (1.6 % and 1.8 %) in (Bazian (Bz) and Darbandikhan (Da) respectively. While in Wasit sections indicated an average (3.7 % and 2.25 %) in (Zurbatiyah (Zu) and Badra (Ba) respectively.

Biotite is pleochroic brown, yellowish, corroded, mostly irregular to angular in shape, platy grains are common with few long platy grains, biotite is usually fresh with some altered (plate 1, L, M).

c – Muscovite

Muscovite In the Sulaimaniyah samples an average were observed (1.88 %, and 1.87 %) in (Bazian (Bz) and Darbandikhan (Da) respectively. While in Wasit sections indicated an average (2.4 % and 1.85 %) in (Zurbatiyah (Zu) and Badra (Ba) respectively.

Muscovite is colorless, basal flakes, with angular to irregular outline. Most of the observed muscovite grains are clear and fresh.

d- Magesite

Magnsite in the Sulaimaniyah samples have an average (7.34 %, and 3.9 %) in (Bazian (Bz) and Darbandikhan (Da) respectively. While in Wasit sections indicated an average (5.8 %, and 3.57%) in (Zurbatiyah (Zu) and Badra (Ba) respectively (plate 1, N, O).

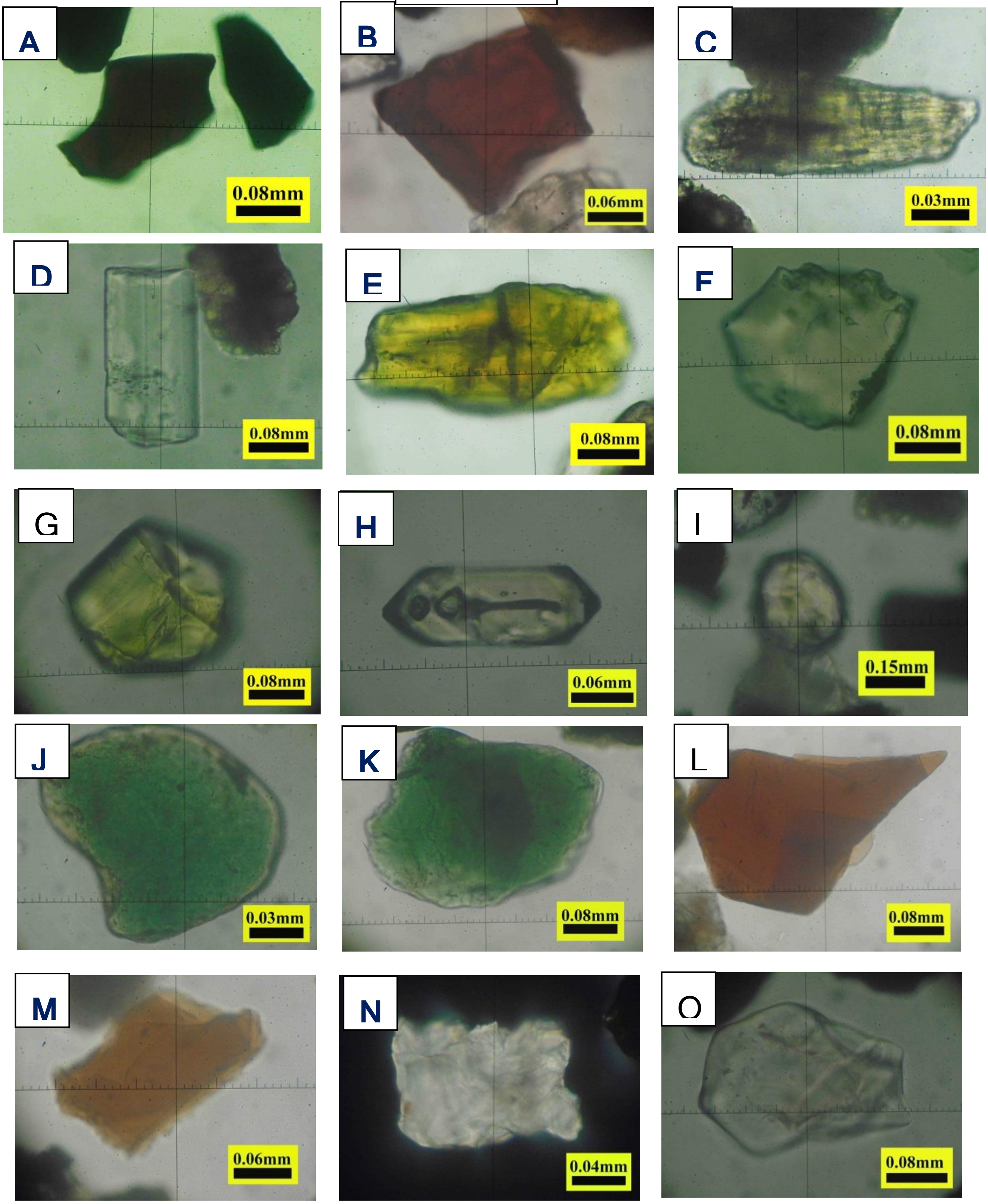
Magnesite usually has a specific gravity of between 3.00 and 3.20. Magnesite is a magnesium carbonate mineral with a chemical composition of $MgCO_3$. It is named after the presence of magnesium in its composition. Magnesite usually forms during the alteration of magnesium-rich rocks such as peridotite or serpentinite during regional, contact, or hydrothermal metamorphism or alteration of limestone, marble, or other carbonate-rich rocks by magnesium-rich solutions during regional, contact, or hydrothermal metamorphism, therefore, can be an indicator of the type of rocks of the source because this type of rock is located in the complexes of ophiolite in northern Iraq, which can be a source of sediments composition of Injana.

Discussion

Heavy minerals represent the most resistant metals to weathering factors and constitute very little of the components of sandy rocks but are of great importance in their study [4]. Heavy minerals are of great importance in determining the rock Provenance [5], as well as indictor to understanding the processes of the origin area, sedimentation and transformational processes [6]. The possibility of benefiting from heavy metals economically, especially when they are found in a large proportion of deposits [4].

Plate 1 A: Angular,, Opaques grain sample number (Da 2), XPL
Plate 1 B: Angular, Chromite spenile, sample number (BZ 50), XPL
Plate 1 C: Light green color, Subhedral amphibole, sample number (BZ 50), XPL
Plate 1 D: Euhedral pyroxene, sample number (Zu 25), XPL
Plate 1 E: subhedral pyroxene, sample number (Ba 33), XPL
Plate 1 F: sub Angular, Epidote, sample number (Da33), XPL
Plate 1 G : Sub Angular, Garnet, sample number (Zu2), XPL
Plate 1 H : Euhedral, Zircon, sample number (Da 2), XPL
Plate 1 I: Rounded , Zircon, sample number (Zu 18), XPL
Plate 1 J : Sub rounded , green chlorite, sample number (Da 33), XPL
Plate 1 K : Sub rounded , green chlorite, sample number (Zu14), XPL
Plate 1 L: Angular, Fresh Biotite, sample number (Zu 12), XPL
Plate 1 M : Angular, Biotite, sample number (BZ 50), XPL
Plate1 N : Sub angular magnsite, sample number (BZ2), XPL
Plate 1 O : Sub angular magensite, sample number (BZ 50), PPL

Plate 1


A
0.08mm
B
0.06mm
C
0.03mm
D
0.08mm
E
0.08mm
F
0.08mm
G
0.08mm
H
0.06mm
I
0.15mm
J
0.03mm
K
0.08mm
L
0.08mm
M
0.06mm
N
0.04mm
O
0.08mm

The heavy mineral assemblages of rock types including metamorphic, igneous, and sedimentary In general, the heavy minerals show slight roundness and in many cases, they occur as angular to sub angular which indicate their closer to source area.

The metamorphic source is indicated by existence of epidote, garnet, kyanite, staurolite, chlorite, andalusite, and blue-green hornblende.

Magnetite, chromite, chromite-spinels, and rutile commonly refer to basic igneous sources, chromite-spinels common accessory mineral in ultrabasic rocks and generally thought to indicates an oceanic crustal provenance [11].

Contribution of these sources takes into account the relative abundance and distribution of each mineral Derivation from metamorphic and basic igneous complexes associated with the ophiolitic complexes along the Zagros thrust is the most probable for heavy mineral assemblages [12, 13].

which closer to basic and ultrabasic basic rock (Ophiolte) northeast of Iraq which represent the main source of injana sandstone deposits, therefore the long distance from source results and the weathering processes cause alteration the rock bearing basic heavy minerals such as Dunite and Pyroxinite and reals basic heavy minerals from these rocks [14,15,16].

Reference

[1]. Buday, T. and Jassim, S., 1987. The regional geology of Iraq (tectonism and magmatism). D.G. of Geol. Sur. and Min. Inv., Baghdad, Iraq, 322p.

[2]. Buday, T., 1980. The regional geology of Iraq (Stratigraphy and paleontology). Dar AL-Kutb publishing House, Mosul, Iraq, 443P.

[3]. Al-Naqib, K.M., 1967. Geology of the Arabian Peninsula, Southeastern Iraq.

[4]. Folk, R.L., 1974. Petrology of Sedimentary Rocks, Hemphill Publishing Comp., Texas, 182p.

[5]. Morton, A.C., Allen, M., Simmons, M., Spathopoulos, F., Still, J., Hinds, D., Zadeh, A.I. and Kroonenberg, S., 2003. Provenance patterns in a neotectonic basin: Pliocene and Quaternary sediment supply to the South Caspian. Basin Research, Vol. 15, pp. 321-337.

[6]. Dill, H. D., 1998. A Review of Heavy Minerals in Clastic Sediments with Case Studies From the Alluvial Fan Through to the Near shore Marine Environment. Earth. Sci. Rev, V. 45, P. 103-132.

[7]. Tucker, M. E., 1988. Techniques in Sedimentology. Black Well. Oxford. 394p.

[8]. Tucker, M. E., 2001. Sedimentary Petrology, An Introduction to The Origin of Sedimentary Rocks, (3rd ed). Blackwell Scientific Publ, Oxford, 262p.

[9]. Carver, R.E., 1971. Procedures in sedimentary petrology. John Wiley and Sons, New York, 653p.

[10]. Kasper-Zubillaga, J. J., Dickinson, W. W., Carranza Edwards, A., and Hornelas-Orozco, Y., 2008. Petrography of Quartz Grains in Beach and Dune Sands of Northland, North Island, New Zealand. NZ J. Geol. Geophys. V.48, P. 649-660.

[11]. Zimmerle W. The geotectonic significance of detrital brown spinel in sediments. Mitt Geol Palaontol Instit Hamburg. 1984; 56: 337–360.

[12]. Numan, N.M.S., 2001a. Discussion on "Dextral transpression in Late Cretaceous continental collision, Sanandaj-Sirjan zone, Western Iran". Journal of Structural Geology, Vol. 23, pp. 2033-2034.

[13]. Numan, N.M.S., 2001b. Cretaceous and Tertiary Alpiansubductional history in Northern Iraq. Iraqi Jour. of Earth Sci., Vol. 1, pp. 59-74.

[14]. Al-Joboury, A.I., 2009. The upper Miocene Injana (upper Fars) Formation of Iraq: insights on provenance history. Saudi Society for Geoscience, 2: 337-364.

[15]. Ali, M.O., 2018. Sedimentology and basin developments of the Miocene Succession in the Zurbatya area, Eastern Iraq. Unpubl. MSc. Thesis, Baghadad University, 191P.

[16]. Ali, S.A., Sleabi, R. S., Talabani, J.A., Jones, B.G., 2017. Provenance of the Walash-Naopurdan back-arcearcclastic sequences in the Iraqi Zagros Suture Zone, Elsevier, Journal of African Earth Sciences 125(73-78).