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Updated stratigraphy, tectonics and boundary conditions of the Mawat and Bulfat Ophiolite Complexes, Kurdistan Region, NE-Iraq

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ABSTRACT

The Mawat and Bulfat Igneous Complexes are two neighboring areas in the extreme northeastern Iraq near the border with Iran. Each complex has about 250 square kilometers in surface area and their stratigraphic and tectonic settings are nearly identical. These settings are established in the seventieth of the last century and since that time no significant changes are introduced till now although tens of the studies achieved on them. Here we introduce dramatic changes in the stratigraphy and tectonics of the two complexes depending on field mapping, eye witness and correlations in addition to applying petrographical, paleontological and boundary conditional studies. The two igneous complexes are changed to metamorphic core complexes by changing the previous ophiolite to metamorphosed greywackes and volcaniclastic sandstones. Additionally the previous three allochthonous sheets are considered to be autochthonous sedimentary stratigraphic units which include non-metamorphosed greywackes and limestone (Walash-Naoperdan Series) metamorphosed greywackes (previous ophiolite sheet) and metamorphosed Naoperdan Series (previous Gimo thrust Sheet). The deposition timing, source areas and their relation with other units of the Paleocene-Eocene are clarified and their boundaries are changed from tectonic to depositional. These attributes are linked with historical development of Sanandij-Sirjan Zone as the main part of Neo-Tethys sedimentary basin. It is concluded also that these sedimentary rocks are buried deeply during Late Eocene and metamorphosed regionally then uplifted as Core Complex during Pliocene bringing up with them self- Cretaceous units such a Shiranish Formation.

Key words: Bulfat Complex, Mawat Complex, Walash-Naoperdan Series, Zagros Metamorphic greywackes, Zagros Metamorphic core complex

1. Introduction

The Bulfat and Mawat Complexes are observable side by side on the maps in the extreme northestern Iraq near the border of Iran to the north of Mawat and Qaladiza town in Sulaimanyiah Governorate. Each of these complexes has about 250 sequre kilometers in surface area and have oval shapes with their long axes trending nearly N27^{o}W (Fig.1 and 2). In the present study, the two complexes are treated together due to their closeness to each other which are no more than 15 km far from each other and they nearly share same stratigraphical, petrological and tectonic settings. They surrounded by Walash and Naoperdan Formations (or groups) in addition to Red Bed Series (or group) and located directely to the notheast of Main Zagros Thrust Zone. Both complexes located in the Penjween- Walash Zone of Jassim and Goff (2006), additionally, they have similar geomorphological features such as elevation, topography and surrounding by rivers. Since fiftieth of the last century, they are the most actractive areas for Iraqi and foreign geologists who achived tens of scientific and academic articles in addition to many reports for geological Surveys directories. These articles postulated the complexes as part of ophiolite oduction and volcanic eruption during Late Cretaceous and Paleocene-Eocene respectively. These studies focused on the geochemisty, petrography, chronology, tectonics, metamorphism and economic aspects of these igneous rocks.These studies are such as Al-Mehaidi, (1975), Buda and Al-Hashimi, (1977), Jassim and Al-Hassan (1977), Jassim et al. (1983), Buday and Jassim (1987), Aswad et al.(1988), Jassim and Goff (2006), Mohammad (2008), Abdulzahra (2008), Koyi (2009), Azizi et al. (2013), Mohammad et al.(2014), Kareem (2015), Karo (2015), Mohammad and Qaradaghi (2016), Ali et al. (2017), Ghazal et al.(2018). Conversely, Karim and Al-Bidary (2020) a reviewed these studies and changed the two complexes to metamorphosed volcaniclastic sandstones (greywackes). The present study tries to establish new stratigraphical and tectonical relations between the three thrust sheets (as main constituents of the two complexes) and change their relations to stratigraphic and depositional ones.

According to Al-Mehaidi (1975); Buda and Al-Hashimi (1977), the Mawat Ophiolite Complex consist of Mesozoic oceanic crust and mantle which was obducted on the Afro-Arobian plate during the Late Cretaceous. They added that it over-thrusting above the Noopurdan-Walash Series and this latter series in turn thrusted on the Red Bed Group during Miocene. These two thrust sheets are taken from the idea of two nappes of earlier study by Heron and Lees (1943 in Al-Mehaidi, 1975). From this pioneer study it is obvious that Walash-Naoperdan Group is separated from Ophiolite, tectonically and stratigraphically and both related to different environments and ages. Conversely, the presents study tries to put both the ophiolite and the series in one model that manifest same tectonical, environmental and stratigraphical settings.

Aziz (1986), Jassim and Goff (2006) (Fig.3a), Aziz et al. (2011 and 2013) (Fig.3b), Al-Qayim et al. (2012) (Fig.3c), Ali et al. (2013) (Fig.3d) and Mohamad and Cornell (2017) (Fig. 3e) mentioned ophiolite obduction on the northeastern margin of Arabian Plate during late Cretaceous. They added that the Walash Naoperdan Series developed on an island arc during Eocene-Oligocene in a double subduction Neo-Tethys Ocean. Opposite to aforementioned studies, Azizi et al. (2013) refused this tectonic setting (obduction during converging) of the Mawat ophiolite in the studied area and concluded that it established as intrusion of mantle plume into an extensional tectonic setting on the thinned lithosphere of the Arabian Passive Continental Margin (Fig.3f).

In these studies, four points worth mentioning, the first is the Zagors Ophiolite and Walash-Naoperdan Group are too far from each other geographically; they are spatially and temporarily separated and their present location is claimed to be tectonic. The second is assumption that Sanandij-Sirjan Zone (SSZ), when mentioned, it refers to a continental block (Fig.2a, c, and e) which is opposite to ideas of the present study. The third is disagreement between above studies concerning timing, location and kinematic of the development two complexes and their surrounding rocks (Fig.3). The fourth is when new articles were published, about ophiolite and Walash-Naoperdan; they did not discuss the old ideas and conclusions objectively.

The previous stratigraphy of the two complexes and their surrounding rocks are consisted of the two allochthonous thrust sheets; the upper one is Walash-Naoperdan Series of Paleocene-Oligocene. The second is the Ophiolite and Gimo sequence of the late Cretaceous (Al-Mehaid, 1975), Buda and Al-Hashimi (1977), Al-Qayim et al.(2012) (Fig.4b) and Ali et al. (2014) (Fig.4a). Latter, this stratigraphy is changed radically in two ways, the first is consideration of Mohammad (2020) and Mohammad and Cornell, (2017) in which they concluded that the Mawat Ophiolite Complex is overturned during obduction without showing any evidences of their upturn idea. They showed that basalt is located the base of the ophiolite profile while peridotite and dunite located at the top. In the past Jassim and Goff (2006, p.302) mentioned that the basalt (with marble) is at the roof (top) of the Mawat Complex and this true for all other previous studies.

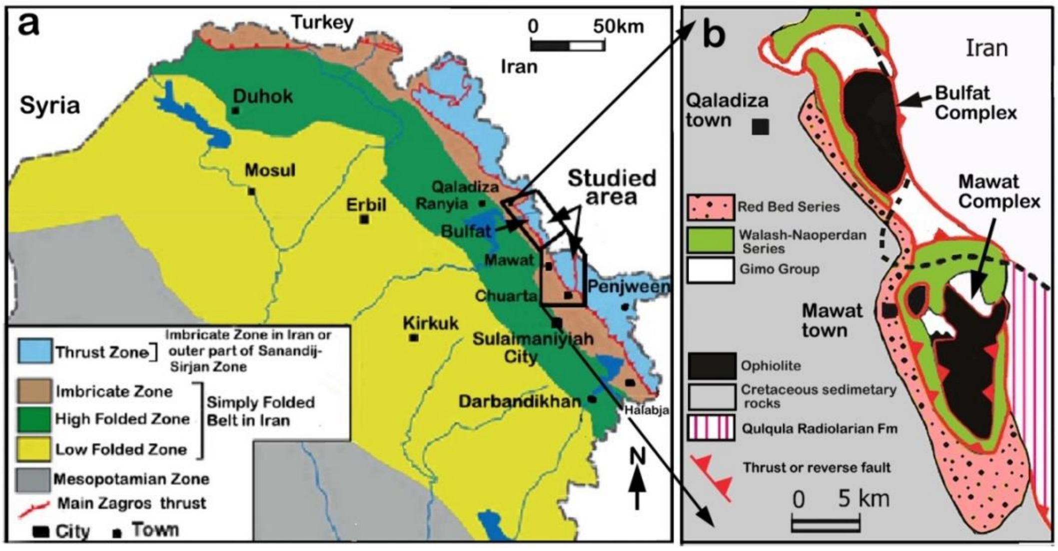

Fig. (1) a) Location map of the studied area on the tectonic map of northern Iraq (Jassim and Goff, 2006), b) Geological map of Mawat-Bulfat area (modified from Sisakian, 2000),

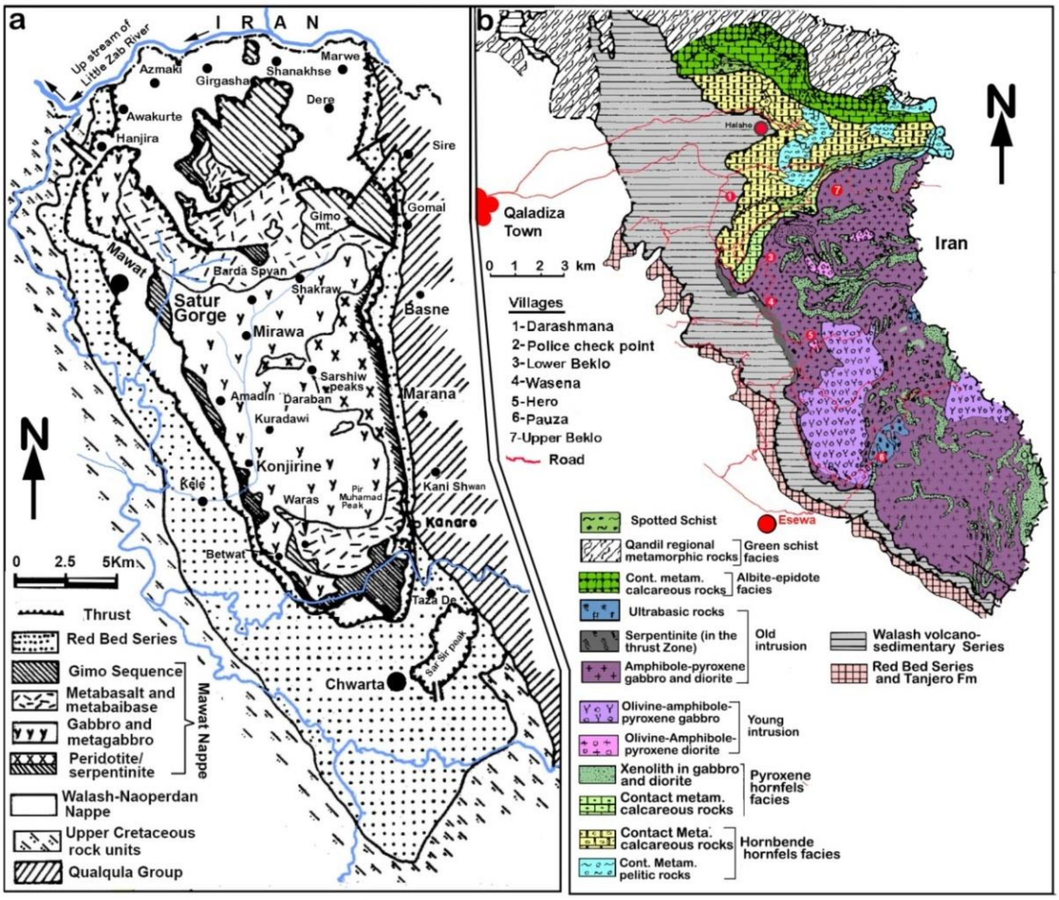

Fig.(2) a) Geological map of Mawat area (Al-Mehaidi,1975), b) Geological map of Bulfat (Qaladiza) area (Buda, 1993).

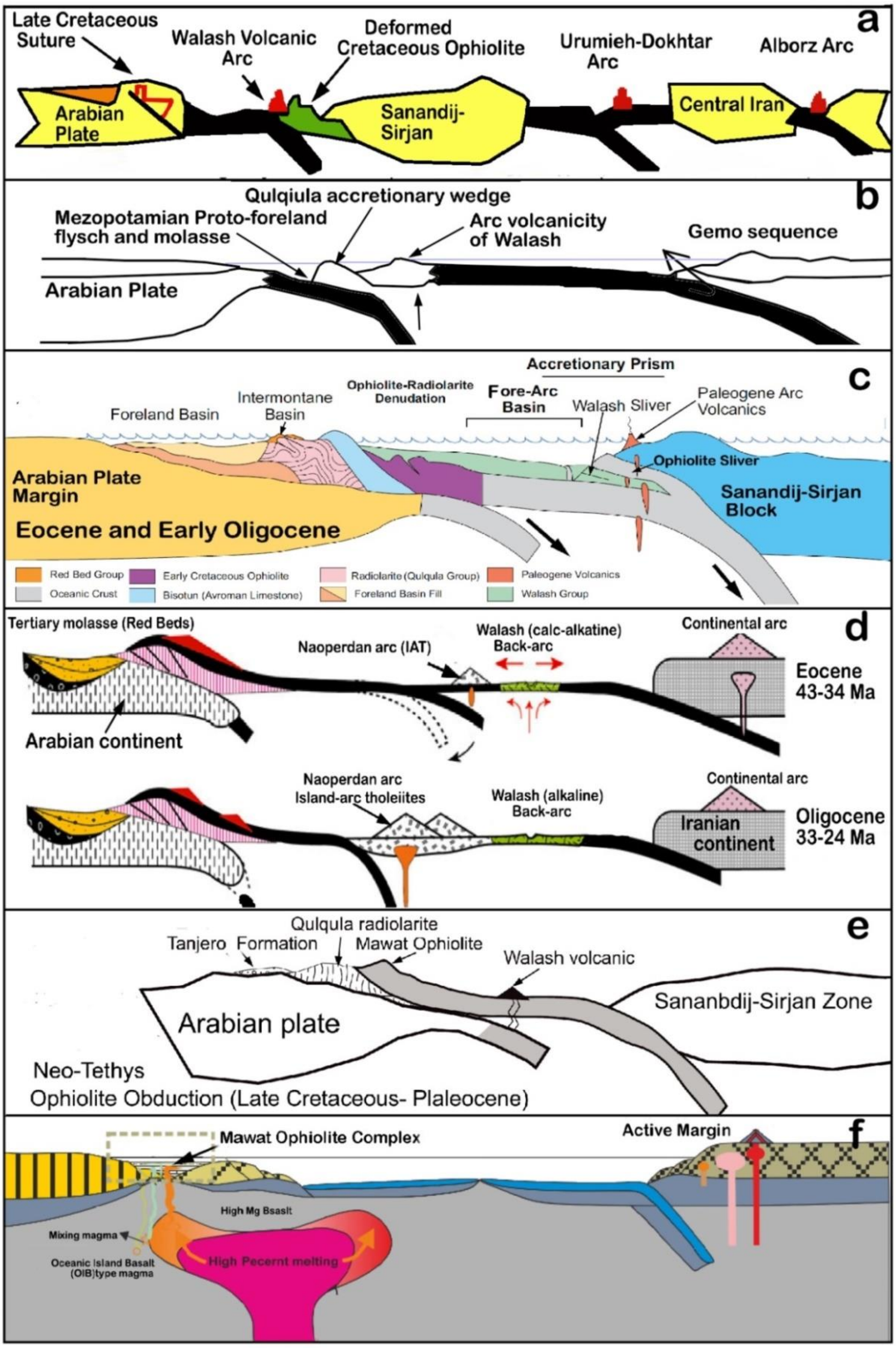

Fig.(3) Different tectonic models of previous studies show obduction of Mawat Ophiolite Complex and volcanism of Walash Formation on an Island arc, a) Jassim and Goff (2006), b) Aziz et al (2011), c) Al-Qayim et al.(2012), d) Ali et al.(2013), e) Mohamad and Cornell, (2017), f) Azizi et al. (2013) this latter model shows development of Mawat area as an intrusion of mantle plume into an extensional tectonic regime on the thinned lithosphere of the Arabian passive margin.

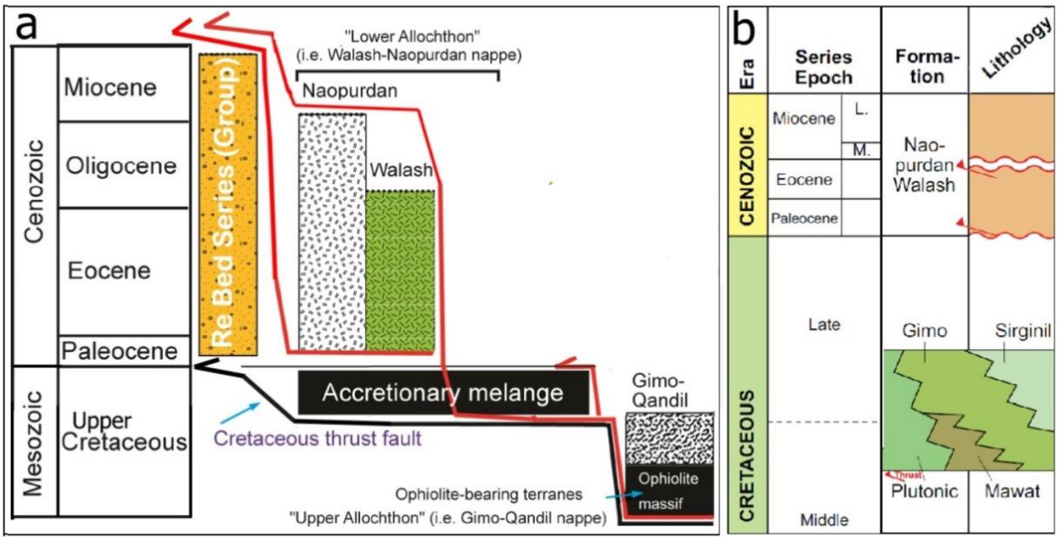

Fig.(4) Previous stratigraphy and tectonic of the Mawat Ophiolite Complex and Walash-Naoperdan Series (Group) in the Iraqi Zagros Suture Zone, a) Ali et al.(2014) and b) Al-Qayim et al. (2012), only those units are shown that are related to the present study.

1.2. Materials and methods

Our study is concerned with the Mawat and Bulfat areas which constitutes the most important part of northeastern Iraq, Kurdistan Region where the ophiolite, volcanic and metamorphic rocks are found all together in previous studies. The principle stratigraphy and tectonic of the two areas are not changed since fiftieth of nineteen century. During fieldworks on the two complexes and their surrounding areas massive evidences are found that signifying the possibility of changing the previous ophiolite and volcanic rocks to metamorphosed sandstones (greywacke and volcanic wackes).

During the fieldworks, the boundary conditions evidences and internal properties of the two complexes signified possibility of changing the ophiolite complexes to metamorphic core complexes. In these fieldworks, for more than 20 years, tens of stratigraphical, structural and petrographical evidences are found contradicted the previous ideas. The laboratory analyses such as thin section studies, fossils analyses of the present study and the evaluation of the age determinations of the previous studies are all against previous ideas. The evidences of structural and petrographical analysis are documented by Karim and Al-Bidry (2020) via which proved that the two complexes are metamorphic core complexes in which the volcaniclastic sandstones and conglomerates are metamorphosed to schist, amphibolite, gneisses and granulites. They proved that sandstones are transported from remote source areas inside Iran by turbidity currents. In the present study, tens of the field and laboratory proofs are exploited to draw new stratigraphic column, boundary between units and cross-sections of the two complexes. The new columns and results show the updated and realistic geology of the two complexes in which the result of the previous studies are objectively discussed and compared to result of the present study.

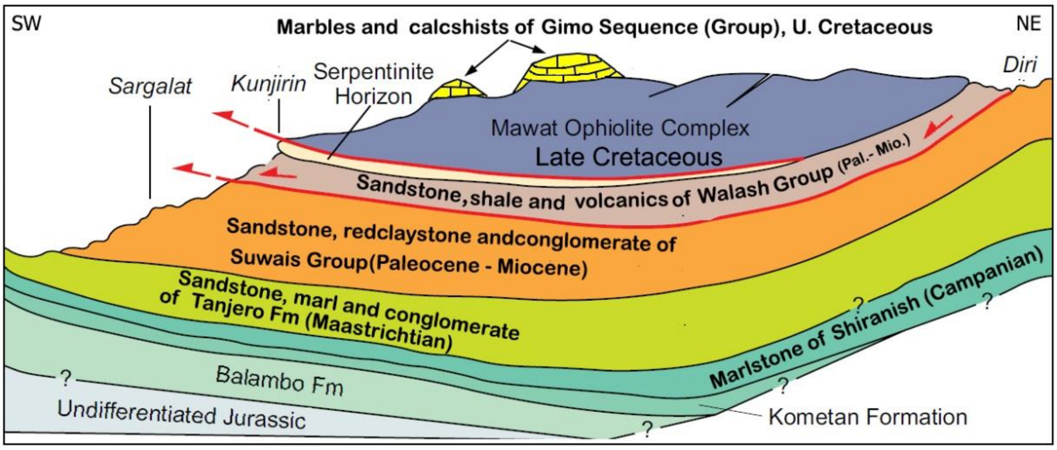

Fig. (5) Cross section of the Mawat Ophiolite Complex shows its tectonic stratigraphy and surrounding rock units (modified by Al-Qayim et al., 2012, from Mehaidi, 1975).

2. Result

As mentioned in the introduction, the previous stratigraphy of the two complexes is controversial which can be categorized in three constrains. The first one is thrusted (tectonic) stratigraphy in which the older units (Late Cretaceous Ophiolite) are thrusted over the younger one (Walash-Naoperdan Series) and the latter series is in turn thrusted over Red Bed Series (Figs.3 and 4). The second is overturned and thrusted stratigraphy in which the ophiolite section has overturned consequently volcanic rocks (pillow basalt) upside-downed to the base (see Mohammad and Cornell, 2017; Mohammad, 2020).

The third is local intrusion of upper mantel magma to the studied area during extension which denoted neither thrusting (tectonic) nor overturned stratigraphy (see Azizi et al., 2013). In contrast to the above three theories, the present one tries to refuse all of them and shows that the two complexes have normal stratigraphic condition (columns) similar (when restored to original condition) to undeformed sedimentary sequences of the other parts of Iraq. For proving this new stratigraphy, we discussed the properties (their stratigraphic units and rock types) of the interior of the two complexes then the boundary conditions (exterior of the two complexes) are analyzed.

2.1. Interior properties of the Mawat and Bulfat Ophiolites

The ophiolite inside these two complexes considered incomplete ophiolite sequence by Jassim and Goff (2006). It is divided into two successions in the two complexes by Al-Mehaidi (1975), Buda and Hashimi, (1977); Buday and Jassim, (1987); Mirza and Ismail (2007); Aswad et al. (2014). These successions are: 1- Volcanic and metavolcanic rocks (Mawat and Bulfat volcanic Groups), 2- Plutonic Igneous rocks (Mawat and Bulfat Intrusive Complexes).

2.1.1. Mawat and Bulfat volcanic Groups

According to previous studies, the volcanic groups inside the two complexes consist of metabasalt, spilite, keratophyre with some metamorphosed sedimentary interbreds. According to Jassim (1973 in Jassim and Goff, 2006, p.302) these volcanic rocks are commonly metamorphosed in the green schist facies but the pillow structures, amygdales are well preserved. The present study observed that these claimed volcanic rocks are mainly located at the western parts of the complexes. When one walks on their out crops can observe thousands of layers of felsic and mafic compositions in addition to intermediated ones. These layers have planner lower and upper surfaces with regular thickness between 5 cm to 30 cm. These layers are laminated and cross bedded (Fig. 6). In some place they are intensely deformed (fractured, brecciated and faulted) such as around Kunjirin, Chinara and Amadin villages. The present study has not found any evidence of volcanism such as dykes and pillow lavas, volcanic flows, volcanic vents and volcanic cones; therefore, it aids the conclusions of Karim and Al-Bidry (2020) about refusal of the presence of volcanic rocks and attribution of the outcropped rocks to volcaniclastic sandstones (greywackes).

2.1.2. The Mawat and Bulfat Intrusive (Plutonic) Complexes

According to previous studies, they comprised of banded and laminated Gabbro, peridotite and dunite, serpentinite, pyroxenite and minor diorite, dolerite dykes and plagiogranite. They added that these rocks intruded, in some places, into Mawat and Bulfat Groups (volcanic rocks) (Buday and Jassim, 1987). These rocks covered main surface of the two complexes and their thicknesses reach 1000 m of which the gabbro is main constituents. Although the boundary is indicated between the volcanic and plutonic rocks in geological map of Mawat area by Al-Mehaidi (1975) and that of Bulfat (Qaladiza) area by Buda (1993) but in the field, as observed in the present study, this boubary is not exist. In cotrary, the boundary between the volcanic rocks (mildly metamorphosed greywackes) and plutonic rocks (intensly metamorphose greywacke) is gragational and changes across hundred of meters. Even the bundary between Walash Formation (fresh greywackes) is gradation with both the claimed volcanic and plutonic rocks. The rocks of the both complexes are extensively layered and the layers, although folded and faulted, they extends for several kms in parallel condition which more or less similar to stacking pattern of the layers of the Tanjero or Kolosh Formation.

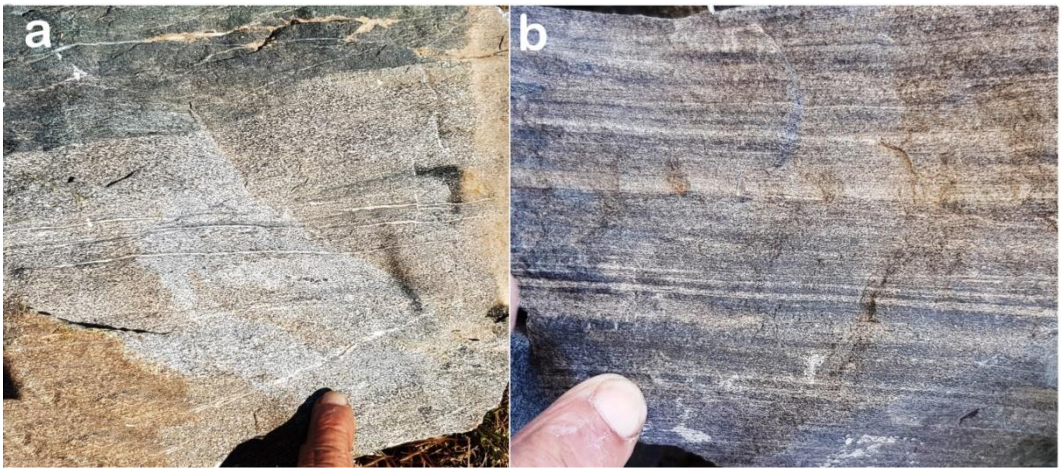

Fig.(6) Metamorphosed greywackes (previous gabbro and diorite of Mawat Complex) at 500 southwest of Syre village, a) lamination and cross bedding shaped by alternation of felsic and mafic laminae, b) planar lamination with felsic laminae (white) and mafic ones (black)

2.1. Properties of the boundary condition of the two complexes

According to Al-Mehaidi (1957), Buday (1980) and Jassim and Goff (2006), two stratigraphic units are exposed around and under the two complexes. These units are Walash-Naoperdan Group and Red Bed Series while there is a third unit which is Qulqula Radiolarian Formation that is located at the north of Mawat Complex. The field works of the present study, will describes all stratigraphic units that have more or less historical or stratigraphical relations with the two complexe as listed below.

2.1.1.Walash Formation (Group)

In the present study, this formation is considered the closest unit spatially and genetically to the two complexes. As will be stated later, the two complexes are metamorphosed sediments (greywackes or volcanic detritus) of this formation. According to Buday (1980), this formation (group) is first described by Bolton in 1958 to the northeast of Rawanduz town near Walash village. According to this author it consists of about 1000 m of alternation of volcanic and sedimentary rocks. The lithology of the later rocks is highly variable which consists of red mudstone, siltstone, shale, white bedded and lenticular limestone, greywacke sandstones, conglomerates and volcanic rocks. He addaed that volcanic rocks includes andesite, spilitic diabase, basic dyke and basaltic and acidic flows in addition to pyroclastic and pillow lavas. Al-Qayim et al. (2014) recorded many igneos bodies such as tuffs, lapillis, pyroclasts, irregular sills and dykes inside it.

The studied area, apparently the above rocks occur but in reality they are barren from any volcanic and pyroclastic rocks, while what are called volcanic rocks is mafic, felsic or andesitic volcaniclastic sandstones (greywackes). According to Lee (1992), volcaniclastic sandstones in deep-sea environments (as the case for Walash Formation) occur in both back-arc and fore-arc basins of the active plate margins. Their main source is the volcanic arc, and sandstones are rich in basaltic to andesitic volcanic rock fragments and glass matrix. He added that these volcanic materials are highly susceptible to alteration under burial conditions.

In Mawat area, the Walash Formation contains many intervals of conglomerates with erosional bases and have the thickness of 20 cm to 3 m (Fig.7a) when they intensely sheared, they look as if pyroclastic volcanic rocks or agglomerate. The thick volcanic wackes and arenites parasequences are so deformed (folded, squeezed, and sheared) that lost most of their bedding pattern which look like lava flow and pillow. Especially the shearing along two conjugated joints generate (with the aid of the weathering) pattern of small bodies that are similar to basaltic pillow. In these rocks, the badly sorted textures (large detrital clasts in fine matrixes) are comparable to the porphyritic textures of the volcanic rocks (Fig.7b). The border of the two complexes are sheared and pulverized in brittle condition during uplift, due to forceful slipping against hard and cold surrounding sedimentary rocks. These sheared and pulverized sedimentary rocks are look like serpentinite due to retrogressive crystallization of the mafic and ultramafic volcanic grains of greywackes to serpentine, hornblende and chlorite minerals along sheared surfaces.

The volcanic clasts are unstable (Lee,1992 and Boggs, 2009), therefore, they altered to secondary minerals or removed by diageneses, metamorphism and weathering. When their emptied spaces filled with calcite or quartz or albite, they look like amygdaloidal basalts. This formation is more or less similar to Kolosh Formation since they deposited by turbidity current in Paleocene. Their difference are two issues, the first is the source area of Walash formation was volcanic arc, so their detrital clasts of sandstones, siltstones, shales and conglomerates are mostly belong to mafic or andesitic volcanic arc. Due to deformation and metamorphism of latter formation in Metamorphic Core Complex, its deformation is several time more intense than Tanjero or Kolosh formation. Due to this intense deformation, in many cases, the distal and proximal facies can be seen side by side by faulting and tight folding. Due to these deformations, it is difficult to identify synclines and anticlines inside the succession of Walash Formation. In Mawat area, best location to see the Walash Formation is the Satur Gorge between Dashty Tile and Gabarwa (Fig. 8 and 9). The same thing is true for Awakurte-Shasho villages at the northwest border of the Mawat Complex. In Bulfat Complex similar succession occur too at the southwest of Beklo, Darashimana, Halsho and Gira, Darwina, Badin and Shodan villages (Fig.1c) but with lesser conglomerate. In this area Karim and Al-Bidry (2020) studied this succession in the field and in thin sections and proved that it metamorphosed gradually toward center of the complex and change to gneiss and granulite.

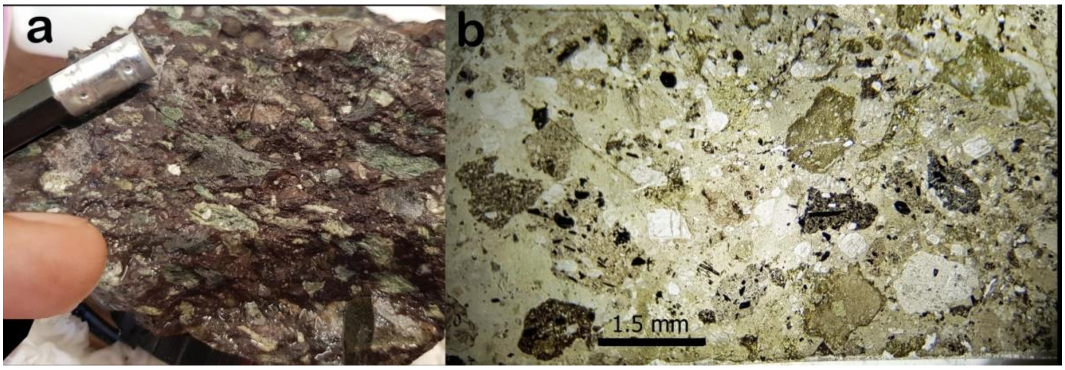

Fig. (7) a) volcaniclastic conglomerate at northeastern end of the Satur Gorge, 1km south of Gabarwa village, b) coarse volcaniclastic sandstone show volcanic clasts, 1km north Dashti Tile village at southwestern end on the latter gorge.

Fig. (8) A succession as a part of Satur Gorge (more than 300 m thick) totally consists of volcanic clastic sandstone of volcanic wackes and arenites.

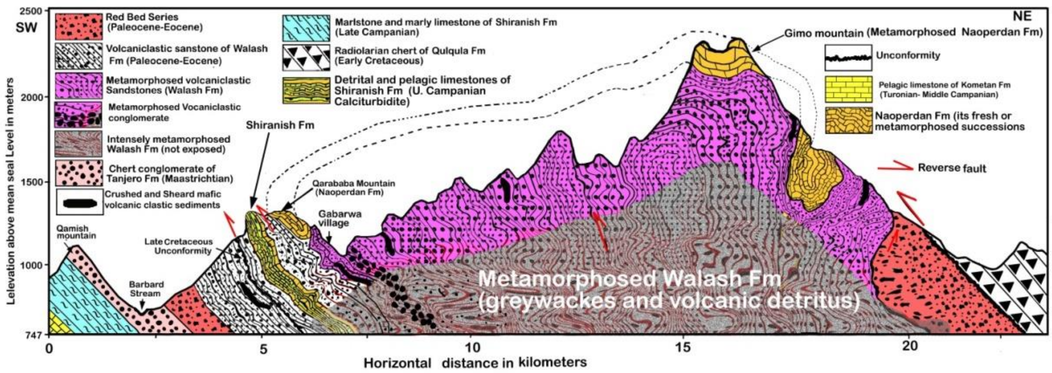

Fig. (9) Geologic cross section of Mawat Metamorphic Core Complex passing through Satur gorge, Gimo (Gmo) mountain and Dere village.

2.1.2. Naoperdan Formation (Naperdan Shaly Series)

In the present study, this formation is considered the second closest unit spatially and genetically to the two complexes. As will be stated later, this formation is overlain the two complexes and slightly younger than them. According to Al-Hashimi (1975), the formation is first described by C.M.G. Bolton during 1958 near Naoperdan village, northeast of Rawanduz Town. It contain different rocks such as grey shale layers, coralline limestone, tuffaceous slaty beds, felsic volcanics, basic conglomerate and clastic red beds. According to the present fieldwork these rocks are observed in the Walash Formation (Group) too, while in this study the name of "Naoperdan Formation" is used instead of Naoperdan Shaley Series or Group.

In the studied area, the lithology of the formation consist of massive or well bedded milky limestones rich in nummulites and alveolina foraminiferas, with many intervals of detrital limestone that contain reworked foraminifera. Its thickness are highly variable range from 10-70 meters and it deformed in the scale of microscope ~~and~~ to ten of meters of the outcrops, the deformations include brittle (fracturing, stylolitization, grain suturing and faulting) and ductile ones such as bending, folding, stretching and flowage. The formation contains frequent oncoids, stromatolite, erosional surfaces and changes to toward the south to calciturbidite (Fig.10). Its outcrops are observable on the Sarsir, Qarababa and Gule (Pshti Mawat) mountains but in Satur Gorge it outcrops is not approved palentologically due to metamorphism of the limestone in the stratigraphic location of the Naoperdan Formation.

The thickest and widest outcrop of the Naoperdan Formation is located on Sarsir Mountain directly to the northeast of Chwarta town. Below this outcrop, in all place, occurs Walash Formation (greywacke and shale) while the overlying unit is eroded by present day's erosion but sporadic blocks of sandstone of Red Bed Series can be seen on the top of the Naoperdan Formation. This surface is barren from any signs of greywacke of Walash Formation which indicated that the Naoperdan Formation is overlain by Red Bed Series. In Satur Gorge the same setting is observable between the series and the formation whereas very distal facies of this latter is outcropped in the middle of Dashti Tle and Satur gore. At this locality the deep facies of Naoperdan consist about 50 m of green marl and detrital sandy limestone with few bed of coralline limestone.

2.1.3. Gimo Sequence

This sequence is described by Bolton (1957) as Eocene marble on the Gimo (Gmo) mountain in the upper part of the Mawat Ophiolite Complex. Smirnov and Nelidov (1962) gave the age of Upper Cretaceous-Paleocene to this sequence. According to Al-Mehaidi (1975) it consists of alternation of marble and dark grey calc-schist with thin sheets of Metabasalt. He added that its thickness ranges from few meters to 600 m and rest on the top of the Mawat Ophiolite Complex with depositional contact.

The result of the present study aids the depositional contact (gradational contact) of the latter author and Eocene age of (Bolton, 1957). In Mawat area, it regionally metamorphosed and rest on the metamorphosed medium grain volcaniclastic (previous volcanic rocks) without showing contact metamorphism and angular relationship (Figs. 9 and 11).The same metamorphosed sequence (marble) is present in the Bulfat Metamorphic Complex (previous Ophiolite Complex) in the same stratigraphic position (on the top of the ophiolite) in the northeastern part of the complex (Figs.12 and 13). In earlier studies, here it is not called Gimo Sequence but only described as "contact metamorphosed calcareous rocks) by Buda, (1993) while it called metamorphosed geosynclinal volcano-sedimentary series and included in the Bulfat Group by Jassim et al. (1983) and called Gimo Series by Buday and Jassim (1987).These latter authors mentioned that the Gimo sequence (in Mawat area) together with the meta-volcanics are identical to the similar metamorphosed rocks in Bulfat and Penjween Complexes. In the map of the latter study (p.195) it clear that the Bulfat Group (including Gimo Sequence) surrounds the complex and exist on the top too in some localities. Jassim and Goff (2006) changed the Gimo Sequence to "Gimo Calcareous Croup" and mentioned that it occur too in Bulfat area.

In this latter area gradational contact is very clear in spite of folding and faulting between what called previously ophiolite (gabbro and basalt) and Gimo Group where all regionally metamorphosed without any thermal metamorphism or presence of dykes (Fig.12 and 13). In both metamorphic core complexes what called Gimo Group or Sequence is regionally metamorphosed limestone of the Naoperdan Formation which intensely deformed and coarsely crystallized to marble. Due to crystallization, the fossils cannot be identified in the Gimo Sequences but on the weathered surface the approximate shape and size of nummulites can be defined especially when compared with the same fossil of unmetamorphosed Naoperdan Formation (Fig.14). Due to similarity of the lithologies and fossils of the sequence and series a linking of the two units is possible (Fig.9) by which a simple correlation is drawn which connect Naoperdan Formation with Gimo Group along cross section of Mawat Metamorphic Core Complex which is more or less applicable for Bulfat (Qaladiza) Core Complex too.

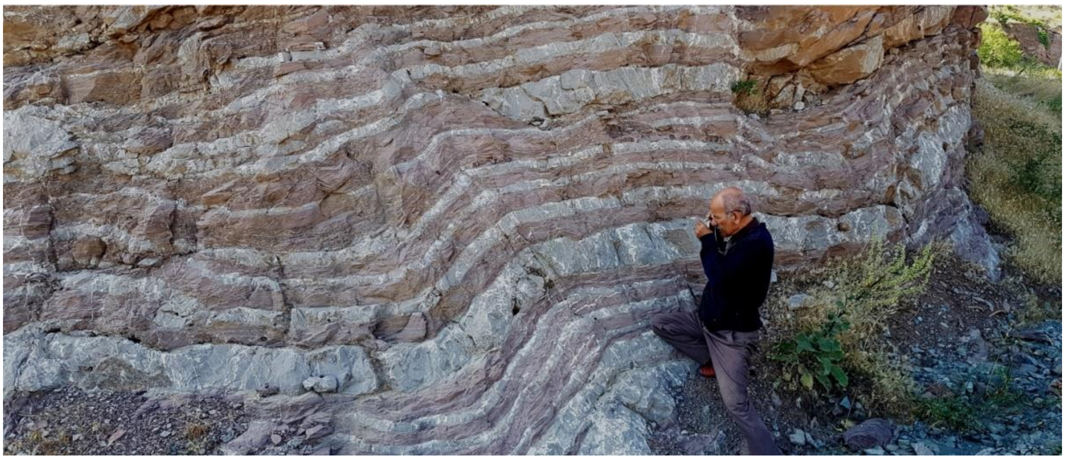

Fig. (10) Distal part of Naoperdan Formation as calciturbidite in western part of Mawat Metamorphic Core Complex (previous Mawat Ophiolite Complex) at 4 km northeast of Mawat town. The light layers consist of coarse detrital limestone which contains reworked nummulite forams. The dark layers are calcareous shale.

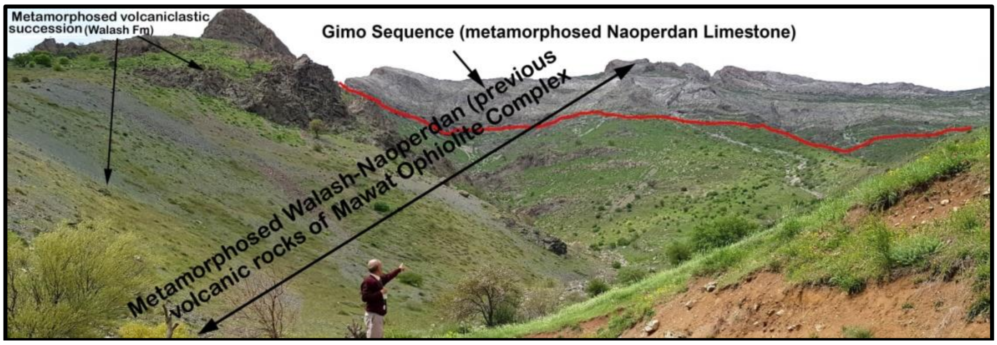

Fig.(11) A southern part of Gimo mountain show metamorphosed Naoperdan Formation (previous Gimo Sequence) and metamorphosed sandstone and siltstones of the Walash Formation (previous volcanic rock of Mawat Group), at the head of Saraw valley, south of Deri village

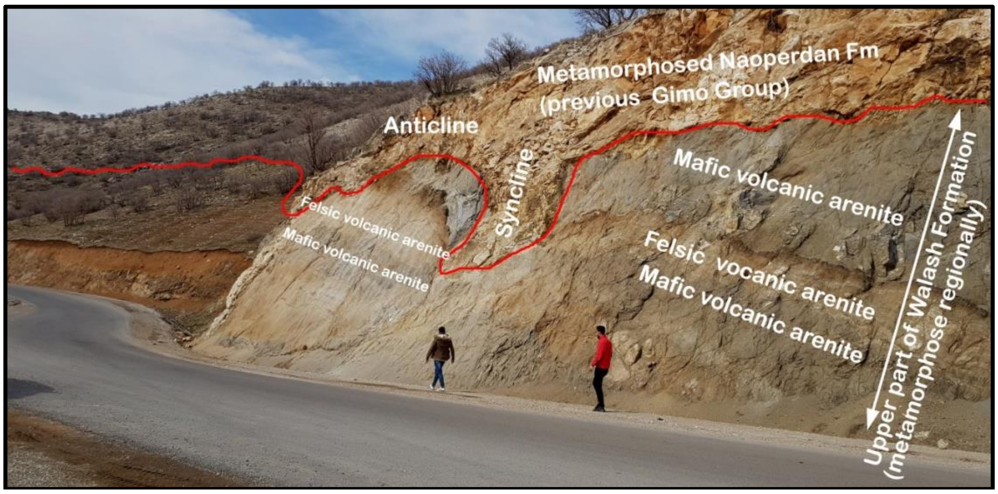

Fig.(12) the Bulfat Core Complex, like Mawat Metamorphic Core Complex, is caped (overlain) by metamorphosed limestone of the Naoperdan Formation (Previous Gimo Sequence) at 1km north of Biklo village on the paved road to Kele border Police station.

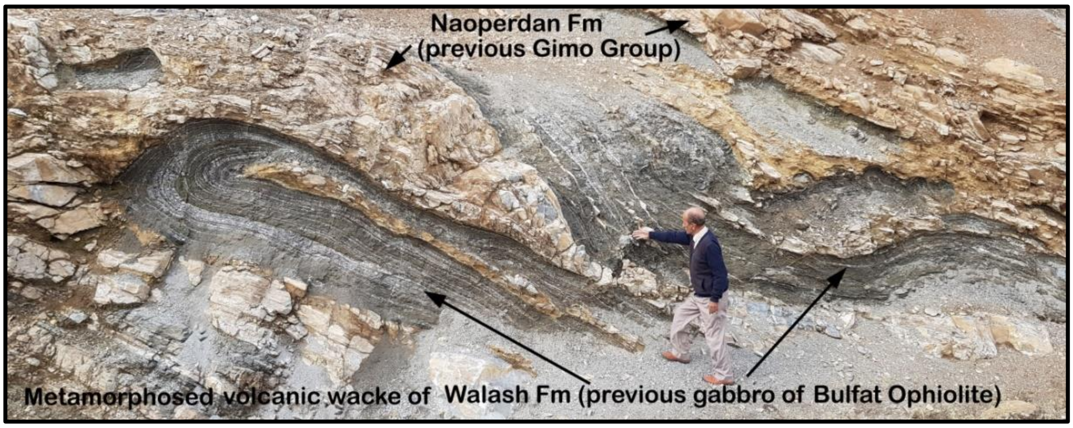

Fig.(13) Folded and laminated alternation of the greywacke (previous gabbro) and limestone of Naoperdan Formation (pervious Gimo Sequence) which are regionally metamorphosed to green schist facies. The location is Bulfat Mountain at the middle of the paved road between Darashmana village and the Kele border police station. It can be seen that there are no contact metamorphism between the previous Gabbro and the limestone.

Fig. (14) a) hand specimens of the Naoperdan Formation contain nummulites on Qarababa mountain 1km southwest of Amadin village, southern border of the Mawat Metamorphic Core Complex, b) Gemo sequence at 1.5 km west of Seri Village, show nearly similar shape of nummulites in the latter photo but with small size and more packing due to high stress of deep burial and metamorphism in the ductile conditions

2.1.4. Shiranish Formation

The formation is first defined in northern Iraq near Shiranish Islam village, about16 km northeast of Zakho town. According to Bellen et al. (1959) and Buday (1980), in its type section, is composed of blue marls in its upper parts and of thin bedded marly limestones in the lower division and the sediments are pelagic marls, sometimes dolomitic with occasional marly limestone beds, with rich microfauna.

In Sulaimanyiah Governorate, it has thickness of 100- 200 m and according all previous studied it has the same lithology of type section but most recently this lithology is changed by Naeem et al. (2020) who proved that Shiranish Formation contains sporadic intervals of calcitubidite which consists of alternation of pelagic or hemipelagic and detrital limestone beds with erosional surfaces and Bouma sequence

(Fig.15). They added that the share of calciturbidite increase toward northeast.

In the studied area, we found it in unexpected place in the middle of Walash Formation at direct southwestern boundary of the Mawat Core Complex. It found exactly at the tightest point of the Satur gorge between Barda Pan and Gabarwa villages (Figs.9 and 16). At this locality the thickness of the formation is about 25 m and dipping nearly 45 degrees toward northeast and its outcrop extends laterally in both sides of Satur gore for about 1.5 km. In the eastern side of the gorge, the outcrop disappears on peak Qarababa mountain at the northeast of Zaynal village while its western outcrop disappears on the Gula mountain at east of Mawat town. The formation consists of rhythmic alternation of couplets of detrital and pelagic limestone beds. The thickness of each bed reaches 3-10 cm (Fig.16) and the detrital beds contain badly sorted clasts of fossil skeleton and non-skeleton ones. In fresh surface, the pelagic layers are white but toward lower part change to light brown while the detrital ones are grey (Fig.17a). The paleontologic study of the pelagic limestone revealed late Campanian index fossils such as *Globotruncana cf. ventricosa*, *Radotruncana subspinosa*, *Globotruncanita stuartiformis*, *Rugoglobigerina rugose*, *Contusotruncana*, *patelliformis*, *Globotruncana cf. insignis*, *Globotruncanita elevata* (Fig.18). It can be considered as Kometan Formation since Al-Khafaf (2014) found similar fossils in the Kometan Formation while Al-Bana ((2010), Ameen and Gharib (2014) and Malak (2015) found similar foraminiferas inside Shiranish Formation. But, in the present study, it is considered as the Shiranish Formation because it is not known till now that Kometan Formation contains detrital limestone and calciturbidite.

Fig. (15) a) Calciturbidite in the middle of the Shiranish Formation at 10 km west of Esewa village, 30 km northeast of Qaladiza town, b) close up view of the turbidite bed near the hammer head show sharp erosional surface, graded bedding and laminations.

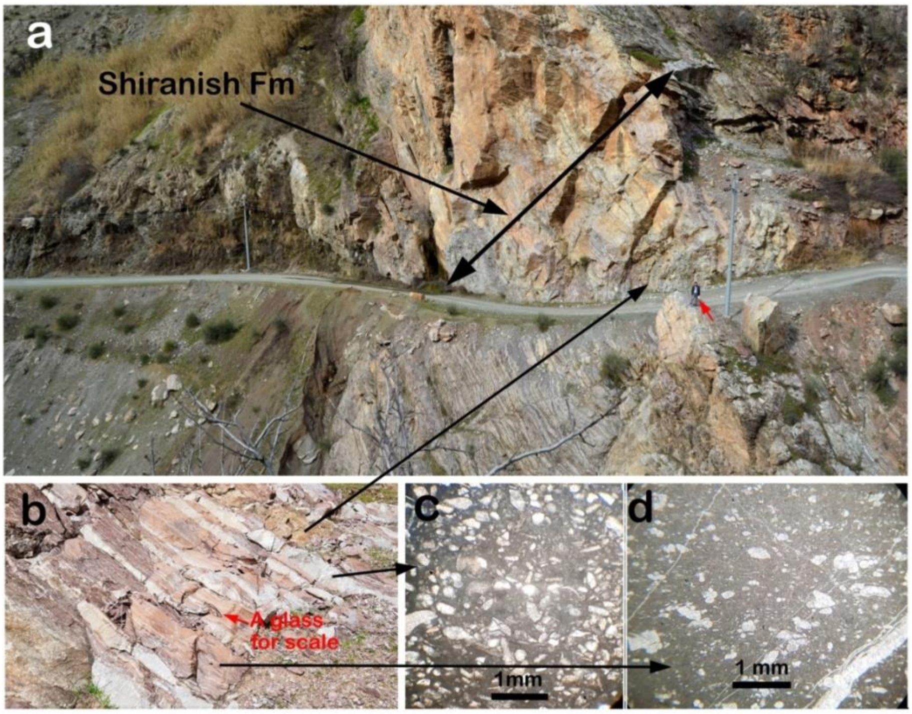

Fig.(16) a) general view of Satur gorge shows about 25 m of Shiranish Formation in the middle of the Walash Formations, the red arrow refers to a person for scale, b) close view of alternation of detrital and pelagic limestone beds forming calciturbidite, c) Thin section of detrital limestone under ppl, d) pelagic limestone contain planktonic foraminiferas.

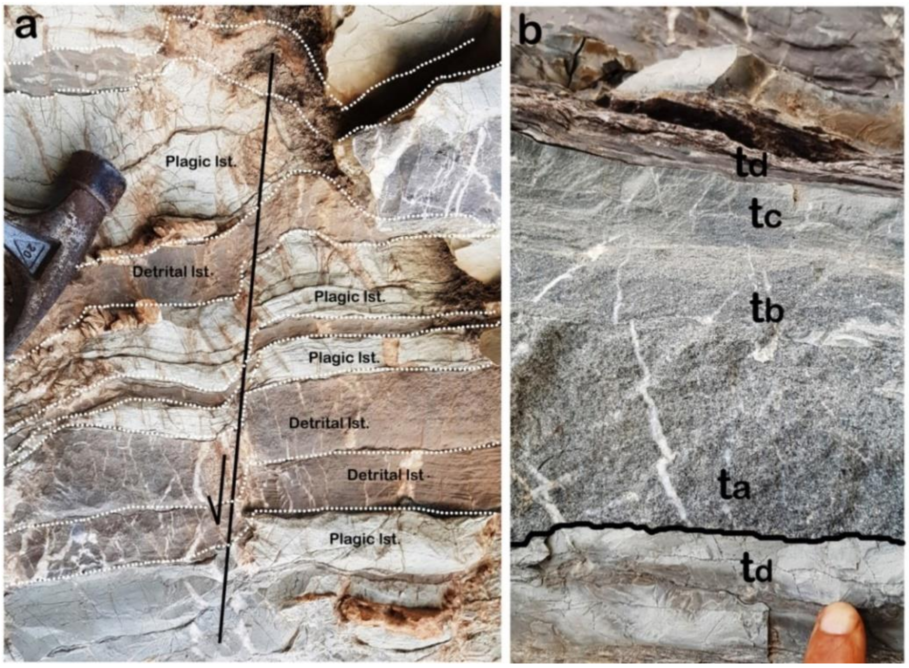

Fig. (17) a) alternation of detrital limestone (light brown) and pelagic limestone (white or light grey) of the Shiranish Formation in the Satur gorge. b) Detail of calciturbidite in the Satur Gorge shows division of the Bouma sequence.

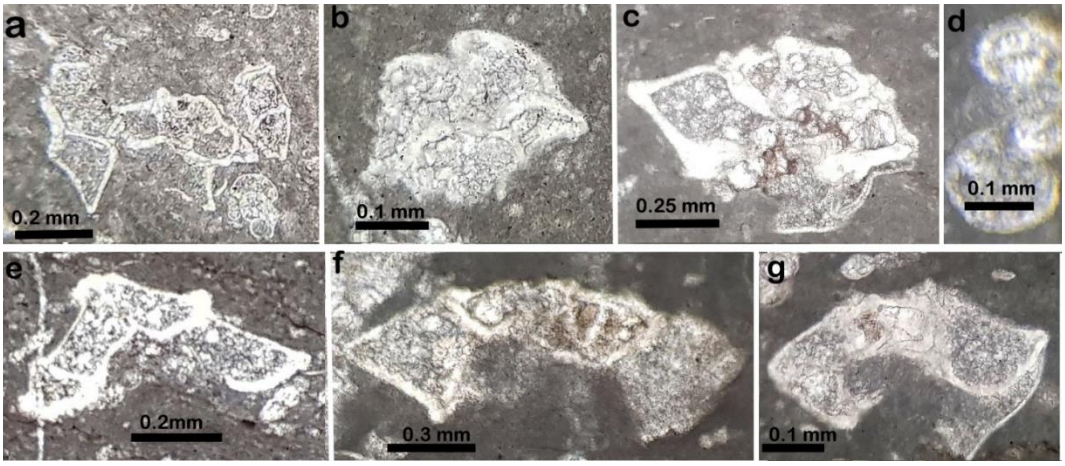

Fig. (18) Planktonic foraminiferas inside the pelagic layers of Shiranish Formation in the Satur gorge belong to Upper Campanian, a)*Globotruncana* cf. *ventricosa,* b) *Radotruncana subspinosa,* c) *Globotruncanita stuartiformis,* d) *Rugoglobigerina rugose*, e) *Contusotruncana, patelliformis,* f) *Globotruncana* cf. *insignis,* g) *Globotruncanita elevata*

2.1.5. Kolosh Formation (Paleocene)

Kolosh Formation is unrelated spatially to the two complexes since its outcrops located more than 30 km to the south at south of Sulaimanyiah city and Dokan town at the north of the boundaries between Low and High Folded Zones. But it genetically and chronologically closely related to the two complexes since it contains first appearance of the deposition of the volcaniclastic sandstone (greywackes) and conglomerates. In previous studies Bellen et al. (1959 and Buday, (1980) mentioned that it contains clasts (grains) of igneous rocks derived from obducted ophiolites on the Arabian Passive continental Margin. Most recently Karim and Al-Bidry (2020) refused occurrence of ophiolite in the northeast Iraq and proved that what are called ophiolites and basalts are metamorphosed volcaniclastic sandstones including greywackes and arenites types. They added that these sediments were deposited during Paleocene-Eocene and derived from Urumieh-Dokhtar magmatic Arc as recently eroded detritus or reworked from uplifted old lithified sedimentary rocks.

During deposition of the wackes and arenites in Mawat and Bulfat areas, a significant part of the volcaniclastic sediment bypassed these two areas and deposited in Dokan and Sulaimani areas as distal turbidites which named stratigraphically (Kolosh Formation).

The lithology and color of Kolosh Formation and volcanoclastic secessions (Walash Formation) are very identical to each other; the only difference is more coarseness of the latter formation than the former one. Both formations share many properties, the first one is they have nearly same age (Paleocene-Early Eocene), the second is some intervals of Kolosh Formation are completely composed of black or grey sandstones most of their clasts are igneous ones. The third is both formation has similar contact with Sinjar and Naoperdan formation, this relation is shown in the (see Figs. 11, 12, 13 and 19) and the only difference is the contact of Walash and Naoperdan Formations are highly deformed (folded) and metamorphosed (Figs.13 and 16) but when returned to horizontal condition it is similar to that of Kolosh and Sinjar formations (Figs.13 and 19).

The Kolosh Formation was deposited during early lowstand system tract when the sea level in lowest position and the source area was in the most elevated condition. When the accommodation increased, in response to relative sea rise, the deposition had migrated to the Mawat and Bulfat (Qaladiza) areas. Karim et al. (2008) discussed in detail and modeled this migration of deposition and attributed it to uplift and subsidence of the proximal and distal areas during Middle Eocene. Therefore, the deposition of the Kolosh Formation is slightly predated deposition of the Walash Formation. The source area of this formation was not only volcanic arc rocks but in some places charged with sediments of radiolarites and limestone source area. Therefore, in its lower and upper part volcaniclastic sediments are predominate while in the middle part chert and limestone sediments are more common.

Fig.(19) the boundary between Sinjar and Kolosh Formations in Dokan area, 300m southwest of Kalka Simaq village, it is very similar to boundary between Walash and Naoperdan Formations in Mawat and Bulfat areas (see fig, 12 and 13 for comparison)

2.1.6. Red Bed Series

The Red Bed Series surrounds the Mawat Complex from all sides while only it occurs at the south, southeast and east of the Bulfat Complex. This series (group) consists, in most outcrops, of more than 1000 of red or grey sandstone, conglomerate and claystone and with some grey marlstone. In all previous studies such as Mehaidi, (1975), Buday, (1980) and Al-Qayim et al. (2012), this series considered as an autochthonous units while the two complexes and Walash-Naoperdan series are assumed as allochthonous units. They stated that the relation with Red Bed Series is tectonic and they thrusted from northeast over the Red Bed Series toward southwest (Fig.5). In the present study, the boundary condition study of the complexes and series revealed close relation of the series with the two complexes. This relation is aided by very clear field evidence, this evidence is deposition of succession of 50 m of black volcaniclastic sandstone and conglomerate (with few beds of detrital limestone) between Tanjero Formation and Red Bed Series in the Chwarta area about 100 m to the south and southwest of Tagaran village. This succession is located above Aqra Formation and considered as part of the Red Bed Series in the present study. But Karim (2004) called it "Tagaran conglomerate" and considered it as the most upper part of Tanjero Formation (Fig.20). Although it contains reworked Maastrichtian Macro fossils such as Amphalocyclus, Loftusia and orbitoids (Fig.21). but nannofossils analysis indicated Paleocene age; therefore it belong to Red Bed Series and it has equivalent conglomerate in distal area (Dokan area) which is, according to Kharajiany, et al. (2018) it located inside succession of the Paleocene. Hassan et al. (2014) geochemically proved that the lower part of the Red Beds Series is mainly enriched with HREEs which ascribed to mafic and ultramafic source rocks contrary to the middle and upper parts which have less HREE.

Therefore, the lower part of the Red Bed Series is lithologically and stratigraphically equivalent to the Walash Formation while its middle and upper parts, are more or less different from the latter formation since its age is younger and they ~~are~~ fed by sediments from two different sources. The main source was the radiolarites (Qulqula Formation) and limestone of the Avroman Formation which was supplied the series with normal siliciclastic sediments (chert and limestone clasts) which has red or grey colors. The second source subordinate and intermittent which consisted of the same volcanic arc that fed the lower part of the Red Bed Series by volcaniclastic sediments. The expression of the two sources of middle and upper parts of series is very clear in the field which manifested by alternation of two types of the sediments (red and bluish grey layers) in certain stratigraphic intervals (Fig.22). Therefore, there are close relation between Walash and Kolosh Formations with Red Bed Series which were sharing, in most their time span, same basin of Paleocene-Lower Eocene.

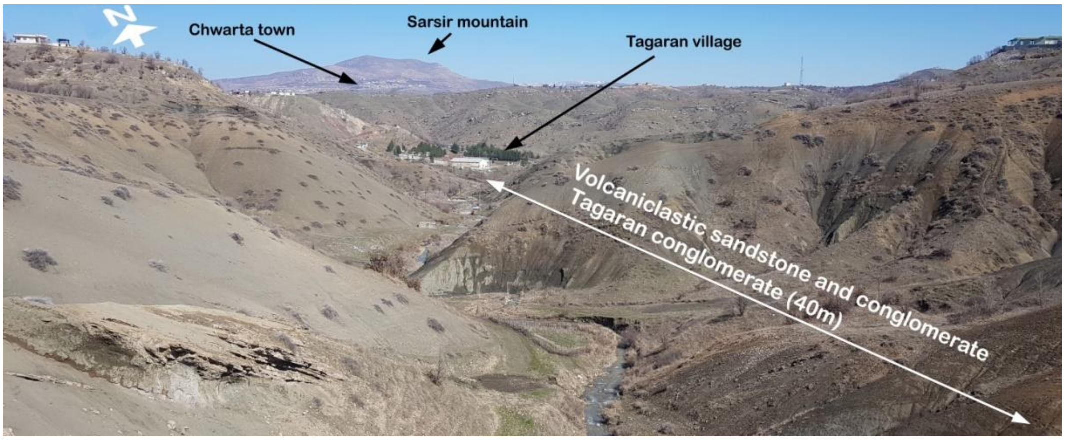

Fig. (20) Volcaniclastic sandstone (greywackes) and conglomerate at 1km south of Tagaran village at the base of Red Bed Series and t the top of Aqra Formation.

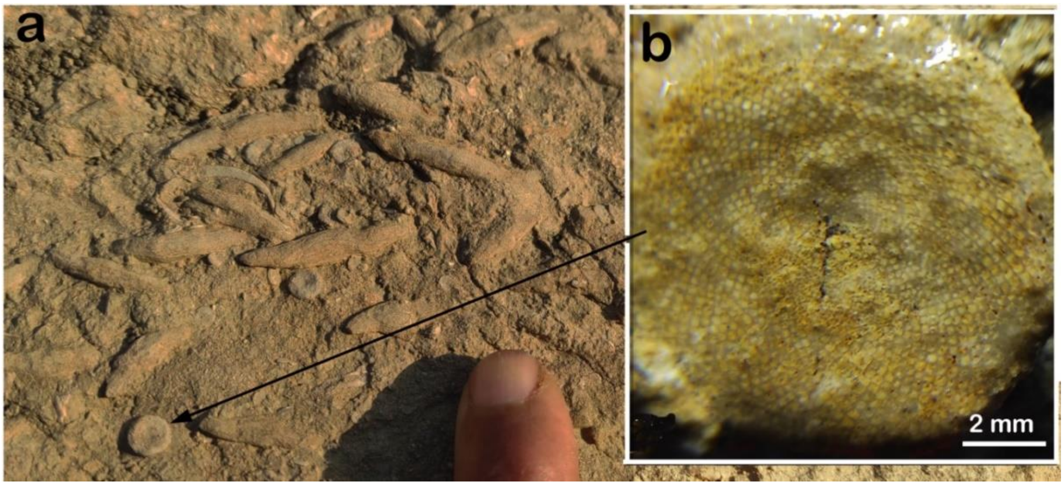

Fig. (21) Reworked Maastrichtian macrofossils in the lower part of the Red Bed Series in Chwarta area 500m southeast of Tagaran village, a) Loftusia, b) Amphalocyclus

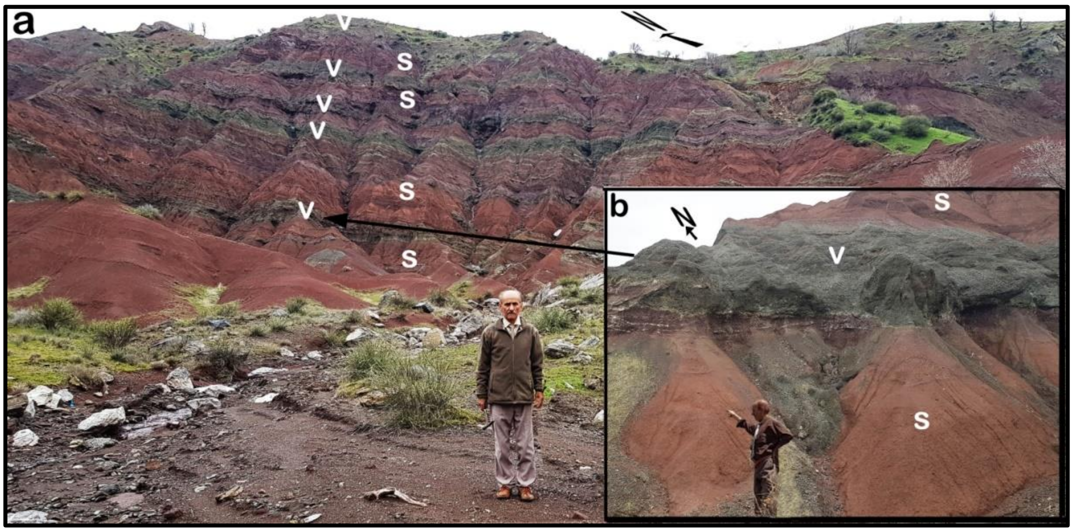

Fig.(22) Middle part of Red Bed Series at 2km west of Mawat town, contains several thick beds of volcaniclastic sandstone and conglomerate (V) interbedded with normal lithology (red claystone and sandstone) of the series (S),

2.1.7. Qulqula Radiolarian Formation

This Formation consists of very thick and intensely deformed alternation of bedded cherts, siliceous green or brown marls, shale and thick or thin detrital limestone about 1000 thick. In the studied area it located in the east and northeast of the Mawat Metamorphic Core Complex. According to Buday (1980) its age is Jurassic-Early Cretaceous. The field input of the present study, don't aid the stratigraphic (genetic) relation with Mawat Ophiolite Complex due to absence of any slice or sheet of radiolarites inside its structure or in front of ~~it~~ latter complex. Instead of radiolarites, the claimed Mawat Ophiolite complex is overlain and headed by shallow marine carbonate of Naoperdan Formation. According to the most researchers of the Zagros Collisional Belt, ophiolite is uplifted from deep oceanic floor of Neo-Tethys Ocean and obducted onto the Arabian Passive Margin (Fig.3), therefore, it must be fronted and topped by oceanic pelagic mudstone and radiolarites. The ophiolite must carry with its self the latter two deep ocean sediments during transferring from oceanic realm to continental one. But neither radiolarite nor pelagite are found in front or on top of the ophiolite, in contrary shallow marine carbonate was found as mentioned before.

3. Discussion

3.1. Model of the deposition and stratigraphy

During its geological history, the studied area is the most intensely deformed area in Iraq due to its location in the most tectonically active zone between colliding Arabian and Iranian plates. This deformation including folding and faulting on millimeter and kilometer scale which include grain suturing, grain stressing manifested by wavy extinction to a degree that geologist rarely can find few millimeter without deformation in thin sections. Deformations of the kilometer scale is discussed in detail by Karim et al. (2020) in which they explained the effects of Mawat Metamorphic Core Complex on surrounding areas. Therefore, the established and modeling the deposition and stratigraphy of the two complexes are very difficult.

However, the study of the interior and boundaries of the two complexes enable the present study to extract many evidences and key features that aid visualizing the actual depositional model. For finding these features, the interior of the bodies are studied by surveying the deep valleys, hills and high mountains of the two complexes by which more than 500m of their thicknesses are inspected in tens of localities. Even the deep buried formation such as Shiranish Formation is found for the first time which is uplifted by the core complex at one locality in its periphery. The same processes are true for boundaries (boundary conditions) of the two complexes whereas more than 50 km are inspected around them for building relation of the complexes with other surrounding stratigraphic units. Recently, Karim and Al-Bidry (2020) discussed in detail evidences by which they changed the previous two ophiolite complexes to metamorphic core complexes and reused presence of the ophiolite. ~~The~~ they proved that what called "ophiolites" are metamorphosed greywackes, volcaniclastic sandstones and conglomerates of Walash Formation which are crystallized to different types of metamorphic rocks such as schist, gneisses and granulites.

The stratigraphy of Iraq includes depositional sequences and models that can be useful for establishment model of deposition of the two complexes. Iraqi depositional sequences show an important fact which is termination of the siliciclastic successions (formations) with carbonate deposition. In this stratigraphy, the deep clastic units are always overlain by reefal limestone such as Sarmord (early Cretaceous), Tanjero (Maastrichtian) and Kolosh (Paleocene) Formations which are overlain by the reefal limestone of Qamchuqa, Aqra and Sinjar Formation respectively (Fig.19). Another example is Gercus Formations which ended with Pila Spi Formation (Upper Eocene limestone). Thus, the Walash Formation either its fresh sediments or its metamorphosed (previous ophiolite) rocks are very similar to above mentioned model in three points, the first is its overlying by reefal limestone of Naoperdan Formation or t's metamorphosed equivalent represented by Gimo sequence (Figs. 8, 9, 10, 19 and 23). The second is its presence of the Walash Formation which comprised of alternation of fine and coarse grain parasequences of sandstones and siltstones with several thick bed of conglomerate that deposited by turbidity current (Fig.6, 7 and 8) which are very similar to the Tanjero and Kolosh Formation. These lithologies are all derived originally from Island Arc (Urumieh-Dokhtar Magmatic Arc) (Karim and Al-Bidry, 2020). The third is close age relation of the Walash Formation with the latter two formations (Maastrichtian-Paleocene)

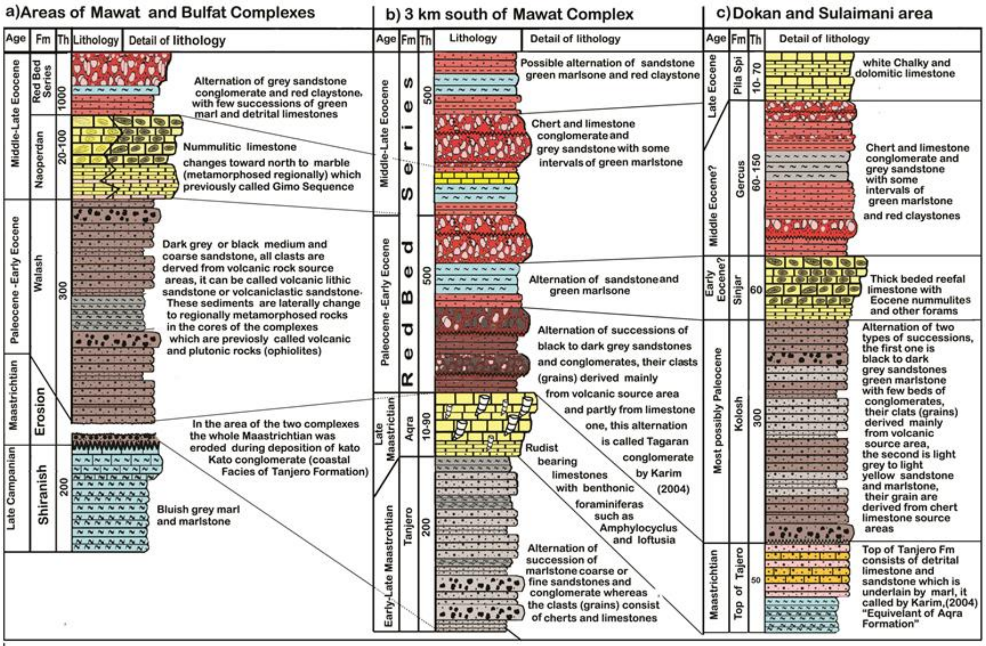

Fig. (23) Three stratigraphic columns of the studied area, a) General representation of the Mawat and Bulfat Core Complexes which consists of fresh and metamorphosed sediments of the Walash and Naoperdan Formations (the metamorphosed sediments are not shown), b) Near Tagaran village 5 km south of Mawat Metamorphic Core Complex, c) a column represent Dokan and Sulaimani areas. It can be seen that the depositional succession of Walash-Naoperdan Series is very similar to that of Kolosh and Tanjero Formation.

3.2. Tectonic important of presence of Shiranish Formation in the middle of Walash-Formation

As stated in the section (2.1.4), a succession of the Shiranish Formation is exposed in the middle of Walash Formation and about 25 meters thick. It directly located at the southwestern boundary of the Mawat Metamorphic Core Complex. This exposure is dipping about 45 degree toward northeast and underlied and overlied by highly deformed (crushed) succession of the Walash Formation. The graded bedding (unit A of Bouma sequence) and erosional surfaces show that the succession of Shiranish Formation is not overturned. From the upper part of Shiranish Formation, the Walash Formation gradually shows regional metamorphism.

The tectonic significant of this exposure of the latter formation is it's uplift to the surface from deep burial by reverse fault not thrust. The uplift of the Shiranish Formation is more than 250 meters which estimated from the stratigraphy of the Mawat area. This uplift is another evidence of the Core Complex that proposed by Karim and Al-Bidry (2020) who published several evidences for justification of their proposal. Another new proof for uplifted metamorphic core complex instead thrusted (obducted) ophiolite Complex of the previous authors (see Figs. 3, 4, and 5) is the dips of the strata of the two complexes. Nearly all strata around the two complexes are dipping toward their centers which are similar to a bell mouse. This central dipping is clear from observation of the present study and from the cross section of Mawat Complex by Mehaidi (1975) and Al-Qayim et al. (2012) (Fig.5).

The previous thrusts such as Walash-Naoperdan, ophiolite and Gimo sequence thrust sheets are structurally not proved in the present study since not thrust fault is found inside the two complexes while the reverse fault is common. In more extreme condition, Ali et al. (2019) indicated many thrusts inside ophiolite complexes of Mawat, Bulfat and Penjween area (Fig. 24). The present authors think that these thrusts, in the latter figure, are indicated theoretically to justify location of basalt at the base of ophiolite sections of the two complexes. In the present study these thrusts are replaced by realistic stratigraphic sections and geologic cross section according to the results of our fieldworks (Fig.23 and 24). In the latter figure the actual stratigraphic position of stratigraphic units such as Red Bed Series, Walash Formation (its unmetamorphosed and metamorphosed parts), Naoperdan Formation, claimed Basalt and ophiolite are indicated. The indication is correlated with the stratigraphy (thrust sheets) of Ali et al. (2019). According to the previous tectonic models these sheets are considered as arc in the Neo-Tethys Sea and developed far from the stratigraphy of the Mawat and Bulfat Complexes (Aziz et al., 2011, Ali et al., 2013, Mohamad and Cornell, 2017, Fig.3) and transported for long distance by thrust, therefore, they must have very low dip angles to support long distant transportation but this low dips are not observable in the field.

In some of these models, the geologic setting of the Mawat and Bulfat Complexes; Walash and Naoperdan Formations are so complex, that their present coexistence cannot imagined (see Numan,

1997) (Figs. 3 and 25). While, the present study dramatically simplified the geology of the two complexes and whole northeastern Iraq. This simplification includes establishment stratigraphic relation between the stratigraphic units that are discussed in the previous sections and refusal of the previous two models, i.e. thrusting (allochthonous) (see Figs. 3, 4 and 5) and overturned models. In this simplification, the ophiolites and basalts are all considered as metamorphosed sedimentary units and their deposition occurred sequentially in the present location but intensely deformed during burial, metamorphism and uplift as metamorphic core complexes. Additionally they are all more or less affected by main Zagros Thrust Fault by which some southwest shifting had occurred to all units. This shifting (southwestern transport) is described and justified by several field evidences by Karim et al. (2020). Previously Karim (2020) considered Sanandij-Sirjan Zone as a sedimentary basin (Fig.26) during Cretaceous which supplied by clastic deposits from Arabian continental margin and Urumieh-Dokhtar Magmatic arc.

In the simplifications processes, new geological maps are drawn to the two complexes (Fig.27) on which the outcropped sedimentary units and their metamorphosed equivalents are shown. This simplification is not surprise since it has history in which Karim et al. (2008) indicated the shifting of depositional depocenter to the location of the Mawat and Bulfat area during Eocene and refused presence of volcanic arc in the two areas (Fig.28). In the same manner, Karim and Taha (2009) modeled tectonic and depositional history during Cretaceous (Fig.28) which does not contradict the result of the presence study while opposes other models that shown in previous section of this study (Figs. 3 and 24a).

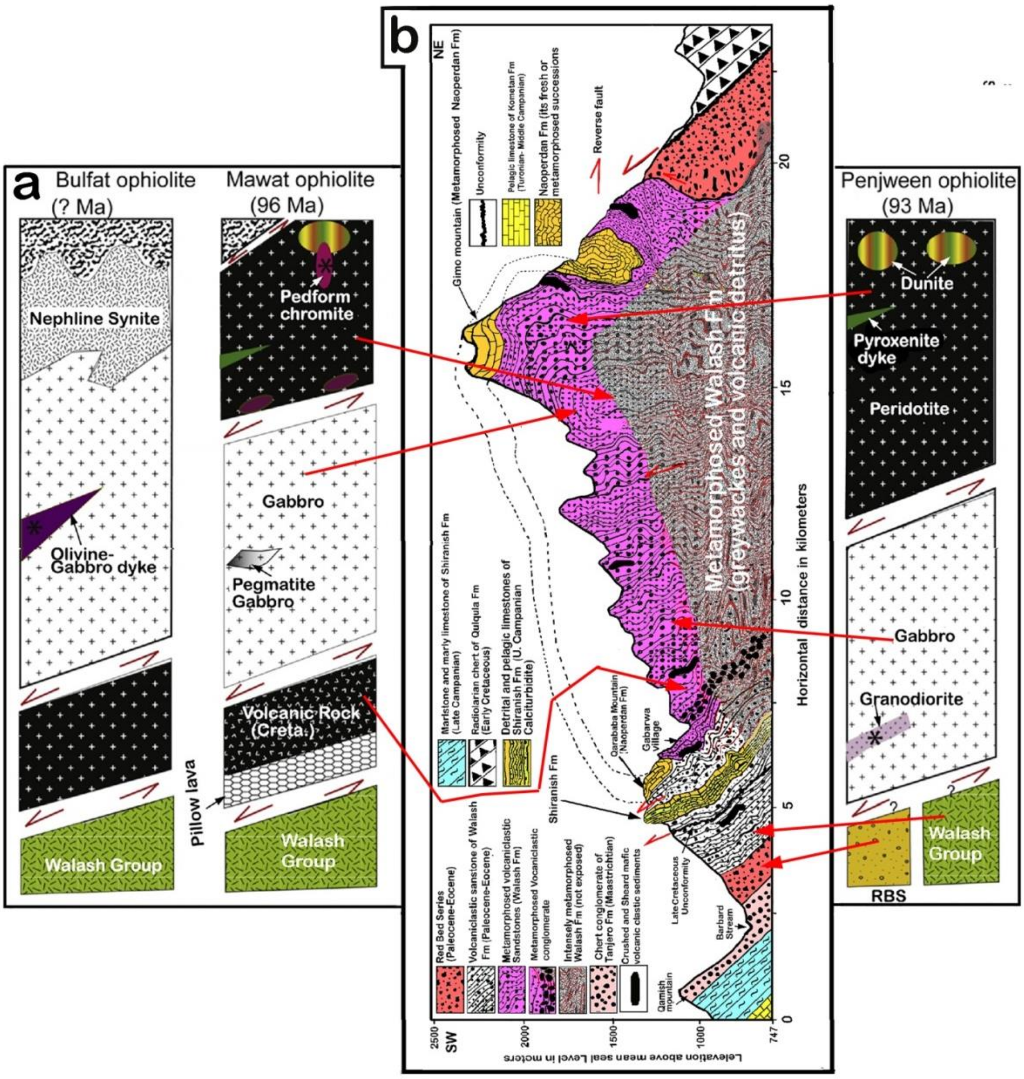

Fig. (24) a) Ophiolite section of the northeast Iraq by Ali et al. (2019) in which there are several thrusts sheet in the section of Mawat Bulfat and Penjween areas on which volcanic rocks and dunite located at the bottom and top of the sections respectively which oppose true section of ophiolite. b) True geologic cross section of the Mawat Metamorphic Core Complex shows true stratigraphic position of the two complexes (and Penjween area too which agree with age tectonic and fieldworks of the present study (the red arrows indicate correlated positions of the units of the present study with that Ali et al.(2019)

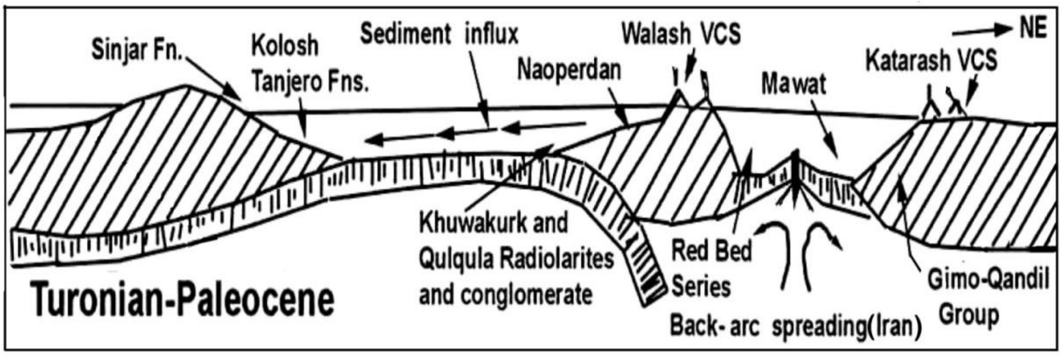

Fig. (25) Tectonic model of Zagros during Turonian-Paleocene (Numan, 1997), it can be very complex

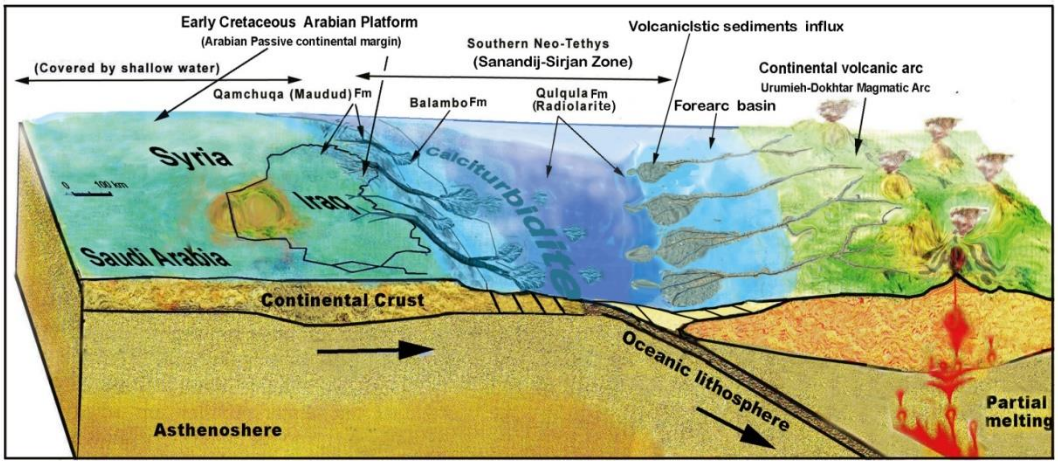

Fig.(26) Paleogeograohy and tectonic model of the Sanandij-Sirjan Zone (as part of the Neo-tethys sea) during Early Cretaceous (modified slighly from Karim, 2020).

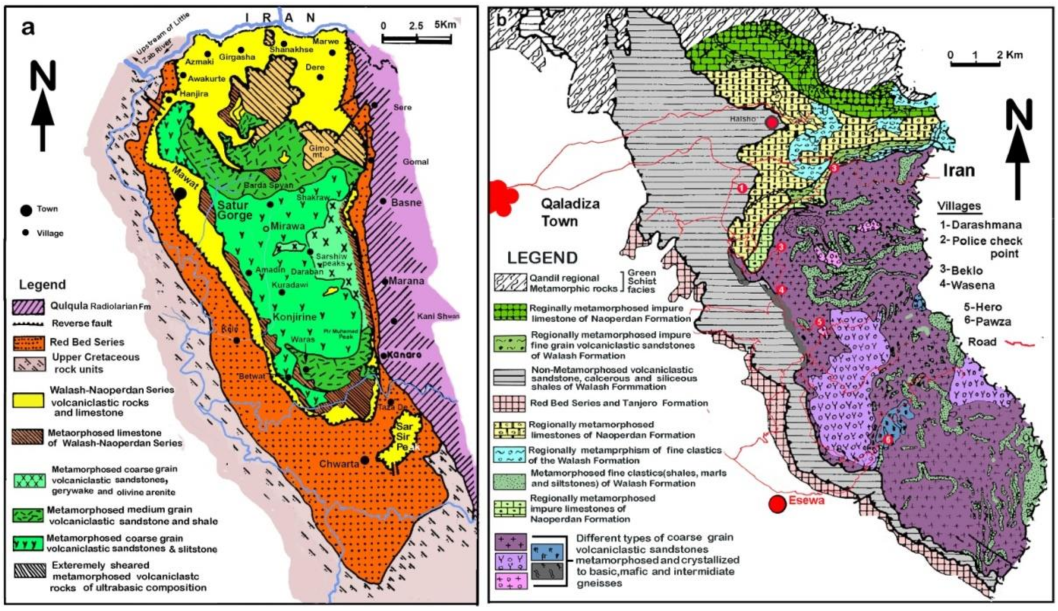

Fig.(27) Geological maps of Mawat (a) and Bulfat (b) on which the previous igneous rocks are eplaced by metamorphosed sedimetary units.

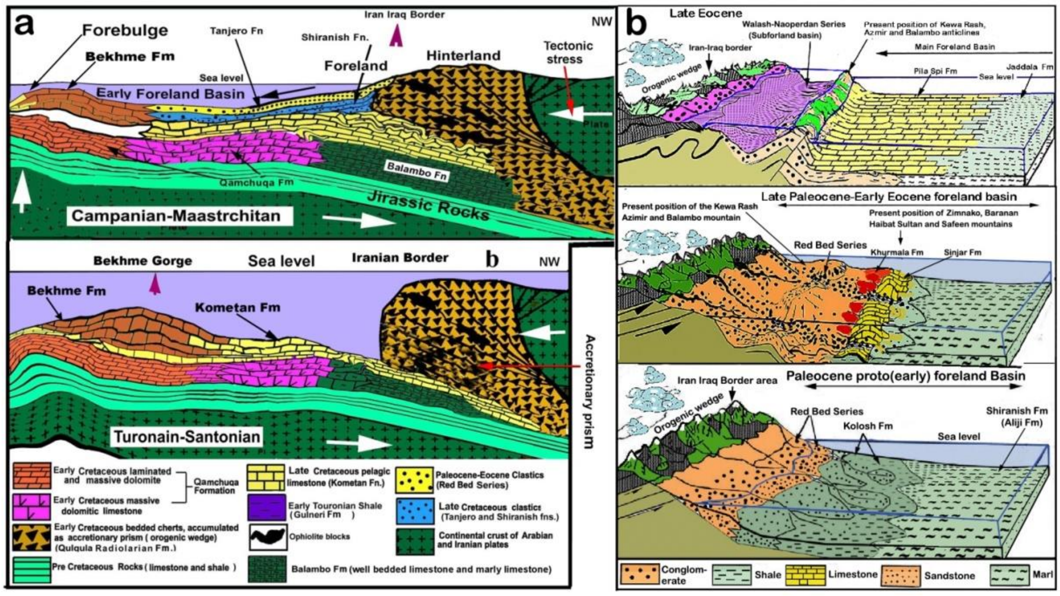

Fig.(28) a) Late Cretaceous tectonic models (Karim and Taha,2009) that agree with present study since there is not ophiolite obduction and opposes the models in the figures (Figs. 3 and 24). b) Realistic tectonic models (Karim et al. 2008) show how depocenter shifted toward northeast during Eocene.

References

Abdulzahra, IK (2008) Petrology, Geochemistry and Petrogenesis of gabbroic rocks (Central sector) of Mawat Ophiolite Complex, NE Iraq, A MSc Thesis of Department Geology, university of Baghdad, p.101

Al-Banna, NY (2010) Sequence stratigraphy of the Late Campanian-Early Maastrichtian Shiranish Formation, Jabal Sinjar, northwestern Iraq, GeoArabia (2010) 15 (1): 31–44.

Al-Hashimi, HA (1975) Contribution to the Stratigraphy and micropaleontology of the Naopurdan Shaly Group in Chwarta are, northeastern Iraq: Journal of the Geological Society of Iraq, special issue, p. 27-36.

Ali S A, Nutmana AP, Aswad KJ, Jones BG (2019) Overview of the tectonic evolution of the Iraqi Zagros thrust zone: Sixty million years of Neotethyan ocean subduction, Journal of Geodynamics 129,162–177.

Ali SA, Sleabi RS, Talabani M JA, Jones BG (2017) Provenance of the Walash-Naopurdan back-arc- arc clastic sequences in the Iraqi Zagros Suture Zone Journal of African Earth Sciences 125: 73-87.

Ali S, Mohajjel M, Aswad K, Ismail S, Buckman S, Jones B, (2014) Tectono-stratigraphy and general structure of the northwestern Zagros collision zone across the Iraq-Iranborder Journal of Environment and Earth Science, 4(4): 92-110.

Ali SA, Buckman S, Aswad KJ, Jones BG, Ismail SA, and Nutman AP (2013)The tectonic evolution of a Neo-Tethyan (Eocene–Oligocene) island-arc (Walash and Naopurdan groups) in the Kurdistan region of the Northeast Iraqi Zagros Suture Zone Island Arc 22:104–125.

Al-Khafaf, AO (2014) Biostratigraphic contribution to the differentiation of the Lower-Middle Cretaceous units in the Imbricated Zone of Sulaimani Governorate, North Region, NE Iraq, PhD thesis, University of Sulaimani, 230p.

Al-Mehidi, HM, (1975) Tertiary nappe in Mawat range. Iraqi Journal of Geological Society, 8:31– 44.

Al-Qayim B, Ibrahim AO, Koyi H (2012) Tectonostratigraphic overview of the Zagros Suture Zone, Kurdistan Region, Northeast Iraq. GeoArabia 17(4):109–156.

Al-Qayim, B, Ghafor, I & Jaff, R (2014) Contribution to the stratigraphy of the Walash Group, Sulaimani area, Kurdistan, Iraq. Arab J Geosci 7: 181-192.

Ameen F.A. & Gharib H. (2014) Biostratigraphy of the Tethyan cretaceous successions from northwestern Zagros fold–thrust belt, Kurdistan region, NE Iraq, Arab J Geosci 7:2689–2710.

Aswad K.J. and Elias E.M. (1988) Petrogenesis, geochemistry and metamorphism of spilitized subvolcanic rocks of the Mawat Ophiolite Complex, NE-Iraq. Ofioliti, 13 (2/3): 95-109.

Aswad KJA, Al-Samman AHM, Aziz NRH and Koyi AMA (2014) The geochronology and petrogenesis of Walash volcanic rocks, Mawat nappes: constraints on the evolution of the northwestern Zagros suture zone, Kurdistan Region, Iraq, Arab J Geosci , 7:1403–1432.

Aziz N RH, Aswad KJA, Koyi, H A. (2011) Contrasting settings of serpentinite bodies in the northwestern Zagros Suture Zone, Kurdistan Region, Iraq, Geol. Mag. 148 (5–6):819–837.

Azizi H, Hadi A, Asahara Y and Mohammad Y O (2013) Geochemistry and geodynamics of the Mawat mafic complex in the Zagros Suture zone, northeast Iraq Cent. Eur. J. Geosci., 5(4): 523-537, DOI: 10.2478/s13533-012-0151-6.

Bellen, RCV Dunnington, HV Wetzel R and Morton D (1959) Lexique Stratigraphique, Interntional. Asie, Iraq, Vol. 3c. 10a, 333p.

Boggs S (2009) Petrology of Sedimentary Rocks, Cambridge University Press

Bolton, CMG (1957) Geological map-Kurdistan Series, scales 1:100000, sheet K5, Choarta (Chwarta), Site Inv. Co. report, NIMCO Lib. Unpublished report.

Buda G and Al-Hashimi WS (1977) Petrology of the Mawat Ophiolite Complex, Northeastern Iraq, Geological Society of Iraq, 10: 69-98.

Buda, GY (1993) igneous petrology of the Bulfat area (North-East Iraqi Zagros Thrust Zone) Acta Mineralogica-Petrographica, Szeged 34: 21-39.

Buday T, (1980) Stratigraphy and Palaeogeography, The Regional Geology of Iraq 1. GEOSURV, Baghdad.

Buday,T and Jassim, SZ, (1987) The Regional geology of Iraq: Tectonism Magmatism, and Metam-orphism. M.J Abbas and Jassim, S. Z (Eds), GEOSURV, Baghdad, Iraq, 445pp.

Ghazal MM, Salih AM, Mohammed AH (2018) Serpentinite Rocks of Mawat Ophiolite Complex, Northeastern Iraq, Beetwat Village: 1-Petrography and Diffractometry, Tikrit Journal of Pure Science 23 (7).

Hassan, M, Jones, BG, Al Jubory, A Ismail, Ismail, S Ahmed, Saleh, A & Al Gahtani, FM (2014) Geochemistry of Paleogene Red Beds in the northern Iraq foreland basin: evidence for provenance. International Journal of GEOMATE, 7 (1), 938-944.

Jassim SZ, Buda G, Neuzilová M, Suk M (1983) metamorphic development of the Iraqi Zagros Ophiolite Zone, Kryst. Alinikum 16, p. 21-40.

Jassim, SZ, and Al-Hassan MI (1977) Petrography and origin of the Mawat and Penjwin Igneous Complex: a comparison, Jour. Geol. Soc. Iraq, special issue, pp.169- 210.

Jassim, SZ, and Goff, JC (2006) Geology of Iraq, Dolin, Prague and Moravian Museum Brno, Czech Republic, 352p.

Kareem HJ (2015) Mineralogy and geochemistry of Granitoid pegmatite dykes from Mawat Ophiolite, Kurdistan Region, Northeastern Iraq. MSc thesis, Department of Geology, University of Sulaimani.

Karim KH, Al-Barzinjy ST and Ameen BM (2008) History and geological setting of intermontane basins in the Zagros Fold–Thrust Belt, Kurdistan Region, NE Iraq Iraqi Bulletin of Geology and Mining ,4(1): 21− 33 21.

Karim KH and Al-Bidry M (2020) Zagros Metamorphic Core Complex: Example from Bulfat Mountain, Qala Diza Area, Kurdistan Region, Northeast Iraq, Jordan Journal of Earth and Environmental Sciences (JJEES) 11 (2): 113-125.

Karim KH (2004) Basin analysis of Tanjero Formation in Sulaimaniyah area, NE-Iraq, PhD thesis, university of Sulaimani, 148p

Karim KH (2020) Early Cretaceous calciturbidites facies from Zagros Fold–Thrust belt: a key to paleogeography and environment of northeast Arabian Platform Passive Margin, examples from Kurdistan Region, Northeast Iraq, Carbonates Evaporites, 35, 19. https://doi.org/10.1007/s13146-019-00544-w

Karim KH, Khanaqa PA, Ismail KM (2020) Role of facies changes in shifting trends of anticlines in the Zagros Fold-Thrust belt: Examples from Sulaimani area, Kurdistan Region, northeastern Iraq, Journal of Zankoy Sulaimani (JZS), 22(1): 1-28.

Karim, K.H. and Taha, Z.A. (2009) Tectonical history of Arabian platform during Late Cretaceous An example from Kurdistan region, NE Iraq. Iranian Journal of Earth Sciences, 1(1): 1-14.

Karim, KH, Al-Khafaf, AO, Sharbazheri, KI (2016) Critical analysis of the type section of the Balambo Formation (Valanganian-Turonian), Sirwan valley, north Region, NE-Iraq, Journal of Zankoy Sulaimani – Part A, special issue.

Karo NM (2015) Metamorphic evolution of the Northern Zagros Suture Zone (NZSZ) Ph D Thesis, Faculty of Mathematics and Natural Sciences, University of Potsdam.

Kharajiany S.O., Wise S.W. and Al-Qayim B. (2018) Calcareous nannofossil stratigraphy of the Upper Cretaceous–lower Paleocene sequence from the Dokan section, Sulaimani, Kurdistan- Iraq, Journal of Zankoy Sulaimani (JZS), 20 (2):67-71.

Koyi، AM (2009) Sr-Nd isotopical Significance of Walash Volcanic Rocks Mawat Area, NE Iraq, Zanco, Journal of Pure and Applied Sciences, Salahaddin University, Hawler, 21(6): 1-9.

Lee, YI (1992) Diagenesis of deep-sea volcaniclastic sandstones, in: Chilingarian G.V., Wolf K.H. (editors), Diagenesis, III, Developments in Sedimentology, Elsevier, 47: 253-290.

Malak, ZA (2015) Sequence stratigraphy of Shiranish Formation in Dokan area, Northern Iraq Arabian Journal of Geosciences, 8: 9489–9499.

Mirza TA and Ismail SA (2007) Origin of plagiogranites in the Mawat Ophiolite complex, Kurdistan region, NE Iraq, Kirkuk University Journal For Scientific Studies,2(1): 1-26.

Mohammad YO, Cornell D H, Qaradaghi J H., Mohammad F O (2014) Geochemistry and Ar–Ar muscovite ages of the Daraban Leucogranite, Mawat Ophiolite, northeastern Iraq: Implications for Arabia–Eurasia continental collision, Journal of Asian Earth Sciences, 86: 151–165.

Mohammad YO (2020) Cumulate and tectonite dunite from Mawat Ophiolite, Kurdistan Region, Northeastern Iraq: field evidence and mineral chemical constraints Iraqi Bulletin of Geology and Mining 16(1)15- 33.

Mohammad, Y (2008) "Petrology of ultramafic and related rocks along Iraqi Zagros Thrust Zone". Unpublished PhD Thesis, Osaka Prefecture University, Japan, 154 p.

Mohammad, Y.O., and Cornell, D. H.,(2017) U-Pb zircon geochronology of the Daraban leucogranite, Mawat ophiolite, Northeastern Iraq: A record of the subduction to collision history for the Arabia – Eurasia plates. Island Arc, Vol.26, e12188.

Mohammad1, YO and Qaradaghi JH (2016) Geochronological and mineral chemical constraints on the age and formation conditions of the leucogranite in the Mawat ophiolite, Northeastern of Iraq: insight to sync-subduction zone, Arab J Geosci 9:608 DOI 10.1007/s12517-016-2630-4.

Naeem A, Al-Dulaimi S, Karim, KH (2020) Campanian calciturbidites from Northeast Iraq Kurdistan Region: insight into paleogeography and source areas of the Shiranish Formation, Iraqi Journal of Science , 62 (6): 42-67

Numan NMS (1997) A plate tectonic scenario for the Phanerozoic succession in Iraq. Iraqi Geol J 30(2):85–119.

Sissakian VK (2000) Geological map of Iraq, Sheets No.1, Scale 1:1000000, State establishment of geological survey and mining. GEOSURV, Baghdad, Iraq.

Smirnov، VA, Nelidov VP (1962) Report on 1:2,0000 prospecting correlation of the Sylaimaniya-Choarta and Penjwin area carried out in 1961, GEOSURV, Baghdad, Iraq, (Report No. 290)

تجديدالمعلومات الطباقية والتكتونية والظروف الحدودية لمعقدى ماوت و بولفت الاوفيولايتى فى إقليم كردستان ، شمال شرق العراق

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الملخص

معقدا ماوت وبلفت الناريان عبارة عن منطقتان متجاورتان في أقصى شمال شرق العراق بالقرب من الحدود مع إيران. تبلغ مساحة كل المعقد حوالي 250 كيلومترًا مربعًا ولهما نفس وضع الطباقى تقريبًا. تم إنشاء هذه الطابقية في السبعينيات من القرن الماضي ولم يتم إدخال أي تغيرات منذ ذلك الوقت على الرغم من نشر عشرات الدراسات حوله. نقدم هنا تغييرات جذرية في الطباقية للمعقدين اعتمادًا على رسم الخرائط الجيولوجية والفحص الميدانى والمضاهات بالإضافة إلى اجراء الدراسات الصخرية ولأحفورية والحدودية. وتم تغيير المعقدين النارين إلى معقد نواة متحولة عن طريق تغيير الأفيولايت السابق إلى Greywackes المتحول والأحجار الرملية المتاتية من الصخور البركانية. بالإضافة إلى ذلك، تم تغيير الصفائح الثلاثة التكتونية السابقة إلى وحدات طباقية رسوبية أصلية و غير منتقلة والتى تشمل جريواكى المتحول (اللوح افيوليتى السابق) و سلسلة والاش – ناوبردان (كاحدى الالواح السابقة ومتكونة من الحجر الرملى غير النقى غير المتحول والحجر الجيري). و لوح سلسلة نابردان المتحولة (التى عرفت السابقا بلوح زحف جيمو Gimo). وتطرق البحث الى توضيح توقيت الترسيب وصخور المصدر وعلاقتها بالوحدات الأخرى من العصر الباليوسيني–الإيوسيني حيث عدلت حدودها من التكتونية إلى الترسيبية. ربطت هذه الصفات بالتطور التاريخي لمنطقة سنندج – سيرجان باعتبارها الجزء الرئيسي من حوض نيو تيش الرسوبي. الدراسة خلصت أيضًا على أن هذه الصخور الرسوبية دفنت بعمق خلال العصر الأيوسيني المتأخر وتحولت إقليميًا و من ثم رفعت كمعقد اللبى المتحول خلال العصر البلايوسيني حيث رفع مع نفسها وحدات كريتاسى مثل تكوين شيرانيش.