

## THE OCCURRENCE OF EARLY AND MIDDLE MIOCENE ROCKS (EUPHRATES, DHIBAN AND JERIBE FORMATIONS) IN ASHDAGH MOUNTAIN, SANGAW AREA, SULAIMANIYAH VICINITY, NE IRAQ

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### ABSTRACT

The stratigraphy of Ashdagh anticline is insufficiently described previously by geologists; hence the present study describes and differentiates the Oligocene units from Miocene units in the aforementioned mountain. The differentiated rocks in Ashdagh anticline are Early and Middle Miocene units of Euphrates, Dhiban and Jeribe formations, which are located between the overlying Middle – Late Miocene rocks and the underlying Oligocene rocks (Kirkuk Group). These units may have been previously mentioned as possible exposed rocks, like Euphrates and Jeribe formations, but Dhiban Formation has not been mentioned before.

For ascertaining these formations, stratigraphy, lithology and fossils content are utilized. The Euphrates Formation consists of two lithologies: sedimentary breccia (6 m thick), which may have been brecciated by solution, and about 3 m of limestone contains *Borelis melo melo* index fossil. Jeribe Formation consists of grey limestone, which is slightly marly, about 2 m thick and contains *Borelis melo curdica*. Dhiban Formation consists of anhydrite and chalky limestone, about 2 m thick.

تواجد الوحدات الصخرية للمايوسين المبكر والأوسط (تكوينات الفرات والذبان والجريبي)  
في جبل أشداغ، منطقة سंगाو، محافظة السليمانية، شمال شرق العراق

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### المستخلص

لم تدرس سابقاً طباقية طية أشداغ بالتفصيل من قبل الجيولوجيين، وإن الدراسة الحالية وصفت وميزت بين الوحدات الصخرية العائدة إلى عمر الأوليغوسين عن الوحدات الصخرية العائدة لعمر المايوسين في الطية المذكورة أعلاه. إن الوحدات الصخرية التي تم تمييزها في طية أشداغ تعود إلى عمر المايوسين الأسفل والأوسط وهي تكوينات: الفرات والذبان والجريبي التي تقع تحت الطبقات الصخرية للمايوسين الأوسط والمتأخر وفوق الطبقات الصخرية للأوليغوسين (مجموعة كركوك). إن تكويني الفرات والجريبي كانا قد ذكرا سابقاً باحتمال تواجدهما في طية أشداغ، بينما تكوين الذبان لم يذكر سابقاً.

للتأكد من تواجد هذه التكوينات المذكورة في أعلاه، تمت الاستفادة من دراسة الطباقية المتكشفة والصخرية ومحتويات المتحجرات. إن تكوين الفرات يتكون من وحدتين صخريتين: 6 أمتار من البريشيا و3 أمتار من الحجر الجيري الحاوي على البريشيا ويحتوي على المتحجر الدال *Borelis melo melo*. إن تكوين الجريبي يتكون من مترين من الحجر الجيري الطفلي الحاوي على المتحجر الدال *Borelis melo curdica*. أما تكوين الذبان فيتكون من مترين من الأنهدرايت والحجر الجيري الطباشيري.

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## INTRODUCTION

Ashdagh Mountain is located in Kurdistan Region, northeast Iraq, at the mid distance between Cham Chamal and Darbandi Khan towns, and is about 50 Km to the southwest of Sulaimaniyah city (Fig.1).

The Early and Middle Miocene rock units in Iraq are represented by the Euphrates and Dhiban formations of Early Miocene age, and the Jeribe, Fatha and Nfayil formations of Middle Miocene age, respectively (Fig.2). Bellen *et al.* (1959) suggested that the Euphrates Formation was deposited under shallow marine, reef and lagoonal conditions, with local coral reefs and with intermediate fore-reef conditions on one side, and lagoonal conditions, on the other side.

The Dhiban Formation forms in evaporitic – anhydrite development, and is distributed in two local basins, separated by a narrow ridge area of the deposition of chemical limestones. The Jeribe Formation however, was deposited in lagoonal (backreef) and reefal environments, with predominant back-reef facies.

The aforementioned formations, especially the Euphrates, Dhiban and Jeribe have not been considered to be exposed in Sulaimaniyah vicinity or northeast of Iraq. Even the stratigraphic correlation of Jassim and Goff (2006) does not include this part of Iraq (Fig.2). Also in the geologic map of the studied area and near surroundings, the Early Miocene rocks did not cover the studied area (Fig.1), where Mio 2 represents Middle Miocene rocks and Mio 3 represents Late Miocene rocks, whereas Mio 1, which belongs to the Early Miocene rocks, is not presented.

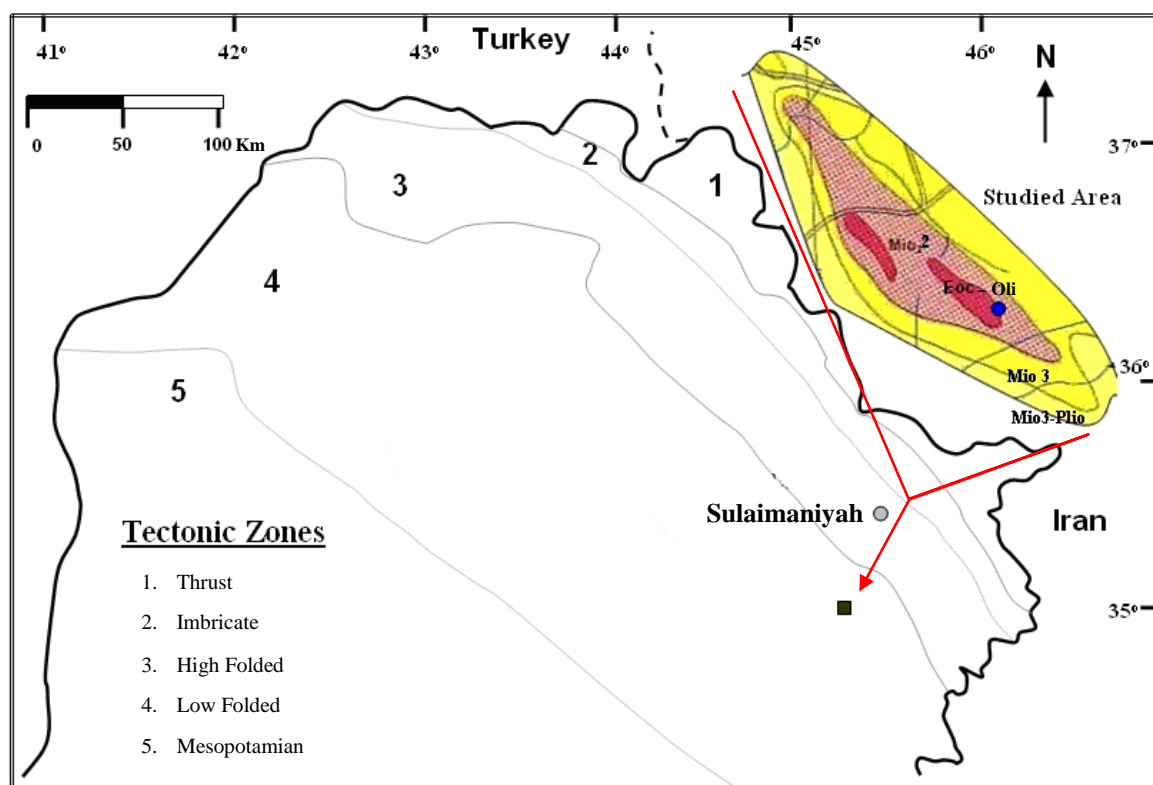


Fig.1: Geologic map and tectonics of Ashdagh anticline  
(Geological map after Sissakian and Fouad, 2014)

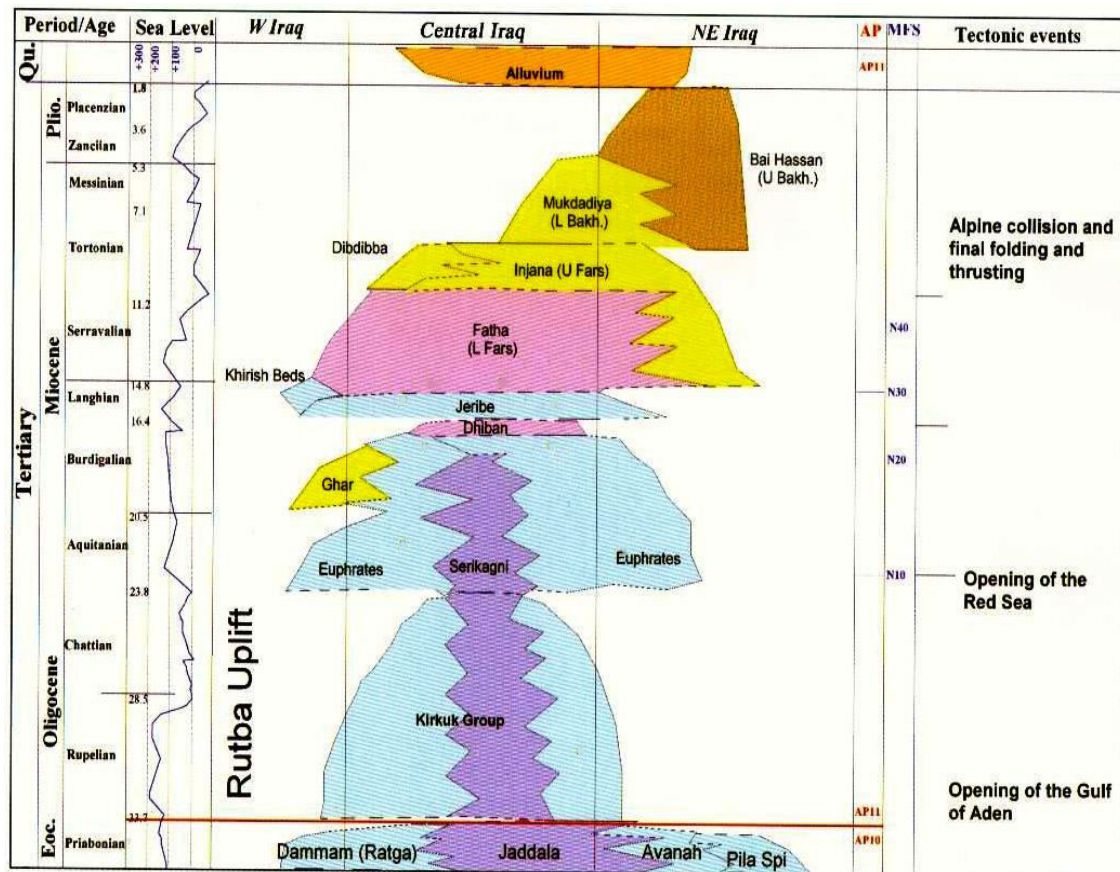


Fig.2: Stratigraphic correlation of formations of Mega Sequence AP11 (after Jassim and Goff, 2006)

### ■ Geological Setting

Tectonically, Ashdagh anticline is located within the Outer Platform, Low Folded Zone (Fouad, 2012). It is located between the latitudes N: 35° 03' 43" and N: 35° 12' 20" and the longitudes E: 45° 11' 56" and E: 45° 17' 40" (Fig.1).

The rock beds are distributed on both limbs and crest of the anticline (Fig.3), the crest is dissected by a valley, which contains milky color sulfuric water that had produced attractive valley and number of caves. The southwestern limb is faulted and thrust, while the northeastern limb has a gentle slope. Therefore, the best locations to observe the outcrops of Early and Middle Miocene are the crest and the northeastern limb. These rocks are overlying the Oligocene rocks; such as Anah and Bajwan formations and underlying the Fatha Formation (Figs.4 and 5)

### ■ Methodology

The selected sections for sampling and studying are located on both limbs and the crest of the anticline (Fig.3). The field work included 13 trips to check and record the outcrops of the three aforementioned formations and their coverage areas. For the sampled sections, 15 specimens have been collected, thin sectioned, and studied under polarized microscope.

If the upper part of the Early – Middle Miocene rock units (Fig.4) is inspected from a closer view, then a perfect succession of the Euphrates, Dhiban and Jeribe formations could be seen (Fig.5).



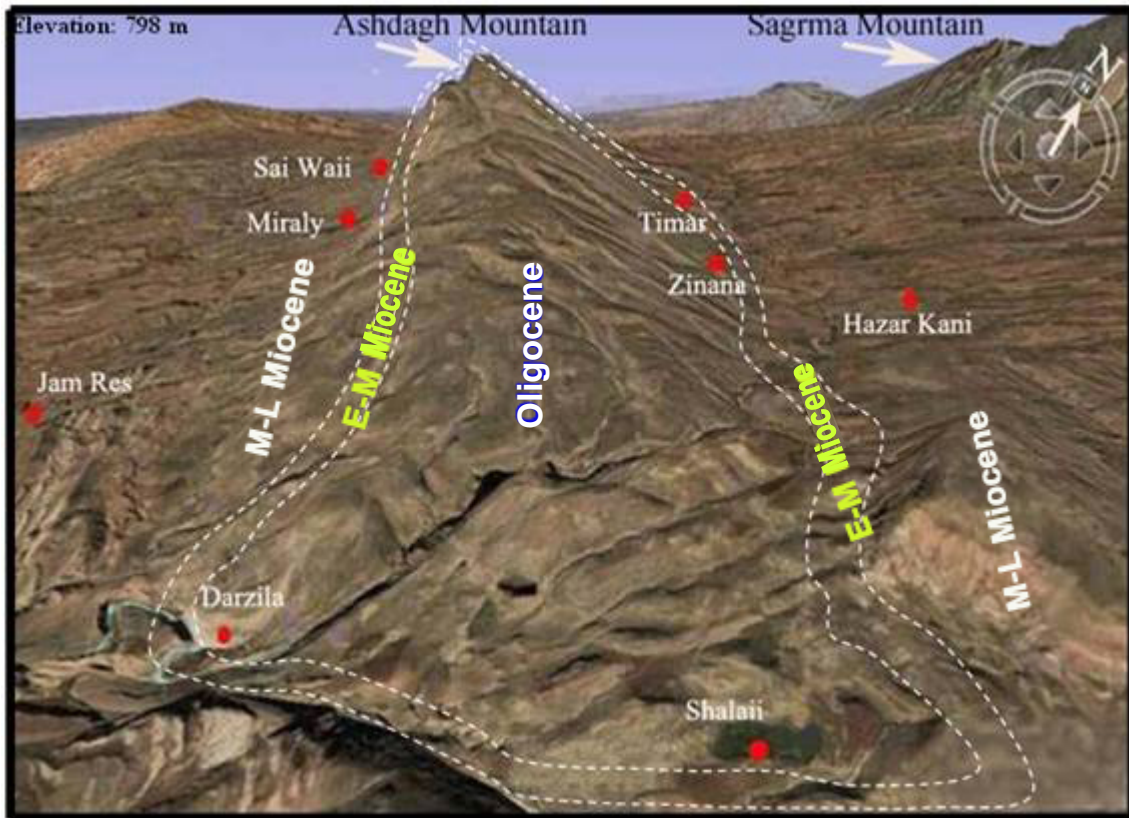


Fig.3: Google Earth image showing the distribution of the Early and Middle Miocene rock units. The dashed lines separate Early – Middle Miocene beds from the underlying Late Oligocene and Overlying Middle – Late Miocene beds (tilted image, 2013)

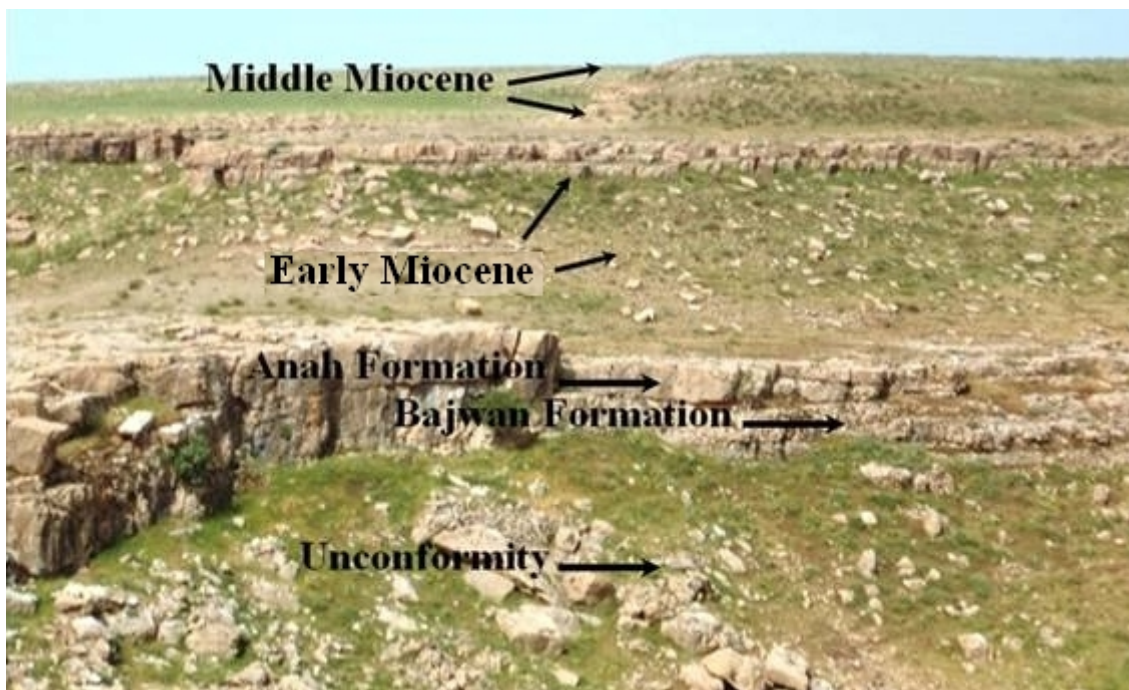


Fig.4: Stratigraphic succession of the Middle Oligocene – Middle Miocene, near Hazar Kani village, NE limb of Ashdagh anticline

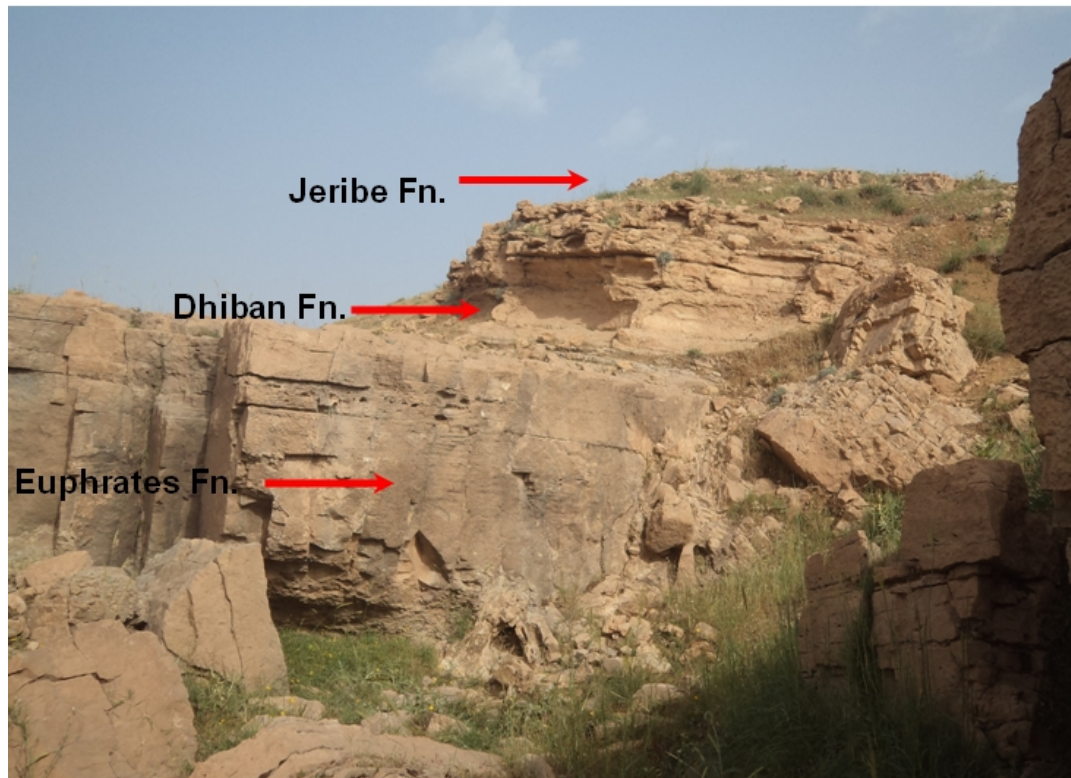


Fig.5: Stratigraphic succession of Early – Middle Miocene rocks; the Euphrates, Dhiban and Jeribe formations; west of Hazar Kani village, NE limb of Ashdagh anticline

#### ▪ Previous Studies

The Euphrates Formation is the most widespread formation of the Early Miocene Sequence.

- De Boeckh (1929) in Bellen *et al.* (1959) described the formation for the first time. The type locality is near Wadi Fuhaimi in Anah vicinity, it comprises of 8 m of shell, chalky and well bedded recrystallized limestone; however it represents only a small part of the formation and does not include the basal conglomerate (Jassim and Goff, 2006).
- The Jeribe Formation was first described by Damesin (1936) in Bellen *et al.* (1959), but was defined by Bellen *et al.* (1959) from the type locality near Jaddala village in Jabal Sinjar. It is composed of recrystallized and dolomitized, generally massive limestone beds of (1 – 2) m thick.
- The Dhiban Formation was defined by Henson (1940) in Bellen *et al.* (1959) from the type locality near Dhiban village in Sinjar Mountain. The formation comprises of 72 m of gypsum, thin beds of marl and brecciated recrystallized limestone. Between Mosul and Qaiyarah, the anhydrites are replaced by chemical limestones due to brecciated interaction and sulfur formation (Bellen *et al.*, 1959).
- Philip and Youash (1966) in Berbakesh (1990) divided the Euphrates Formation into 2 units: The lower unit, which is affected by dolomitization and recrystallization, whereas the upper unit is not affected by diagenetic processes.



- Al-Ayobe (2004) studied the Jeribe Formation from northwest of Iraq. Stratigraphically, he divided the formation into two informal rock units. The upper and lower contacts of the formation are interpreted as unconformities.
- Jassim and Goff (2006) indicated that the Euphrates Formation is heterogeneous; the formation consists mainly of limestones with textures ranging from oolitic to chalky limestone, which locally contains corals and shell coquina; they are often recrystallized and siliceous, beds of green marls, argillaceous limestone, brecciated conglomerate and conglomeratic limestone also occur.
- Khanqa *et al.* (2009) explained the probability of the presence of the Euphrates Formation in Qara Dagħ (Sagħma limb) anticline, north of Ashdagh anticline. They also stated that the identified fauna in the collected samples of the Qara Dagħ anticline indicated most probably Anah/ Ibrahim and Serikagni/ Euphrates formations, or might be a new Late Oligocene – Lower Miocene lithostratigraphic unit.
- Al-Saigh (2010) reported about the Jeribe Formation as medium to very hard recrystallized dolomitized limestone and marly limestone. It also contains very porous chalky limestone as well as some bituminous limestone.

### **EUPHRATES FORMATION**

In the studied area, the Euphrates Formation includes two main units: **1)** In the bottom, there is a thick bed of conglomeritic brecciated unit (sedimentary breccia bed), **2)** Brecciated limestone unit (Fig.6), locally discrete thin red algal limestone appears within the upper unit.



Fig.6: The Lower and Upper Units of the Euphrates Formation, Hazar Kani Section

The lower part of the Euphrates Formation comprises about 6 m of sedimentary breccia bed, it is a mixture of rounded and angular fragments of limestone derived from erosion of Anah Formation; then re-deposited again. The fossils content of these fragments are similar to those of Anah Formation; the fragments are big-sized ranging from pebble to gravel, badly sorted with concretions of paleosoil. Chert and reworked patches are also present within this sedimentary breccia bed, but in all other sections such as Shalaih, Darzila, and Miraly, this sedimentary breccia bed can not be seen; instead, limestone beds of the Euphrates Formation are found directly above Bajwan Formation (Fig.7). The Bajwan Formation is white to creamy, very thickly bedded, highly jointed, fractured, and cavernous, with foraminiferal (miliolidae) limestones. The age of the Bajwan Formation in Ashdagh anticline is correlated with the Middle Oligocene; based on the index fossils *Austrotrillina howchini*, *Archias kirkukensis* and *Praerhapydionina delicata*.

The sedimentary breccia bed is most probably an erosional unconformity surface resulted from passing the stages of "keep up" and "sub-aerial exposure" of the reef body; after growth of the reef structure and regression of the sea level. This sedimentary breccia bed is underlain by a medium to thick bed of coralline limestone of the Anah Formation. The Anah Formation has previously been ascertained and mentioned by Kharajany (2008), it is a thick bed of foraminiferal – coralline limestone (Fig.4). The age of the formation in the Ashdagh anticline is correlated with the Upper Oligocene; based on the index fossils *Austrotrillina asmarensis*, *Archias hensoni*, *Peneroplis farsensis*, *Meandropsina anahensis* and *Meandropsina iranica*.

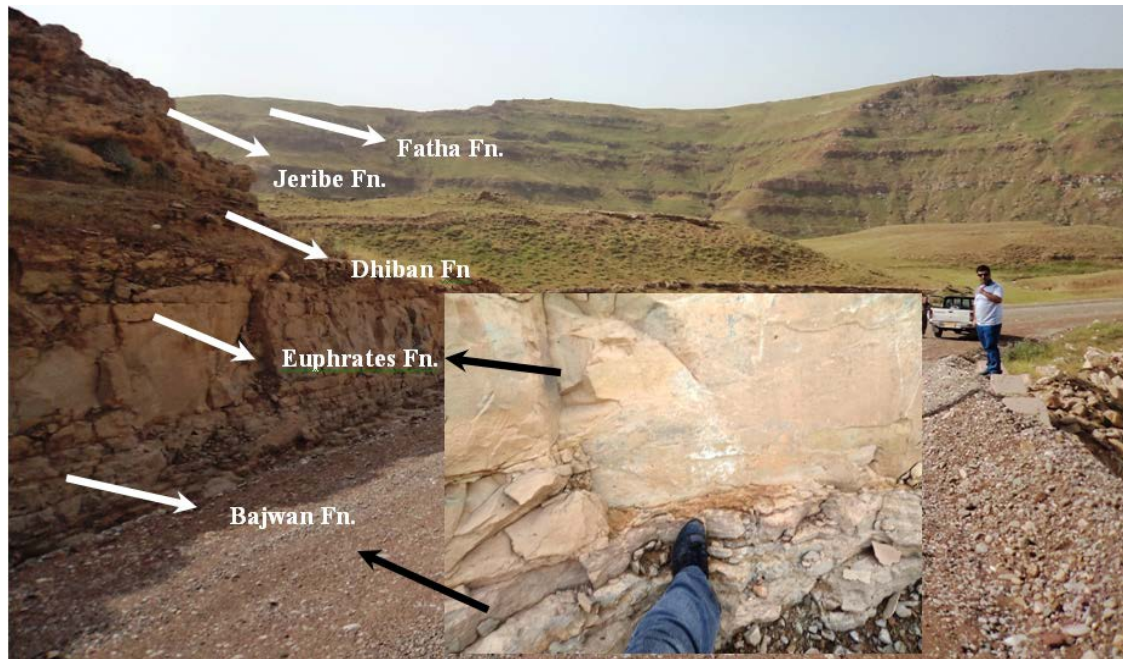
In the middle part of the Euphrates Formation, the limestone beds contain thin beds of reworked fossils and shell fragments, towards the upper part of the mentioned beds (Fig.8c), the occurrence of thin beds of red algal limestone can also be seen. Then a bed of bituminous – shaly limestone of 20 cm thick; at the uppermost part of the Euphrates Formation can be seen (Fig.9) and a new facies of evaporite begins, which represents the Dhiban Formation.

The upper unit of the Euphrates Formation comprises of 3 m thick; beds of grey to creamy, dolomitized, fossiliferous, highly jointed limestone; locally they are toppled due to the gravity (Figs.5 and 6). These beds have been weathered showing rubble surfaces (sometime the beds are brecciated by solution). The bottom of these limestone beds is bioturbated and they contain many skolithos trace fossils, which are vertically and laterally distributed between these limestone beds and the breccia bed (Fig.8a and b). Locally, near the bottom, there are beds of conglomeratic limestone, which contain clay balls (paleosoil).

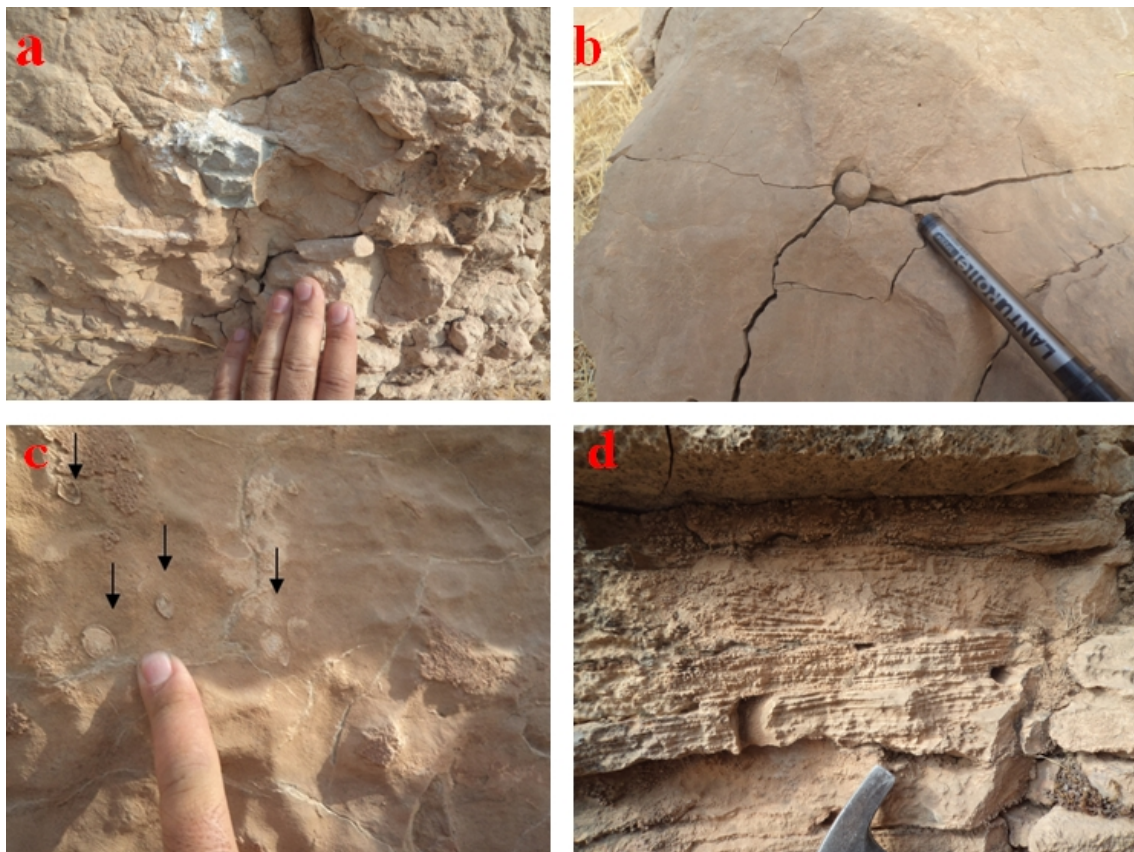
The description of the lithologies is given in the stratigraphic column of the Ashdagh anticline (Fig.10a and b). Conspicuous phenomenon can be sensed within the limestone beds of the Euphrates Formation, which is the presence of trough cross bedding and ripple marks that are located under the bottom and on the top of these limestone beds (Fig.8d); this phenomenon indicates agitated water environment.

In Ashdagh anticline, along the NE limb; near Hazar Kani village, the Euphrates Formation overlies the Late Oligocene Anah Formation (in Hazar Kani section, Anah Formation consists mainly of coralline – miliolidae limestone). However, in the other sections; like Miraly, Sai Waii and Shalaih, the formation overlies the Middle Oligocene Bajwan Formation. In Shalaih section, the contact between Bajwan and Euphrates formations is represented by a thin bed or lamella of Anhydrite; about 10 cm thick. For instance in Shalaih section (Figs.7 and 10b), locally this anhydrite bed is missing and Bajwan Formation underlies directly the Euphrates Formation.





**Fig.7: The Bajwan, Euphrates, Dhiban, Jeribe and Fatha formations, Shalaih Section, Ashdagh anticline**



**Fig.8: a) Lateral skololithos trace fossil, b) Vertical skololithos trace fossil, c) Shell fragments, d) Trough cross bedding, within the Euphrates Formation**



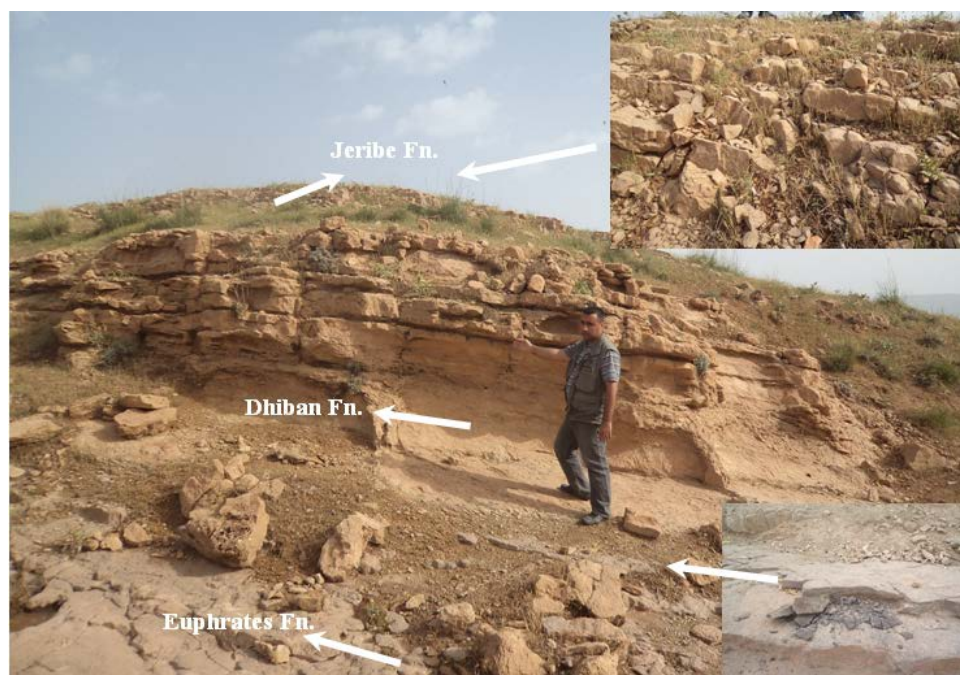


Fig.9: Euphrates, Dhiban and Jeribe formations, near Hazar Kani village, Ashdagh anticline

Bellen *et al.* (1959) stated that in some areas, a thin anhydrite occurs between the Euphrates Formation and the underlying offshore Oligocene rocks. They also thought that, in Iraq, this thin anhydrite does not seem to have a regular distribution.

Prazak (1974) in Jassim and Goff (2006) reported that the Euphrates Formation usually unconformably overlies the Oligocene and Eocene formations. In the type locality, the basal beds of the formation comprise conglomerates and residual clays, which infill uneven surfaces at the top of the Oligocene Anah Formation. Al-Omari and Sadek (1977) in their study of Kirkuk section of the Euphrates Formation considered that the conglomerate beds belong to Baba and Bajwan formations (Oligocene). This is similar to what is observed from Shalaih section, but not in Hazar Kani section. Al-Hashimi and Amer (1985) concluded that the base of the Euphrates Formation reflects typical organic (coral) reef facies followed by restricted environment (back-reef facies).

The common fossils content of the Euphrates Formation are reported from Bellen *et al.* (1959), Brun (1971), Ctyrocky and Karim (1971) (in Jassim and Goff, 2006), Buday (1980), Al-Jubouri *et al.* (2006), Al-Ghreri *et al.* (2010) and Seyrafian *et al.* (2011) are: *Peneroplis evolutus* Henson, *Peneroplis farsensis* Henson, *Archias* sp., *Robulus* sp., *Quinquelculina aknariana* D'Orbigny, *Triloculina* sp., *Ostracodes*, *Hydrobia* sp., *Macoma* sp., *Nodosaria* sp., *Sigmoilina* sp., *Miogypsina globulina*, *Borelis melo melo*, rotaliids, *Dentritina* sp., *Cibicides* with macro fauna; Gastropods and Pelecypods. Many of the above mentioned fossils are detected in the studied area. Figure (11) shows the fossil contents; like the index fossil *Borelis melo melo* (Fig.11-6), *Archias hensoni*, *Praerhapydionina delicata*, *Meandropsina anahensis*, *Heterillina hensoni* and *Austrotrillina howchini*.

Mukhopadhyay *et al.* (1996) concluded that the Euphrates Formation was deposited under shallow marine reefal and lagoonal conditions, terrigenous clastic admixture occurs where the sediments approach the shoreline towards the Stable Shelf.

The thickness of Euphrates Formation reaches to 9 m in the Hazar Kani section, but in other sections, it is only 3 m.

Epoch	Age.	Fn.	Thick.	Lithology symbols	Lithology description
Miocene	Middle	Fatha Fn.	~ 50m		Fossiliferous limestone. Alternation of red claystone and gypsum beds.
		Jerbe Fn.	2m		Gray to olive highly jointed and fractured limestone, partially dolomitized and marly.
	Early	Dhiban Fn.	2m		Whitish chalky limestone. Gypsum-Anhydrite beds, sometimes inclusions of sand size grain fill the pores.
		Euphrates Fn.	20 cm		Medium of bituminous-shaly limestone. Thin bedded of red Algal limestone.
			3m		Pale thick bed highly jointed brecciated recrystallized limestone contains shell fragment.
Oligocene	Late	Anah Fn.	1.5m		White thick bedded, highly jointed-fractured coralline limestone (solitary and colony coral).
	Middle	Bajwan Fn.	8m		Milky to white very thick bedded, highly jointed dolomitized fossiliferous (Miliolidae) limestone.
	Unconformity		5m		Polygenetic greenish marly glauconitic cherty beds of breccia and conglomerate.

	Unconformity		Brecciated		Evaporite		Claystone
	Fossiliferous		Trace fossil		Biturren		Dolomitized limestone
	Conglomerate		Coral		Chert		Limestone
	Marl		Paleosoil				

Fig.10a: Lithostratigraphic column of Hazar Kani village, Ashdagh anticline

Epoch	Age	Fn.	Thick.	Lithology symbols	Lithology description
Miocene	Middle	Fatha Fn.	> 50m		Fossiliferous limestone. Alternation of red claystone and gypsum beds.
		Jerbe Fn.	2m		Gray to olive highly jointed and fractured limestone, partially dolomitized and marly.
	Early	Dhiban Fn.	2m		Whitish chalky limestone. Gypsum-Anhydrite beds, sometimes inclusions of sand size grain fill the pores.
		Euphrates Fn.	3m		Thin bedded of red Algal limestone. Pale thick bed highly jointed brecciated recrystallized limestone contains shell fragment.
Oligocene	Middle		10 cm		Thin bed or lamella of anhydrite.
		Bajwan Fn.	18m		Milky to white very thick bedded, highly jointed dolomitized fossiliferous (Miliolidae) limestone.
		Baba Fn.	1m		Dense coralline – Lepidocyclinidae limestone
				The bottom is not exposed	

Fig.10b: Lithostratigraphic column of Shalaih village, Ashdagh anticline



Figure 11:

1. Foraminiferal wackestone, (a) *Archias hensoni*, (b) *Praerhapydionina delicata*, lower unit of the Euphrates Formation, Hazar Kani section, Slide no. 1H, 10X.
2. Foraminiferal wackestone, (c) *Meandropsina anahensis*, (d and e) *Peneroplis thomasi*: Breccia rock fragment, lower unit of the Euphrates Formation, Hazar Kani section, Slide no. 2H, 10X.
3. Foraminiferal wackestone, (f) *Heterillina hensoni*, (g) fossiliferous limestone fragments, the Euphrates Formation, brecciated rock fragments, lower unit of the Euphrates Formation, Hazar Kani section, Slide no. 2H, 10X.
4. Foraminiferal wackestone, (h) *Austrotrillina howchini*, Breccia, rock fragments, lower unit of the Euphrates Formation, Hazar Kani section, Slide no. 3H, 10X.
5. Foraminiferal wackestone, (i) *Mendropsina anahensis* with *miliolidae* sp.: Euphrates Formation, Breccia, rock fragments, lower unit of the Euphrates Formation, Hazar Kani section, Slide no. 3H, 10X.
6. Foraminiferal wackestone, (j) *Borelis melo melo*, Breccia, rock fragments, lower unit of the Euphrates Formation, Hazar Kani section, Slide no. 4H, 10X.
7. Pellitoidal bioclastic grainstone, (k) Miliolids, (l) *Lithothamnium* sp., (m) *foraminifera* spp., upper unit of the Euphrates Formation, Shalaih section, Slide no. 5H, 20X.
8. Pellitoidal bioclastic grainstone, (n) *Spirolina austriaca*, (o) *foraminifera* sp., upper unit of the Euphrates Formation, Shalaih section, Slide no. 6H, 20X.

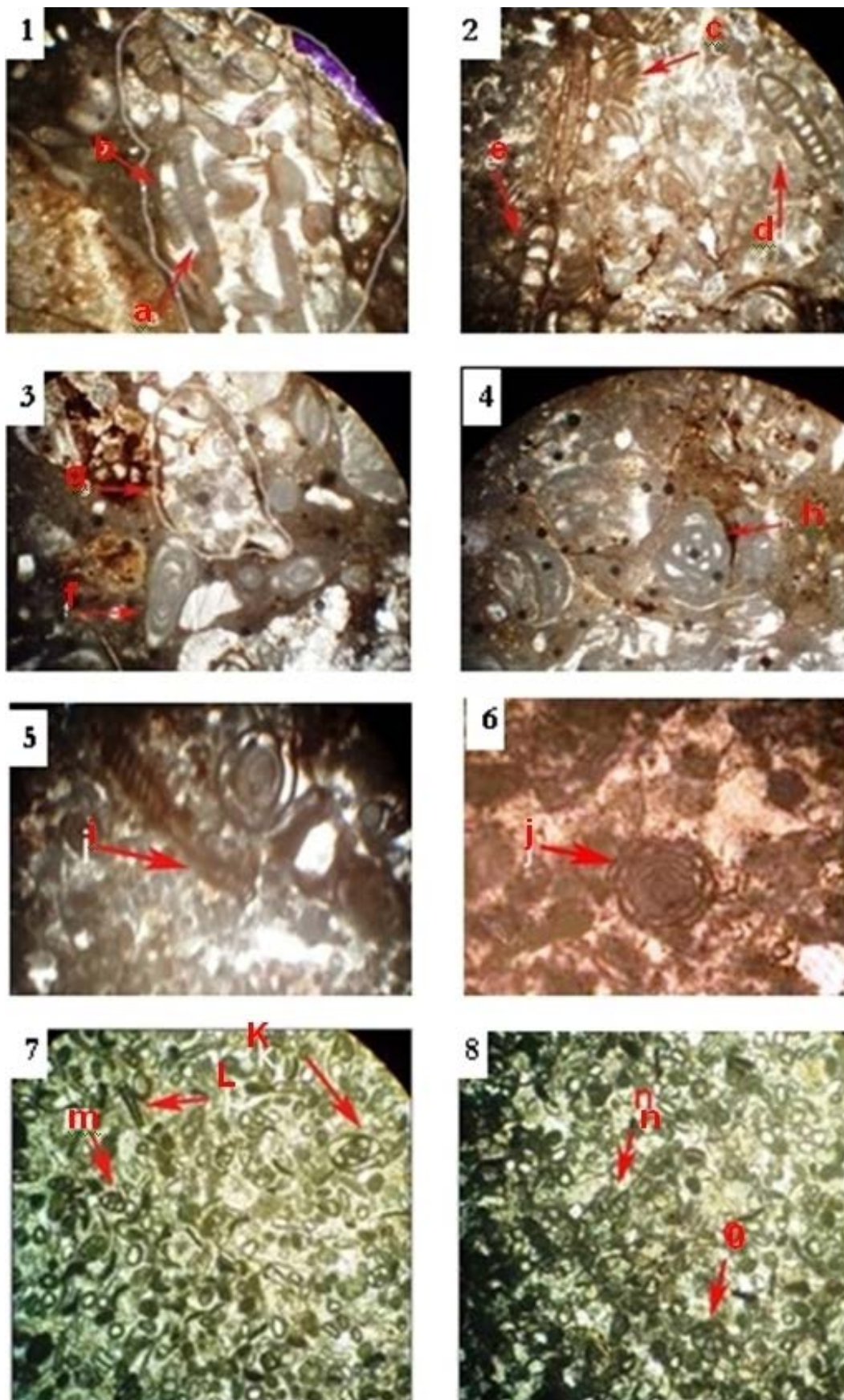


Fig.11: Recognized fossils in the studied area

## **DHIBAN FORMATION**

In Ashdagh anticline, the Dhiban Formation is found above thin beds of bituminous shaley limestone of the Euphrates Formation. It is described as 2 m thick of whitish yellow to pale muddy evaporitic beds (gypsum and anhydrite) and known as Dhiban Formation (Figs.5, 8 and 9), locally, the beds become porous-vuggy due to dissolution.

The presence of muddy materials has changed the white color of gypsum – anhydrite face to pale yellow, locally nodules of yellow native sulfur can be observed. Towards the upper part, the evaporite beds change to chemical limestone (evaporitic – chalky limestone) and intercede with each other. Partially, the pores of the dissolved evaporites are filled with clastic grains of sand and silt. But, a different description of Dhiban Formation is reported by Al-Jubouri and Al-Dabbagh (1980) in their study of Sinjar area. They mentioned that the Dhiban Formation is mainly composed of gypsum. No fossils have been detected within the lithology of the Dhiban Formation.

In the studied sections, the lower part of the Dhiban Formation overlies directly the Euphrates Formation and the contact is unconformable. The upper contact is also unconformable; it changes from chalky limestone to marly limestone of the Jeribe Formation (Figs.5, 7 and 9). However, Bellen *et al.* (1959) suggested that the Dhiban Formation overlies the Serikagni Formation, which interfingers with the Euphrates Formation and is overlain by Jeribe Formation. Therefore, its age has been established as Early Miocene. The Serikagni Formation is not reported in Ashdagh anticline; and the Jeribe Formation overlies Dhiban Formation directly (it is considered as unconformity).

Al-Jubouri *et al.* (2009) and Salih *et al.* (2012) cited to salt bearing formations in Iraq; they recorded bedded salt deposits from the Early and Middle Miocene Dhiban and Fatha formations. The salt rock beds do not appear in the studied area, but from Mamlaha anticline; 15 Km west of Ashdagh anticline, they exist in subsurface and are used locally.

## **JERIBE FORMATION**

In the studied area, the Jeribe Formation consists of grey to white, medium to thickly bedded, dolomitized, highly jointed (three-multiple joint sets) of marly limestone. Those multiple joint sets caused these marly limestone beds to be weak, friable and crumbled. The bed lies directly on the chalky limestone of the Dhiban Formation (Figs.5 and 9). The thickness of these strata reaches 2 m and the contact between them is unconformable.

Fossils in the Jeribe Formation are locally abundant; the most conspicuous fossil in the formation is *Borelis melo curdica*. According to Karim and Prazak (1973) (oral communication in Jassim and Goff, 2006) and Al-Hashimi and Amer (1985) *Orbulina* occurs in the formation too. Besides, *Elphidium* sp., *Nonion* sp., *Rotalia beccarii*, *Dendritina* cf. *rangi*, *Peneroplis farisensis*, *Meandropsina anahensis*, fragments of gastropods, pelecypods, echinoids and Lithophyllid algae are reported too. Some of the mentioned fossils are detected in the studied area (Fig.12), like *Borelis melo curdica*, *Dendritina rangi*, *Ophthamidium*, *Rotalia beccarii*, *Algae* sp. (*Ethelia alba*), fragments of gastropods, pelecypods and echinoids.

The lower contact of the Jeribe Formation is unconformable with the underlying Dhiban Formation; the lower contact of the formation in the type area is unconformable, where it overlies the Serikagni Formation. Other areas, conglomeratic beds are present at the bottom of the unit indicating the transgressive character and possible unconformable nature.



In the studied area, the upper contact of the Jeribe Formation is unconformable with the overlying Fatha Formation (Fig.7). According to Bellen *et al.* (1959) and to the above suggested relations between Jeribe and Lower Fars (Fatha) Formations, a conformable contact should be postulated.

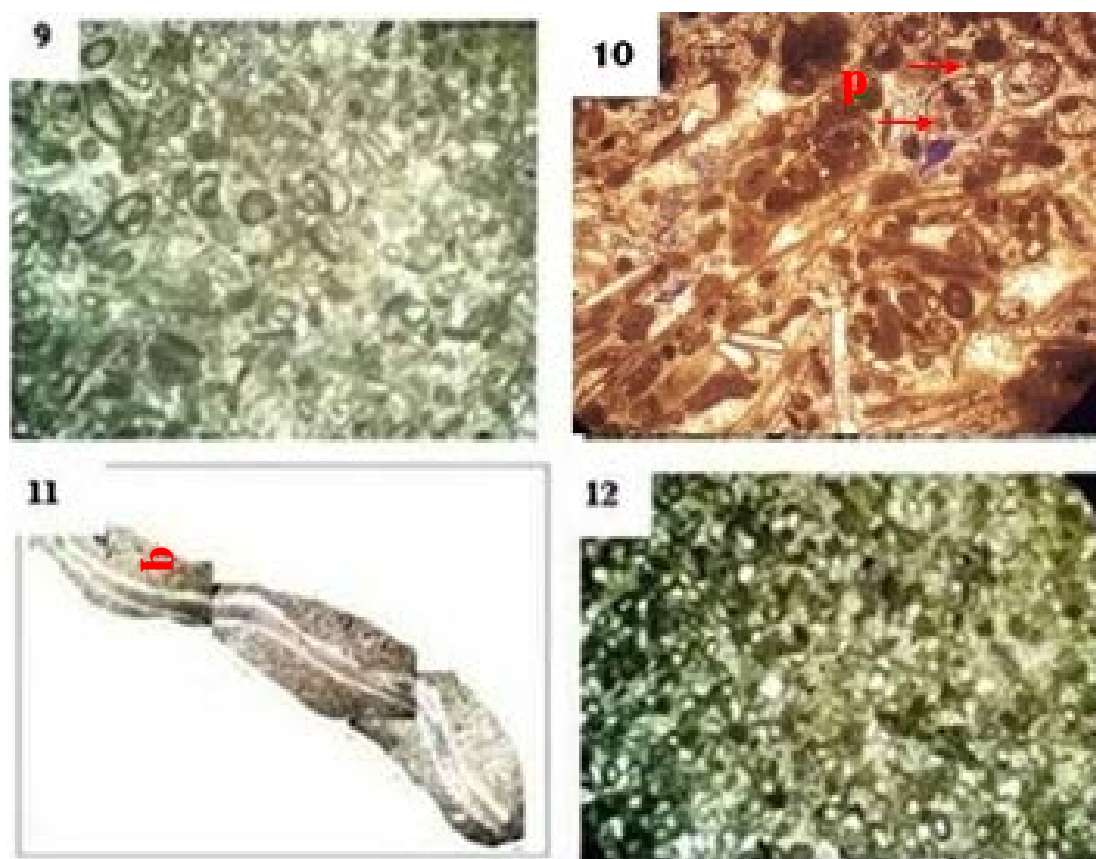
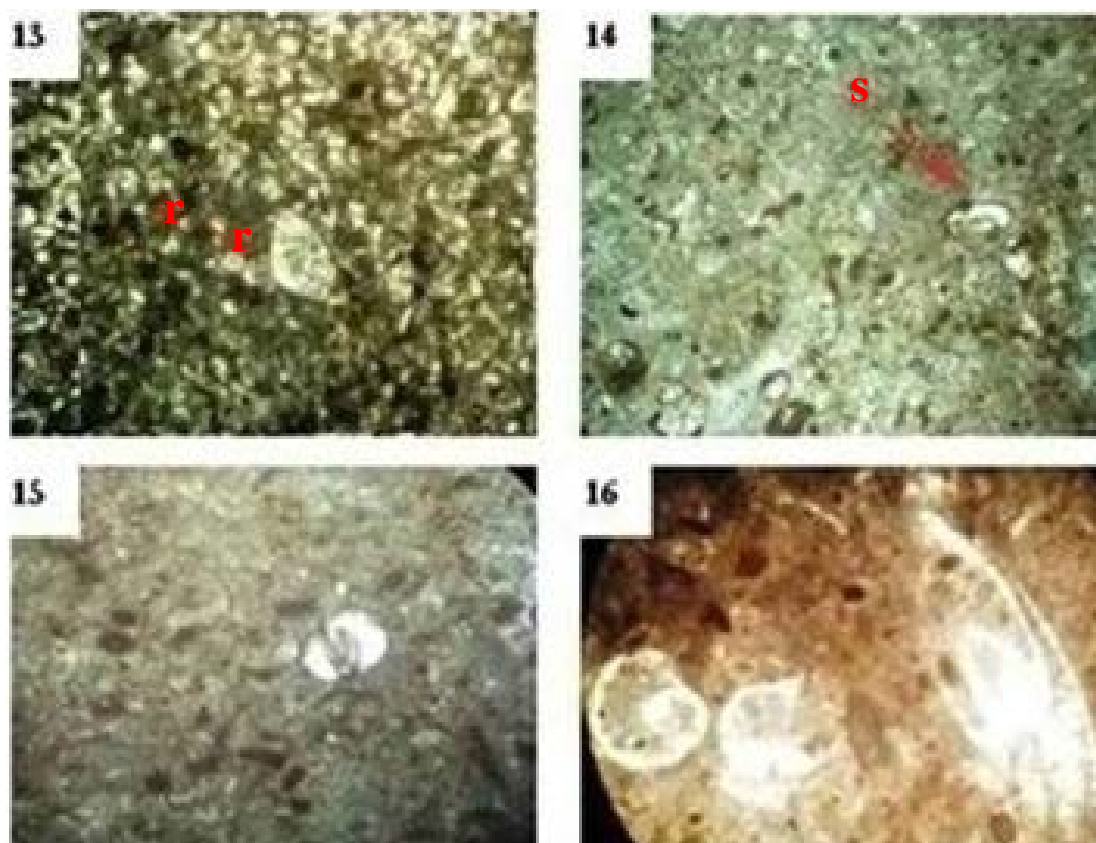


Fig.12: Recognized fossils in the studied area

9. Pellitoidal bioclastic grainstone, *Dentritina rangi*, and *Ophtalmidium*, upper unit of the Euphrates Formation, Shalaih section, Slide no. 7H, 20X.
10. Pellitoidal – Bioclastic grainstone, (p) *Pelecypodes* spp., the Jeribe Formation, Zinana section, Slide no. 8H, 20X.
11. Dolomitized foraminiferal wackestone, (q) *Algae: Ethelia alba* (PFENDER), the Jeribe Formation, Hazar Kani section, Slide no. 9JH, 20X.
12. Dolomitized foraminiferal wackestone, Recrystallized and dolomitic Pellitoidal (pseudoolitic), the Jeribe Formation, Darzila section, Slide no. 1S, 20X.



Cont. Fig.12:

13. Dolomitized foraminiferal wackestone, (r) *Rotalia beccarii*, the Jeribe Formation, Darzila section, Slide no. 3D, 20X.
14. Dolomitized foraminiferal wackestone, (s) *Dentritina rangi*, the Jeribe Formation, Hazar Kani section, Slide no. 3H, 20X.
15. Dolomitized foraminiferal wackestone, Unidentified sp, the Jeribe Formation, Miraly section, Slide no. 3M, 20X.
16. Dolomitized foraminiferal wackestone, Pelecypods and Echinoids: the Jeribe Formation, Hazar Kani section, Slide no. 10JH, 10X.

## DISCUSSION

The distinction between the Euphrates and Jeribe formations is a matter of debate. But, based on the presence of index fossil, *Borelis melo melo*, which is an index fossil of the former formation and *Borelis melo curdica* for the latter, they can be distinguished, but not in the field. Locally, when there is no Dhiban anhydrite, the two formations are combined and called Euphrates – Jeribe formations. But, in the studied sections, it is clear that they are two different rock units; since they are separated by Dhiban Formation (Fig.13).

Another difference is that the Jeribe Formation is fairly hard, partially marly, frequently jointed and fractured, while the Euphrates Formation consists of two distinguishable units, which are sedimentary breccia and the thick bed of brecciated limestone.

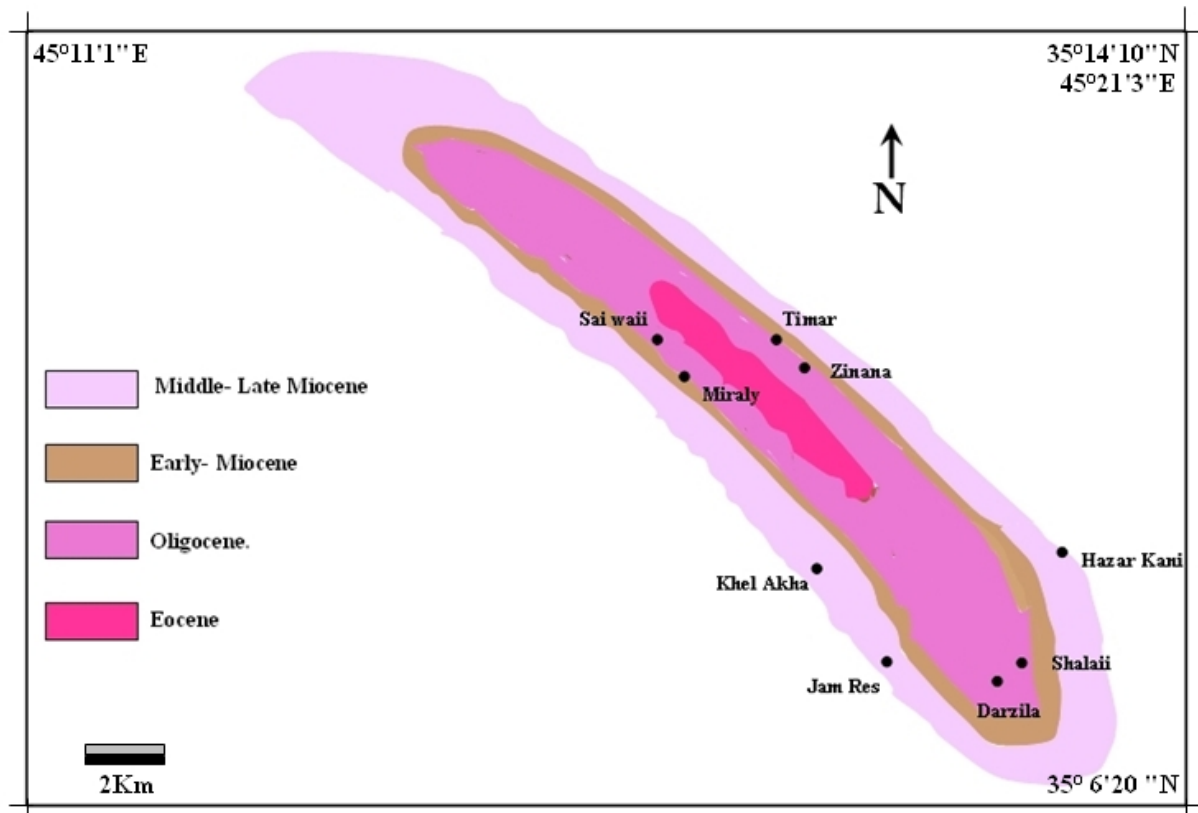


Fig.13: Geologic map of Ashdagh anticline (after Kharajiany, 2008);  
the brown color represents Early – Middle Miocene rock units  
(Euphrates, Dhiban and Jeribe formations)

## CONCLUSIONS

From this study, the following points are concluded:

- The lithology of the exposed rocks in Ashdagh anticline is mostly Oligocene, but the limbs consist of Early and Middle Miocene rock units, which belong to the Euphrates, Dhiban and Jeribe formations; from oldest to the youngest, respectively.
- Stratigraphically, the Euphrates Formation comprises two main units; the lower unit, is 6 m thick; sedimentary breccia bed derived from erosion of the Anah and Bajwan formations of Oligocene age, while the upper unit is 3 m thick, brecciated limestone with discrete algal limestone on the upper part.
- The Dhiban Formation consists of 2 m thick; evaporite beds (gypsum and anhydrite) with chalky limestone on the upper part.
- The Jeribe Formation comprises of 2 m thick; grey to white, highly jointed and fractured limestone, which is slightly marly.
- The faunal contents show different ages for the formations. *Archias hensoni*, *Praerhapydionina delicata*, *Meandropsina anahensis*, *Heterillina hensoni*, *Austrotrillina howchini* and *Pelecypodes* spp. are the fossil contents of the Euphrates Formation. *Dendritina rangi*, *Ophthalmidium*, *Rotalia beccarii*, *Algae* sp. (*Ethelia alba*), fragments of gastropods, pelecypods and echinoids are the fossil contents of the Jeribe Formation, while no obvious fossils were detected from the Dhiban Formation.



- The Euphrates and Jeribe formations are separated by an evaporitic facies of the Dhiban Formation. The contact between the three formations is unconformable; and the contact between Euphrates and Anah is erosional.
- In most of the studied sections, the Euphrates Formation overlies Bajwan Formation; locally they are separated by a thin bed of anhydrite, but only in Hazar Kani and Darzila sections, the formation overlies directly the Anah Formation.

## **RECOMMENDATION**

The Three mentioned formations may have extensions to the surrounding areas, though detailed study is required to reconstruct the paleobasin of Early – Middle Miocene age.

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