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Oligocene and Miocene Rock Beds in Mamlaha anticline, Chamchamal town, Sulaimani city- Kurdistan region/ Iraq.

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Abstract

Previously, the Oligocene rock beds in the Mamlaha anticline have neither mentioned nor proved. There are some selected sections that detected during field surveys but did not verified weather belong to Oligocene- Miocene ages or not. Through this research, it is proved that they are composed of Oligocene and Miocene rock strata. They are well-known as excellent rock reservoirs for hydrocarbon accumulation in Kurdistan region and Iraq as a whole.

Field survey and stratigraphic study with microfacies analysis showed that nearly 37 meter of the rock units from Mamlaha anticline (Mamlaha, Khwelin and Pungala sections) are representing these formations; Bajwan Formation (Middle Oligocene), Anah and Ibrahim formations (Late Oligocene) ages, Serikagni, Euphrates and Dhiban formations (Early Miocene) and Jeribe Formation (Middle Miocene) ages respectively.

The contact between Bajwan and Anah is unconformable; the Lower contact of Bajwan Formation is not exposed in each of the section. Ibrahim Formation however not exposed as well beds of marly limestone; it shows as pocket of marly limestone, but it sandwiched between Bajwan and Anah formations and shows no clear boundary.

The upper contact of Anah Formation is separated from Euphrates Formation by 2 meters of green marl which indicates abrupt change in the lithology. The upper contact of Euphrates shows unconformity, while Dhiban Formation is unconformably underneath the marly sandy bituminous limestone of Jeribe Formation; Jeribe Formation is also unconformably lies beneath the claystone of Fatha Formation.

Keywords: *Archias kirkukensis, Austrotrilina howchini*,, Mamlaha, Oligocene- Miocene, Kirkuk Group Formations, Chamchamal, Kurdistan Region.

I. Introduction

The names Mamlaha and Khwelin are meaning salty area; the salt quarries of Khwelin village are well known in Kurdistan. It considered as an economic source of salt production. From its underground, salty water pumps up, collects on the surface inside artificial pools, evaporates by sun exposure and collects then it markets as a commodity.

The stratigraphy of Mamlaha anticline is consisting of Middle- Upper Oligocene and Early- Middle Miocene rock units which are not proved formally nor plotted in the geological column of Iraq (figure 1). Earlier, only Fatha Formation is recorded which belongs to Middle- Late Miocene age.

Baba sheckh (2000) studied Hydrogeochemistry of caves and springs in Sangaw- Chamchamal area which included Mamlaha section, he also expected the existence of Oligocene rock strata in the area. The study of Kharajiany (2008) from Ashdagh anticline; nearby Mamlaha anticline (Ashdagh anticline is far about 30kms toward east of the Mamlaha); for the first time he described the Oligocene sequence as these formations: Shurau and Sheikh Alas of Lower Oligocene, Baba, Bajwan and Tarjil that return to Middle Oligocene, and Anah of Upper Oligocene times respectively.

Khanqa et al (2009) recorded Upper Oligocene- Lower Miocene sediments from Basara gorge of Sulaimani city- High Folded Zone but the formations not specified exactly.

Ameen (2011) studied the Karsitification processes of the gypsum beds in Sangaw sinkholes (from which Ashdagh mountain also included)

Ghafur (2012) studied the Sedimentology and Reservoir Characteristics of the Oligocene-Early Miocene Carbonates (Kirkuk group) of Southern Kurdistan. She defined the studied beds in Ashdagh and Bamo anticlines as Bajwan and Anah Formations and those in Sagrma as Anah Formation; whereas she identified Sheikh Alas Formation in Belula Gorge, and Azqand with Ibrahim formations in Sharwal Dra anticline.

Karim et al (2012) studied facies analysis of the Oligocene succession on the Sharwaldir anticline; they recorded Baba and Anah formations of Middle and Late Oligocene age.

Kharajiany (2014) also described the Miocene rock units of Ashdagh mountain as: Euphrates and Dhiban (Lower Miocene), Jeribe and Fatha Formations (Middle Miocene) respectively.

Al Qayim *et al*, (2014) recorded Oligocene and Miocene rock units (Bajwan, Anah, Euphrates and Jeribe formations) from Gwlan mountain- Darbandikhan tow from High Folded Zone; the distance between Mamlaha and Gwlan mountains is about 47km.

Through this research, it proved that the formations of Mamlaha anticline are consisting of Bajwan which dates back to Middle Oligocene, Ibrahim and Anah assessed to Late Oligocene ages, Serikagni, Euphrates and Dhiban date back to Early Miocene while Jeribe return to Middle Miocene ages. For the first time Jeribe and Serikagni formations were recorded from outcrops of the anticline and its surroundings.

II. Geological setting

Mamlaha anticline locates between southwest of Sulaimani city and the southeast of Kirkuk city (27 km southeast of Chamchamal town). Tectonically, Mamlaha anticline located within the Unstable Shelf, Low Folded Zone, Foot Hill Zone, Erbil-Chamchamal Subzone (figure 2). This zone characterized by low Tectonic effects on the lithology of the anticline more than those of High Folded Zone.

From structure looking, Mamlaha anticline is one of the three enechelon anticlines (Ashdagh- Qara Wais- Mamlaha). It consists of a small anticline rather than both. As it exists within the Low Folded Zone, the limbs have gentle slopes and trends NW-SE like its surrounding anticlines. El-Makhr and Abd (2011) concluded that the axes of Fatha and Jeribe formations in Hamreen anticline-

Central of Iraq are oriented in the direction NW-SE and no major twisting was observed Hamreen anticline is next to Mamlaha from south).

III. Methods

The selected locations for sampling comprise Pungala, Mamlaha and Khwelin sections as marked by red squares on the figure (3); the selected areas locate at the western limb of Mamlaha anticline, from which the rock beds well exposed.

The reason why these three spots are selected is because the valleys are deep and make the lithology obvious especially Pungala valley (location No.1). Six field trips have done to demonstrate the real vision about the outcrops of the supposed lithology, construct stratigraphic column for the studied area. More than 55 hand specimen rock samples have collected from the lithologies of the outcrops and studied by observation, 50 thin sections prepared to be exanimate and study under polarized and binocular stereoscope microscopes to demonstrate the microfacies and fossil contents.

Based on the field trips, lithologic description and thickness measurement, a stratigraphic column is made for the sections. The three sections from which lithologies studied are discussed below and illustrated in figure (3):

● Pungala Section:

Pungala section locates at 1.1km of the west side of Pungala village (figure 1), it locates at cross coordinations N: 35° 19' 58" and E: 45° 03 '09". It is the deepest valley that rock strata of the Oligocene and Miocene age appear. It is the suitable place for taking rock samples because the lithologies are well exposed and showed the relatively reasonable thickness of the rock units rather than other sections as illustrated in the figure (4B).

● Mamlaha Section:

The location lies within caves of Mamlaha village which far from this village by 1.85 km to the northeastern direction, it represented by coordinations N: 35° 21 '30" and E: 45°01' 26" (figures 1&5). It is also important section like Pungala they because almost have the same lithologies exposing.

● Khwelin Section:

It is available at 1.2km of northern side of Khwelin village with N: 35° 22' 09" E: 45° 00'52" Coordinations. Hence mostly the Lower and Middle Miocene rock beds appeared.

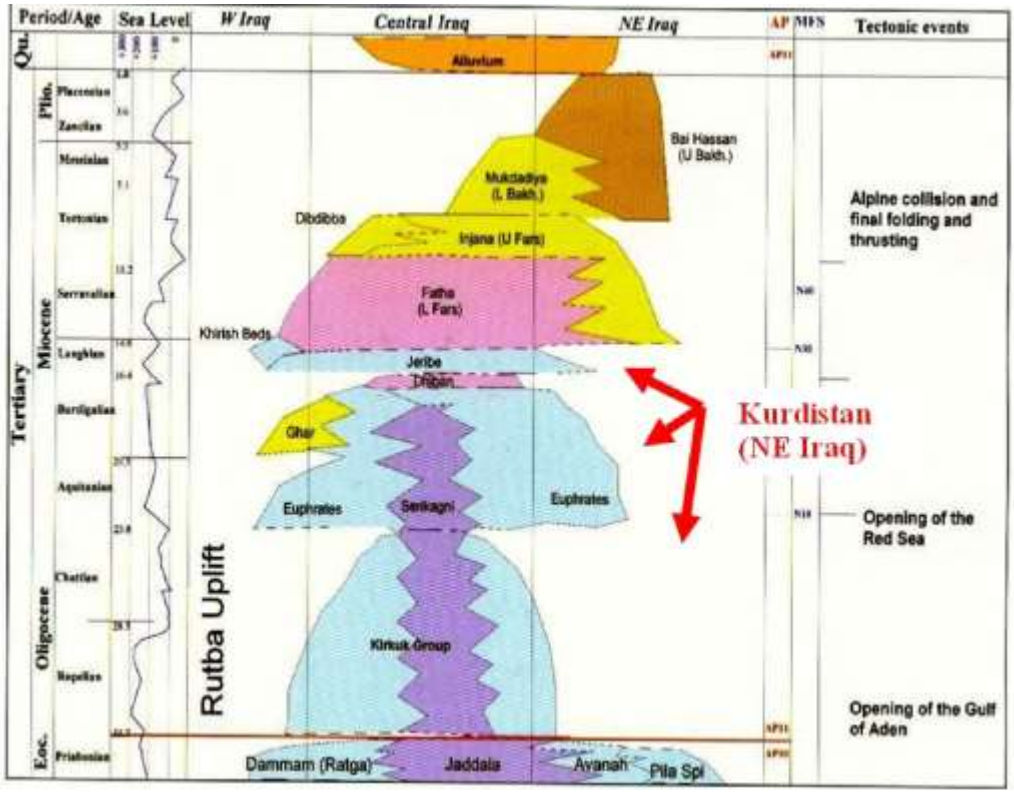

Fig. 1 Time- Stratigraphy relations of Tertiary (after Jassim and Goff, 2006).

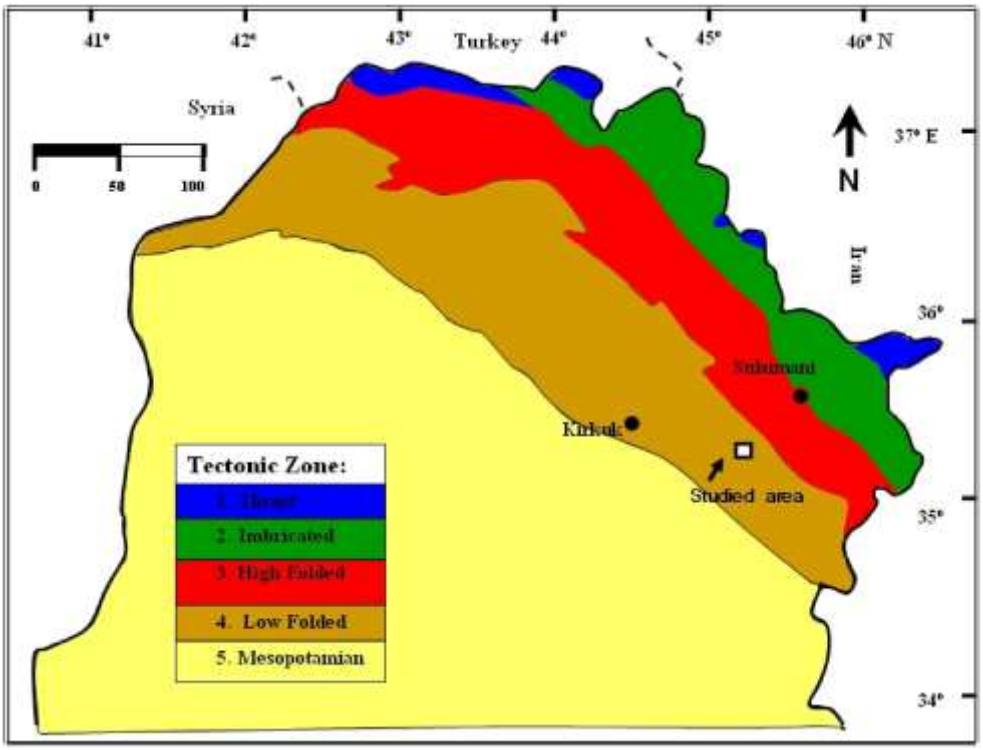

Fig. 2: Tectonic map and geographic location of Mamlaha anticline, after Sissakian *et al* (2000).

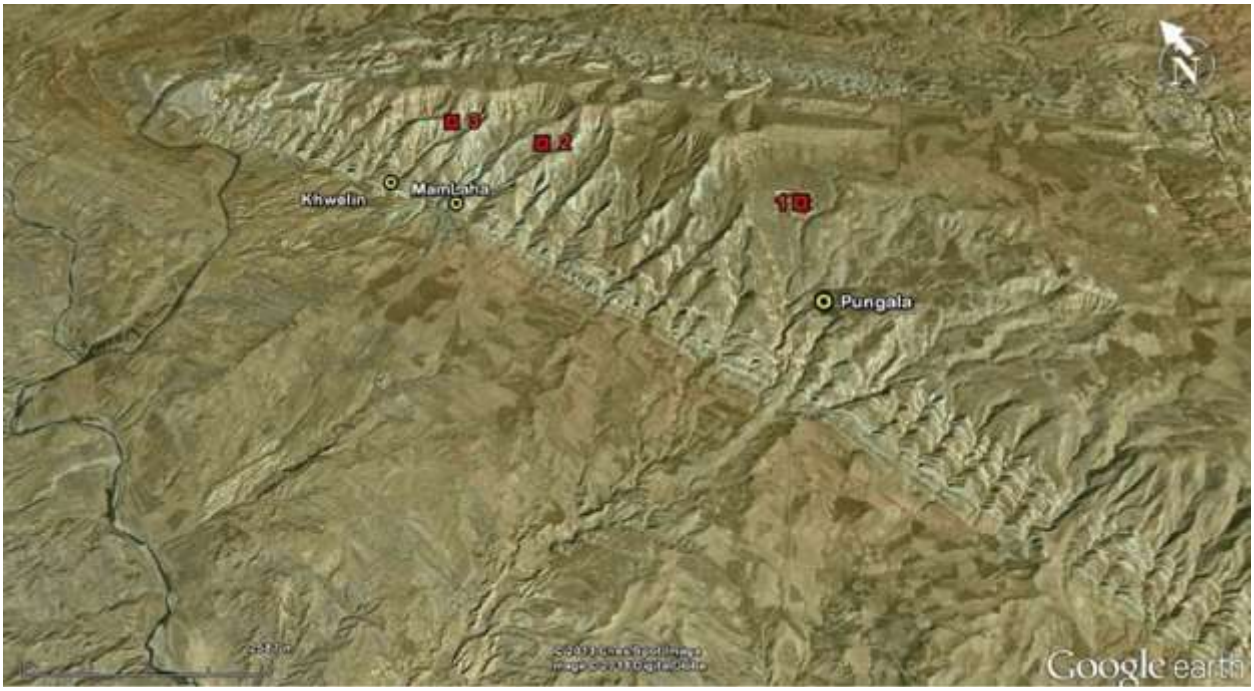

Fig. 3: the satellite image of Mamlaha anticline, (Google earth, tilt 37o, heading 56o, range 2587 m), the yellow circles are representing the locations of the villages and the red squares representing the locations of sampling (1- Pungala, 2- Mamlaha, 3- Khwelin).

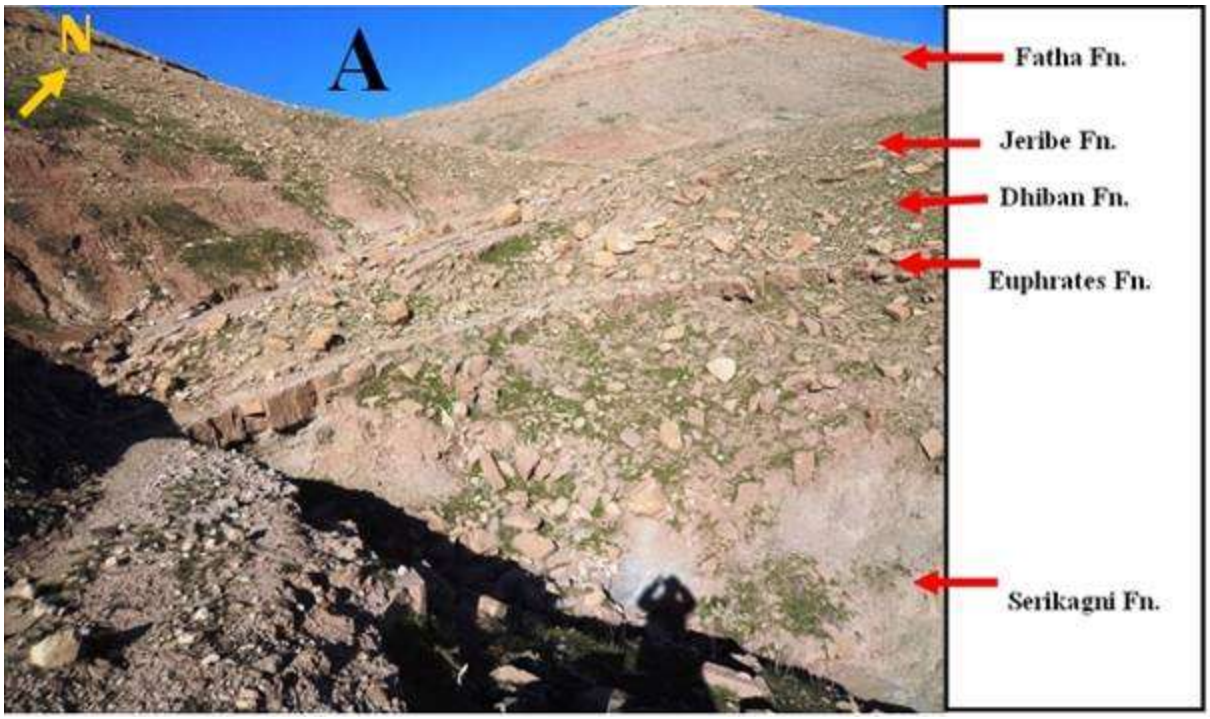

Fig. 4: Lithostratigraphy of Pungala section; it shows Lower, Middle and Upper Miocene rock beds.

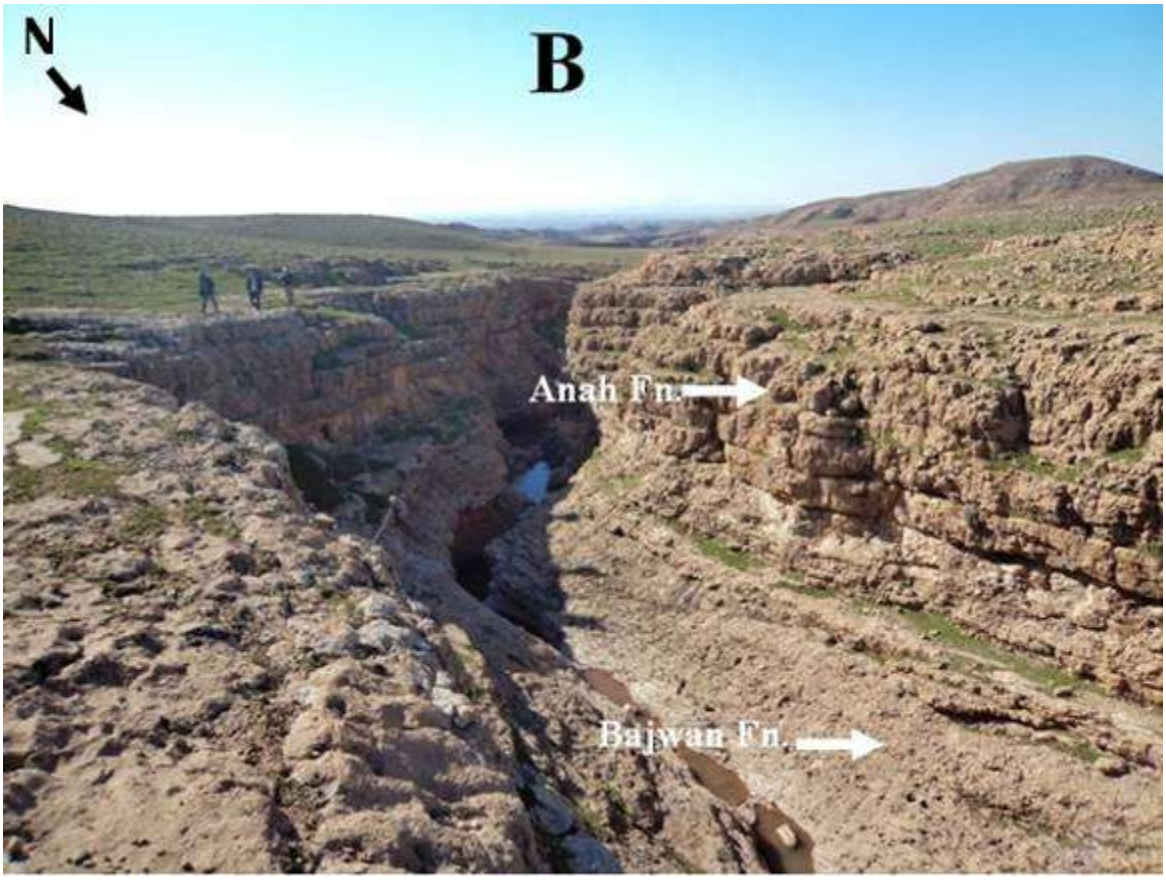

Fig. 5: Lithostratigraphy of Pungala section shows Early-Middle Miocene Rock units.

figure (5): Lithostratigraphy of Mamlaha section; Upper Oligocene to Middle-Upper Miocene rock units.

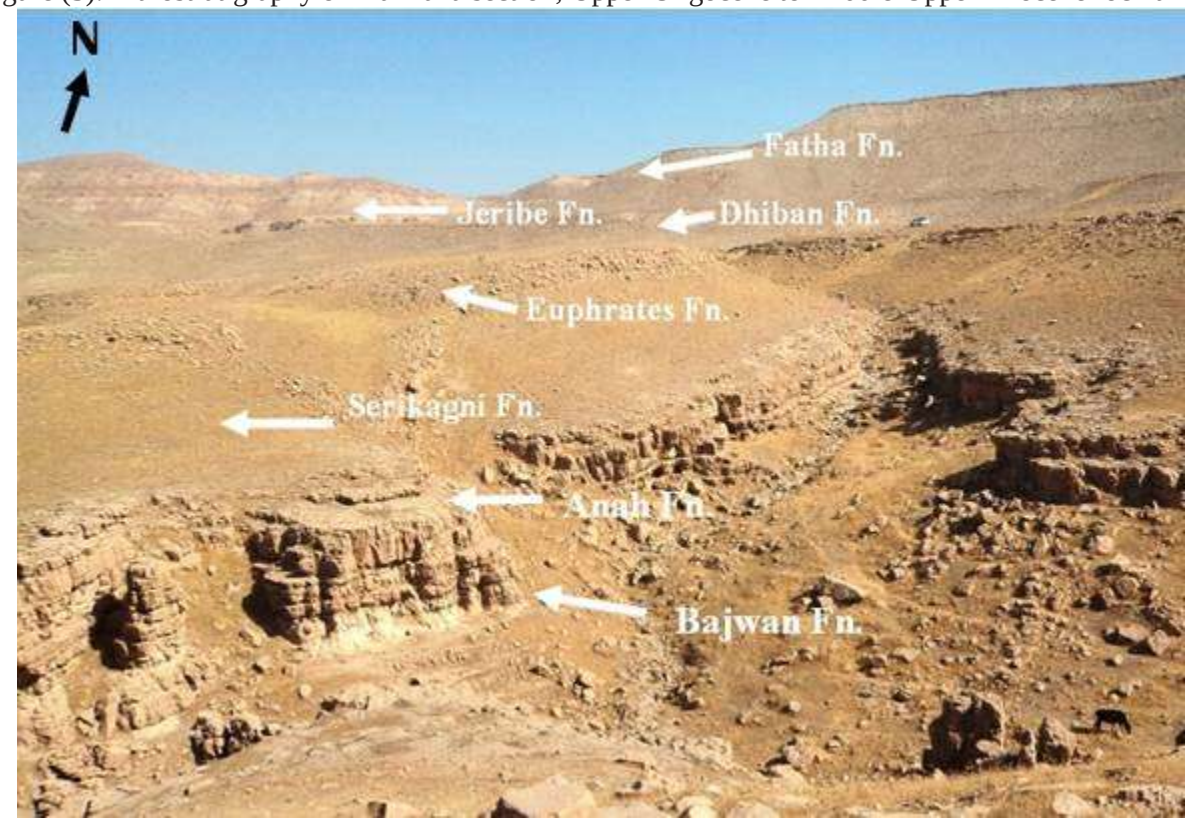

Fig. 6: Lithostratigraphy of Khwelin section; Middle Oligocene to Middle-Upper Miocene rock units.

IV. Discussion

The Oligocene rock units of Iraq also known as Kirkuk Group Formations are first described by Bellen et al, (1959) from Kirkuk oil fields and Qara Chough anticline, they include 9 formations according to their lithologic description and age determination.

The sedimentation cycles spanned nearly 10 million of years (33.7-23.8 MY) as shown in figure (1). They deposited in a platform which represent a reef system; backreef, forereef and open sea basins.

The lithologies of backreef and forereef rocks are mainly limestone (Shurau, Sheikh Alas, Baba, Bajwan, Azqand and Anah formations), but the marly limestone represents the open sea deposits (Palani, Tarjil and Ibrahim formations).

The Lower- Middle Miocene rock units in Iraq are represented by shelf to isolated basin; they determined by Serikagni Formation which consists of marly globigerinal limestone, Euphrates and Dhiban formations of Lower Miocene age, and Jeribe with Fatha formations of Middle Miocene age (The cycles took time about 12.6 million of years (23.8-11.2MY).

Bellen *et al* (1959) explained that Euphrates Formation was deposited under shallow marine, reef and lagoonal conditions, with local coral and Lithophyllid reefs and with intermediately fore reef conditions on the one side, and lagoonal conditions on the other side, and Serikagni Formation considered to be the off-shore facies of the Euphrates limestone.

Dhiban Formation formed in evaporitic-anhydritic development, is distributed in two local basins, separated by a narrow ridge area

of the deposition of chemical limestones. But the overlying Jeribe Formation however was deposited in lagoonal (back reef) and reef environments, the back reef facies are predominant.

These rock beds previously have not determined in Northeastern of Iraq and Kurdistan's stratigraphic columns (figure 1).

Those selected sections neither studied in detail nor surveyed. So mostly this part of stratigraphy column is missed in the geological map of the area and considered as a gap. But through this research, from the deep gorges and valleys of Mamlaha anticline, the existence of so called missing stratigraphic column of the area is determined. So the lithostratigraphy (based on the field study and biostratigraphy (depending on index fossil contents) studies emphasized the existence of the following formations from older to younger are determined as:

A. Bajwan Formation

The lithology of Bajwan Formation includes white to milky very thick Bed highly jointed, fractured, cavernous, recrystallized, fossiliferous (miliolidae) limestone, nearly 25 meters thick. Although the whole bottom is not cropped out, but it should be thicker than 25m, and the Lower contact of the formation is most possible to be Tarjil Formation as recorded from Ashdagh mountain (Kharajiany, 2013).

The Upper contact of Bajwan Formation in Pungala and Mamlaha sections is Anah Formation (figure 4B), the contact is unconformable, and the lithology of latter is coralline limestone.

The Upper contact is characterized by appearance of chert nodule, patch and sometimes as horizon (figure 7a).

Also near the contact between Bajwan and Anah formations, reworked silicified gastropods are observed (figure 7b). Sometimes, the Upper part of Bajwan Formation filled with nodes or pockets of globigerinal marly limestone (figure 9); these pockets represents the sediments of Upper Oligocene time which known as Ibrahim Formation, but it has no real thickness to be considered as a stratified bed.

Based on the index fossils such as *Archaias Kirkukensis, Austrotrillina howchini, Praerhapydionina delicata, and Subterraniphyllum thomasi [(Elliot 1957)]*, the age of Bajwan Formation is correlated to the Middle Oligocene (the age also correlated by Brun, 1971).The aforementioned index fossils with some abundant fossils that recorded from the sections are described as dolomitized pellitoidal milliolidal wackstone- packstone microfacies as shown below.

Fig. 7: a. **chert horizon -Bajwan Fn.**

b. Silicified gastropod- Bajwan Fn.

Note: for all fossil figures, as scale, the circle diameter of the eye piece equals 4 millimeters

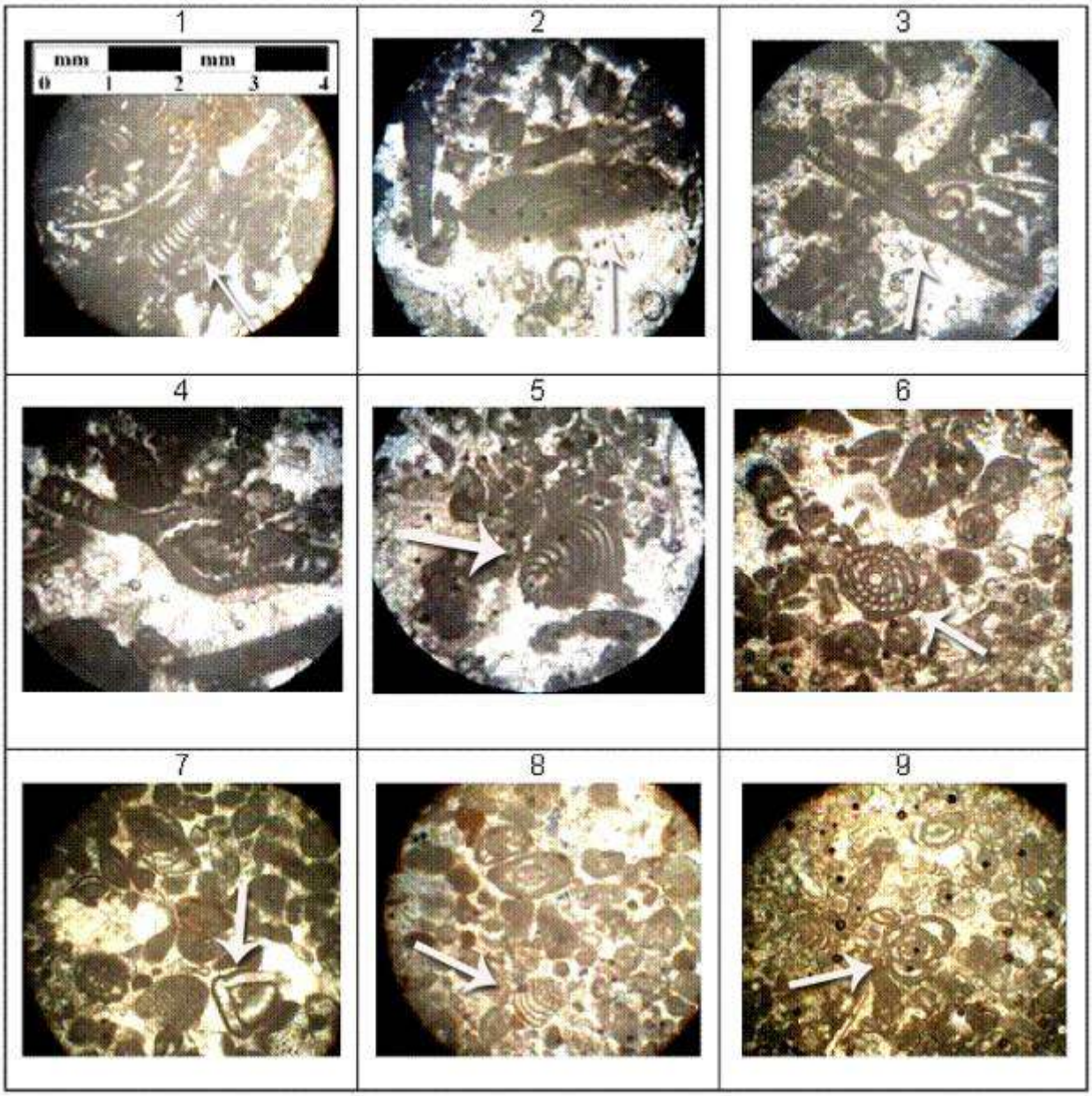

Fig. 8: Dolomitized pellitoidal milliolidal wackstone to packstone, Bajwan Formation, Mamlaha anticline, 1. Subterraniphyllum thomasi. 2. Archaias kirkukensis.3. Peneroplis thomasi. 4. Archaias operculiniformis. 5. Peneroplis evolutus. 6. Archaias operculiniformis. 7. triloculina sp. 8. Lithophyllum sp. 9. Austrotrillina howchini.

B. Ibrahim Formation

Ibrahim Formation does not appear in obvious stratified beds, in little case it appears as discrete beds. Generally, it deposited inside the weathered and cavernous surfaces of Bajwan Formation (it is similar to a reversed vase shape as shown in figure 9).

Generally it consists of hard splinter light green globigerinal dolomitized marly limestone (figure 10). It appears as nodes or

pockets of globigerinal marly limestone (relict aggregate), its thickness about 50-60 centimeters) as shown below in figure (9). These pockets of marly limestone are sandwiched between limestone beds of Bajwan and Anah formations. Chert nodules surround the pockets of these marly limestones. The Lower and Upper contacts of Ibrahim Formation do not precisely appear. Based on the fossil assemblage's contents, Ibrahim Formation is correlated with Late Oligocene age. Most of the fossils are belong to planktonic foraminiferas like *Globigerina spp* and *Globorotalia spp* with high diversity and few benthonic foraminiferas distribution; they also detected by (Al-Hashimi and Amer, 1985).These fossil assemblages attributes to deep sea environment. Some of these foraminiferas are contributed in formation of microfacies globigerinal dolomitized wackestone, and shown below in figure (10).

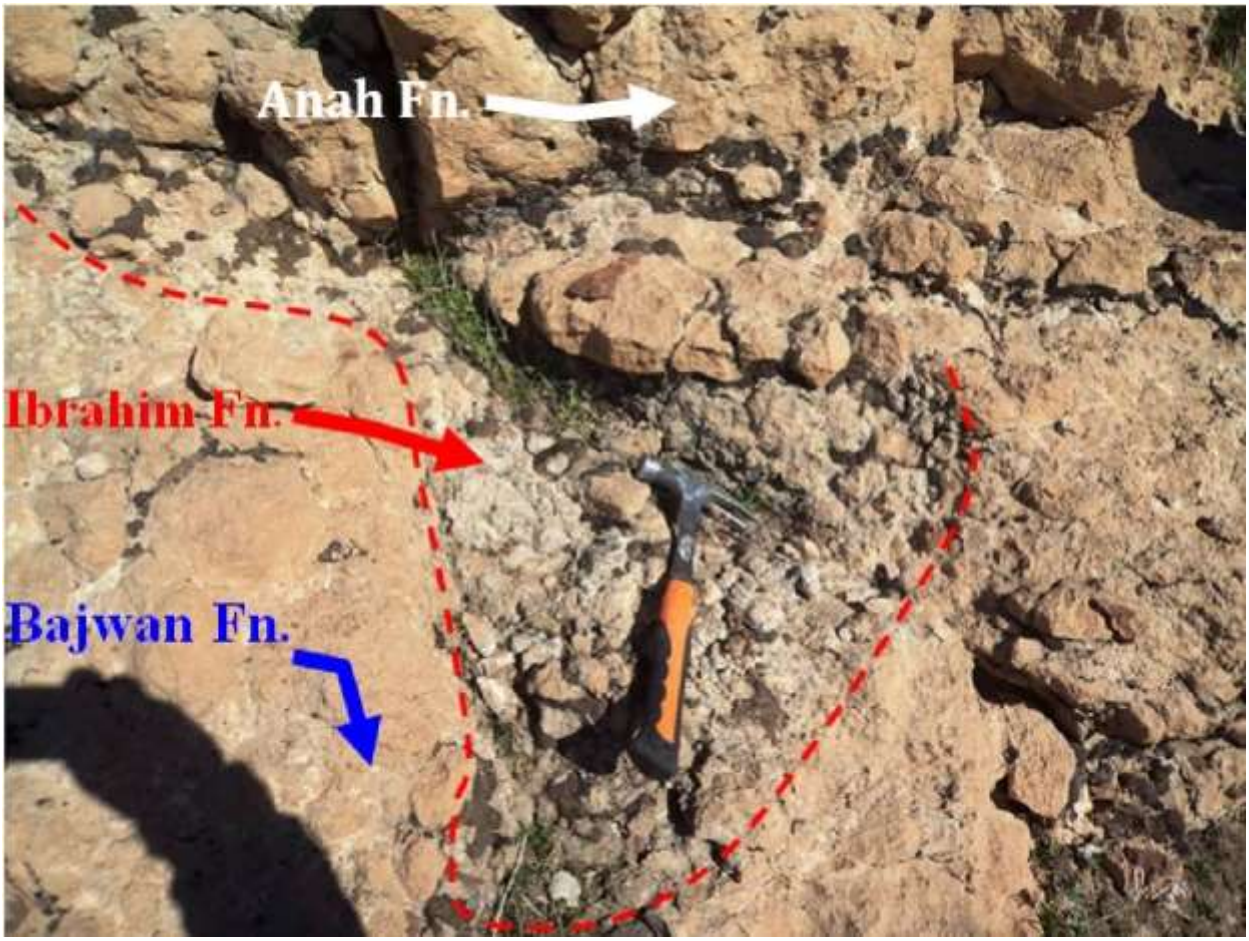

Fig. 9: Ibrahim Formation, the marly limestone beds appear as node or pocket. It located in-between Bajwan Formation (Middle Oligocene) and Anah Formation (Upper Oligocene), Pungala section, Mamlaha anticline.

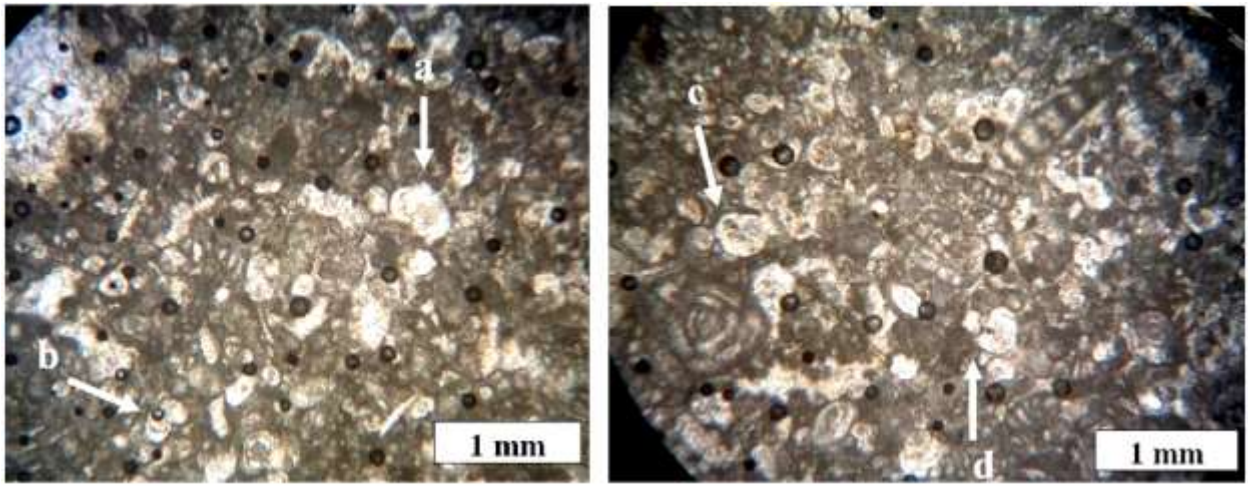

Fig. 10: Globigerinal dolomitized wackestone, Pungala section, Ibrahim Formation, the microfossils includes benthic and large benthonic foraminiferas, a. ***Globorotalia opima.*** b. ***Globigerina angulisutturalis,*** c& d ***Globigerina pareabulloides.***

C. Anah Formation

Anah Formation describes as white sugary to gray very thick bed, massive, hard, detrital brecciated, vuggy- porous recrystallized dolomitized coralline limestone (reefal). The coral species contents are calcareous and mostly solitary (figure11a&b), many of them dissolved and their casts left holes on the surface of the beds (figure 16). The beds have thickness about 7-8 meters (figure 12);

A number of amazing caves originated within these limestone beds. The Lower contact of Anah Formation is unconformable with Bajwan Formation, in some localities where marly limestone of Ibrahim formed in-between, the contact considered to be sharp boundary.

The Upper contact of Anah Formation is sharp and unconformable with
Serikagni Formation from which carbonate beds of limestone changed to chalky marl. Sometimes, from other localities, it is hard to discriminate between Anah and Bajwan formations, but from Mamlaha section (figure 12); the difference is obvious that limestone beds of Anah Formation are mostly coralline and detrital rather than Bajwan beds. Also microscopic examination of fauna contents clarifies the difference between both beds; limestone beds of Anah Formation contain the index fossils of Upper Oligocene age (back reef-lagoon facies) such as *Meandropsina anahensis*, *Meandropsina iranica and Peneroplis farsensis*; they are lack from Middle Oligocene age (Bajwan Formation).

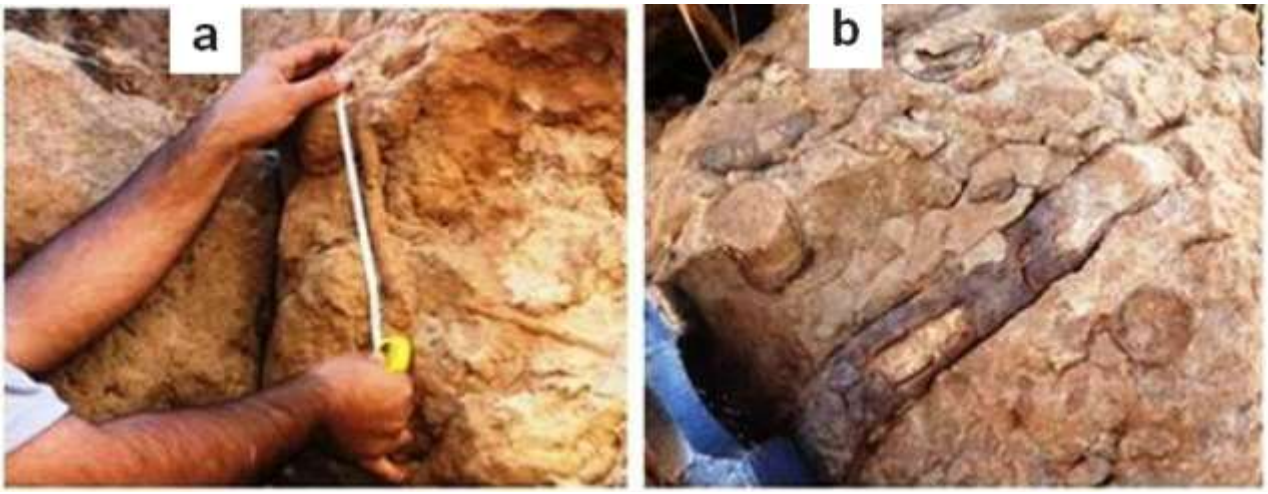

Fig. 11 (a& b): solitary *coral spp* within Anah Formation, Mamlaha anticline.

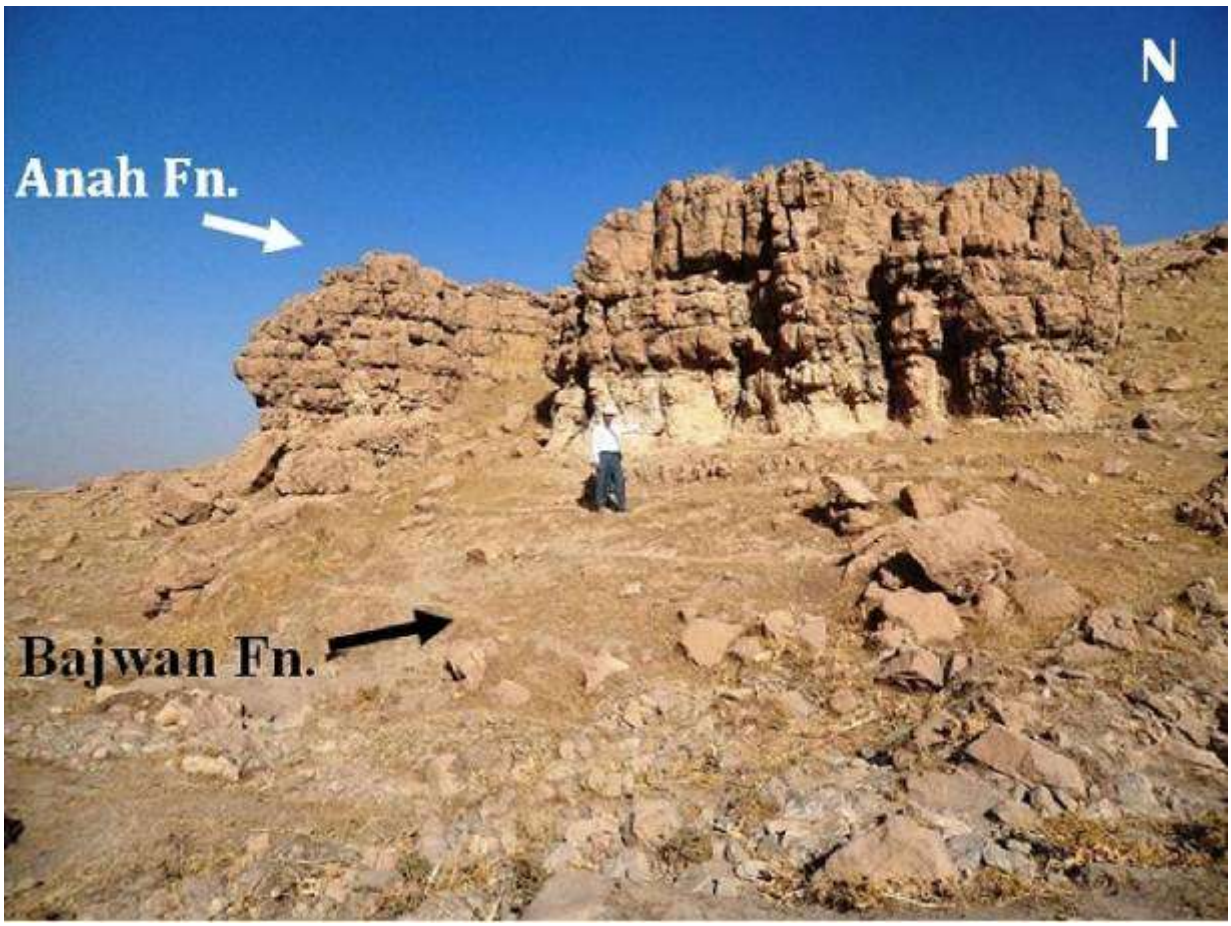

Fig. 12: Bajwan and Anah formations, Mamlaha village, Mamlaha anticline; the distinction between both formations is clear from which the limestone beds of Anah Formation appears as detrital coralline.

Depending on the index fossils like *Austrotrillina howchini, Praerhapydionina delicata, Meandropsina anahensis and Lithophyllum sp, Archaias Kirkukensis, Peneroplis farsensis*; the age of Anah Formation is considered to be Late Oligocene.

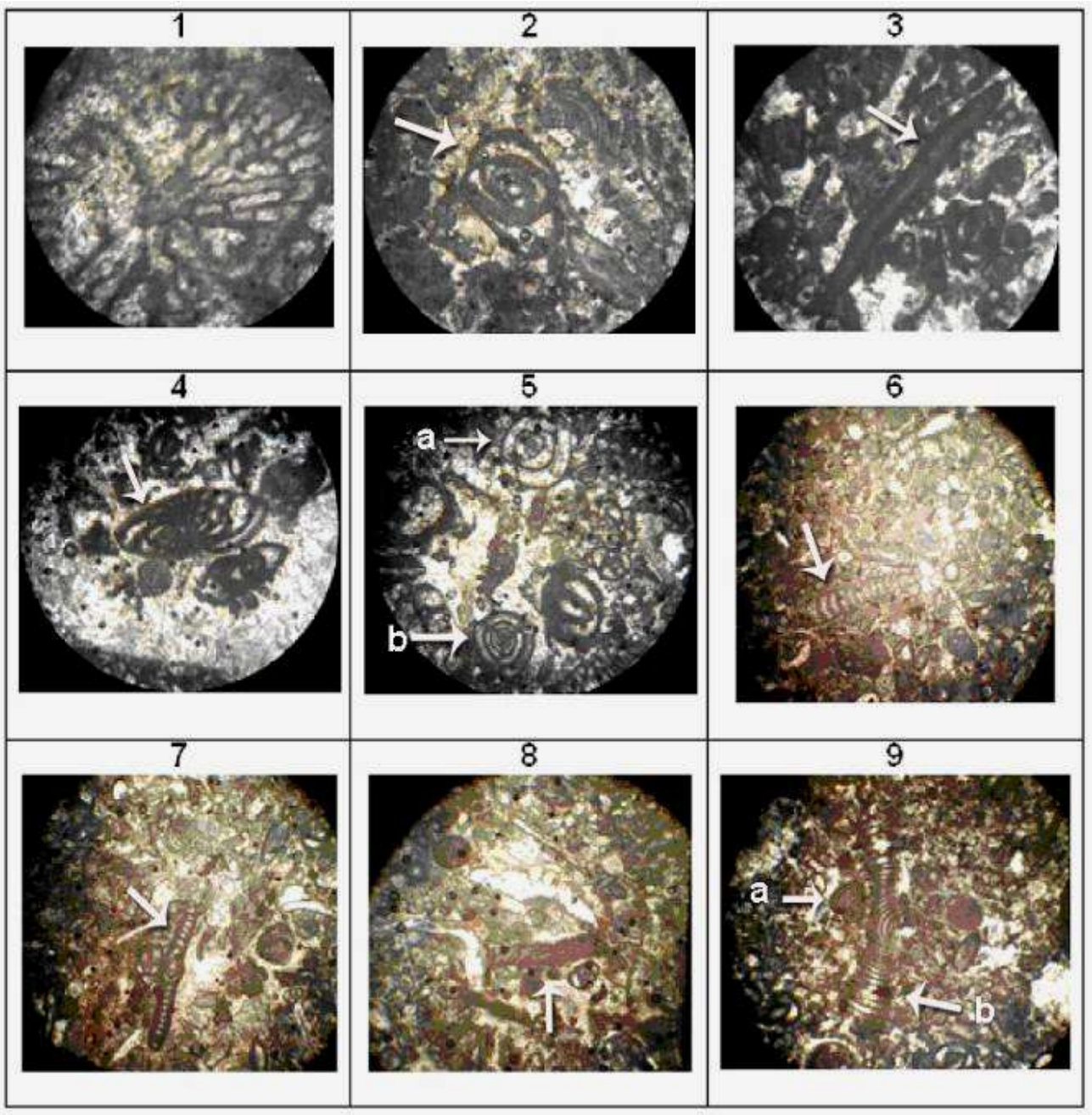

Fig. 13: Dolomitized pellitoidal milliolidal wackstone to packstone and coral boundstone, Anah Formation.1. ***Coral* sp.** 2. ***Austrotrillina howchini.*** 3. ***Lithophyllum johnsoni.*** 4. ***Peneroplis farsensis.*** 5. a. ***pyrgo sp*** b. ***triloculina* sp.** 6.***Praerhapydionina delicata.*** 7. ***Peneroplis evolutus* .**8. ***Archaias Kirkukensis* .**9. a. ***Peneroplis evolutus.*** b. ***Meandropsina anahensis***

D. Serikagni Formation

Serikagni Formation represents the basinal facies of Early Miocene age; it has a restricted distribution which first described by Bellen et al(1959) from the type area at Bara village in Jabal Sinjar which comprises 150 meters of globigerinal chalky limestone.

Serikagni Formation in the type area unconformably overlies the Eocene Jaddalah Formation or the basinal Oligocene formations. The formation is conformably overlain by the Dhiban Formation. In the studied area, the formation comprises six meters of light green to grey globigerinal chalky marl bed (figure 14), it is friable, unconformably overlain by the shelly limestone of Euphrates Formation, while it underlain Anah Formation. This marl bed did not clearly appear in the studied area except in Pungala and Khwelin sections, nonetheless it is not mentioned in the surrounding areas as outcrop (because the evaporite beds are very soft and weathered, so it appears as a clay or soil bed, sometimes it is difficult to recognize and suspicious to be considered as a rock bed).

Fig. 14: Serikagni Formations underlies Euphrates Formation, Pungala section; Mamlaha anticline.

Despite that, the lithology of the formation is marl but mixed with evaporite facies, this is resulted in environmental unsuitability for fauna living (caused planktonic foraminifera's low diversity). That's why we do not observe foraminifer's mass appearance within the lithology components. From other sections such as drilled oil wells in Ibrahim and Injana, the base of the Serikagni formation is frequently subconglomeratic, marking an erosional unconformity (Jassim & Goff, 2006). The characteristic lithofacies of the subconglomeratic beds comprises globigerinal limestones.

The upper boundary of Serikagni Formation is with Euphrates Formation (figure 15), which is unconformable, while its lower contact is with Anah Formation and also unconformable (figure 16).

From Ashdagh anticline, Kirkuk area and Euphrates River, a conglomerate bed covers the Upper Oligocene rock beds and underneath Serikagni Formation, whilst this conglomerate bed had not deposited in Mamlaha anticline, but it represented by coralline limestone (Anah Formation) that changed to a marl bed with no conglomerate existence in-between (the marl bed is equivalent to the conglomerate).

Serikagni Formation is considered to be the off-shore facies of the Euphrates Formation. It interfingers with the Euphrates's bed as in the Qaiyarah, Jawan and Qasab. Further offshore it occurs without significant Euphrates limestone, underlying Dhiban anhydrite, in the Injana, Pulkhana and Jambur areas (Jassim & Goff, 2006). The Upper contact is unconformable with Dhiban Formation. As mentioned above, the lithology's component of the formation is not frequent because of inadequate environment, but there are some species of foraminiferas within lime mudstone to wackestone microfacies as shown below:

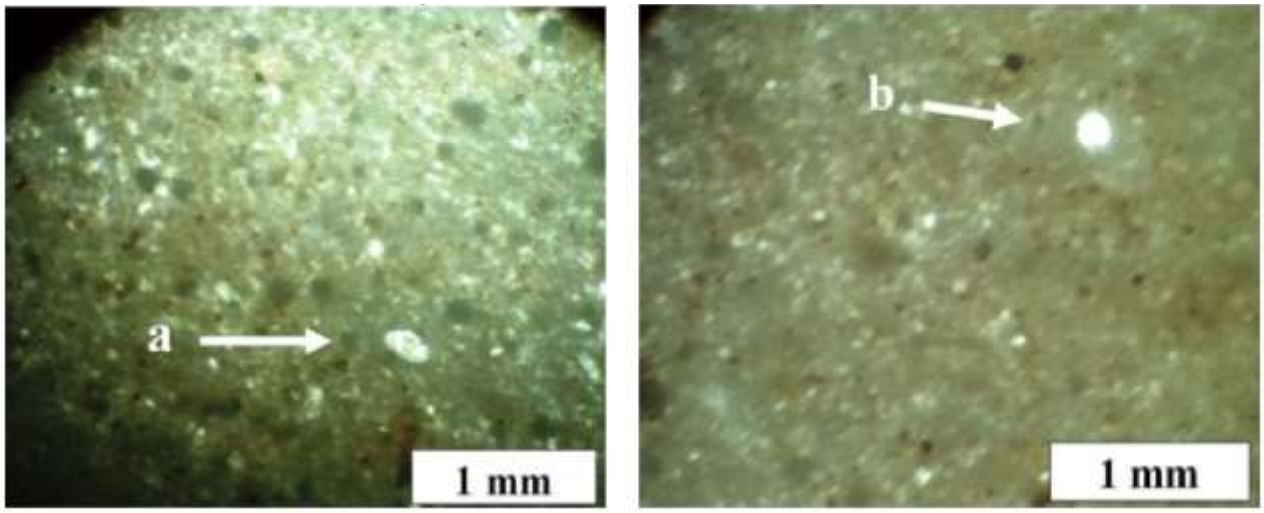

Fig. 15: Micritized mudstone to wackestone. Khwelin section, Serikagni Formation. *a.* ***Globigerinoides sacculiferous or Globigerinoides immaturus.*** *b.* ***Globigerinoides trilobus??***

Same microfacies recorded from western Iraq (Sinjar and sharafadin area) by Al-Banna and Al-Mutwali (2005). But Al- Banna (2004) recognized two microfacies during his study of Serikagni Formation near Bara village, northwestern Iraq: 1. Planktic foraminiferal lime packstone. 2. Planktic foraminiferal lime mudstone- wackestone.

E. Euphrates Formation

The formation includes two meters of grey massive well bedded highly jointed shelly algal

limestone (figures 14 & 16). These beds are very wide spread in the whole areas and extend toward northeast till it reaches Ashdagh anticline of Sangaw area (Kharajiany, 2014) and Gwlan anticline of Darbandikhan area (Al-Qaim et al 2014), from where Euphrates Formation is recorded; in whole sections the beds of Euphrates Formation nearly have same thickness. Abawi and Hani (2005) cited that Serikagni Formation was deposited in upper/middle slope, the Serikagni / Euphrates intertonguing in outer shelf and the Euphrates Formation in inner shelf depths.

From Ashdagh structure (Kharajiany, 2013) and Al-Jazira area (Ma'ala and Al-Kubaysi, 2009), Euphrates Formation includes two units; lower conglomerate unit and upper limestone unit.

But hence from Mamlaha anticline it comprises only limestone unit. The lower part of the limestone bed is brecciated and toward the upper part, they become well bedded. The lower contact of Euphrates Formation is unconformable with Serikagni Formation (chalky marl) and the upper contact is also unconformable with Dhiban Formation (Evaporite facies).

The age of the formation correlated with lower Miocene (Aquitanian) age; it considered being the lateral facies changed of Serikagni Formation; the latter is offshore facies.

In some location else such as Ashdagh and Wadi Al Fuhaimi, Euphrates Formation includes two lithologic units; lower conglomeratic unit and upper limestone units, but in sections of Mamlaha anticline, the formation consists of only limestone unit (the conglomerate unit either have eroded or not deposited). The limestone unit components are shell fragments of pelecypodes, algae and gastropods and form microfacies boundstone to framestone (figure 17).

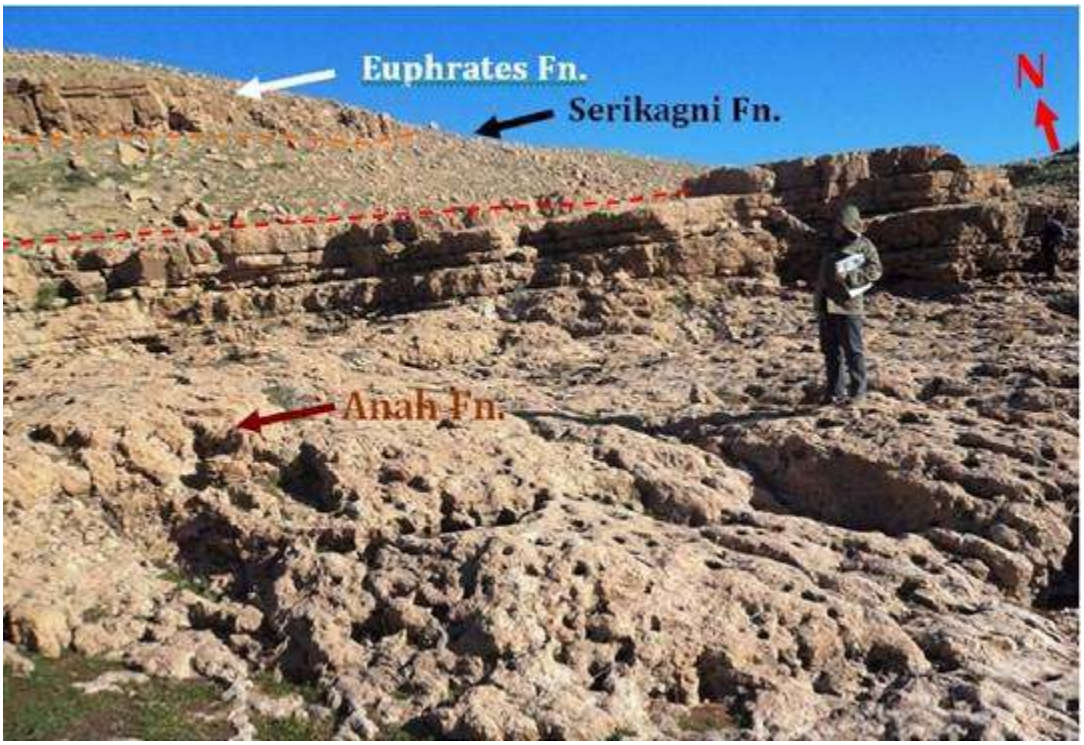

Fig. 16: Anah, Serikagni and Euphrates formations, Pungala section.

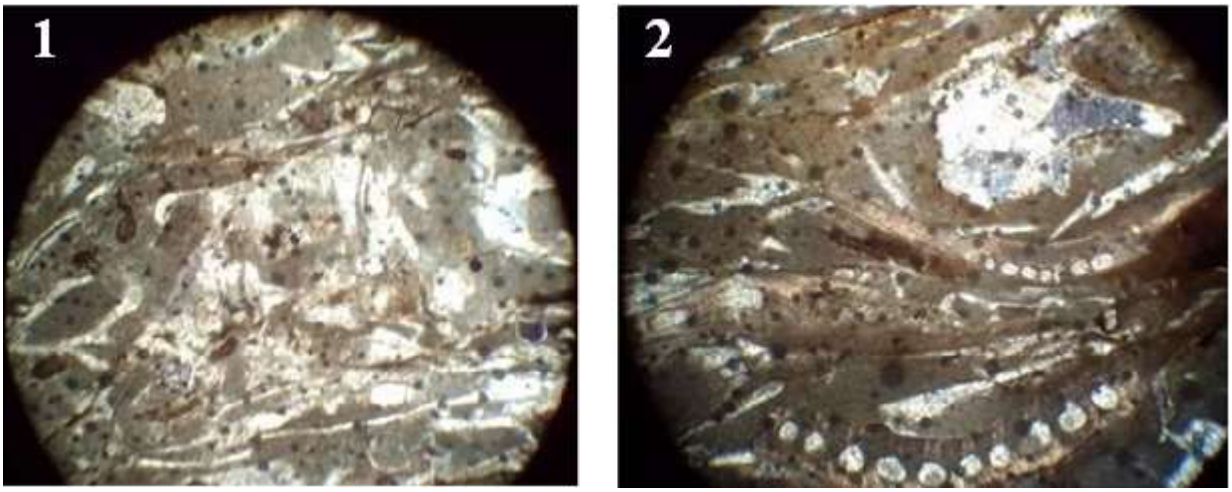

Fig. 17: framestone- boundstone, Euphrates Formation, Khwelin section. 1&.2**: the components are mostly shell fragments, Euphrates Formation.**

F. Dhiban Formation

Dhiban Formation represents 30-50 centimeters of evaporites; gypsum and anhydrite (figure 18). The thickness in Mamlaha anticline is thinner if compared to its surroundings like Ashdagh mountain It is difficult to observe Dhiban Formation everywhere from Mamlaha anticline; sometimes it become thin beds or pinches, and sometimes this evaporite facies disappears; this made difficulty to separate Euphrates and Jeribe formations (even remote viewing shows no obvious evaporite facies (figure 6).

No visible fossil content recorded from thin section study of Dhiban Formation, although its age dated back to Lower- Middle Miocene age as it overlies Euphrates Formation and underlies Jeribe Formation.

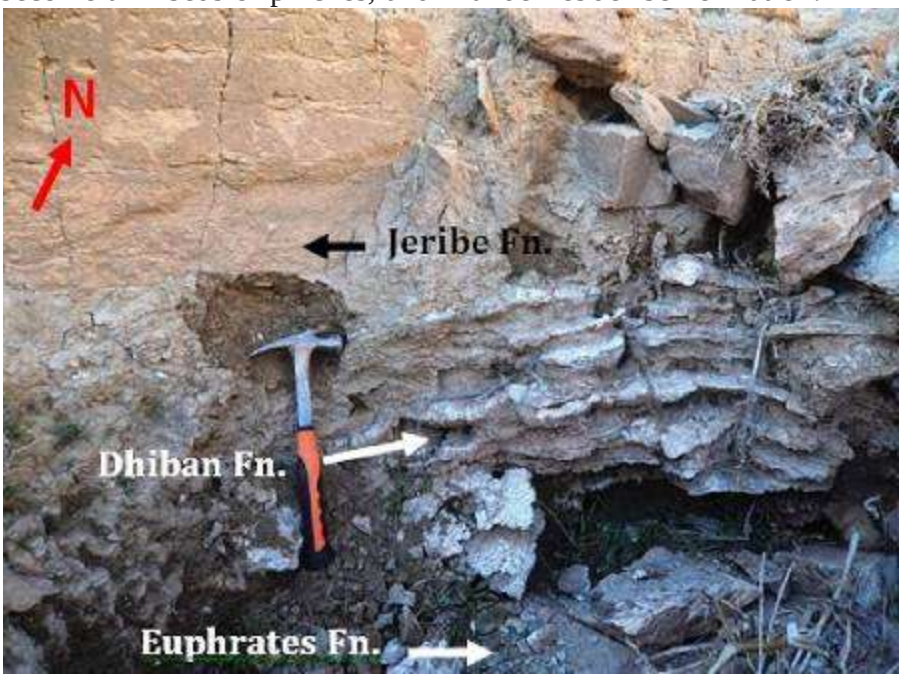

Fig. 18: Euphrates, Dhiban and Jeribe formations, Khwelin section.

G. Jeribe Formation

Jeribe Formation consists of one meter of pale to greenish grey medium to thick bed of bituminous arenaceous to silty limestone which slightly marly and it is friable, the formation has extension towards northeast to Sangaw and Darbandikhan as same as Euphrates Formation. Jeribe Formation unconformably overlies Dhiban Formation and also unconformably underlies claystone of Fatha Formation (figure 6). Al-Ameri et al, (2013) described the Formation in northern and NE Iraq as dolomitic limestones; it is an important reservoir unit and is sealed by the anhydrites of Fatha Formation.

Jeribe Formation was deposited in lagoon and reef environment (backreef). Back reef- reef facies is predominant.

The microfacies characterized by foraminiferal wackestone, it contains some index fossils of Low- Middle Miocene (Langhian) such as *Elphidium sp, Amonia beccarii, Dendritina rangi* and *Discorbis* sp.

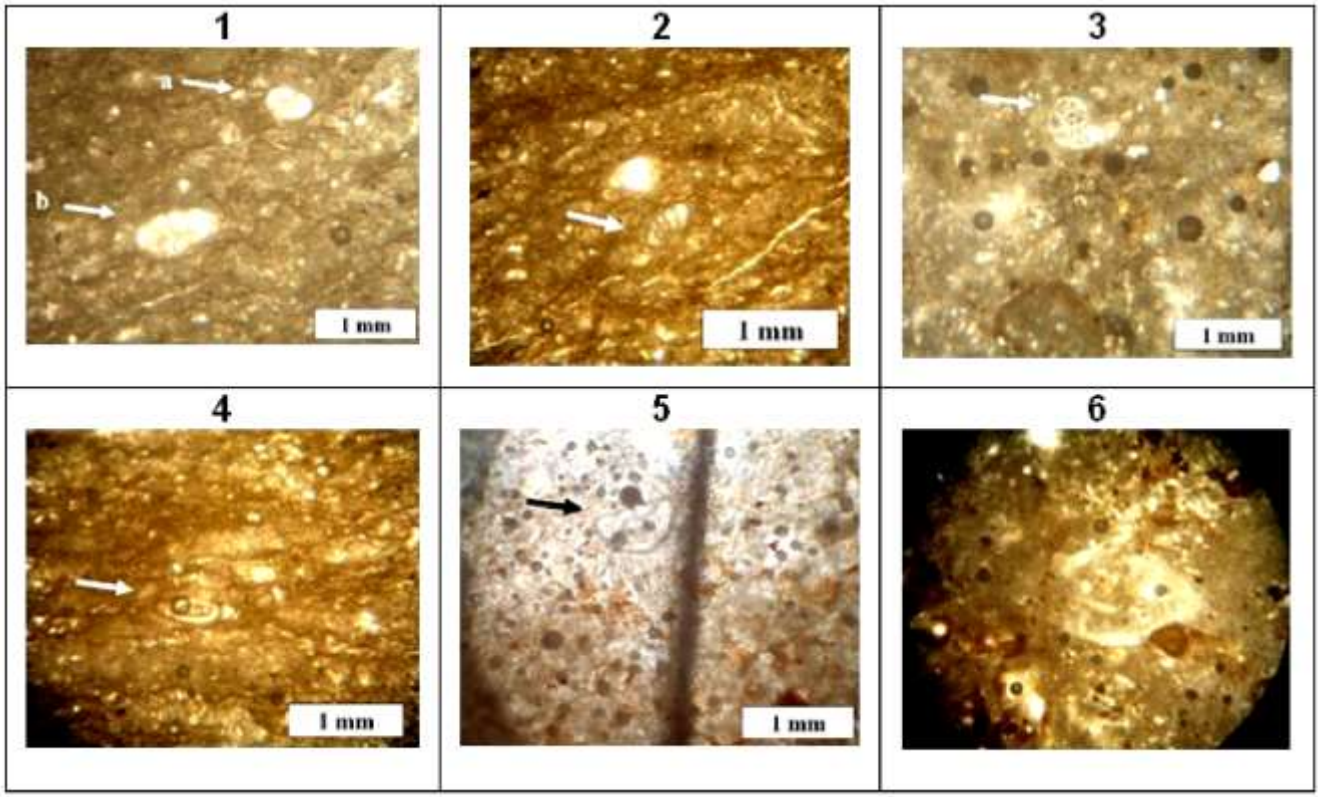

Fig. 19: foraminiferal wackestone, Jeribe Formation, Mamlaha section. 1. a**.** ***Rotalia vennotti.*** b. ***Elphidium*** **sp.** 2. ***Elphidium*** **sp.** 3. ***Amonia*** **beccarii.** 4. ***Dendritina rangi.*** 5. ***Discorbis*** **sp.** 6. ***Pelecypodes*** **sp.**

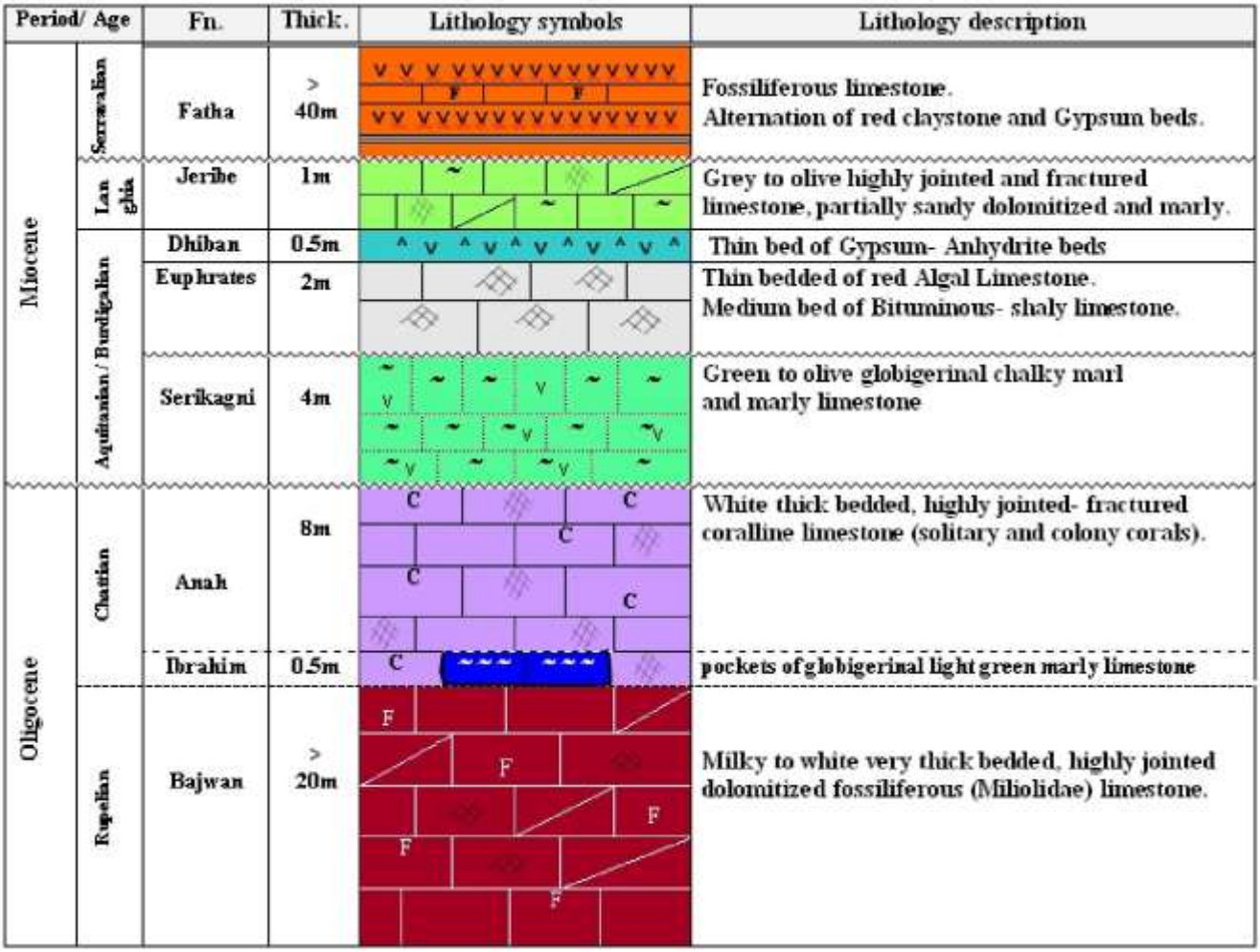

Fig. 20: Stratigraphic column of Mamlaha anticline.

As a final conclusion, and based on the previous description of lithostratigraphy and biostratigraphy, a stratigraphic column constructed for the studied section as illustrated in the figure (20) and an isopach map also set to explain the depositional basin of Middle Oligocene to Middle Miocene age as illustrated in figure (21).

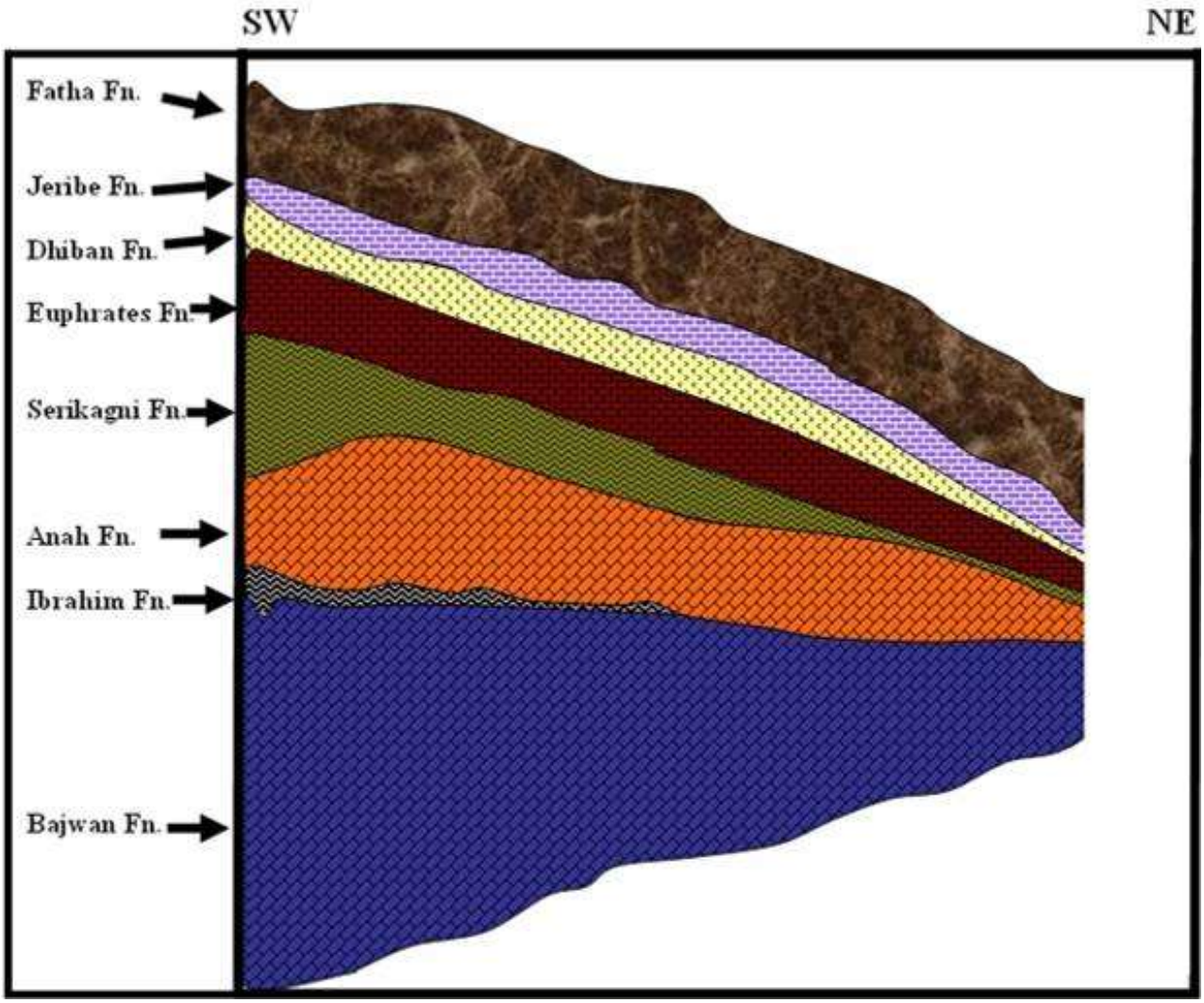

Fig. 21: Cross section shows the depositional basin (isopach map) of Middle Oligocene to Middle Miocene sediments in Mamlaha area (not to scale).

V. Conclusions

1. Mamlaha anticline geologically is very important and the strata are consist of Middle Oligocene to Middle Miocene ages. Formerly, these rock beds have not mentioned in the anticline. The rock beds are very prominent by hydrocarbons.

2. According to the Middle Oligocene to Middle Miocene period of time, the identified formations of the anticline are: Bajwan Formation (Middle Oligocene), Anah and Ibrahim formations (Late Oligocene) age, Serikagni, Euphrates and Dhiban formations (Early Miocene) and Jeribe Formation (Middle Miocene) ages respectively. They are:

A. Oligocene rock units:

Bajwan Formation appears as milky color very thick beds of porous highly, jointed fractured, cavernous limestone, its age belongs to back reef -lagoon of Middle Oligocene based on index fossils *Subterraniphyllum thomasi*,

Praerhapydionina delicata and *Archaias kirkukensis.*

- Anah Formation consists of white very thick bed, vuggy, porous cavernous splintery friable highly jointed fractured coralline limestone. It returns to back reef -lagoon of Late
Oligocene age based on index fossil contents *Meandropsina anahensis, Meandropsina iranica, Peneroplis evolutus,* and *Peneroplis farsensis*.

- Ibrahim Formation characterized by hard light green globigerinal dolomitized marly limestone, it appears as pockets not as extended stratified beds, the age is correlated to Late Oligocene depending on index fossils planktonic foraminiferas such *as Globorotalia opima, Globigerina angulisutturalis* and *Globigerina pareabulloides*. It considered being the deep basin of Late Oligocene and lateral facies change of Anah Formation.

B. Miocene rock units:

-Serikagni Formation consists of globigerinal marly and chalky limestone, they belong to outer shelf of Lower Miocene, the planktonic foraminiferas have low diversity. But contains *Globigerinoides sacculiferous or Globigerinoides immaturus* and *Globigerinoides trilobus??*

- Euphrates Formation comprises grey well bedded, shelly limestone ingredients *Pelecypodes* and *gastropods spp*. the environment of the formation is lagoon of Lower Miocene and it is lateral facies change of Serikagni Formation.

- Dhiban Formation consists of thin bed of evaporite beds with no obvious fossil contents and regards as isolated environment of Lower Miocene; it is facies change of Serikagni and Euphrates formations.

- Jeribe Formation consists of pale to olive friable marly, sandy, bituminous limestone containing Rotalia *sp, Elphidium sp Amonia beccarii, Dendritina rangi, Discorbis sp* and *Pelecypodes* sp. these fossils were fauna's components of lagoon of the Middle Miocene age.

3. The Lower contact of Bajwan Formation is not exposed in any three sections. The contact between Bajwan and Anah is unconformable and represent by erosion surface and chert horizon.

Ibrahim Formation however not exposed as well beds of marly limestone (it shows as pocket of marly limestone and discrete beds) is sandwiched between Bajwan and Anah formations and shows no clear boundary.

The Upper contact of Anah Formation is separated from Euphrates by 2 meter of green marl of Serikagni Formation which indicates abrupt change in lithology. And the latter is also unconformable with lower boundary of Euphrates Formation.

The Upper contact of Euphrates shows unconformity, the limestone is changed to evaporite unit of Dhiban Formation, whilst Dhiban Formation is unconformably underneath the marly sandy bituminous limestone of Jeribe Formation.

Jeribe Formation also unconformably lied beneath the claystone of Fatha Formation.

4. For the first time Ibrahim and Serikagni formations were recorded from outcrops.

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