STRATIGRAPHY OF KARBALA – NAJAF AREA, CENTRAL IRAQ

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ABSTRACT

The exposed formations in the studied area in upward sequence are: Euphrates, Nfayil, Injana, Zahra and Dibdibba. Nfayil Formation consists mainly of two main cycles in the studied area (in some places a third sub cycle is developed); each cycle consists of lower marl unit and upper carbonate unit.

More information has been added to the stratigraphy of the area. A unit consists of alternation of red claystone, siltstone and sandstone which was considered the Upper Member of Nfayil Formation in the previous works has been added to Injana Formation, in the present work based on solid field data. The lower and upper contacts of Injana Formation have been reviewed and defined exactly. In addition, the formation is divided into two units in the present work, these are: the Lower Clastic Unit, which consists of alternation of red to reddish brown claystone, siltstone and sandstone with some thin marly limestone horizon, and the Upper Cave – Forming Claystone Unit, which consists of brown to reddish brown cave – forming claystone, topped by thin marly limestone bed. Clear interfingering between Zahra and Dibdibba Formations is recorded particularly in Lissan area, which indicates that they are of the same age. The contacts between the formations are defined clearly in an area, which is considered to have high economic potential such as celestite, attapulguite and feldspar.

طباقية منطقة كربلاء — النجف، وسط العراق

كريم محمود حسن

المستخلص

إن التكاوين الظاهرة في منطقة الدراسة وبترتيب الأحدث هي: الفرات، النفايل، انجانة، زهرة ودبدبة. تم تقسيم تكوين النفايل إلى دورتين رئيسيتين (في بعض الأماكن هناك دورة ثانوية ثالثة). تتكون كل دورة ترسيبية من وحدة طفلية سفلى ووحدة كاربونية عليا.

تمت إضافة معلومات جديدة إلى منطقة الدراسة حيث أن هناك وحدة تتكون من تعاقب طبقات الأطيان الحمراء مع الصخور الغرينية والرملية كانت تعتبر العضو الأعلى من تكوين النفايل، في الدراسات السابقة. تم إضافتها إلى تكوين انجانة في الدراسة الحالية استنادا إلى معلومات حقلية رصينة. تمت إعادة النظر في الحدود السفلى والعليا لتكوين انجانة وتم تحديدها بصورة دقيقة. إضافة إلى ذلك تم تقسيم تكوين انجانة إلى وحدتين رئيسيتين هما الوحدة الفتاتية السفلى والمكونة من تتابعات الصخور الطينية الحمراء والغرينية والرملية مع وجود بعض الطبقات الرقيقة من ترسبات الحجر الجيري الطفلي، ووحدة الطين المتكهف العليا والمتكونة من الصخور الطينية المكونة للكهوف ذات اللون الأحمر أو البني والتي تعلوها طبقة من الحجر الجيري الطفلي. تم تحديد تداخل واضح بين تكويني الزهرة والدبدبة وخاصة في منطقة وادي اللسان مما يدل على إنهما بنفس العمر الجيولوجي. هذا وقد تم تحديد الحدود الفاصلة بين التكاوين الظاهرة بصورة واضحة في منطقة تعتبر واعدة لبعض الترسبات الاقتصادية مثل السلستايت، الاتابلغايت والفلدسبار.

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INTRODUCTION

A detailed filed work was carried out by the author and others during a mapping project within the State Company of Geological Survey and Mining during 2002 – 2003, including description of many sections, traverses, documented points and mapping. The work is based on topographic maps of scale (1:25 000 and 1:50 000). A lot of samples have been taken for petrology, paleontology, heavy mineral studies, also for chemical analysis and XRD. The present work is concentrated on the stratigraphy of the studied area.

The area is located in the central part of Iraq, between Karbala and Najaf cities. It is a cone-shaped plateau (Fig.1), bounded by two scarps, the northeastern one is called Tar Al-Sayyed and the southern one is called Tar Al-Najaf. The surface of the plateau is nearly flat, dissected by some shallow flat-floor valleys, and almost covered by pebbly or gypsiferous pebbly soil or gypcrete. Some aeolian sand sheets and shrub dunes are present, too.

PREVIOUS STUDIES

There are different previous investigations concerning the studied area, but most of them are concentrated on mineralization, particularly feldspar, attapulgite and celestite. Few of them dealt with the geology of the area. The most important work, concerning the geology of the studied area is that of Lateef and Barwari (1984). They mapped the main part of the studied area and divided the stratigraphic sequence into lithologic units, but they didn't assigned these units to certain formations, these units are:

-Sandstone Unit: the upper part of this unit belongs to Dibdibba Formation and the lower part belongs to Injana Formation.

-Calcareous Claystone Unit: massive, green and grey claystone, contain organic material and secondary gypsum, represents the lower part of Injana Formation.

-Claystone and Limestone Unit: is composed of lacustrine claystone, with limestone, siltstone, sandstone and secondary gypsum which is equivalent to Fat`ha Formation.

-Terrigenous Clastic – Carbonate Unit: belongs to Euphrates Formation.

Al-Mehadi *et.al*. (1975) divided the area west of Tar Al-Sayyed into the following formations.

1- Lower Fars Formation: composed of the following units (from bottom to top).
-Shithatha Marl Unit: green marl and limestone
-Claystone Unit: red, calcareous claystone with marl and sandstone
-Cap Limestone Unit

2- Injana Formation: consists of the following members:
-Lower Member, consists of calcareous claystone, sandstone and siltstone with thin layers of marly limestone.
-Upper Member, consists of cross bedded sandstone and claystone with quartz, feldspar and some heavy minerals. They mentioned that the upper part contains very coarse sandstone with gravel, belongs to Dibdibba or Mukdadiya Formation.

3- Dibdibba Formation: consists of calcareous sandstone, grey to white and yellow with fresh water limestone.

Barwari and Slewa (1995), compiled Karbala quadrangle, scale 1:250 000, which includes the studied area. They summarized the following formations. Fat`ha, Injana, Zahra and Dibdibba Formations and divided Fat`ha Formation into:

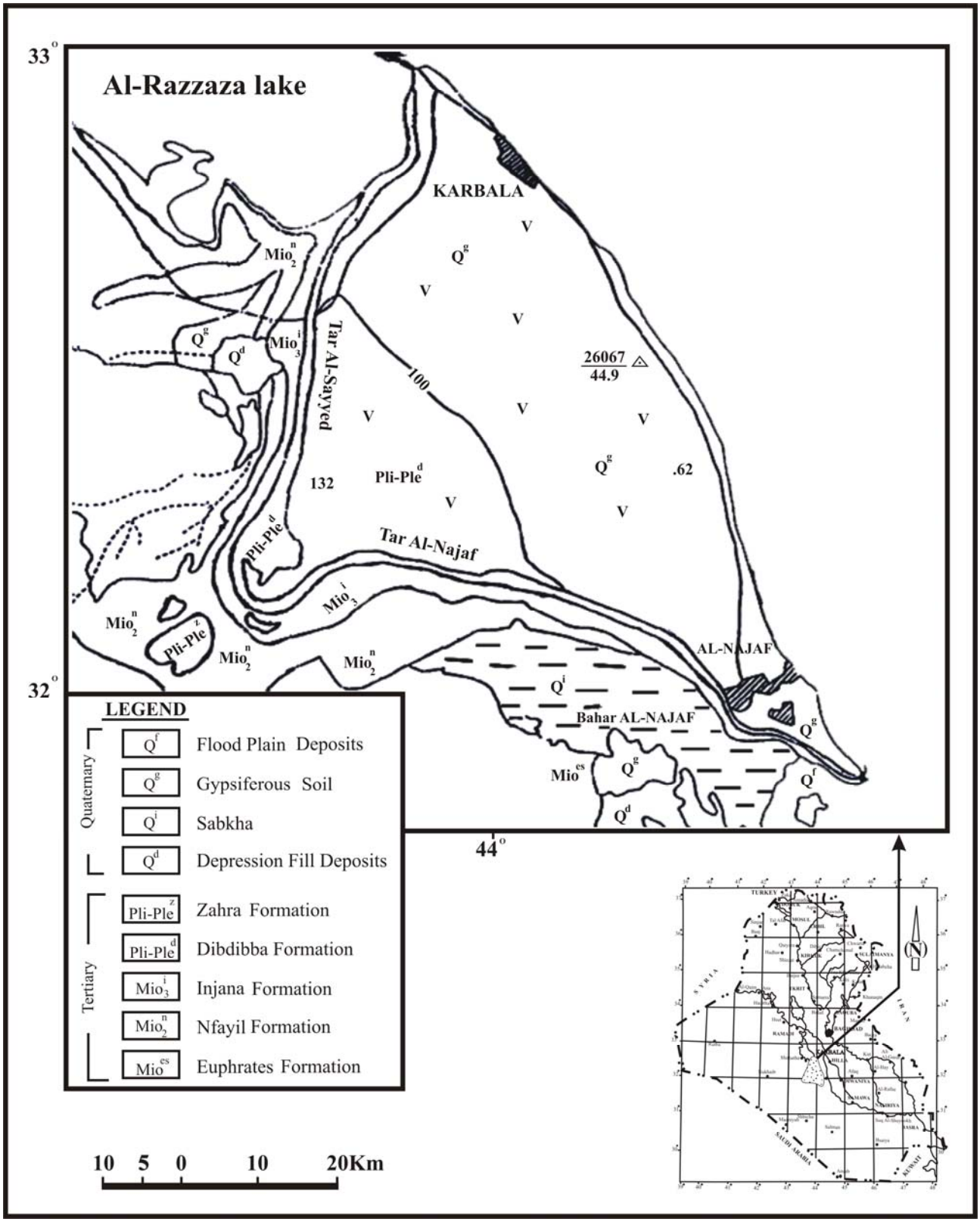

Fig. 1: Location and geologic map of Karbala – Najaf area, modified from Barwari and Slewa (1995)

- **Nfayil Beds,** which consist of marl and limestone
- **Clastic Member,** which consists of red claystone, siltstone and sandstone with thin limestone beds .They, also mentioned that Injana Formation consists of sandstone, siltstone and claystone with thin limestone beds.

Sissakian *et al*. (1999) assigned Nfayil Formation for the previously known Fat`ha Formation in the studied area and divided the formation into:

- **Lower Member:** consists of three cycles of green marl alternated with limestone, the second cycle bears oyster shells.
- **Upper Member:** consists of alternation of grey and reddish brown siltstone and claystone in the lower part. They mentioned that this member disappears in some places and appears in Sithatha and Rahaliya, where it was called by Al-Mehaidi *et al.* (1975) as the Claystone Unit, consisting of red calcareous claystone alternated with sandstone and some limestone horizons.

Recently, Hassan *et al*. (2002 and 2004), carried out detailed geological survey in the studied area. Beside clarifying the stratigraphy of the area the authors introduced new localities for some mineral occurrences such as celestite, attapulgite and feldspar.

STRATIGRAPHY

The exposed formations in the studied area are (from older to younger): Euphrates, Nfayil, Injana, Zahra and Dibdibba. Primarily recrystallization and lacking of index fossils ultimate age determination to be obtained through analogue in the studied area. Therefore, the age of the formations are based on the previous works.

▪ Euphrates Formation (Early Miocene)

It is the oldest exposed formation in the area. Only the uppermost part of the formation is exposed. It consists of limestone grey to yellowish grey or pale grey, medium tough to tough, medium bedded, almost fossiliferous, the dominant fossils are clausinella, generally step or cliff-forming. The contact with the overlying Nfayil Formation is clear and conformable, taken at the top of the medium bedded limestone and the first appearance of green marl of Nfayil Formation with thickness more than 2.0 m (Fig.2).

▪ Nfayil Formation (Middle Miocene)

It covers the lowland adjacent to Tar Al-Najaf and Tar Al-Sayyed up to the foot of both Tars. The Nfayil Formation lithologically consists of alternation of marl and limestone. Generally, two main cycles can be differentiated in the area, these are:

Lower cycle, consists of yellow to yellowish green marl, slope – forming, overlain by grey limestone, tough to medium tough, medium bedded, cliff to step forming

Upper cycle, consists of yellow to yellowish green marl, slope – forming overlain by oyster – bearing limestone, tough to medium tough, step to cliff forming. The oyster is common in this bed beside some clausinella.

Some sub cycles may be developed in some places, in addition to some thin clayey or sandy beds, particularly in Lissan area. The upper contact with the overlying Injana Formation is clear, unconformable, taken at the top of the limestone of Nfayil Formation and the first appearance of red or reddish brown claystone or siltstone of Injana Formation (Fig.3B).

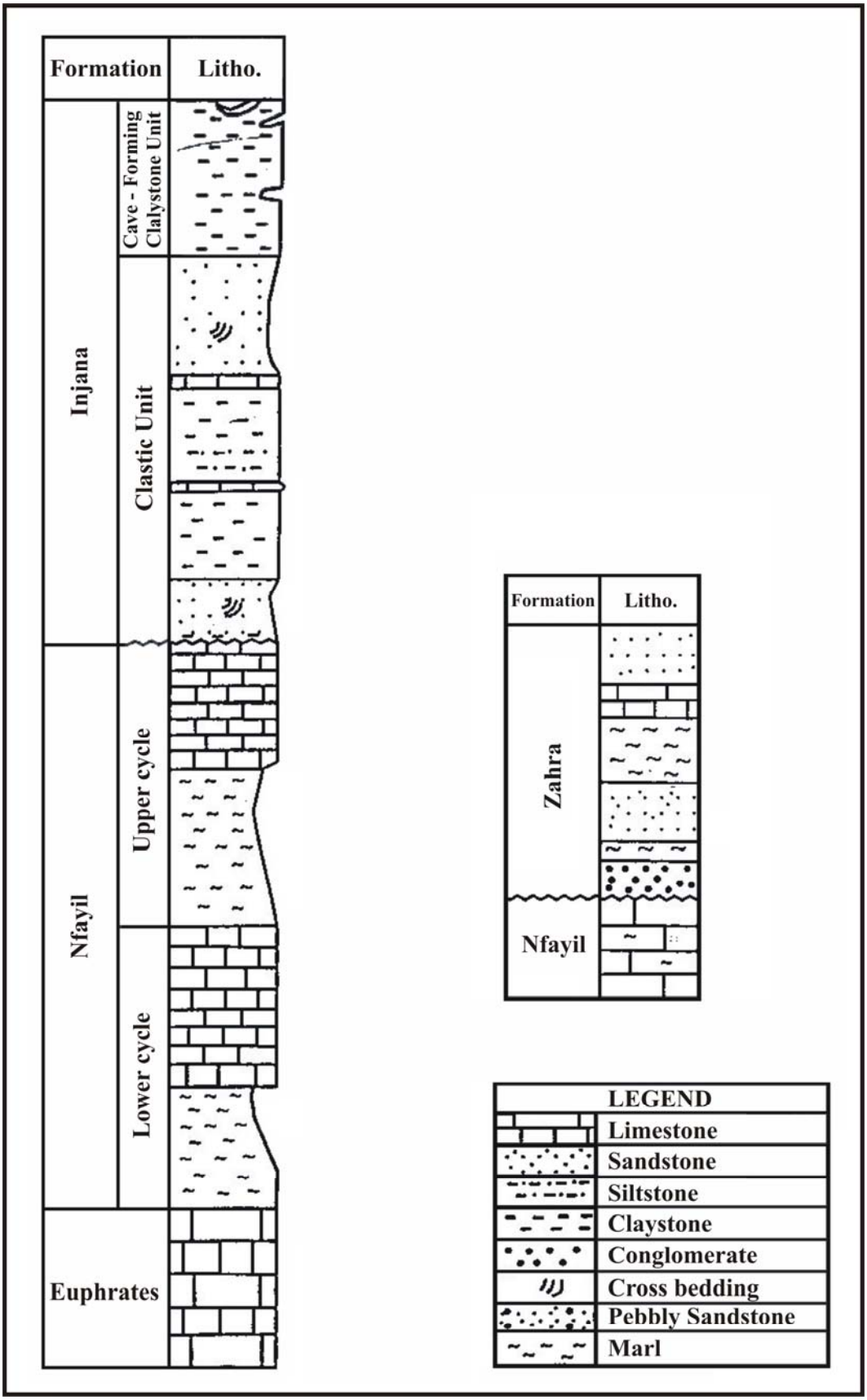

Fig. 2: Lithologic section of Nfayil, Injana and Zahra Formation (Not to scale)

- **Injana Formation (Upper Miocene)**

The formation is well exposed along both Tar Al-Najaf and Tar Al-Sayyed making the main bulk of the tars (cliffs) and many adjacent isolated hills. Lithologically, the formation is divided (in this study) into two main units (Fig.2):

- Lower Clastic Unit

It consists of alternation of different clastic rocks (claystone, sandstone and siltstone) or admixture of these rocks in different ratios. Thin beds of marly limestone are also recorded, two or three times up to 0.3 m in thickness (Fig.2) some celestie-bearing beds are recorded in places (Hassan and Al-Khateeb, 2005). Cementing materials are clay or carbonate. Solution of diagenetic processes occasionally fills the bedding planes and fractures, forming very thin beds or local aggregate of secondary gypsum. Generally, the claystone and silty claystone or siltstone beds are brown to reddish brown in color, medium tough to tough and cliff-forming; while the sandstones are heterogeneous, micaceous, lithic, cross bedded of grey color. Generally, the sequence shows fining upwards cycles. The thickness of this unit reaches up to 25 m. The succession of this unit shows some lateral and vertical variations.

- Upper Cave-Forming Claystone Unit

It is informally named the Cave-Forming Claystone Unit (Hassan and Al-Khateeb, 2005). It consists of claystone, occasionally silty, brown to reddish brown, conchoidally fractured, massive, tough, cliff-forming, changes laterally or vertically to silty claystone. The thickness of this unit reaches 6.0 m or more in some places. It has a wide geographic extension along both Tar Al-Najaf and Tar Al-Sayyed, for about 170 Km. The wide geographic extension of the fine sediments (claystone) without remarkable lateral lithological variation indicates low energy fluvial depositional current, as compared to the Lower Unit. This unit is highly jointed (two sets, generally E – W and N – S). It is overlain by highly permeable coarse grained sandstone of Dibdibba Formation. Some of these joints are enlarged gradually due to water erosion from the overlying beds forming a well developed caves, which reaches to (1×2) m, or more (Hassan and Al-Khateeb, 2005)

- **Dibdibba Formation (Pliocene – Pleistocene)**

This formation is widely exposed in the upper part of both Tar Al-Najaf and Tar Al-Sayyed forming the main plateau. The thickness ranges from one meter or less to more than 18m. Lithologically, the formation consists of sandstone and pebbly sandstone (Fig.3). The sandstone differs from place to another; the main color is brown but it could be gray, yellow and white or yellowish brown. Other physical properties such as grain size, sorting, roundness, spheresity are also varying in some manner.

The major components of the sandstone beds in this formation are quartz, chert, rock fragments and feldspar. The ratio of these components differs from place to another. The cementing materials are clayey, in the friable sandstone and calcareous or gypsiferous, in the medium tough sandstones. Some claystone and siltstone beds are recorded, particularly in the eastern and southeastern parts of the area.

- **Zahra Formation (Pliocene – Pleistocene)**

This formation is exposed as isolated patches or hills, particularly in the junction between Tar Al-Najaf and Tar Al-Sayeed (Lisssan area). It is composed of conglomeratic bed, at the base reaching up to 0.5 m in thickness. This is followed by green marl, then brown claystone, pale grey fine to medium crystalline limestone, occasionally sandy. There are some beds of light grey, friable to medium tough, poorly sorted sandstone. The thickness of Zahra Formation in this area ranges from (0.5 – 6.0) m.

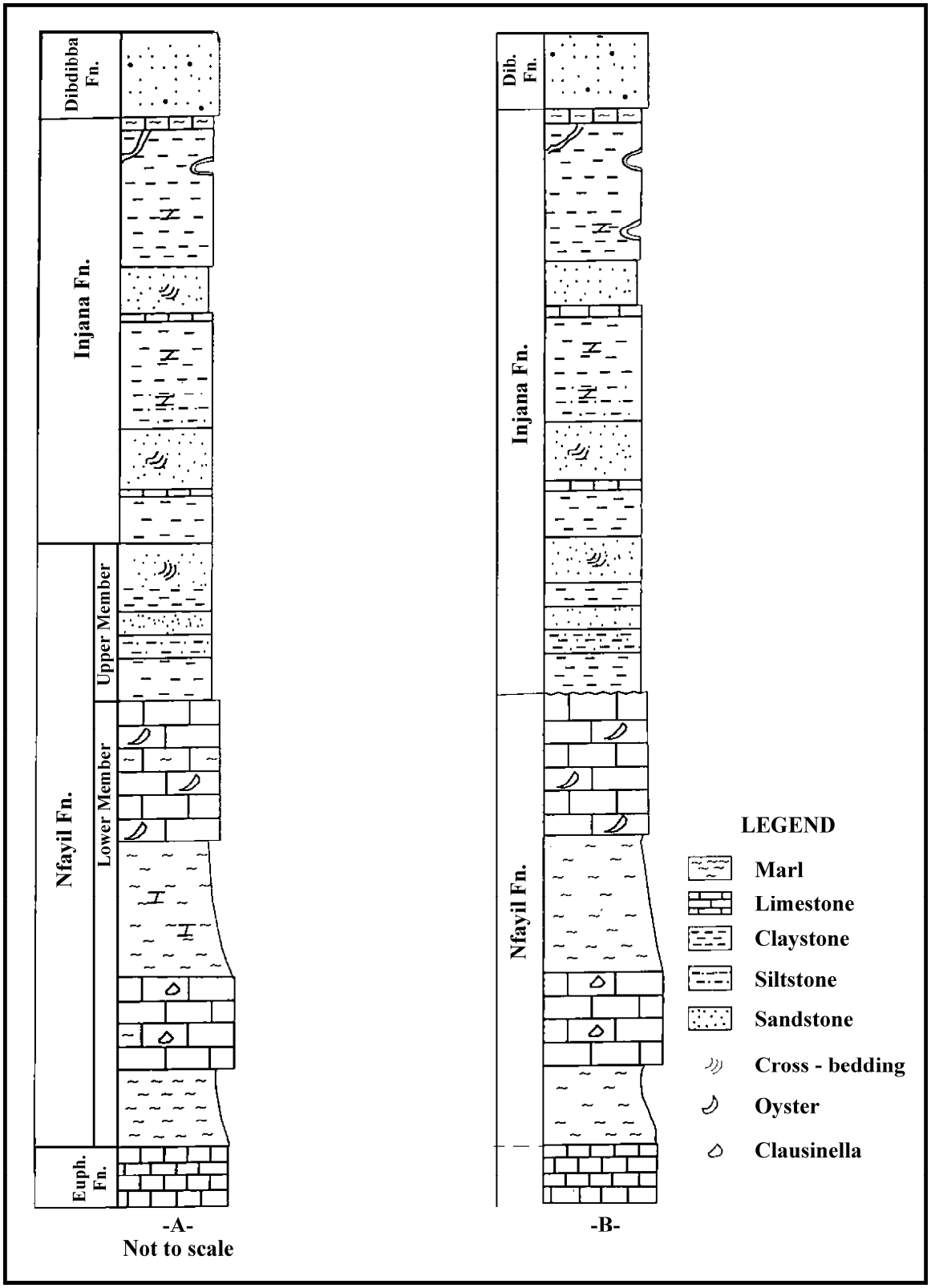

Fig. 3: Generalized columnar section of Nfayil and Injana formations in the studied area, showing Nfayil – Injana contact.
A) According to the previous work **B)** According to Hassan and Al-Khateeb (2005)
(Not to scale)

It is worth to mention that there is clear interfingering between Zahra and Dibdibba formations in Lissan area, where the conglomerate of Zahra Formation interfingers with the quartzitic (occasionally) pebbly sandstone of Dibdibba Formation in many places (Fig.4). Sometimes, the conglomerate and marl of Zahra Formation interfinger with the quartzitic sandstone of Dibdibba Formation .This indicates that Zahra and Dibdibba formations are synchronous.

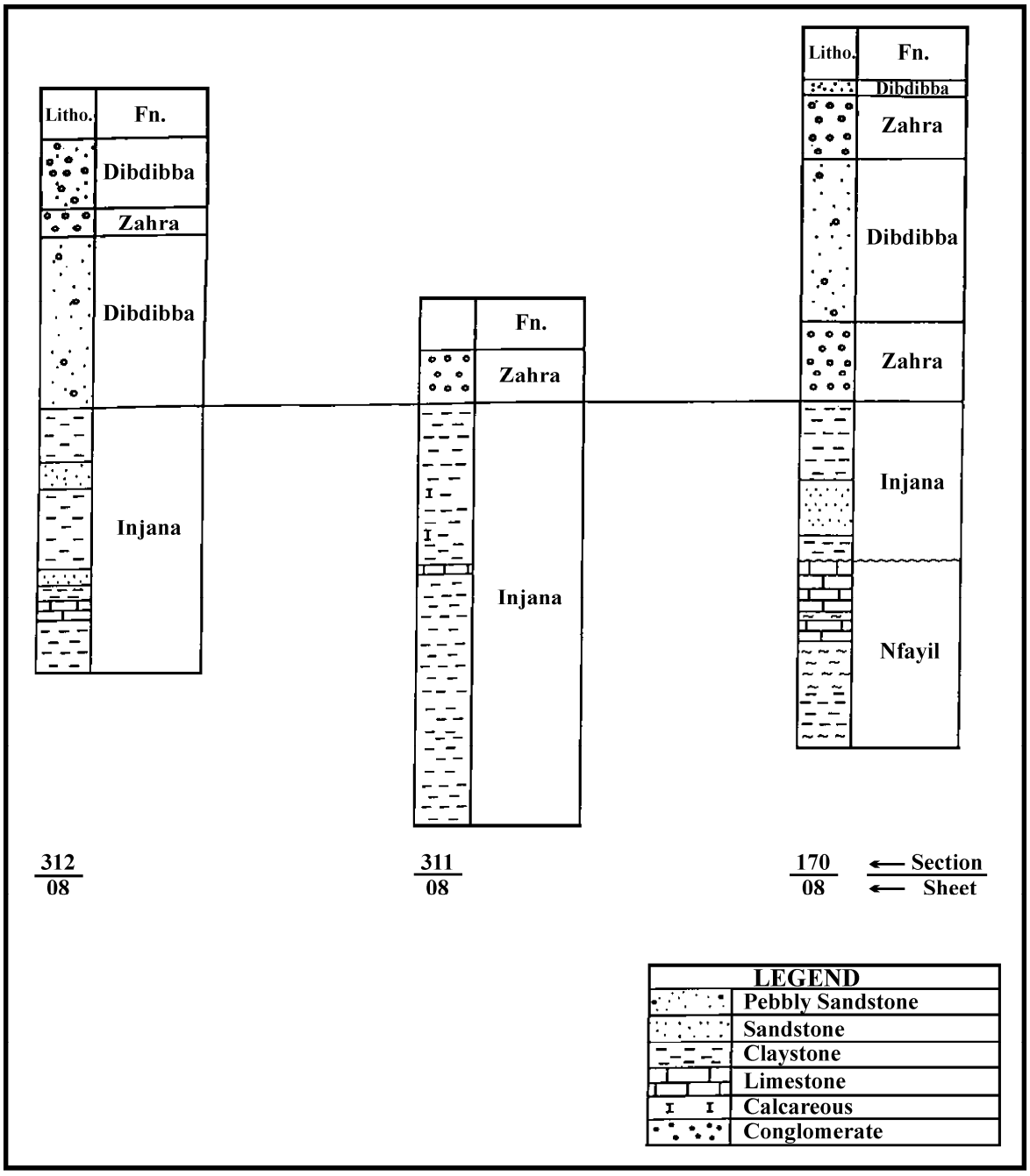

Fig. 4: Chart showing alternation of Dibdibba and Zahra formations in Lissan area. (Not to scale)

DISCUSSION

In the present work the author believes that the Upper Member of Nfayil Formation should be added to the overlying Injana Formation (Fig.3B) due to the following reasons:

- The Upper Member of Nfayil Formation is similar to Injana Formation in both colour and lithology. It consists of alternation of brown to reddish brown claystone, siltstone and sandstone. Injana Formation also consists of alternation of brown to reddish brown claystone, siltstone and sandstone. This member is different from Nfayil Formation in both colour and lithology, where Nfayil Formation consists of alternation of yellow to yellowish green marl and grey to pale grey limestone.

- If this member belongs to Nfayil Formation, it is difficult to be separated from the overlying Injana Formation, due to similarity in both colour and lithology and it is difficult to recognize the contact between these two formations.

- In the western part of the studied area, a clear highly oxidized rusty soil of 25 cm thickness is separating between the oyster – bearing limestone bed (2^{nd} cycle of Nfayil Formation) and the overlying reddish brown claystone, siltstone and sandstone beds which indicates a small break in sedimentation between these units, i.e. between Nfayil and Injana formations.

- If the Nfayil Formation is a lithostratigraphic unit with clear lower and upper contacts, it is better to include the Upper Member with Injana Formation and in this case the contact between Nfayil and Injana formations is based at the top of grey to pale grey limestone, which belongs to Nfayil Formation and the base of the brown to reddish brown claystone or siltstone, which belongs to Injana Formation (Fig.3B)

- Thin limestone horizons are present through the whole succession of Injana Formation up to the contact with the well defined Dibdibba Formation and actually the contact between Injana and Dibdibba formations are marked by thin marly limestone bed. This limestone devoids fauna, except few tiny gastropods which are similar to fresh water fauna. Generally, three beds of limestone are present, each of about 25 cm.

- The Upper Member of the Nfayil Formation contains a well defined grey, cross-bedded sandstone beds, up to 5 m thickness, which is similar to the fluvial Injana Formation, rather than to the marine Nfayil Formation.

- From environmental point of view, it is more convenient to consider the Upper Member of Nfayil Formation, which is characterized by frequent red colour (iron oxides) resulted from oxidizing condition on land, which is characteristic of continental environment (Gall, 1976) within the overlying Injana Formation, which is characterized by continental environment, as well and should be separated from the underlying cycles of Nfayil Formation, which is characterized by marine environment.

According to the aforementioned remarks the author believes that the previously called Upper Clastic Member of Nfayil Formation should be included within Injana Formation (Fig.3B)

CONCLUSIONS

The field work on the stratigraphy of Karbala – Najaf area revealed that:

- The exposed formations in upward sequence are Euphrates, Nfayil, Injana, Dibdibba and Zahra.
- The Upper Clastic Member of Nfayil Formation, which consists of alternation of brown to reddish brown claystone, siltstone and sandstone should be included within Injana Formation, which consists of alternation of brown to reddish brown claystone, siltstone and sandstone, as well.
- Nfayil Formation consists of two main cycles, in the studied area.
- Injana Formation has been divided into two units in the present work, the Lower Unit and the Upper Cave-Forming Claystone Unit.
- The lateral and vertical variations in the lithology of Injana Formation indicate relatively high energy current during the deposition in the lower unit, as compared with the low energy current of the upper unit.
- Clear interfingering between Dibdibba and Zahra formations has been recorded in the studied area, which indicates that these formations are synchronous.

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