MODIFICATION OF THE TIME-EXPANDED STRATIGRAPHIC COLUMN OF NORTH EAST IRAQ DURING CRETACEOUS AND TERTIARY

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Abstract

The time expanded stratigraphic (time-stratigraphic or chronostratigraphic) column of Iraq was established in the fifties of the last century by Oil Companies working in Iraq. During this long time the column remained without important changes. Therefore, the present study tries to update and modify the column according to recent sedimentoggical and stratigraphic studies of the northeastern Iraq. The main modifications include removing of all previous unconformity between the following formations: Qamchuqa with Dokan and Kometan, the later formation with Dokan and Gulneri, Kometan and Shiranish, Qamchuqa and Bekhme, Tanjero and Kolosh formations. The contacts between the above formations are changed to conformable and their boundary assigned as gradational in the new chronostratigraphic column. The modifications also include lateral combining of the lower and upper parts of Red Bed Series with Kolosh and Gercus Formations respectively which are deposits of one large foreland basin. Moreover, during Eocene, the tectonic and geographic location of the Walash Naoperdan Series is indicated and correlated with Pila Spi Formation which is separated by paleo-high from the series.

On the new chronostratigraphic column, locations of the stratigraphic units are indicated according to present tectonic zones (Low and High Folded, Imbricated and Thrust Zones) of Iraq instead of previous general geographic position. Another type of location which is followed, in the new column, is putting the formations in their historical position of deposition within foreland basin of Late Cretaceous and Tertiary. In the studied area, the coarse clastic units are put in the costal area near to source areas while the very fine ones (marl and Shale) put near to basin plain of the foreland basin. Between the two, the medium grain clastics and biogenetic limestones are deposited in intermediated depth (shelf and slope).

تغير العمود الزمن الطباقي لشمال شرق العراق للعصر الكريتاسي و الثلاثي

من قبل: كمال حاجي كريم

المخلص

اسست عمود الزمن الطباقي للعراق منذ خمسينيات القرن الماضي من قبل شركات النفط العملة في العراق و خلال هذه المدة الطويلة بقيت بدون تغير كبير. لذلك تحاول الدراسة الحلية الى تجديد و تغير العمود الزمن الطابقي للشمال الشرق العراق لكي يتضمن جميع التغيرات الحاصلة اعتماد على الدراسات الرسوبية و الطباقة الحديثة بحيث يتفق التغيرات مع تطورات العلمية الحديثة حول الجيولوجية المنطقة. ان تغيرات الرئسيسة عبارة عن ازالة عدم التوافقات السابقة بين التكاوين التالية: قمجوغة مع دوكان و كوميتان و بين هذا التكوين مع دوكان و كولنيري، كوميتان مع شيرانش وقمجوقة مع بخمة و تانجرو مع كولوش. ان حد التماس بين التكاوين السابقة تم تغيرها من عدم توافق الى توافقي و غيرت حدودهم التباقي الى تدرجيا في العمود الجديد. ويشمل التغير كذلك دمجا افقيا لجزء السفلي و العلوي للسلسلة الطبقات الحمراء مع تكوين كولوش و جركس بالتوالي و اعتبار كلاهما ترسبات الحوض المقدمة القارة و باضافة الى ذالك تم تحديد الموقع التكتوني و الجغرافي للسلسلة والاش ناوبردان و مضاهاته زمنيا مع تكوين

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بلاسبي حيث يفرق بينهما مرتفعا. حددت موقع الوحدات الطباقية طبقا للانطقة التكتونية الحالية للمنطقة (انطقة الطيات الواطئة والعاليةو التراكب والزاحفة) بدلا للموقع الجغرافي العام المتبع سابقا. نوع اخر متبع هو تحديد موقع حسب موقع تأريخ الترسيب كل وحدة ضمن حوض المقدمة القارة في العصر كريتاسي المتأخر و الرباعي في العمود الجديد. وضع الوحدات ذات الصخور الفتاتية الخشنة في النطقة الساحل الحوض الترسيبي لقريبة من الصخور المصدر. بينما وضع الصخور الناعمة كالصلصال و المارل قرب وسط الحوض الترسيبي. و يقع الصخور الفتاتية المتوسطة و الصخور الكلسية الحياتية في نطقة متوسطة بين الموقين السابقين (في الرف و منحدر).

INTRODUCTION

The time expanded stratigraphic column (time-rock or chronostratigraphic column) is that type of stratigraphic column on which many chronostratigraphic unit and the missing ages (the time is expanded) are shown and very useful for basin analysis and oil exploration. The missing ages are those age that have not representative lithology in the rock column due to erosion or non-deposition. In this type of column, the rock body is deformed (mainly expanded or exagurated according to time span of depostion) to fill the age in which it deposited (wheeler, 1953). In Iraq, most of the missed ages (unconformities) are indicated between the formations by Bellen et al (1959), Buday (1980) and Jassim and Goff (2006).

According to North American Stratigraphic Code (1983), chronostratigraphic units are bodies of rocks established to serve as the material reference for all rocks formed during the same span of time. Each of its boundaries is synchronous. The body also serves as the basis for defining the specific interval of time, or geochronologic unit represented by the referent. In the mentioned Code, it is cited that the purpose of these units are to be used as a means of establishing the temporally sequential order of rock bodies. The same Code farther added that the principal purposes are to provide a framework for (1) temporal correlation of the rocks in one area with those in another, (2) placing the rocks of the Earth's crust in a systematic sequence and indicating their relative position and age with respect to earth history as a whole, and (3) constructing an internationally recognized Standard Global Chronostratigraphic Scale.

The present study tries to update and modify the column in order to include all the recent studies (they are indicated in the text and diagrams as “st”) and agree with new development of the tectonic setting of the area. The study mainly limited to the northeast Iraq where the most recent studies (that are relevant to the subject) are conducted (Fig.1). Even, in this area each part (Arbil and Sulaimanyia Governorate) need their specific chronostratigraphic column but now both are represented by one column until the adequate concerned sedimentologic and stratigraphic projected are conducted.

The time expanded stratigraphic (time-stratigraphic) column of Iraq and Northeastern Iraq was established in the fifties of the last century by Bellen, *et al* (1958) (Fig.2 and 3). During this long time, the column remained nearly without main changes which are widely used for teaching, academic purposes in all Iraqi university and for practical implication by petroleum and other economic companies. These columns can be called wheeler diagram in honor to H. E. Wheeler (1953) who showed that these columns consist of two axes: time as vertical axes and horizontal one as geographic (spatial axis) extend. He clarified that the disadvantages of these columns are the deformations of rock bodies that deposited in certain time. He added that these deformations are not occurring in normal stratigraphic (lithologic) column in which erosion and no-deposition are shown as zero thickness.

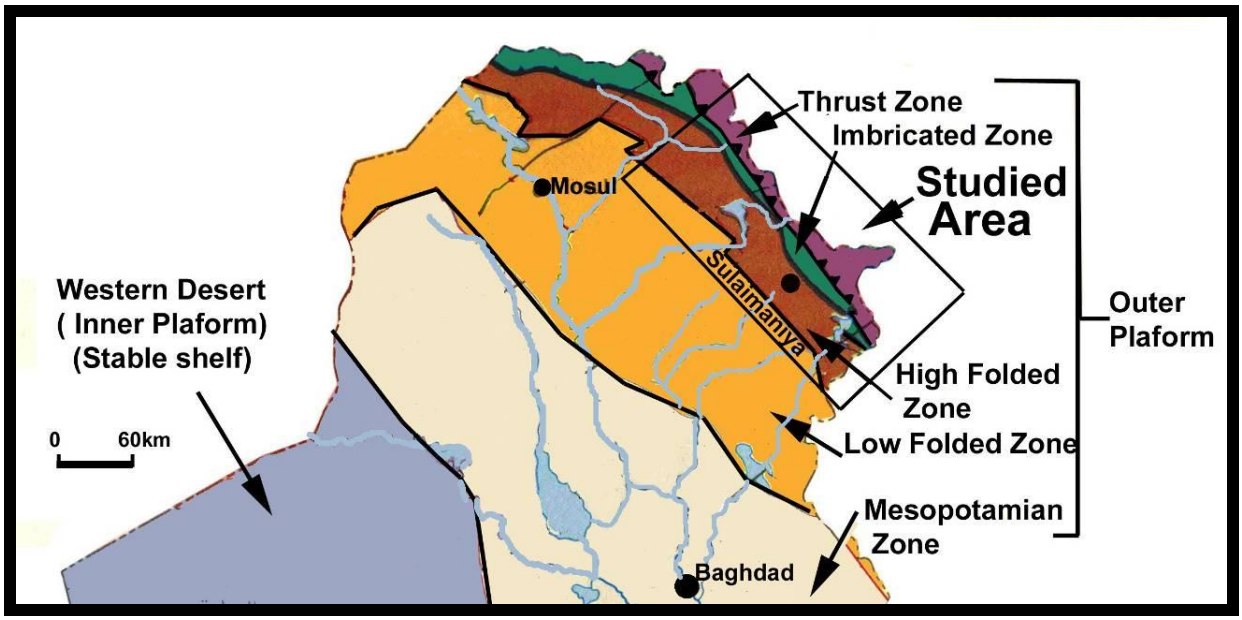

Fig.1: Tectonic subdivision of North Iraq (Simplified Al-Kadhimi et al., 1996) showing the studied area. The Inner and outer platform terms are from S. F. Fuad: Personal communication

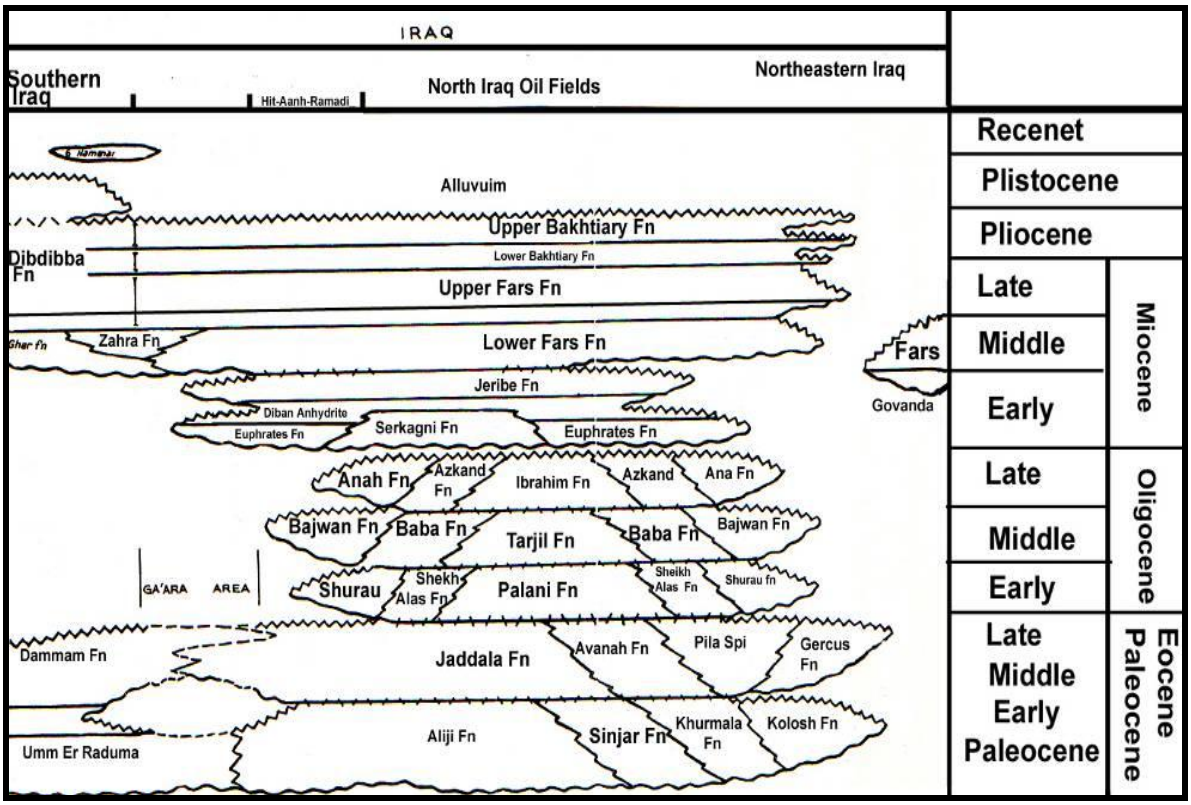

Fig.2: Tertiary Chronostratigraphic column of Iraq including Northestern Iraq (Bellen *et al*, 1959).

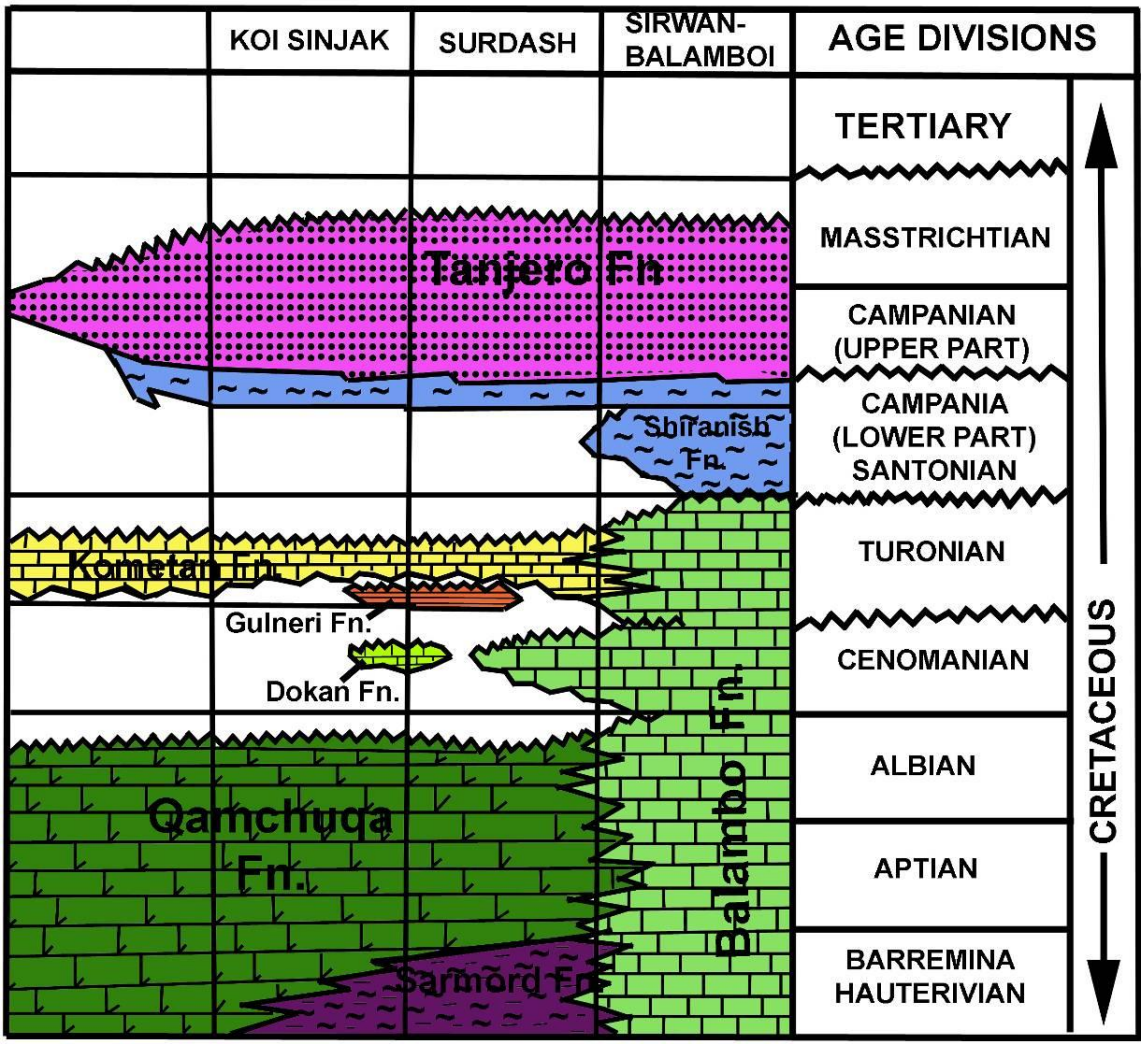

Fig.3: Cretaceous Chronostratigraphic column of Northeastern Iraq (Bellen *et al*, 1959)

DISCUSSION

In the recent years many sedimentologic and stratigraphic papers are conducted on the studied area that make the present modifications are possible. These studies are shown by numbers and letters (st_1, st_2….) on the modified column and on the area where the modification are made (Fig.4). The recent relevant studies that are used for modification are:

1-The study of Karim(2004) (St_1) and Karim and Surdashy(2006) in which the Wheeler column (diagram) is drawn for northeast Iraq in which 500m of conglomerate is correlated and combined ,in Chuarta-Mawat area (Imbricate and Thrust zones), with 400 of sandstone and shale in Dokan areas and South of Sulaimanyia City (High Folded Zones). In the column a gap of about 1million years (at proximal area near the coastal area) is shown within Tanjero Formation in the Chuarta-Mawat and become conformable in the south of Sulaimanyia and Dokan Area (distal area: basin and slope areas). On the column, the gap is widening toward Coastal area and tightens toward the basin (Fig.5).

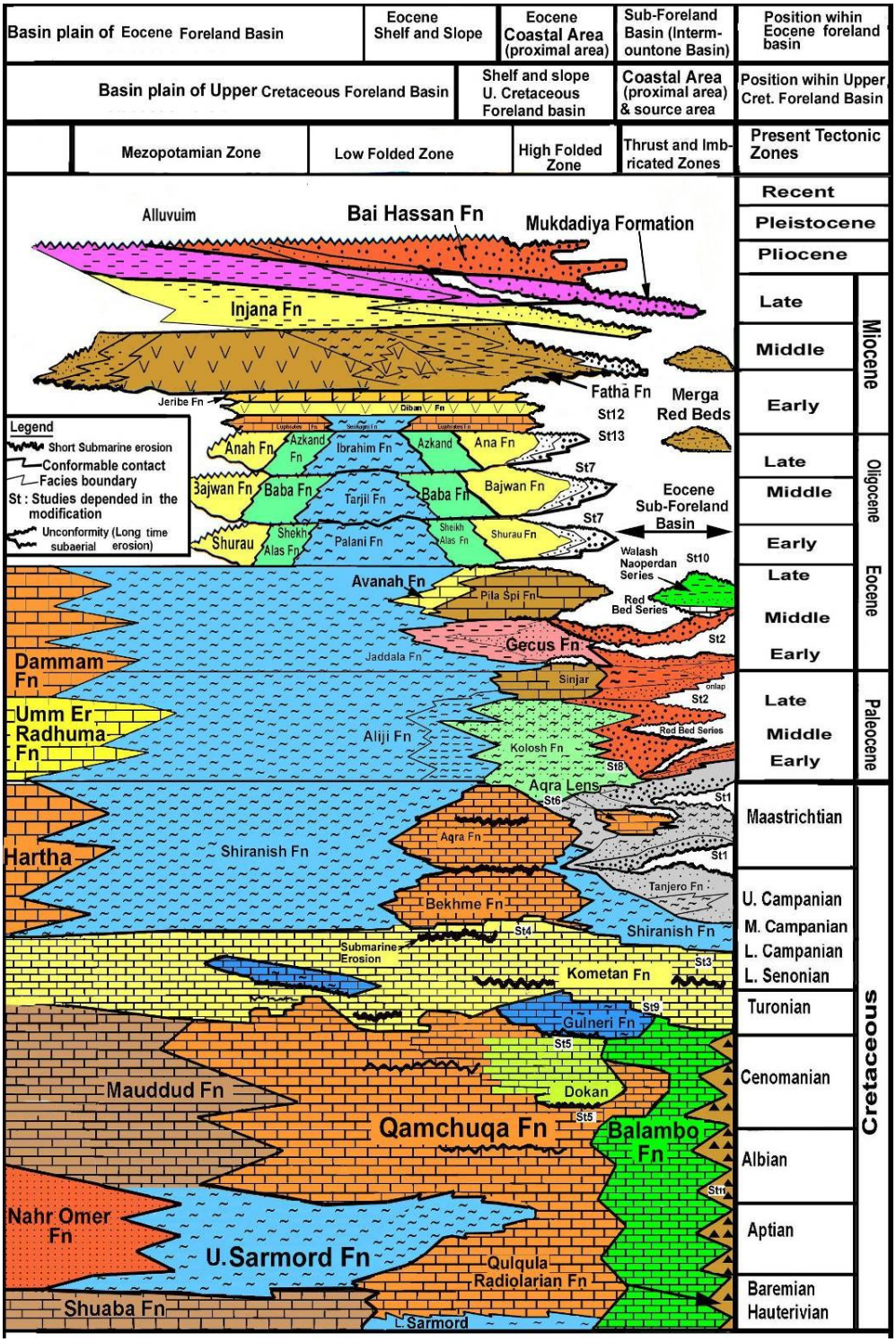

Fig.4: New chronostratigraphic column of Northeast Iraq in which the stratigraphy of the Imbricated and Thrust Zones are shown and most of the previous unconformities in the High and Low Folded Zone are rejected (modified from Bellen *et al*, 1959 and Omeri and Sadiq, 1977).

2- The study of Al-Barzinjy (2005) (St_2) which is concerned with Paleocene-Eocene and studied the Red Bed Series in Sulaimanyia governorate in the view of sedimentology, tectonics and sequence stratigraphy. Red Bed Series was remained mysterious units as concerned to its tectonic and lateral relation to other units. Previously no one has correlated (as concerned to basin and facies changes) this unit (in the Imbricated Zone) with other units of the same age in the High Folded Zone. But the in the st2 study, it combined basins of the lower part and upper part of Red Bed Series with Kolosh and Gercus formations respectively. It also put the basin of the Kolosh Formation and the series in one single basin (Paleocene Foreland Basin) and considered them as lateral facies of each other (Fig.6). It showed the possible gaps by Diagram of Wheeler (1953) (Fig.7) .In the previous studies such as Lawa (2004) and Jassim and Goff (2006), the basin of the two units are separated by paleohigh.

3- The study of Karim, *et al* (2008) (St_3) in which the unconformable contact between Kometan and Shiranish Formations is refused and changed to conformable one. In this study six sections are studied only in one, short sub-marine gap is observed. Later, Taha (2008) found fossils (nanofossils) of middle Campanian age in a section at northwest of Sulaimanyia city and ascertained the result of the study of Karim, *et al* (2008). Previously, this age (Middle Campanian) is assigned as a gap by Buday (1980) and Bellen *et al* (1959).

4-The study of Ameen and Karim (2008) (St_4) in which the unconformity between Qamchuqa and Bekhme formations is changed to conformable one. Previously this unconformity is estimated to be about 18 million years between the two formations by Bellen et al (2008) Buday (1980) which extended from Cenomanian to Upper Campanian (Fig.3). The unconformity is previously based on occurrence of 20m conglomerate but in the all six sections that are studied by Ameen and Karim (op cit) it is not found.

5- The study of Ameen (2008) (St_5) in which the unconformity between Qamchuqa and Kometan and Dokan is changed to conformable. In this study it is shown that the Dokan Formation is a transitional facies between shallow facies (Qamchuqa Formation) and deep one (Kometan Formation).

6-The study of Sharbazhery (2008) (St_6) in which the unconformity between Tanjero and Kolosh formations is changed to conformable on the basis of the biozonation. In this study many species of planktonic formas (Fig.8) are found in the sediment of Danian that survived during this age. This age is previously assigned as a gap.

7- The study of Baba Shekh (2006) (St_7) and Ameen (2009) in which it is mentioned that the Oligocene rocks are occurring near Draband Bazian and in the southeast of Sangaw towns. The first study found Oligocene rocks between two conglomerates. These two studies are indicated on the modified column (Fig.4) by (St7).

8-The study of Karim et al (2007)(St_8) in which the possibility of concurrent deposition of the molasse and flysch sediments is discussed in same basin as lateral facies of each other during Late Cretaceous and Paleocene in Northeastern Iraq. By this work, the present author is able to modify the relation and distribution of Paleocene and Eocene units in Thrust, Imbicated and High Folded Zones (Fig.4).

9-The study of Taha (2008) and Taha and Karim(2009) (St_9) in which it is shown that the unconformable upper and lower contact of Gulneri formation is changed to conformable one with Dokan and Kometan formations respectively. It is proved that the previously mentioned conglomerates are nothing except diagenetic ball-and pillow structures. In this two studies, the previous ideas are refused that the Gulneri and Dokan formations are deposits of small and euxinic basin that are bounded by unconformity from all sides as assigned by Bellen *et al* (1959) Fig.(3). Taha (2008) has shown that both formations deposited in large foredeep basin during post drowning and drowning phase of Arabian Platform (as represented by Qamchuqa and Gulneri formations) respectively.

10-The study of Karim (2007) (St_{10}) in which the relation between Walash Naoperdan Series with both Pila Spi and Sinjar formations are discussed. It showed that during Middle Eocene the boundary between Imbricated and High Folded Zone was uplifted and divided the Zagros Foreland basin into two basins. In the northeastern and southwestern basins, Walash Naoperdan Series and Pila Spi Formation are deposited respectively (Fig.4 and 9).

11-The study of Karim and Baziany (2007) (St_{11}) in which the Qulqula Conglomerate Formation is combined with Red Bed Series and proposed to remove the formation in the stratigraphy of Iraq. Therefore, the formation is not shown in the modified column while the Qulqula Radiolarian Formation is shown as equivalent of Sarmord and Balambo formations (Fig.4).

12- The study of Aghwan and Abdul Rahman (2008) (St_{12})) in which, succession of Burdigalian stage (represented by Euphrates and Diban formations in the Northeastern Iraq(Kor Mor Oil Field) are found in the Low Folded Zone in the studied area. Due to this study, the author is able to insert the above formation in the new chronostratigraphic column of the Northeastern Iraq (Fig.4).

13- The study of Khanaqa et al (2009) (St_{13}) in which, for the first time, the Oligocene rocks (represented by Anah and Ibrahim formations) are found in the High Folded Zone. In the previous studies the extent of the Oligocene rock not exceeded Low Folded Zone. Due to this study, the author is able to extend the distribution of the Kirkuk Group further toward northeast in the High Folded Zone in the chronostratigraphic column (Fig.4).

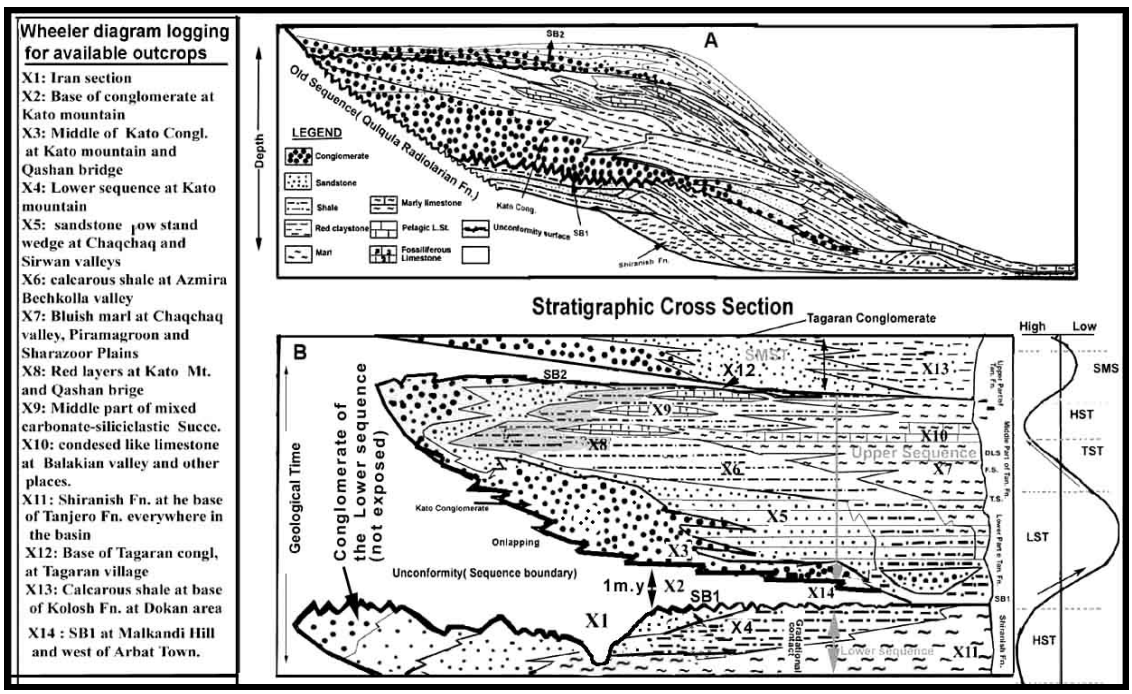

Fig.5: A) Topographic (geographic) cross section of Tanjero Formation. B) Time expanded (Wheeler) Diagram shows the unconformity at the lower part of Tanjero Formation which at X1 exists between Tanjero and Shiranish formations. The conglomerate of the lower sequence is also indicated (modified from Karim, 2004).

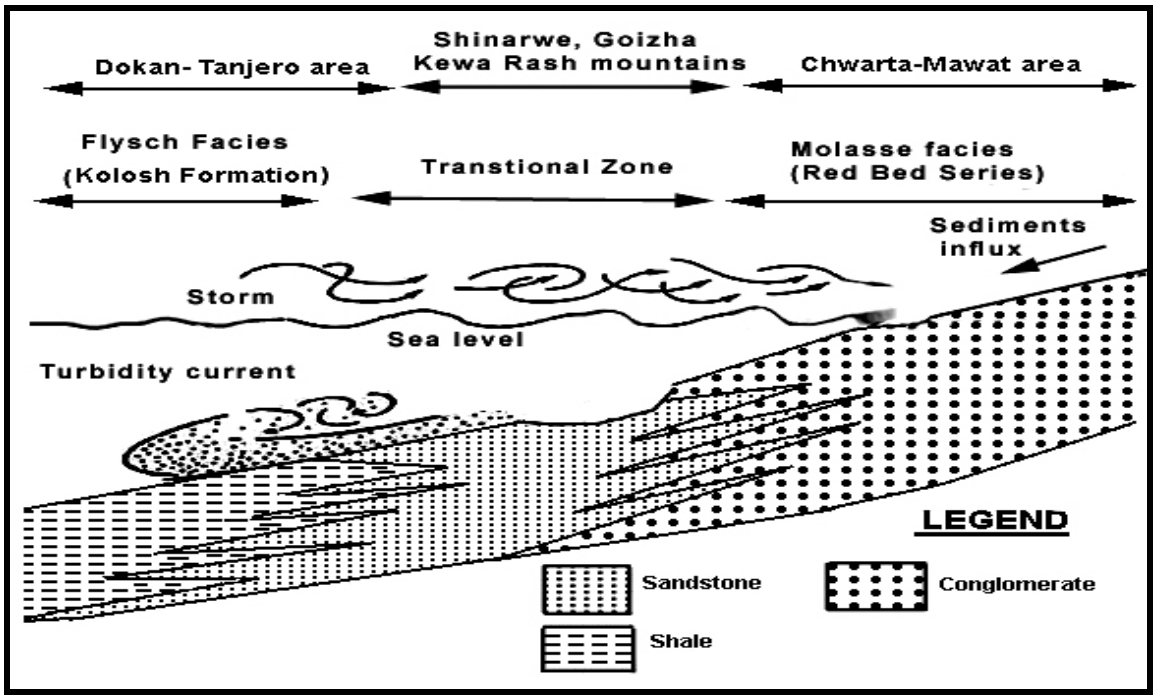

Fig.6: Simplified cross section of Chuarta and Sulaimanyia areas showing possible relation between Kolosh Formation and Red Bed Series during Paleocene (Al-Barzinjy, 2005).

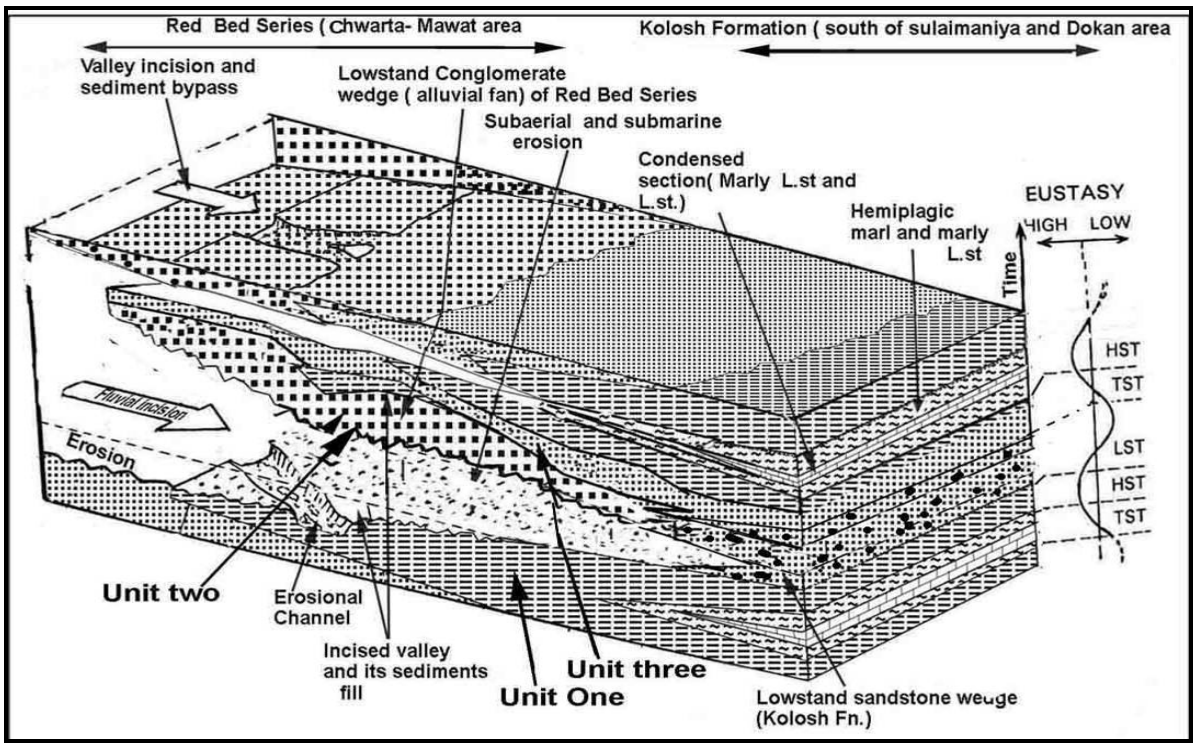

Fig.7: Chronostratigraphic (Wheeler) diagram which shows two unconformities in the lower part of Red Bed Series (Al-Barzinjy, 2005).

METHOD OF MODIFICATION

The modifications are not dependent competently on the aforementioned studies as the modification is aided by field studies of the author in the studied area for tens of years. This is including checking and evaluation of the result of the above studies (st). The paleontological results are inspected by the author for their compatibility with the tectonic and Sedimentology of the area. Another checking is to see if the modifications agree with the stratigraphy of neighboring regions in Iraq. For this, the *boundary conditions* of the modified contacts are checked between formations. The study of the boundary condition is aimed to fine equivalents or products of the previously mentioned unconformities. If an unconformity (erosion or non-deposition) exists in a place, the equivalent (sediments or paleosoil) of this unconformity must be present in other places around the claimed conglomerate.

When an unconformity is assigned such as the previously mentioned gap between Qamchuqa and Bekhme formations (with 18 million years gap), the inspection of boundary condition is important for removal of doubt. The inspection includes search for the product of the 18milion years of erosion or non-deposition. The products (as clastic sediments or intense karstification or paleosoil) of this long time must be enormous and clearly observable in the surrounding areas in outcrop and wells. But if the products are not found, this means that the unconformity is suspicious. Therefore, many unconformities, preciously assigned, now they are changed to either conformable or to very short duration of a local submarine erosion which indicated by short zig zag lines with in the modified column (Fig.4).

In the modification, the principles of the sequence stratigraphy are considered in which the deposited rocks "how it is thick or thin" are inserted between the time lines between which the rocks are deposited. Therefore, the thick and rapidly (during short time) deposited rocks have thin vertical representation on the column while the thin and slowly (during long time) deposited rocks have shown as thick interval on the column. Therefore, the thickness of 500m conglomerate of Tanjero Formation may be thinner (on the column in the figure 4) than 6.5m of the Gulneri and Dokan formations.

Previously, the unconformities in Iraq are assumed as regional such as that exist at Cretaceous-Tertiary boundary and that of Middle Campanian (between Shiranish and Kometan formations). Another example of such unconformities is that of Lower Cenomanian and Upper Campanian (Between Qamchuqa and Bekhme Formation). These unconformities, if true, they are local because till now no angular unconformities (which are mostly regional) are found in Iraq.

Now, the sequence stratigraphic models of the marginal basins such as foreland basins of Iraq during Cretaceous and Tertiary can be applied. In Iraq, the tectonically active coastal areas of these basins are located mainly in the northeast Iraq near the border with Iran (Karim, 2004 and Barzinjy, 2005). As shown in the modified column (Fig.4), many unconformities elongate from coastal area and they become conformable toward the basin center. But some of these unconformities are located in the Thrust and Imbricated Zones which are not included in the column of Bellen *et al* (1959). Compound unconformities (Potter and Pettijohn, 1977), is characteristics of some of these unconformities which may spit into several smaller unconformities toward the deeper water. Karim (2004) has observed this phenomenon in the Tanjero Formation which is represented by spliting of single thick conglomerate succession (in the coastal area in Chuarta-Mawat-Qandil area) into several relatively thin beds of conglomerates (separated by thick bed of shale or sandstone) in the deeper water of the formation. In the column, these compound unconformities are not shown but the simplified ones are inserted (Table 1 and fig.10).

In the modification the presence of index fossils for age determination and removal of unconformity is accepted as an undisputable fact. But the establishment of the unconformities on the basis of absence of index fossils is disputable and even danger. This is because the absence of index fossils does not

mean that the sedimentation is stopped or erosion is happened. The absence of the fossils many be due to the following:

1-The change of environment is important factor for absence of certain fossils such as those have short time duration. Previously some of the unconformities are indicated by absence of index fossils in the boundary between formations. Across the boundaries, the lithological change is due to environment changes. Therefore, disappearance of the certain fossils is attributed to environment changes not to erosion or non-deposition. The absence of fossils (when used for unconformities) must be aided by either terrigenous conglomerate and sandstone or karistfication and paleosol in nearby and surrounded areas.

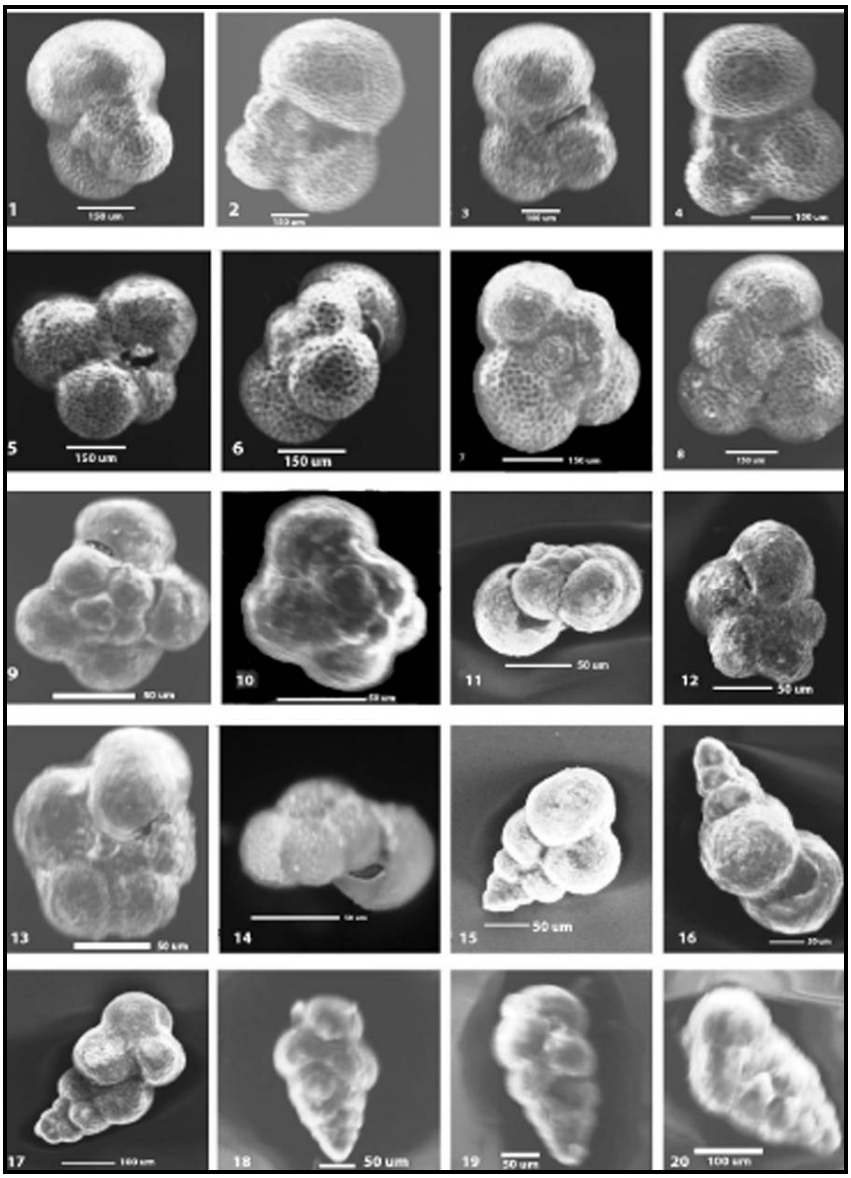

Fig. 8: Planktonic Foramineral species as indicators of the continuous sedimentation at the Cretaceous/Tertiary boundary (Sharbazery, 2008).

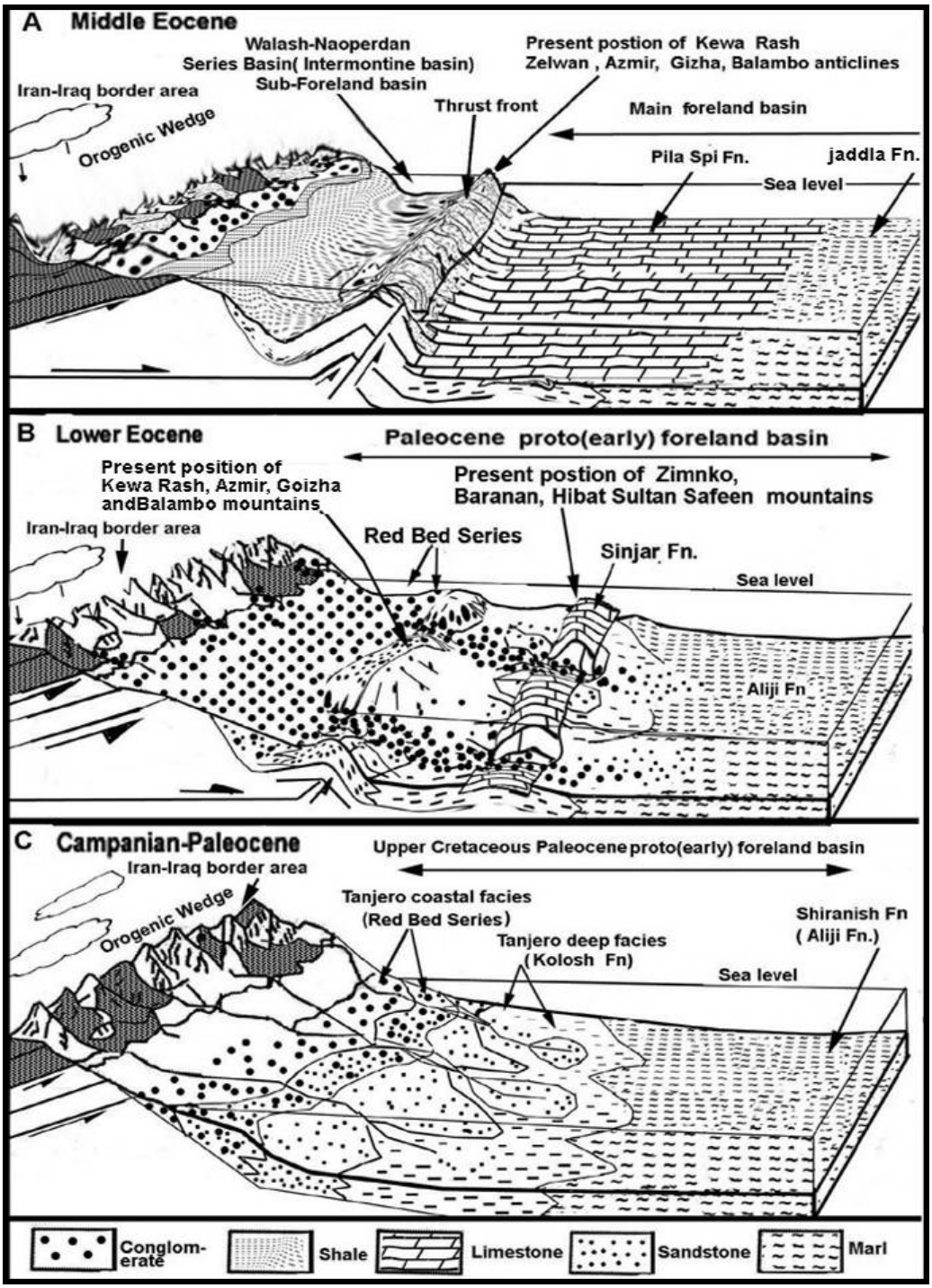

Fig.9: The conclusions of present study as shown by conceptual models of paleogeography and tectonic evolution of the intermontane basin in Iraq. A: Middle Eocene, B: Lower Eocene, C: Upper Cretaceous and Paleocene**.**

2- The diagenesis has great role in removal of fossils in certain rock intervals. This is very clear in the Kolosh Formation which in certain areas such as Sartak Bamo (25 km) to the east of Darbandikhan town) contain abundant well preserved index planktonic forams (Khafoor and Karim, 2000). But in the south of the Sulaimani City, 600m of the same formation of the same lithology (marl) contain no any index fossils.

3- The methods of the sampling and cooking may result in losing of the index fossils especially when the certain rocks contain scarce fossils.

4- The patient of the worker is also important especially when the rocks contain abundant silt and sand-size grains which cause relative dilution of the number of the fossils in the sample.

5- The wave, current and bioturbation have more or less negative role in the dispersal and mixing of microfossil in certain beds. Now it is known that even very deep water sediments can be affected by deep marine erosion by deep marine currents.

Table (1) Stratigraphic position and geographic location of the dependent (in modification) conglomerates in the present this study.

No.	Stratigraphic position of conglomerate	Maximum thickness	Location of the conglomerate as GPS reading	Paleocurrent (measured by imbricated pebbles)
1-	Lower Part of Tanjero Formation	500m	A) N: 35° 39' 13.22" E:45° 36' 12.76" B) N:36° 21' 41.28" E:45° 0.3 '50.40 C) N:36° 24' 59.60" E:44° 57 '06.23	Southwest
2-	Upper Part of Tanjero Formation	10m	N: 35° 36' 19.35" E:45° 32 '12.31"	South and southwest
3-	Lower part of Red Bed Series	20m	N: 35° 36' 28.1" E:45° 32' 13.31"	South and southwest
4	Upper part of Red Bed Series	1000m	N: 35° 22' 12" E:45° 12' 14"	Southwest
5	Inside Gercus Formation	60m	A) N: 35° 14' 56.82" E: 45° 46' 19.90" B) N: 34° 56' 55.99" E:45° 45' 08.89"	Southwest
7-	Base of Pila Spi Formation	10m	N: 36° 24' 19.73" E: 44° 20' 49.69"	Not measured
8-	Top of Pila Spi Formation (two beds separated by limestone)	7 m	N: 35° 38' 57.35" E: 44° 57' 16.69"	South and southwest
7-	Base of Fatha Formation	3m	N: 35° 38' 17.0I" E: 44° 58' 17.96"	South

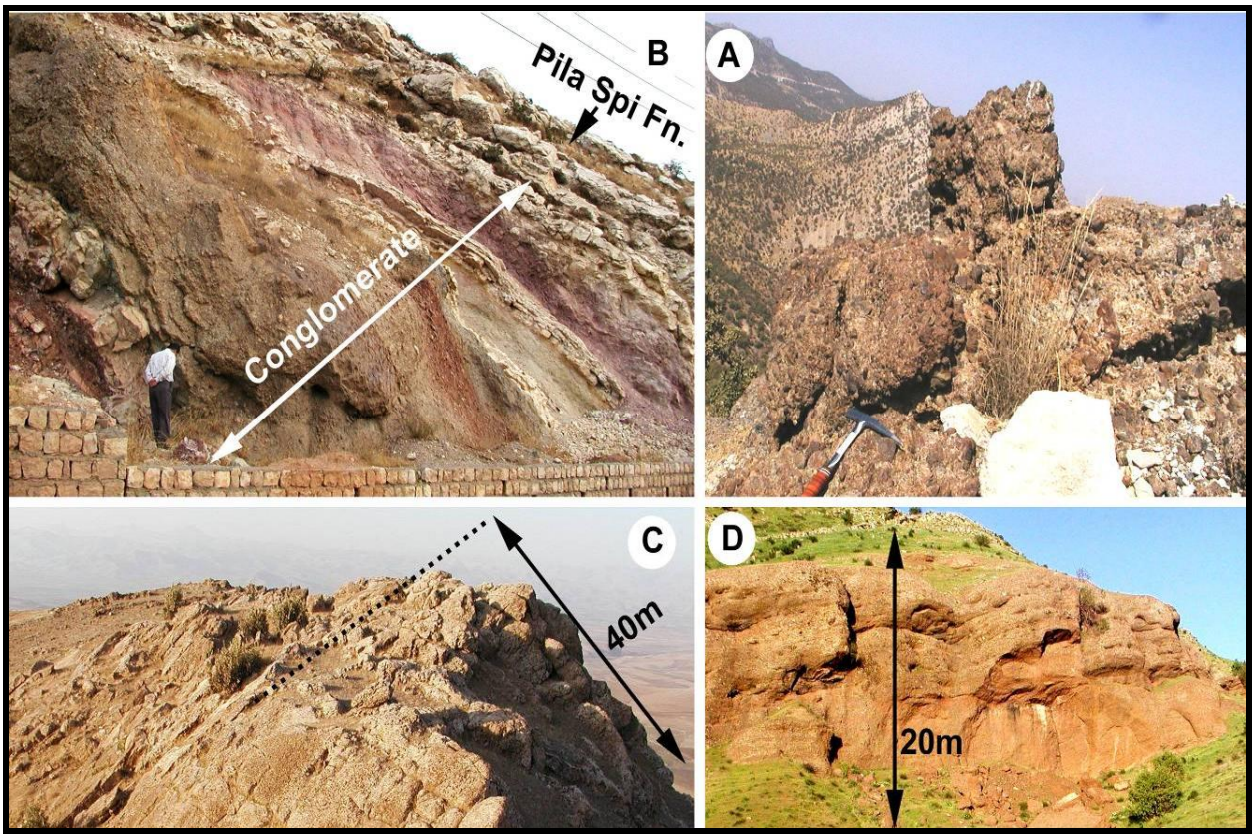

Fig.10: Some of the pebble and boulder terriginous conglomerates at different geographic locations and stratigraphic positions. A and B) At the base of Pila Spi Formation, at 7km to the west of Shaqlawa town and 10km south of Qaradagh town respectively. C) Inside Gercus Formation 15 km south of Zarayeen town. D) In the lower part of the Red Bed Series 5km south of Chuwarta town.

CONCLUSION

1-A New chronostratigraphic column of Northeast Iraq is drawn

2- In this column the relation between the stratigraphy of Imbricated and Thrust Zones with Low Folded Zone are shown.

3- Most of the previous unconformities in the High and Low Folded Zones are rejected while many unconformity are introduced in the Imbricated and Thrusted Zones.

4-The modification is compatible with new ideas of sequence stratigraphy, tectonic and sedimentology of the area.

5-The previous unconformities are based on the absence of the index fossils but now it known that there are several factors other than erosion or non-deposition that cause absence of index fossil.

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