NEW SEDIMENTOLOGIC AND STRATIGRAPHIC CHARACTERISTICS OF THE UPPER BOUNDARY OF QAMCHUQA FORMATION (EARLY CRETACEOUS) IN NE ERBIL, KURDISTAN REGION, NE IRAQ

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ABSTRACT

The contact between Qamchuqa (Early Cretaceous) and Bekhme (Late Cretaceous) formations is studied in the field and laboratory. On lithological basis, the contact is described and analyzed in four different sections. In all four sections, the result of the study showed that the boundary seems to be gradational; two of four sections (Zante gorge and Perse Mountain) are barren of conglomerate, breccias or erosional surfaces, so the contact seems to be conformable in the field. The other two sections (outlet and inlet of Bekhme gorge) contain beds of apparent conglomerate (or conglomerate-like masses), which in the present study are inferred to be not depositional, but diagenetic in origin. They are secondary ball and pillow structures, which formed during burial by lithostatic stress. In the inlet of Bekhme gorge section, there is a mass of breccia (about 1.5 m thick), which is located 10 m above the beds, which include ball and pillow structures. This breccia is not depositional as it consists of extremely angular clasts of limestone. These clasts are believed to be tectonic in origin and derived from younger beds, above the contact, which are not more than 20 m higher from their location. The clasts are transferred to this location, possibly by a reverse fault across Greatyer Zab river.

In contrast to previous studies, the contact suffered from deepening relative to the overlying and underlying Bekhme and Qamchuqa formations, respectively. This is manifested by green marl, marly limestone, limestone bearing planktonic forams and breccias. The soft succession at the boundary (about 30 m thick) is most possibly deposited during the previously suggested gap or unconformity.

خصائص رسوبية وطباقية جديدة للحد العلوي لتكوين قمجوقة (الكريتاسي المبكر) شمال شرق أربيل، إقليم كردستان، شمال شرق العراق

بختيار محمد أمين و كمال حاجي كريم

المستخلص

درس الحد الفاصل بين تكويني قمجوقة (الكريتاسي المبكر) وبخمة (الكريتاسي الأعلى) من الناحيتين الحقلية والمختبرية. وقد تم وصف وتحليل أربعة مقاطع صخارية في مناطق مختلفة. وفي جميع هذه المقاطع، تبين بان الحد الفاصل قد يكون سطح توافقي، حيث يظهر بشكل واضح بان مقطعي كلي زنطة وجبل بيرس خاليين من المدملكات والبريشيا أو أي سطح للتعرية. وفي المقطعين الآخرين، في مدخل ومخرج كلي بخمة، توجد طبقات تشبه المدملكات. أثبتت الدراسة الحالية بان هذه الطبقات ليست مدملكات رسوبية وإنما هي تراكيب كروية ووسائدية ذات أصل تحويري وليست رسوبية وتكونت من خلال عمليات الدفن العميق. وفي مقطع مدخل كلي بخمة توجد كتلة من البريشيا بسمك 1.5 م تقع فوق الطبقة الكروية والوسائدية بمسافة 10 م. وتعد هذه البريشيا ذات أصل تكتوني وليس رسوبي،

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حيث تحتوي على فتات من الحجر الجيري ذات زوايا حادة، وان مصدر هذا الفتات هو الصخور الأحدث الواقعة فوق الحد الفاصل بمسافة لا تتجاوز 20 م. حيث نقل الفتات من هذا الموقع، على الأرجح، بواسطة فالق عكسي من المحتمل تواجده في المنطقة.

إن الحد الفاصل بين تكويني قمجوقة وبخمة قد تأثر بعمليات التعمق النسبي للحوض الرسوبي وليس نهوضاً وكما ذكر سابقا. ويظهر هذا واضحاً من خلال وجود الطفل الأخضر والحجر الجيري الذي يحتوي على الفورامينيفرا الطافية والبريشيا. ان التتابع الناعم في الحد الفاصل (بسمك 30 م) قد ترسب، على الأرجح، أثناء فترة عدم التوافق المقترح سابقا.

INTRODUCTION

According to Bellen *et al.* (1950), the type section of Bekhme Formation is located in the Bekhme gorge, in the High Folded Zone (Fig.1). It consists nearly of the same lithology as that of Qamchuqa Formation. According to all previous studies, the Qamchuqa Formation is overlain by Bekhme Formation unconformably. Bellen *et al*. (1959) mentioned the occurrence of polygenetic and basal conglomerate and breccias (about 10 m thick) between the two formations. They mentioned that the conglomerate represents a gap, which extends from Late Albian to Early Campanian. Buday (1980) mentioned that the contact is, as a rule, unconformable due to occurrence of conglomerate at the base of Aqra – Bekhme Formation. Recently, Al-Qaradaghy (1989); Al-Qayim and Shaibani (1995); Omar (2006) and Jassim and Buday in Jassim and Golf (2006) have mentioned unconformable contact too.

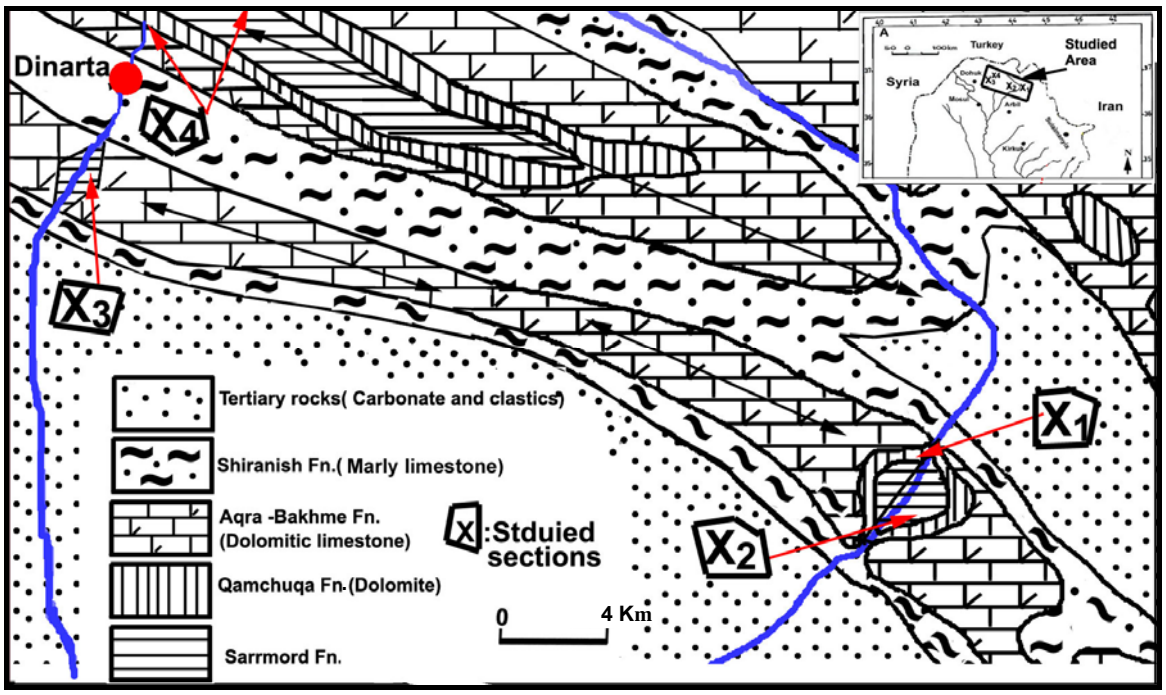

Fig.1: Location map and simplified geological map of the studied area
(modified from Sissakian, 2000)
X1, X2, X3 and X4 are studied sections of
inlet and outlet of Bekhme gorge, Zanta and Perse sections, respectively

LITHOLOGY AND STRATIGRAPHY OF THE BOUNDARY

Recently and during fieldworks, new observations are recorded in many different localities that show a probable conformable boundary between the two formations. Considering the basin analysis of northern Iraq, the boundary, in all observed sections seems to be continuous in deposition, which yielded more or less similar lithologies (Fig.2). The nature of the boundary is relatively soft, consists of marl, marly limestone; white and nodular beds of limestone with breccias. To explain why this contact was assigned, previously by all authors, as unconformable and repeatedly mentioned and ascertained to be represented by basal conglomerate, the following **eight** points must be taken in consideration:

The first point is, at the type locality of Aqra – Bekhme Formation, breccias and conglomerate-like beds of limestone are observed by present authors (Fig.3). These beds, most possibly, are those "sedimentary breccias and basal conglomerates" mentioned by Bellen *et al.* (1959) at the base of Bekhme Formation. The approximate location of the breccias and basal conglomerate as given by Bellen *et al.* (1959, p.61) has latitude 36^{o} 41' 45" and longitude 44^{o} 16' 30", which is located by GPS. These two lithologies are associated with bluish white marl and milky marly limestone. Field and laboratory studies showed that the observed breccias are not sedimentary but tectonic and occur at one section, out of four. This section is located at the right side (down stream) of the inlet of Bekhme gorge at the contact of the two formations and along the bank of Greater Zab River (Fig.4A). The development of the breccias (Fig.5) is attributed to a possible reverse fault that extends across the river bed and both sides of the gorge, directly south of the proposed dam site. The clasts of the breccias are extremely angular (show no transportation) and derived from the nearby beds (such as finely laminated and massive limestone clasts). The parent rocks of these clasts are located at younger level than the breccias, which are located no more than 20 m higher from the present location of the breccias. The most obvious evidence for the fact that the clasts are not sedimentary, is that their parent rocks (layers) are located, stratigraphically, in higher level (have younger age) than the position of the breccias. The younger stratigraphic position of the parent rocks of the breccias is very clear along the inlet of Bekhme gorge. When stepping 300 m from the upper part of Bekhme Formation to the lower part, along the stream, three beds (each 10 cm thick) of grey laminated limestone can be observed in their depositional place near the contact (Fig.4A). After that, blocks of breccias appear at 20 m above the laminated limestone. The breccias contain clasts (2 – 5 cm in size) of the same lithology of the laminated limestone (Fig.4B). It appears that the movement along the fault has transferred the clasts of the breccias to a location that is stratigraphically older than the original parent rocks of the clasts. Consequently, the clasts are lithified to form fault breccia. The presence of the blocks in the zone of the boundary between the two formations is attributed to the softness of the boundary, which can act as a host for foreign bodies. The marly boundary is cited by Bellen *et al*. (1959) and Sissakian and Youkhanna (1984) and was seen by the present authors in all sections, as shown in Figs. (2 and 4).

The second point is the described conglomerate by Bellen *et al.* (1959) and seen by the present authors is not sedimentary in origin. They are ball and pillow-like structures, which are formed by the pressure due to presence of alternation of competent limestone beds with incompetent beds of marl (Fig.3). The origin of these conglomerate-like structures (ball and pillow) is described in detail by Karim (2006) in Tanjero and Kolosh formations. He found these structures in sandstones and limestones; the development of these structures is attributed to the stress during burial (Fig.6). Tucker (1991, p.163) mentioned that pelagic limestones (present marl and marly limestone) are characterized by nodular structure, which is surrounded by pressure solution clay seams.

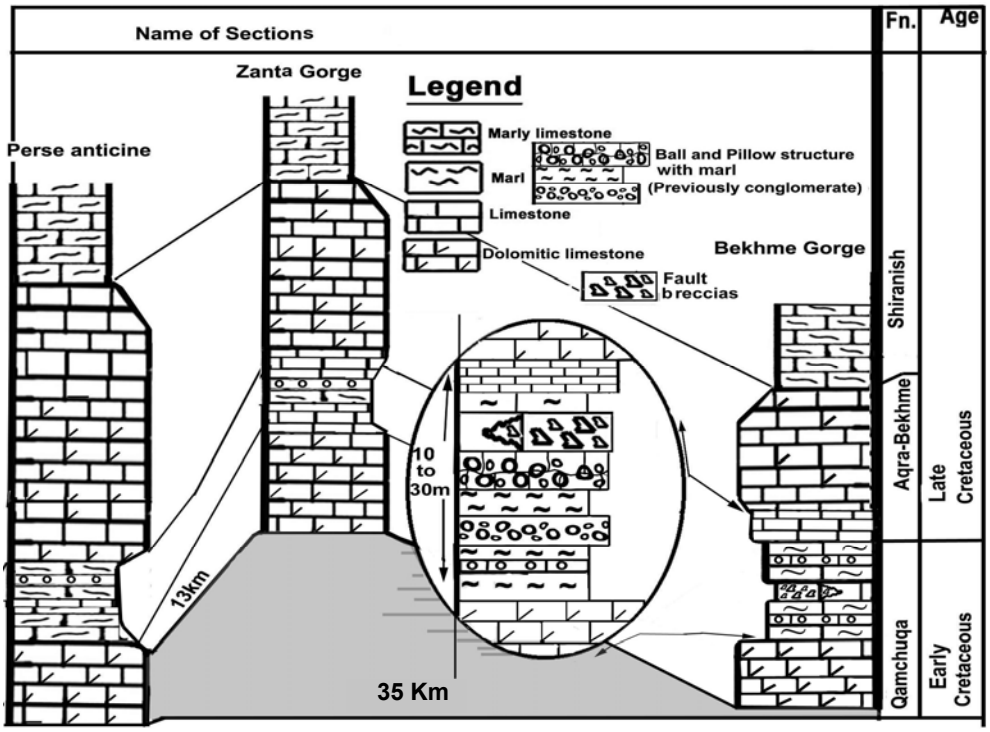

Fig.2: The nature of the boundary between Qamchuqa and Aqra – Bekhme formations at three different sections in Bekhme and Zanta gorges and Perse anticline

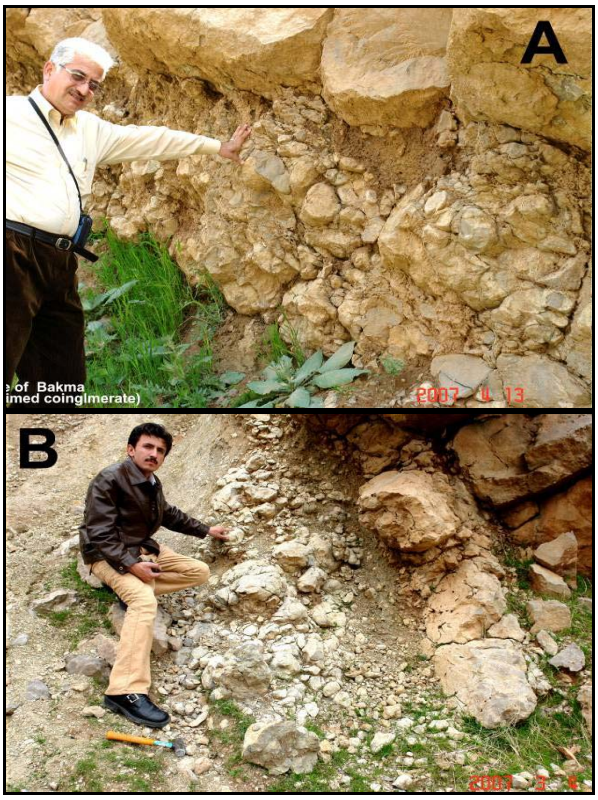

Fig.3: Boundary between Qamchuqa and Aqra – Bekhme formations in two different sections, which are showing secondary ball and pillow-like structures, previously might be assigned as depositional conglomerate
A) Bekhme outlet; B) Bekhme inlet (according to stream flow direction)

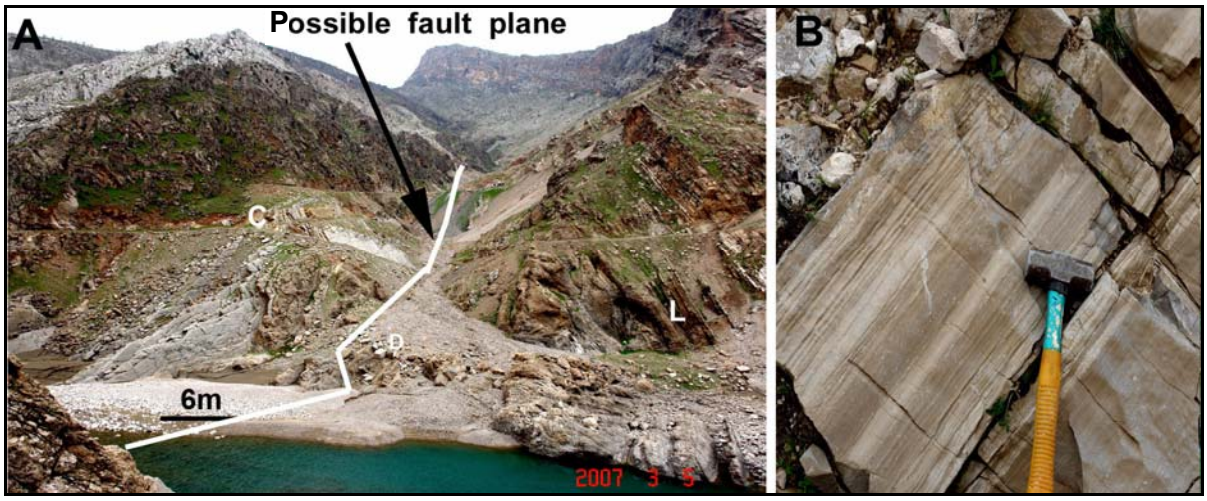

Fig.4**:** A) Boundary between Qamchuqa and Aqra – Bekhme formations at Bekhme inlet (according to stream flow direction) showing location of Ball and Pillow-like structures (**C**), breccias (**D**). The trace of the possible reverse fault is indicated across the valley surface by white line.
B) Close-up photo of laminated limestone beds (**L**).

Fig.5: Extremely angular fault breccia between Qamchuqa and Aqra – Bekhme formations in the left side of inlet of Bekhme gorge
A) All clasts are derived from nearby laminated beds.
B) All clasts are white, thin beds of limestone that are located in a higher stratigraphic level.

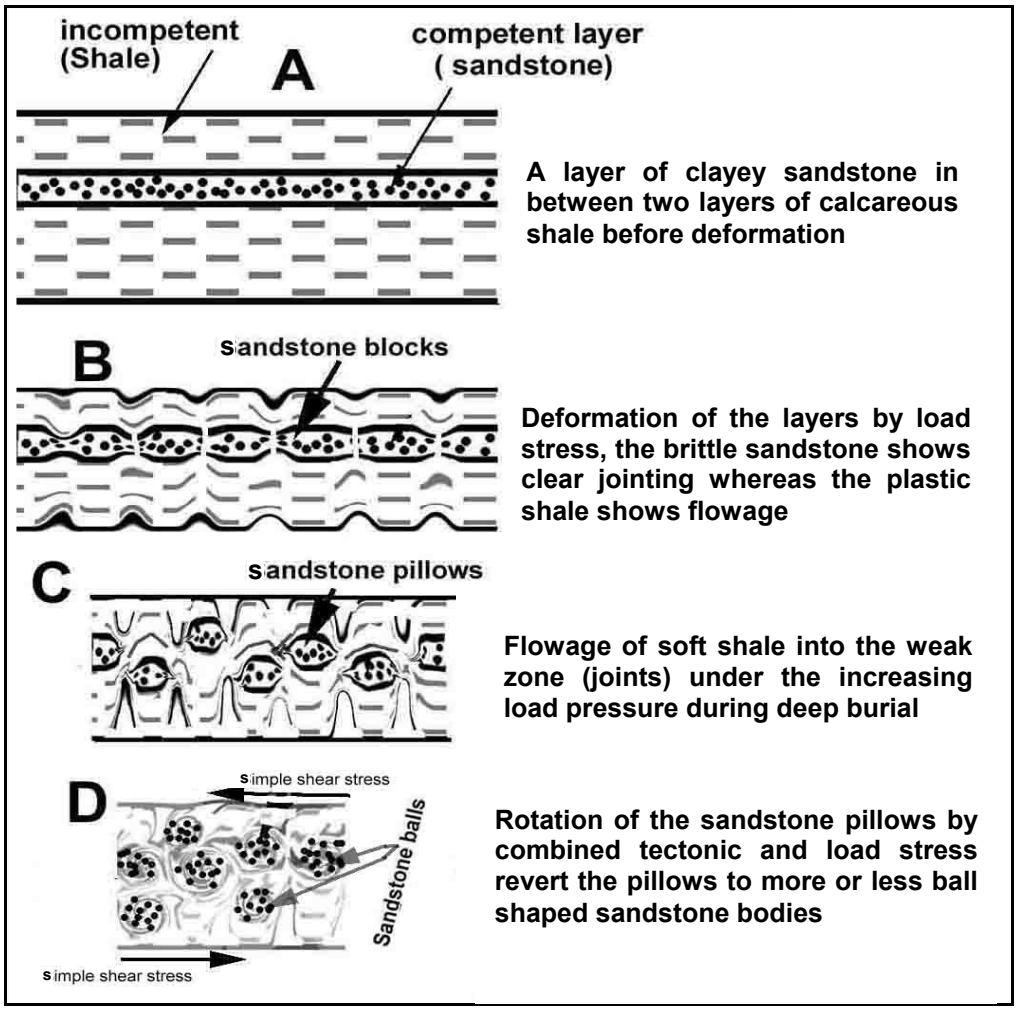

Fig.6: Four stages of development of Ball and Pillow-like structure by non-tectonic stresses, when competent and incompetent beds are associated (Karim, 2006)

Bellen *et al.* (1959) have mentioned variable characters and thicknesses for the conglomerate, even over very small exposed area from the Bekhme gorge section. They added that the conglomerate changes laterally to marl and in other place it is 3 m thick and laterally changes to massive bed of about 20 m thick. These conglomerate-like masses, in the present study, are found (as beds) in three localities in the inlet and outlet of the Bekhme gorge. At these localities, the white and rounded ball and pillows are concentrated in marly matrix as beds of limestone about (0.2 – 1) m thick (Figs. 4 and 7). These balls and pillows are very similar to the sedimentary conglomerate in appearance, but in close looks and under microscope they consist of the same lithologies (fine crystalline limestone with same type of planktonic forams). Tucker (1990, p.163) described deep water limestones (pelagic limestones) and mentioned that they contain nodular limestone, which is surrounded by clay due to pressure solution.

Fig.7: Conglomeritic-like Ball and Pillow structures formed in marly limestone bed near the boundary of the two formations

The third point is, the claimed or assumed conglomerate, by previous authors, (present Ball and Pillow-like structure) is located inside the bluish green marl, which contains planktonic forams. Moreover, it is not associated with sandstone or sand size clasts, this give another evidence of non-sedimentary origin for the conglomerate mentioned by Bellen *et al*. (1959) and other authors. The matrix of the previously supposed conglomerate is marl. The deposition of marl and conglomerate (gravels and boulders without sand) is abnormal, according to hydrodynamic and sedimentologic principles, if not associated with more or less sand size grains (Blatt *et al.*, 1980).

The fourth point is, in the 10 m thick lower division of Aqra – Bekhme formation, Bellen *et al.* (1959) mentioned the occurrence of marl and Globigerinal forams. It is clear that, the environment, across the boundary, is deepened instead of shallowing. Most possibly the environment changed from reef to fore-reef environment, in the boundary. In sequence stratigraphy literatures (Vail *et al.*, 1977; Loutit *et al.*, 1988; Haq, 1991 and Emery and Myers, 1996), the conglomerate is deposited during regression (lowstand systems tract). However, the coexistence of marl and planktonic forams in the boundary is evidence for transgression (high stand system tract) and deepening. But, the submarine erosions must not be excluded, which occur in many formations.

The fifth point is, in the Zanta gorge, 35 Km west of Bekhme gorge, neither erosional surface nor breccias or Ball and Pillows-like structure were observed in the contact. In this locality, the massive Aqra – Bekhme Formation is underlain, across the boundary, by well-bedded limestone and marly limestone, downwards by massive Qamchuqa Formation. Therefore, it seems that the contact is gradational in this locality (Fig.8).

The sixth point is, all previous studies have not shown any clear photos for the occurrence of conglomerates between the two formations. Omer (2006), however, showed two colored photos (Fig.9) for the unconformity nature of the contact between the two formations. However, none of them shows clear conglomerate, as the first one, which more likely appears to be solution cavity, is covered internally by white coating (Fig.9A). The second photo (Fig.9B) shows saccharoidal dolomite. This type of dolomite could be generated by groundwater erosion. Karim *et al.* (2000) found same type of dolomite (they called it friable dolomite) in Qamchuqa Formation in the southwestern limb of Piramagroon anticline. They attributed the generation of these friable dolomites to be due to the percolation of groundwater.

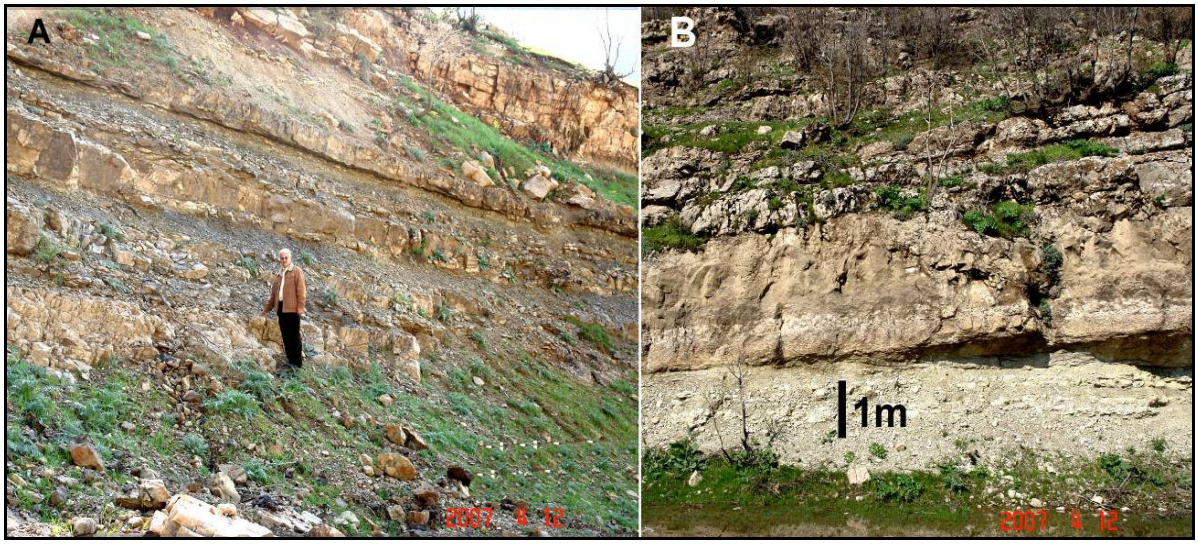

Fig.8: Boundary between Qamchuqa and Bekhme formations at southwestern and northeastern limbs of Perse anticline, northeast of Dinarta town.
The boundary consists of intercalation of marl and bioturbated dolomitic limestone, which is possibly gradational

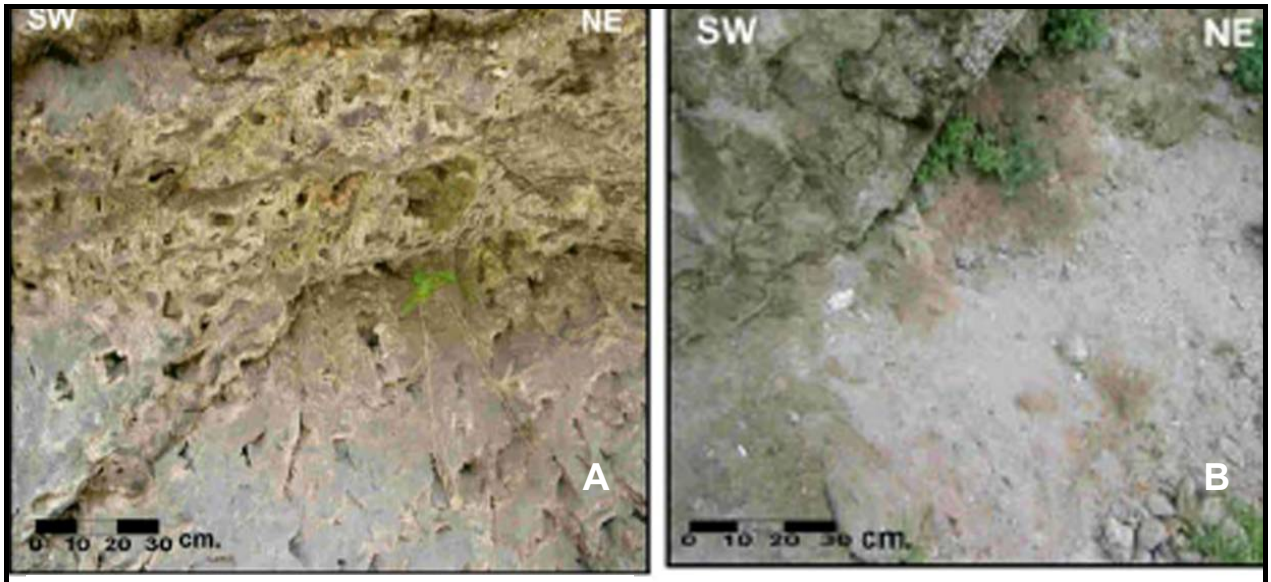

Plate (2.3): Basal conglomerate 4 m thick between Qamchuqa and Bekhme formations in Perse anticline contain clasts of limestone of Qamchuqa Formation

Plate (2.4): contact between the two formations in the Shakrok anticline composed of saccharoidal dolomite nearly (5 – 6) m thick

Fig.9: Two photos with their title and plate numbers, as presented by Omer (2006) for the unconformity between Qamchuqa and Bekhme formations

The seventh point is, Sissakian and Youkhana (1984) have mapped the area including Safeen, Harir and Shakrook anticlines. They neither found conglomerate nor erosional surface, between the two formations. However, they have found a succession of 65 m of soft rocks (green marl and marly limestone) that is located at the top of Qamchuqa Formation. They claimed Albian age to this succession depending on the recorded following fossils: *Orbitiolina* spp., *Valvulammina* sp., *Pseudolituonella* sp., *Pseudocgrysalidea* sp., *Orbitolina* cf. *discoidea* (GRAS), *Guneolina* sp., *Iraqia* sp., *Orbitolina* cf. *concava* (LAMARK). Moreover, they claimed unconformable contact between the two formations. But, the authors believe that some of the identified fossils indicate Cenomanian age and the soft rocks succession could be correlated with Kometan Formation, age wise.

The eighth point is, Al-Jassim *et al.* (1989) studied biostratigraphy of Kometan Formation in Qara Chuq well No.1 and Kirkuk well No.K166 (Fig.10). In these two wells they mentioned the following:

- The age of Kometan Formation is Late Turonian – Early Campanian.
- In the two wells, the Kometan Formation consists of shale and marly limestone.
- In the two wells, they did not observe any unconformity or missed ages from Turonian till Middle Campanian.

The results of the above study support the results of the present study by the following two points:

- Kometan Formation was continuously deposited in all parts of northeast Iraq, but as different facies. The well bedded limestone of the type section changes, in some place, to shale, marl and marly limestone as in the wells studied by Al-Jassim *et al.* (1989) and in the Qamchuqa gorge, as mentioned in the present study.
- If there is no unconformity in Kirkuk – Qara Chuq vicinity (as mentioned by Al-Jassim *et al.*, 1989) then why must be in the Bekhme gorge and extends from Late Albian to Early Campanian, as suggested by Bellen *et al.* (1959)? This gorge is only about 50 and 100 Km far from Safeen and Qara Chuq anticlines, respectively.

CORRELATION OF THE STRATIGRAPHIC POSITION

In the present study, samples were collected from marl, marly limestone and white limestone in the boundary zone between the two formations, but none of them yielded identifiable planktonic forams, as in studies of Bellen *et al.*(1959); Buday, (1980); Al-Qayim and Shaibani (1995) and Jassim and Golf (2006). They did not mention any index forams that are related to the boundary zones between Qamchuqa and Bekhme formations. As the authors are aware, the study of the Al-Qaradaghy (1989) did not record any index planktonic forams for age determination across the contact. The absence of index forams is attributed either to environmental constrain, which was not suitable for surviving certain organisms, or may be related to destruction by diagenesis. Therefore, the age determination and the correlation of the stratigraphic position of the boundary zone with other sections (of the same age) in the surrounding areas that are related to the claimed unconformity (or gap) are based on Bellen *et al.* (1959).

As previously mentioned, in Bekhme gorge there is about 30 m of soft lithologies between the two formations. In Kirkuk and Qara Chuq areas, same lithologies are recorded by Al-Jassim *et al.* (1989). These lithologies are nearly located in the same stratigraphic position and have the same age of the claimed unconformity. These lithologies are well dated by planktonic zonation in Kirkuk well No.K166 and Qara Chuq well No.1 (Fig.10). The

correlation is shown in Fig.(10) between these two wells, with the soft lithologies in Bekhme gorge in the boundary between the two formations.

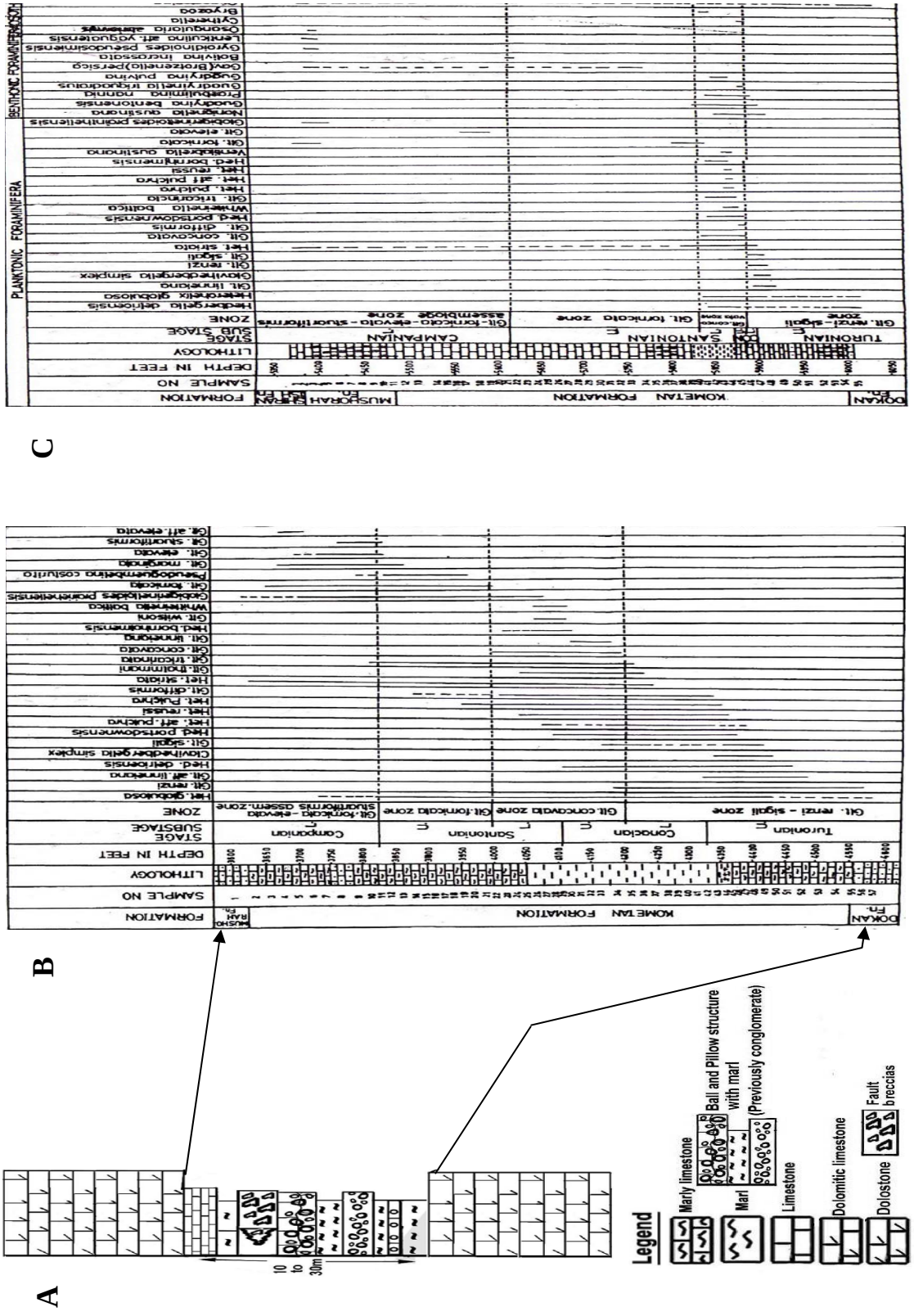

Fig.10: A) The boundary zone between Bekhme and Qamchuqa formations in Bekhme gorge.
B) Biozonation chart of Kirkuk well No.K166 (after Al-Jassim *et al.*, 1989).
C) Biozonation chart of Qara Chuq well No.1 (after Al-Jassim *et al.*, 1989).

It is possible that this gap coincides with the deposition of the relatively soft interval (marl, limestone and white limestone) that exists between the two formations in the four studied sections and as in Shaqlawa vicinity, where Sissakian and Youkhana (1984) have found soft facies (marl and marly limestone) in the uppermost part of Qamchuqa Formation, which may be the equivalent to the soft lithologies that are recorded in the present study in Bekhme gorge at the boundary zone between the two formations.

DISCUSSION

The possible results of the seemingly conformable boundary are manifested by the following three points:

- The first is, it may deny the long and huge gap that exists between Early and Late Cretaceous rocks in the studied area. This gap extends from Late Albian to Early Campanian (Fig.11) and persists for about 18 million years. The authors tried to prove that sediments of this gap do exist, therefore, we cooked samples from the marl, but the existed forams were not identifiable. This is also true for thin sections of the white limestone beds, which gave no evidences to contradict our suggestions. The clasts of the breccia contain planktonic forams that are younger than Cenomanian (Dr.K.M. Ismail, personal communication, 2008). This aids the present work, because the authors believe that the age of the boundary zone must be younger than Cenomanian. When the removal of this gap is accepted, then the whole stratigraphy of the area has to be changed and a new age determination and correlation will be very necessary.
- The second is, according to Bellen *et al*. (1959); Buday (1980) and Jassim and Goff (2006) the Qulqula Conglomerate Formation has age of Albian – Cenomanian and represents a tectonic movement during this interval. But, Baziani (2006) and Karim and Baziani (2007) denied the occurrence of the Qulqula Conglomerate Formation and requested to cancel it from the stratigraphic section of Iraq. Therefore, both, the present work and those of Karim and Baziani (op. cit.) are evidences for the absence of intense tectonic activity, which would be able to uplift and deposit conglomerates or to form a large gap that persisted for 18 million years (Fig.11).

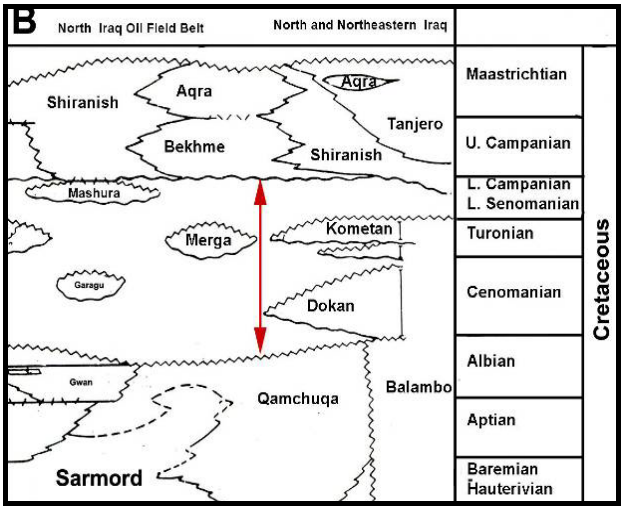

Fig.11: The time expanded stratigraphic column of Northern and Northeastern Iraq shows the position and extent of the gap (unconformity) (Bellen *et al.*, 1959)

– The third is, this gap, possibly coincides with deposition of the relatively soft interval (marl, limestone and white limestone) that exists between the two formations in the four studied sections and in Shaqlawa – Harir vicinity (Sissakian and Youkhana, 1984). Moreover, this succession may be the equivalent of the lowermost part of Kometan Formation, since part of the mentioned fossils by Sissakian and Youkhanna (1984) indicate Cenomanian age.

CONCLUSIONS

This study has the following conclusions:

- The previous unconformable contact between Qamchuqa and Aqra – Bekhme formations is re-studied in four sections. In all these sections no conglomerate or erosional surface was observed.
- This study inferred that the contact is most possibly conformable, which shows no sub aerial erosion. However, submarine erosion is not excluded. The breccia, which was found in the present study, is a fault breccia.
- The conglomerate-like structures that were found in the boundary zone are secondary (diagenetic) in origin, as they formed during burial by stress of the overburden and their ball-like shape is enhanced by weathering.
- The boundary zone, across the contact had suffered from deepening (deposited during highstand systems tract) in contrast to previous studies that claimed shallowing, which was assumed to be represented by conglomerate.
- A soft interval of marl and marly limestone occurs along the contact between Qamchuqa and Aqra – Bekhma formations, which makes the contact more clear and traceable, in the field.

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