Journal homepage www.jzs.uos.edu.krd
Journal of Zankoi Sulaimani
Part-A- (Pure and Applied Sciences)

Critical analysis of the type section of the Balambo Formation (Valanganian-Turonian), Sirwan valley, Kurdistan Region, NE-Iraq

Kamal Haji Karim[1], Aras Omer Al-Khafaf[1] and Khalid Ismail Sharnazheri[1]

[1]Department of Geology, University of Sulaimani, Sulaimani City

Kamal.karim@univsul.edu.iq

Article info

Original:
Revised:
Accepted:
Published online:

Key Words:

Balambo Formation, Kometan Formation, Sirwan valley, unconformity, Gulneri Formation

Abstract

The Balambo Formation (Garau Formation in Iran) and its equivalents such as Shuaiba, Qamchuqa and Mauddud are very significant formations since they occur nearly in all oil fields in Iraq and Iran. The first definition of its type section was carried out in 1947 in the Sirwan Valley on the southwestern limb of the Balambo Anticline, about 11 km to the southwest of Halabja town, 3 km to the east of Kawta village. In the present study, the first definition is critically analyzed in the field and laboratory by foraminifera and nannofossils aging. The analysis shows many problems in the thickness, stratigraphy, location and its relation to Kometan and Shiranish formations. Many structural and topographic characteristics (of the section) are shown to prove that the thickness of the type section is less than that indicated previously in the first definition. In the definition of the type locality, the Kometan Formation was not recorded, while the present study confirms its occurrence, with a thickness of about 80 m.. The lithological and Paleontological studies showed that the Kometan Formation has the age of Turonian – Late Campanian and has conformable contact with both Balambo and Shiranish formations. This does not coincide with the definition, which did not mention the Kometan Formation and recorded the presence of erosional unconformity (missing sediment of Santonian-Middle Campanian) under Shiranish Formation. The location of the type section is not clear and it is combination of the three different sections in three different areas which are located in the imbricated Zone. Topographically and structurally, the section is so complex that a nowadays geologists will never think to select it as a type section for definition a stratigraphical units.

Introduction

The studied area is located in the Northeastern Iraq and according to Buday and Jassim (1987) *[1]*, the studied area is located within the High Folded Zone and Jassim and Goff (2006) *[2]* included it in the Balambo-Tanjero Sub-Zone. The Balambo Formation was first described by Wetzel (1947 in Bellen *et al*. 1959) *[3]* from the Sirwan Valley about 11 km to the southwest of Halabja town, NE Iraq (Fig.1 and 2).

The age of the Kometan Formation is Valanganian–Turonian (Bellen *et al*. (1959). According to the latter authors, Kometan Formation is described by Dunnington in 1953 in Ranyia area about 400 m to the southwest of Kometan village at 36^{o} 24^{-} $25^{=}$ N and 44^{o} 48^{-} $15^{=}$ E.

In recent years and during field trip in the valley, many observations are recorded about the type section of Balambo Formation. These observations resulted in finding many geologic facts and features in the area of the type section of the latter formation that are contradicting original definition. These findings are requiring checking of the lithology, stratigraphy, thickness and ages of the formations. The following pervious citation and conclusions are treated in the present study (see detail in the section of the result and discussion).

1-According to Buday (1980) Kometan Formation is the most widespread Turonian Formation in Northern and Central Iraq. It consists of white-weathering, light grey, thin bedded, globigerinal-oligostiginal limestones. According to Wetzel (1947, in Bellen *et al*. 1959), the upper division of the Balambo Formation (Turonian) consists of grey, weathering white thin bedded-globigerinal limestone.

2-The shared species of planktonic foraminifera in Kometan Formation and upper part (deposited during Turonian only) of Balambo Formation are: *Globigerina Cretacea*, *Globotruncana bulloides*, *Globotruncana lapparenti tricarinata*, *Globotruncana lapparenti coronate*, *Rotalipora appenninica*.

3-The thickness of the Kometan Formation is about 36 m, deposited during Turonian-Santonian. This 36 m is deposited during 10 million years (Turonian-Santonian) in type locality in Qandil area (when data of Bellen et al., 1959*)* is considered). The thickness of the most upper part of the Balambo Formation is 315 m and deposited during 4 million years (Turonian) in Sirwan valley.

4-The Kometan and Balambo formations form small scarps and smooth weathering slopes, respectively.

5-The contact of Balambo Formation is erosional or non-depositional with Shiranish Formation and across this contact the sediments of Coniacian - Early Campanian is missing.

6- According to Dunnington (1958) the lithology of Albian-Cenomanian is marl in Sirwan valley (Fig.3).

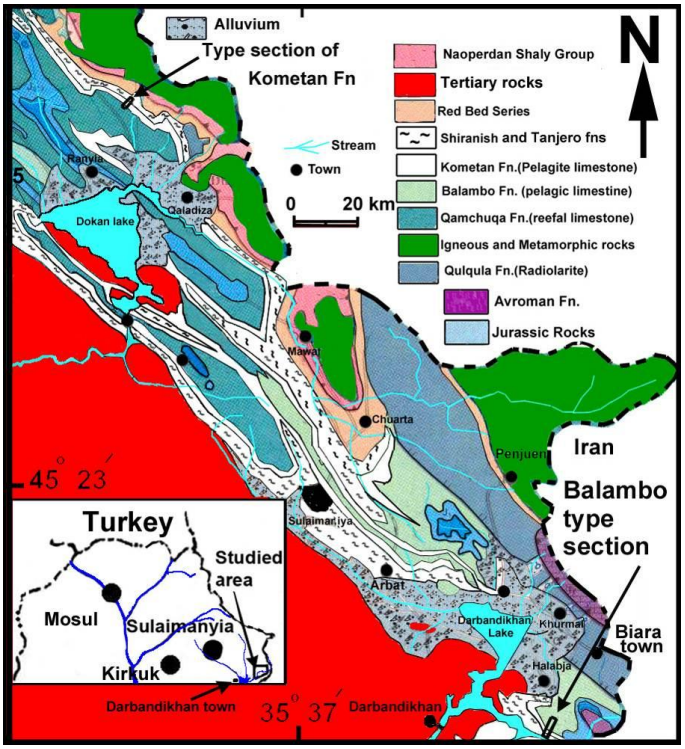

Fig.1: Geological map of the studied area (modified by Karim *et al.* 2008 from Sissakian, 200)

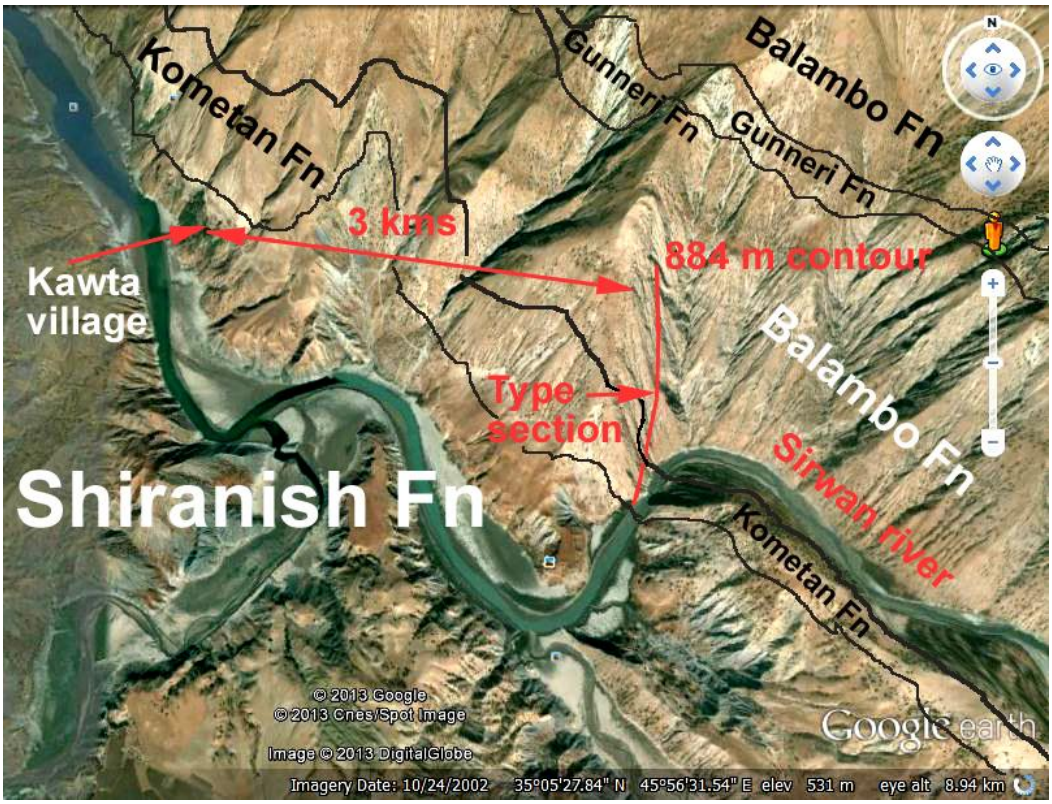

Fig. (2) Google Earth image of Sirwan valley shows location of the type section of Balambo Formation

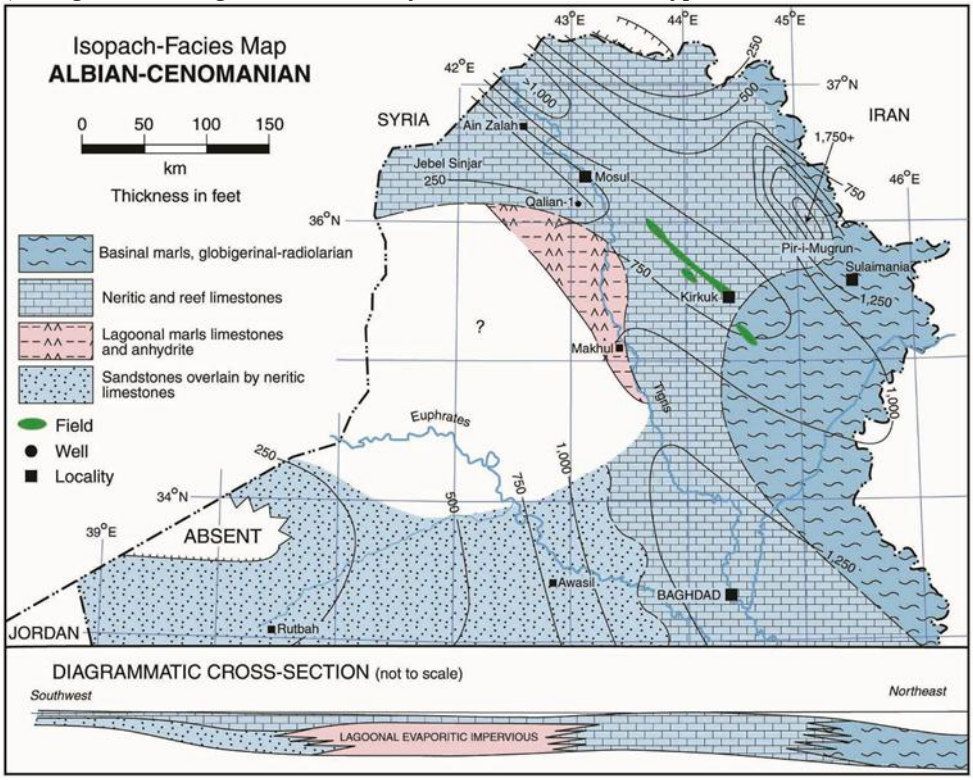

Fig.(3) Isopach facies map of Iraq shows that deposit of Sirwan valley is marl during Albian-Cenomanian (Dunnington, 1958).

Materials and Method of the study

The present study depends on field and lab works to differentiate the stratigraphic units and present them on the geologic map, photos and stratigraphic column. Additionally, the thickness, lithology, structure and geomorphology of the area around type section of the Balambo Formation are documented during the

fieldwork. The stratigraphy of the Sirwan valley is compared with the type section of the Kometan Formation. During the study, the equivalents of the Dokan and Gulneri formations are indicated too.

Seventy samples were collected from the type section of latter formation. The samples are inspected in the field by 10 X and 30 X hand lenses and thin sections prepared for all samples. The thin sections are studied under polarized and stereoscopic binocular microscopes by which the age and stratigraphy of the section is accurately indicated and index fossils were photographed. Five samples are taken for nannofossils age determination for those intervals that does not contain index foraminifera. The five samples are sent to Romania for nannofossils and age determination by Ramona Balc (ramona.balc@ubbcluj.ro) by preparation of smear samples. The results of the field and lab analyses are plotted on a geologic map and stratigraphic sections and field photos.

Results and discussion

In this study, the above mentioned six citations are discussed and the present study has added more scientific consequences to the stratigraphy, lithology, tectonic and paleogeography of the Balambo Formation. Moreover, the previous ideas about Balambo Formation and its relation with Kometan Formation are modified.

In the first point, it is clear that the lithology and age of the upper part of the Balambo Formation is similar to that of the Kometan Formation. The present study showed (by fossil indications) that the latter formation is similar to the upper part of the former one, as both contain same assemblage of planktonic foraminifera (Fig.4). Everywhere in northeastern Iraq, the two formations can be identified by 10 X and 20 X lens by the fact that the Kometan Formation contains abundant globotruncana (with relatively large size) while the Balambo Formation contain smaller foraminifera with radiolarian. Therefore, the present authors confirm that the upper part of the Balambo Formation is actually part of the Kometan Formation. The minor difference in the description is attributed to the fact that the two formations are described by two different authors (point six) and in two different times and areas, which are far from other for more than 200 kms.

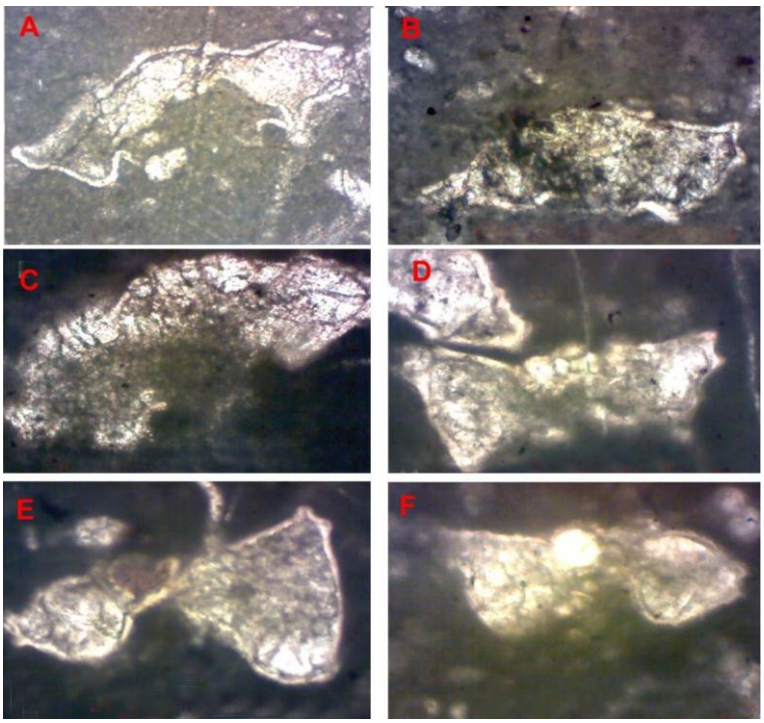

Fig. (4) Index foraminifera of type section of Balambo Formation shows that Kometan formation exists and there is no missed sediment from Turonian to Late Campanian. A: *Radotruncana calcarata* (Late Campanian), X40, Sample No.67. B: *Globotruncana venticosas* (Middle Campanian), X40, Sample No.59. C: *Globotruncana elevata* (Early Campanian), X40, Sample No.55. D: *Dicarinella asymetrica* (Santonian), X40, Sample No.43. *E: Dicarinella concavata* (Late Conacian), X40, Sample No.33. F: *Dicarinella primitive* (Early Coniacian), X40, Sample No.26

In the second point, it is clear that the fossils of the upper part of the Balambo Formation and that of the Kometan Formation are same. But, why did Wetzel included the Kometan Formation (in Sirwan Valley) in Balambo Formation?. The reasons are due to three facts; the first is that during the definition (in 1947) of the Balambo Formation, the Kometan Formation was not defined yet; as it is defined in 1953. The second fact is attributed to the structural complexity of the type section and surrounding areas. The field survey showed that the section measured by Wetzel contains more than four folds and two reverse faults (Fig.5 and 6). These structures are attributed to high intensity of folding; therefore, the present authors suspect that the very high recorded thickness of the upper part of the Balambo Formation is attributed to repetitions of the upper part by the above mentioned folds and reverse faults, which were most possibly not considered by Wetzel (1947 in Bellen et al. 1959). The type section of the Balambo Formation is located in Balambo – Tanjero Sub-Zone of Jassim and Goff (2006), which was mostly included in the Imbricate Zone. Therefore, the formation (including the outcrops of the upper part) is highly deformed, which shows fracturing, faulting and folding (Fig.5). From this figure, it can be seen that there is no any possible direction (traverse) to give suitable section for thickness measurement. The most important field observation is that the top of the Balambo Formation (Originally Kometan Formation) is dissected by a reverse fault by which the older rocks are brought at the contact with the Shiranish Formation. Due to this fault, Wetzel (1947, op cit) considered that the contact of the Balambo Formation is erosional or non-depositional with the Shiranish Formation and across this contact the sediments of Coniacian- Early Campanian is missing.

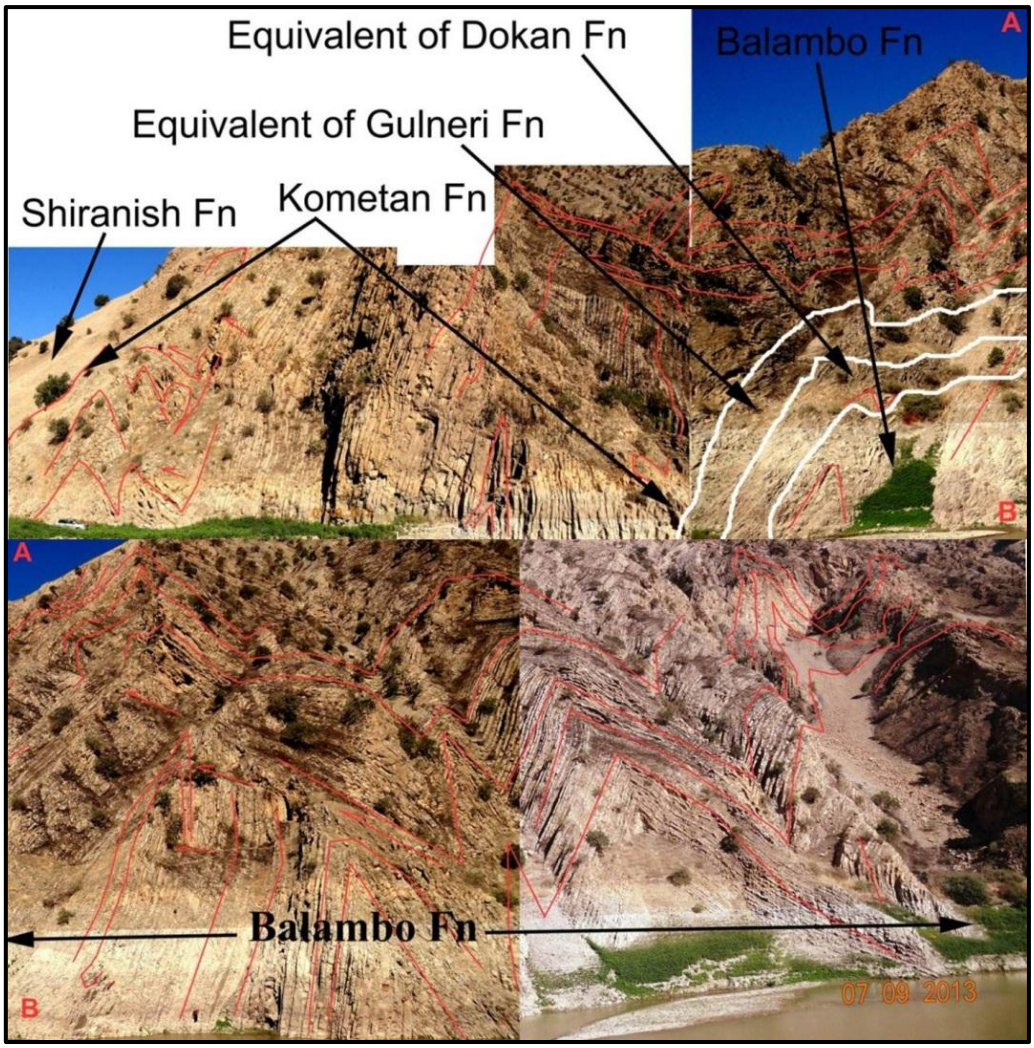

Fig. (5) Panoramic views of the type section and its immediate surrounding show the formations which prevent accurate thickness measurement and stratigraphical differentiation. The upper and lower parts can be combined along line A and B. The photo is looks north and taken from Iranian side of Sirwan River.

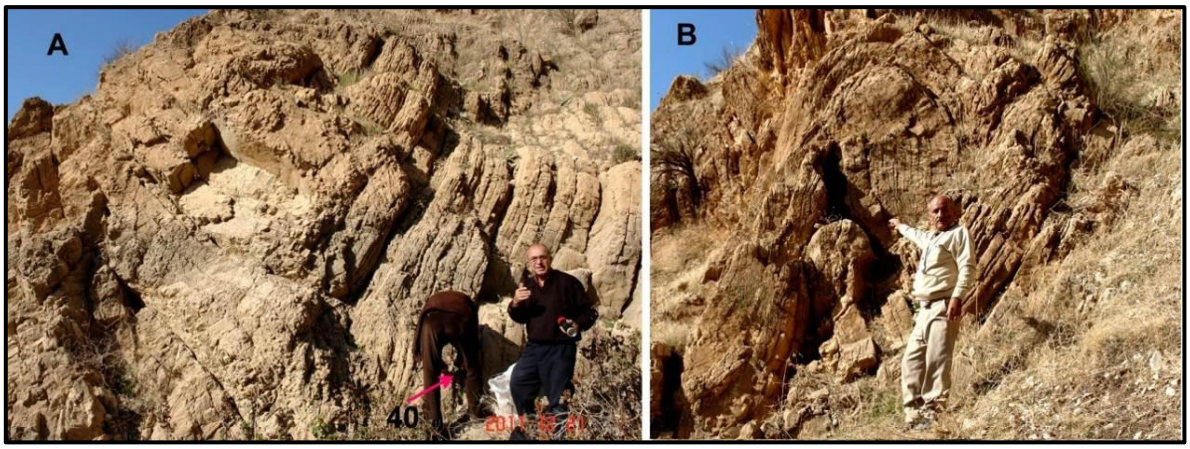

Fig.(6) Two folds in the in the upper part of the Balambo Formation (In the present study it is differentiated as Kometan Formation) along the type section.

Wtzel (1947, op.cit.) has not mentioned anything about the presence of the Kometan Formation in the area of the type section and in the whole area of Sirwan valley. The paleontology paleontological study of the collected samples from Sirwan valley and the studied section proved that the Kometan Formation exists and contains sediments of all ages that the absence of their sediments are claimed by latter author (Fig.4). The Kometan Formation, in the valley, has same age and lithology of its type section in Ranya Area. Previously, Karim *et al*. (2008) indicated the Kometan Formation in Sirwan valley and type locality (Fig.1).

In the point three, the low thickness and long time span of the Kometan Formation in the types section, opposes the very high thickness and short time span of the upper part of the Balambo Formation. This age difference of same lithology and nearly same fossil content is abnormal and needs accurate explanation. The rate of deposition of the Kometan Formation must be more than Balambo Formation as the latter was deposited in deeper basin than the former one. According to Buday (1980), the upper part of the Balambo Formation was deposited in an outer shelf to bathyal environment, relatively deep basin situated along the NE boundary of the Arabian Plate. When the time span and location in the basin is considered, the thickness of the upper part of the Balambo Formation (Turonian) must be no more than 20 meters. Therefore, this high thickness must be discussed and justified.

The thickness of the Kometan Formation, in the High Folded and Imbricate Zones rages between (100-120) m during Late Turonian–Early Campanian (Dunnington ١٩٥٨, Buday, 1980, Buday and Jassim, 1987). The rate of the deposition of the upper part of Balambo Formation was 80 mm/ kyrs while the rate of the deposition of the Kometan Formation was about 4 mm/ kyrs and in Dokan area was 12 mm/ kyrs. Therefore, when the average rate is taken (about 8 mm/ kyrs) the thickness of the upper part of Balambo Formation (Turonian) must be not more than 36 m. Similar rate of pelagic carbonate deposition is cited by many authors such as:

A-Accumulation rates for pelagic sediments are much slower than those of typical neritic sediments. An average accumulation rate for deep-ocean pelagic sediment is 0.5–1.0 cm per 1000 years (Taken from site of: *highered.mcgraw-hill.com/sites/dl/free/.../629954/SGchapter 04.doc*). B-According to Hsu and Jenkyns (1979), the rate of pelagic sedimentation in the Atlantic Ocean is about 1-10 mm/kyrs. C-According to Alexandre *et al.,* (2011), the sedimentation rate of Cenomanian marl and limestone (in Italy) is about 7 mm/ kyrs. D-Turgeon and Brumasack (2006) have estimated sedimentation rates of 5.3-8.1 mm/ kyrs and 2.9 mm/ kyrs for the Scagli Bianca (Cenomanian-Turonian) and Bonarelli Level (Conacian-Maastrichtian) formations respectively. From these rates of sedimentations, it is clear that the thickness of Turonian (315 m) is highly overestimated and not agrees pelagic sedimentations

The fourth point is that according to Bellen *et al*. (1959) the Balambo Formation forms smooth weathering slopes. In the type section at the Sirwan valley, this characteristic is not applicable for the formation since its upper part forms steep and high scarps and ridges (Fig.3 and 4). This topography is characteristics of the Kometan Formation not Balambo Formation.

The fifth points are that the Shiranish Formation is located at the top of the Balambo Formation with erosional contact as mentioned by Wetzel (1947) in Bellen et al (1959). This is very unusual stratigraphic setting of the two formations since in the whole Iraqi territory there is no locality where Shiranish Formation is overlying the Balambo Formation; except in Sirwan valley. This strange citation by Wetzel (1947) proves that the upper part of the Balambo Formation represents the Kometan Formation, which usually underlies the Shiranish Formation. Even in the Bekhme gorge (northwest of Arbil town), Karim et al. (2013a) and Karim (2013) have proved recently that the Shiranish Formation is located at the top of the equivalent of Kometan Formation, which is Bekhme Formation (Turonian-Campanian). Other studies considered the Bekhme Formation as being equivalent to Tanjero or Shiranish Formation (Buday, 1980***[4]***, Al-Qayim, 1989, 2010, and 2012, Al-Qayim et al., 199, and 2012; Jassim and Goff, (2006), Ma'ala, (2008), Lawa et al., (2013, p.78).

The citation "the contact between the Shiranish and Balambo formations is erosional unconformity" (see Bellen et al. 1959) is not accurate, since paleontological study proved that sediments of the Kometan Formation range from Turonian to Early Late Campanian) and the contact is conformable and gradational with the Shiranish Formation (Upper late Campanian). Even the of both Dokan and Gulneri formations (or their equivalent) can be identified between Balambo and Kometan formations (Fig.5). The field and lab study showed that the deposition of the marl during Albian-Cenomanian as mentioned by Dunnington (1958, Fig.3) is not accurate since the rocks of this age consist of black to grey and partially re-crystallized limestone (Fig.5, 7A, 8 and 9).

Topography and location of the type section of the Balambo Formation

According to Wetzel, (1947), type section was defined in two different areas about 12 kms apart. He further mentioned the following paragraph about the type section*:* "The main part (the upper part) has the trend of south-north along a south facing scarp at 3 km to the east of Kawta Village. The base and the top are located at 35^0 5^- $6^=$ N (the longitude is not given) and at 45^o 57^- $12^=$ E (the latitude is not given), respectively. The base is located in the Sirwan River and the top at the elevation of 884 m. He further added that the thickness of the main part is 606 m while the subsidiary part (lower part) is taken in two places near Hawar and Sazan villages and its thickness is about 126 m. The Shiranish Formation is located at the top of the section at the elevation of the 884 m above mean sea level".

From these data, it is clear that the type section has many problems; the first one is the long distance between the lower and upper parts of the formation. The second is that the main part (near Kawta village) of the type section is not indicated accurately since only the latitude and longitude of the base and top are given, respectively. According to Wetzel, the section is facing toward the south at 3 km to east of Kawta village and when the latitude of the base, longitude of the top of the section are plotted on the map and indicated on the earth, the plotted section is neither located on a suitable topography (walkable pass) nor on clear and simple structure. The section being not suitable, means two issues, the first is that the section consists of nearly vertical cliff and cannot be sampled or inspected easily (Fig. 5, 6, 7 and 8). The second is that it shows extreme deformation manifested by several tight and chevron folds by which the same bed is repeated several times on all possible sections; therefore, the thickness of the measured section is several times more than the measured true thickness. The deformation includes several synclines, anticlines and reverse fault, which make the accurate sampling and thickness measurement almost impossible (Fig. 4, 5, 6 and 7).

The citation that the Shiranish Formation is located at the elevation the 884 m above mean sea level is another problem of topography and stratigraphy; because the Shiranish Formation is not found at top of the section along the contour line of 884 m. The formation that is exposed along the 884 contour line is repetition (by folding) of the Balambo Formation. Above 884 m, there are Kometan, Balambo and Gulneri

formations. In Sirwan valley, the Gulneri Formation is very similar, in lithology to the Shiranish Formation as it consists of green marl and marly limestone and it is exposed along the 1100 m contour line and has thickness of about 6 m (Fig.2). The present authors think that Wetzel, most possibly, assumed this latter formation to be Shiranish Formation. The nannofossils analysis of the green marl showed that its age is Cenomanian-Lower Turonian (Fig.9 and 10). The age and lithology of the Gulneri Formation in this location generally coincide with the studies of Abawi et al (2006) and Karim and Taha (2009) and Karim et al. (2013b). Conversely, the Shiranish Formation is exposed extensively along both sides of Sirwan River (upstream of Dilla Rive) below 490 m contour line (Fig.2)

In Iran the equivalent of the Balambo Formation is Garau Formation which is about 448 m thick and has the age of the Early Aptian to Early Cenomanian (Ezampanah *et al*. 20132). This thickness in Iran is very logical when the 313 (Kometan Formation) is subtracted from total thickness (762 m) of the formation in Sirwan Valley, which will be 449 m and therefore it is very close to that of the Iran (448 m). According to presentation of Dr. Saad Z. Jassim (*iraqmining.com/files/Kurdistan.pptx)* the thickness of the Balambo Formation is about 440 m in Miran oil field (about 14 kms south of Zewe Gorge and 25 kms west of Sulaimani city). Wetzel mentioned that the base of the main section is located in the Sirwan River (448 m amsl) and the section runs north-south which is 503 m thick and its top is located at elevation of 884 m. Calculation of the thickness from these data give the thickness of 404 m (if the scarp is vertical) not 503 as mentioned by Wetzel (1947). The 404 m is true if the scarp is vertical and the beds are horizontal but if not the true thickness will be more less than 404 m.

Another fact is the disagreement of the citation of Bellen *et al*.(1959) and Wetzel (1947) in which the former mentioned that the Balambo Formation is forming smooth featureless topography, while the latter author mentioned that the section of the Balambo Formation is measured across a scarp (nearly vertical rock exposure). These two citations prove indirectly that the section of the Balambo Formation includes the Kometan Formation (scarp forming). This study aids the citation of Bellen *et al.* (1959) which states that the type section or any other section of the Balambo Formation does not form scarp. Therefore, it is clear that the thickness and definition of the section is not accurate at all and needs to be restudied completely. The section is so problematic that the present days geologists will never think to select it as a type section for a stratigraphic unit.

Fig. (7) Repetition of the Balambo and Kometan formations along the eastern part of type Section, A) Chevron folds, B) General view taken from upstream of Sirwan River and looks westwards.

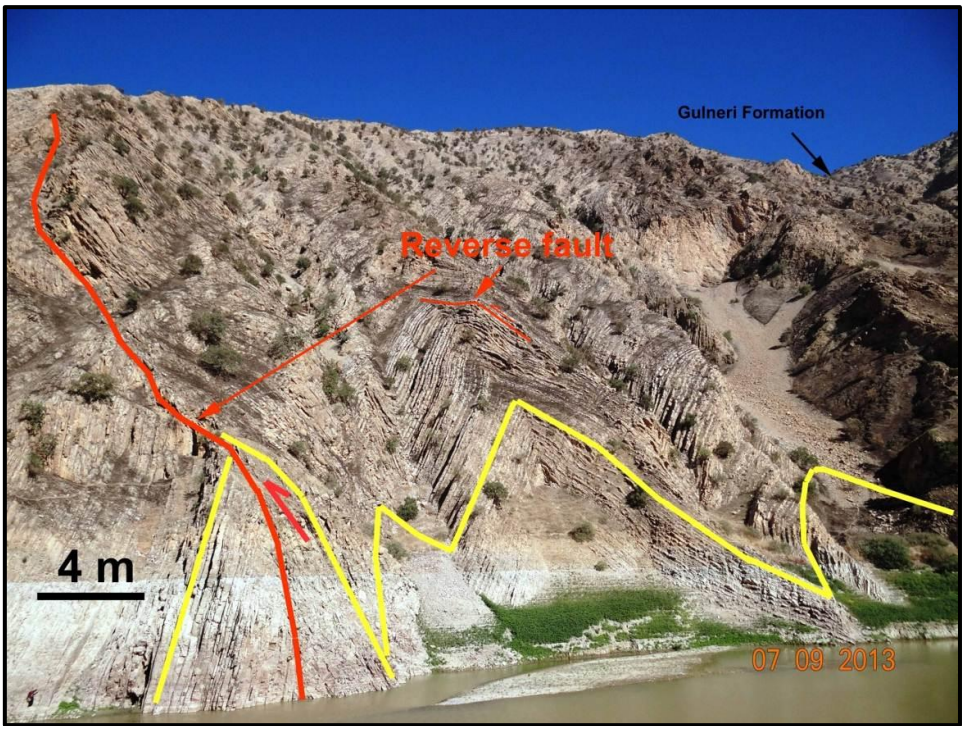

Fig. (8) Reverse fault (red line) and folding (yellow line) in Balambo Formation along the type section

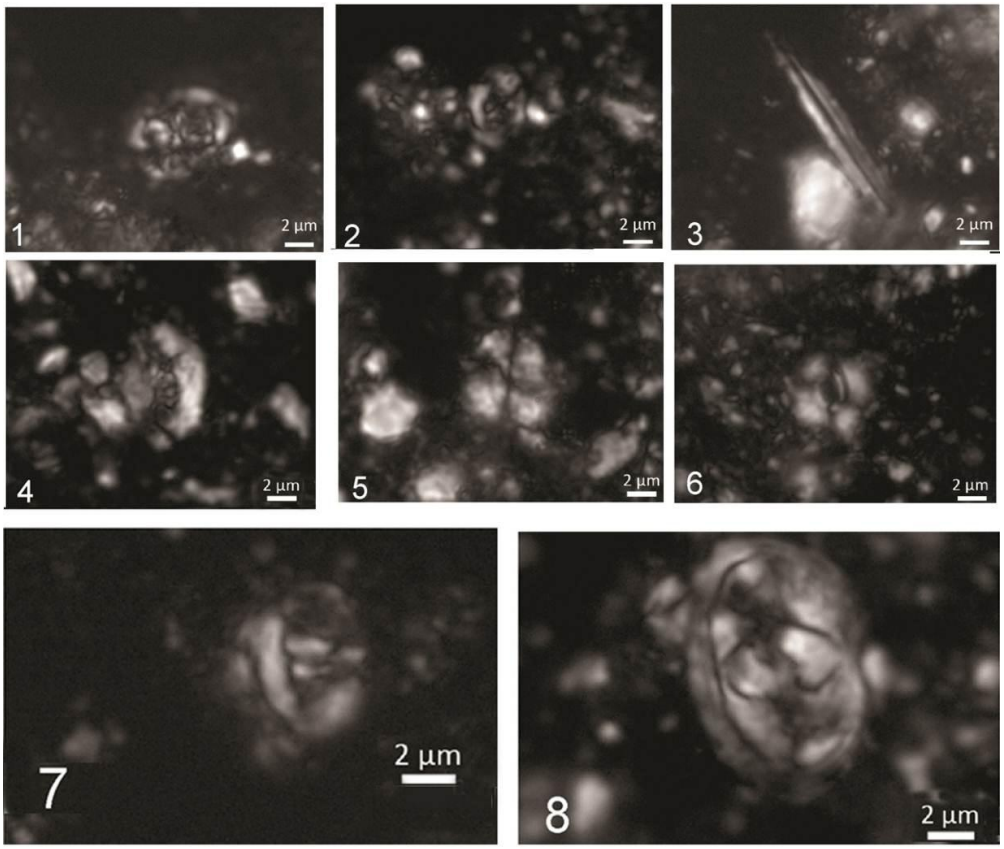

Fig. (9) Nannofossils of the green marl at the elevation of 1100 m, which has the age of Cenomanian

1. *Chiastozygus litterarius*; 2. *Helenea chiastia*; 3. *Lithraphidites acutus*; 4. *Rhagodiscus* sp.; 5. *Watznaueria barnesiae*; 6. *Watznaueria ovata*; 7. *Zeugrhabdotus diplogrammus*; 8. *Zeugrhabdotus embergeri*.

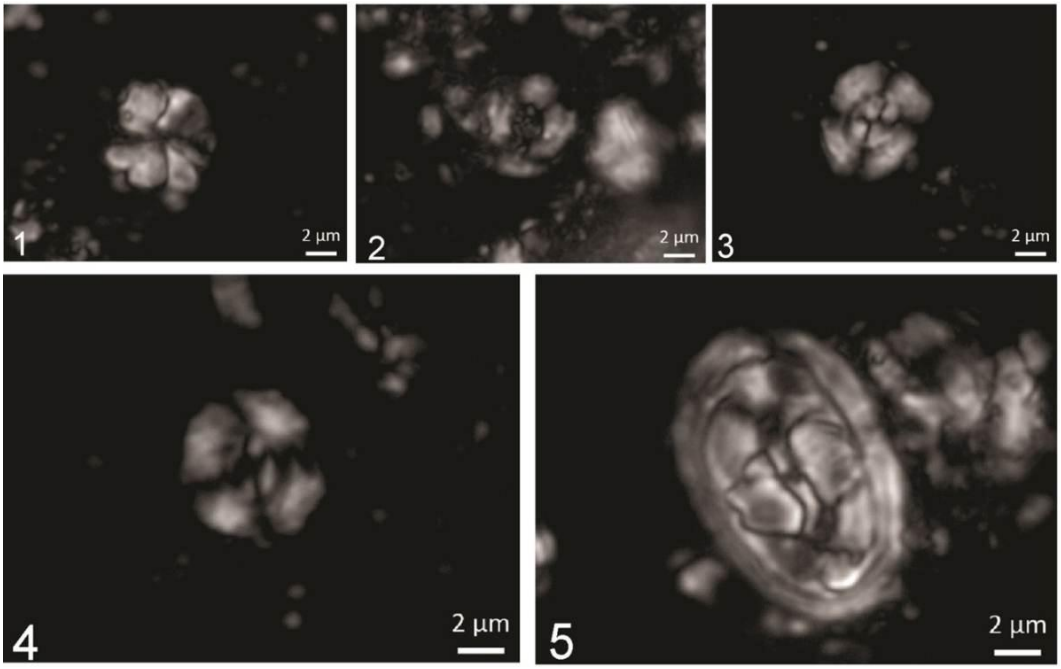

Fig. (10) Nannofossils of the Green marl at the elevation of 1110 m, which has the age of Early Turonian.
1. *Eprolithus moratus* ; 2. *Helenea chiastia*; 3. *Watznaueria barnesiae* ; 4. *Watznaueria ovata* ; 5. *Zeugrhabdotus embergeri*.

Depositional and Tectonic Setting of the Kometan and Balambo formations

The consideration of the upper part of the Balambo Formation with the Kometan Formation (Wetzel, 1947), which is deposited during Turonian (Fig.11) is not accurate in the view of environment and tectonics. This is attributed to different tectonic setting of the Kometan and Balambo formations. The latter is deposited in abyssal environment during the mature phase of Neo-Tethys Sea in which the basin was at the widest and deepest condition. In contrary, Kometan Formation was deposited during the final phase of closure of the Neo-Tethys, which was at narrower and shallower condition. Ameen (2008), Taha (2009), Ameen and Karim (2009) and Karim and Taha (2009) mentioned that the Balambo Formation is the time equivalent of the Qamchuqa and Qulqula Radiolarian formations and they shared one single basin and as a concurrent facies changes (Fig.11).

The Figure (11C) shows that the Qamchuqa, Qulqula Radiolarian and Balambo formations are deposited on (or in) continental platform, trench and continental rise of Neo-Tethys respectively. The Figure (11B) shows the transition phase between oceanic and platform condition of the Neo-Tethys basin. In this transition phase, both Kometan and Bekhme formations are deposited concurrently in the same basin as lateral facies changes. Karim (2013a and Karim *et al*. (2013a) discussed in detail all evidence that aid the lateral facial change of the between the latter two formation. During this phase, the Neo-Tethys basin was contracted to narrower width and lesser depth; as compared to the previous phase (phase of deposition of Balambo Formation and its equivalents).

This contraction is due to colliding of the Arabian and Iranian Plates from each other which reflected by deposition of chalky limestone of Kometan Formation and Dolomitic limestone of Bekhme Formation in the basin plain and on the platform, respectively during late Turonian to Middle Campanian. The deposition of chalky, dolomite and increase of Mg and Ca are increase is attributed to decrease of both current circulation and wave activity during maximum contraction of the basin by continuous southwest advance of Iranian Plate (Fig.10B). The calmness of the basin was discussed by the latter two studies in which they proved that the previous intraformational conglomerate in Bekhme Formation (Al-Mutwali, *et al*.2008) belongs to Aqra Formation, which was deposited in the foreland basin phase.

In the figure (10A) the final phase (phase the foreland basin) can be seen during which the colliding (Karim, 2004) or ophiolite abduction Jassim and Goff (2006) is occurred during which the Neo-Tethys is closed. During this phase Tanjero and Shiranish Formations are deposited. Therefore, late Turonian to middle Campanian is the transitional phase between foreland basin and Neo-Tethys oceanic basin. Thus, each of Balambo and Kometan Formation has different environment and tectonic setting within the neo-Tethys basin.

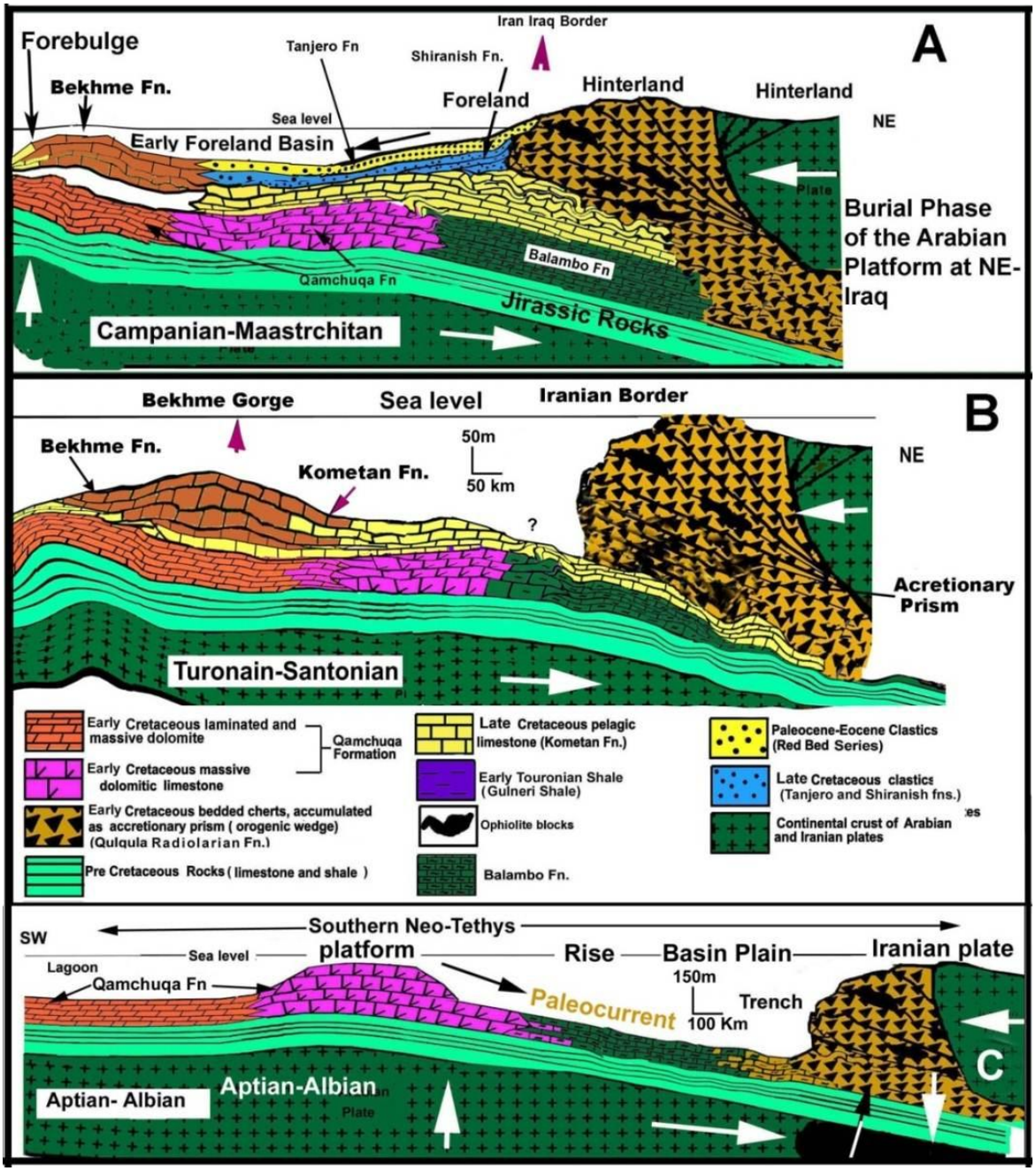

Fig. (11) Tectonic and environment settings of the Kometan Formation and Balambo fns with in Neo-Tethys basin (modified from Taha, 2008, Karim and Taha, 2009, Ameen and Karim, 2009, Karim *et al.*2013a, and Karim, (2013)

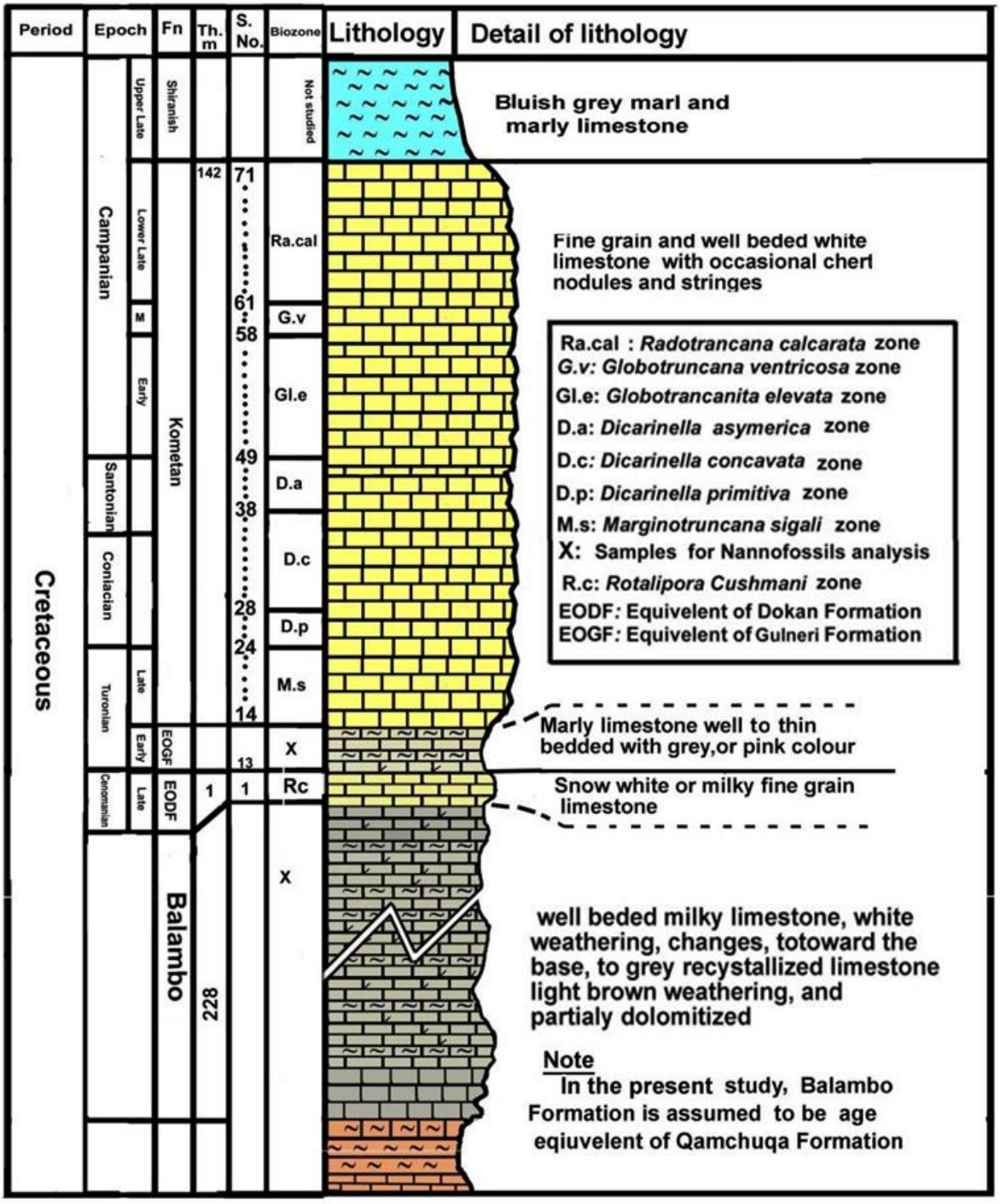

Fig. (12) Stratigraphical column of the type section of Balambo Formation in Sirwan valley shows biozones and differentiated units

Correlation of the Balambo Formation

From the previously studied sections and with the aid of some achieved studies; such as Karim et al. (2013b), Karim and Taha (2009) and Ameen and Karim (2009), it is possible to establish realistic correlation between the sections of the formation in the northeastern part of Iraq (Kurdistan Region). The correlated sections are in Piramagrun, Azmir and Balambo (Sirwan valley) mountains from northwest to southeast, respectively (Fig.13). In all previous studies, only the stratigraphy of the Piramagrun mountain (or anticline) is not controversial, while the Azmir and Balambo sections are not so. The Qamchuqa Formation is neritic reefal limestone with thickness of about 600 m. This 600 m is underlain by the Sarmord Formation and laterally changes to the Balambo Formation toward east and north. In previous studies, the formations such as Gulneri, Dokan, Balambo formations and Sarmord Formation are not differentiated and all are mapped as

the Balambo Formation as appear from red lines in the Figure 13a. Recently Karim et al. (2013b) have differentiated them very clearly as can be seen from the Piramgrun section in Figure13). In previous study and in the Sirwan valley, the Kometan Formation was added to Balambo Formation, which was more complicated the stratigraphy than Azmir section. In the present study, the Sirwan section is differentiated similarly to Azmir section as can be seen from the two green lines in the Figure 13a

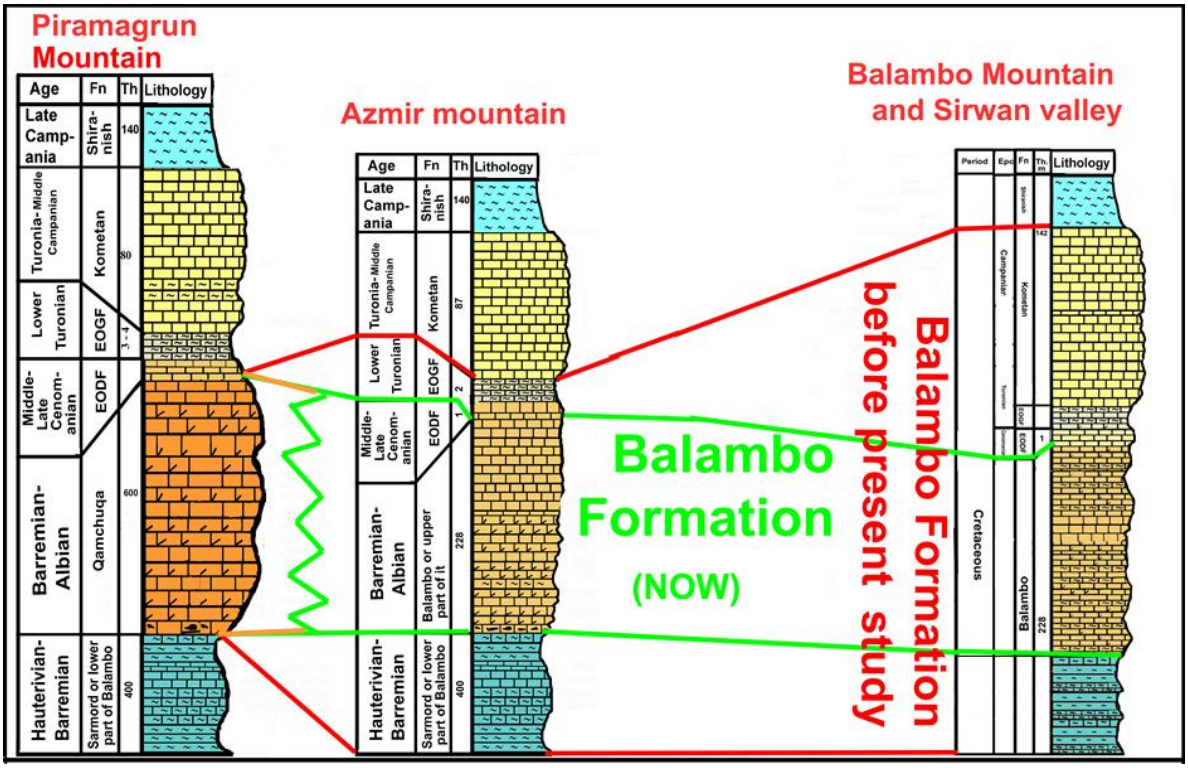

Fig. (13) Correlation of the Balambo Formation in Sulaimani Governorate in three sections, the red lines show previous stratigraphy of formation while the green lines show the stratigraphy relation of the present study

Conclusions

1-It is proved the presence of the Kometan Formation (Turonian-Middle Campanian) in Sirwan valley for the first time, which is previously (Wetzel, 1947) assigned as the upper part of the Balambo Formation.

2-The thickness of the upper part (Turonian) of the Balambo Formation is less than that previously measured due to intense deformation by mean of which the section is repeated four times.

3-This result of this study highly simplifies the geology of the area and changes its paleogeography and tectonic.

4-The upper part of the type section of the Balambo Formation shows conformable contact between the Shiranish and Kometan (previous upper part of Balambo) formations.

5-The type section of the Balambo Formation is very problematic in the view of stratigraphy, structure and geomorphology, therefore, it is better to be abandoned and a new type section must be selected and defined.

6-The Equivalents of the Dokan and Gulneri formations are indicated in the valley for the first time

7- Sirwan valley is not suitable for type section of any formation due to intense deformation.

References

Abawi, T. S., Hammoudi, R. A., and Al-Khafaf, A. O. 2006. Stratigraphy of the Gulneri Formation (Upper Cretaceous) in the Type Section, Dokan Area, Northeastern Iraq, Iraqi Jour. Earth Sci., Vol.6, No.2, pp.33-42, 2006.

Al-Qayim, B., 1989.Diagenetic model of a reef complex, Aqra-Bakhme Formation (Late Cretaceous) northeastern Iraq. Acta Mineralogica-Perographica, Szeged, XXX, 149-159.

Al-Qayim, B., 2010.Sequence stratigraphy and reservoir characteristics of the Turonian-Coniacian Khasib Formation in Central Iraq. Journal of Petroleum Geology, Vol. 33(4), p. 387-404.

Al-Qayim, B. 2012. Foreland Basin System of the Northeastern Arabian Margin, Kurdistan Region, Iraq; Impact on Oil Accumulations. First EAGE Workshop on Iraq - Hydrocarbon Exploration and Field Development ,Session 1: Regional Geology.

Al-Qayim, B. and Al-Shaibani, S.,1995. Lithostratigraphy of Cretaceous-Tertiary transects Bekhme Gore, NE- Iraq. Iraqi Geological Journal, Vol. 28, No.2, p. 127-136.

Al-Qayim, B., Omer, A. and Koyi, H. 2012. Tectonostratigraphic overview of the Zagros Suture Zone, Kurdistan Region, Northeast Iraq, GeoArabia, Vol. 17, No. 4, p.109-156.

Al-Mutwali, M., M., Al-Banna, N.Y. and Al-Ghrear J. S., 2008. Microfacies and Sequence stratigraphy of the Late Campanian Bekhme Formation in the Dohuk area, North Iraq. GeoArabia, Vol.13, No.1. p.39–54.

Alexandre, J. T., Negri, A. and de Boer P. L. 2011. Early Turonian pelagic sedimentation at Moria (Umbria-Marche, Italy): primary and diagenetic controls on lithological oscillations, Palaeogeography Palaeoclimatology Palaeoecology, in press, available online, pp15.

Ameen, B.M., 2008. Lithostratigraphy and Sedimentology of Qamchuqa Formation from Kurdistan Region, NE−Iraq. Unpublished Ph. D. Thesis. University Of Sulaimani,147p.

. Ameen, B. M. and Karim, K. H., 2009. New sedimentologic and stratigraphic characteristics of the Upper boundary of Qamchuqa Formation (Early Cretaceous) at Northwest of Erbil, Kurdistan Region, NE/Iraq. Iraqi Bulletin of Geology and Mining, vol.4, No.2, p.1-13.

Bellen, R. C. Van, Dunnington, H. V., Wetzel, R. and Morton, D., 1959. Lexique Stratigraphique, Interntional. Asie, Iraq, Fasc, 10a, Paris, 10a, 333 pp.

Buday, T., 1980. Regional Geology of Iraq: Vol.1, Stratigraphy: I.I.M Kassab and S. Z. Jassim (Eds) GEOSRVY. Min. Invest. Publ. 445p.

Ezampanah, Y., Sadeghi, A., Adabi, M. H. and Jamali A. M.(2013) Biostratigraphy of the Garau Formation (Berriasian?–lower Cenomanian) in central part of Lurestan zone, northwest of Zagros, Iran Cretaceous Research 46:101–113.

Dunnington, H. V., 1958. Generation, migration and dissipation of oil in Northern Iraq. In Arabian Gulf, Geology and productivity. AAPG Foreign Reprint Series No. 2, 528 p.

Jassim, S.Z. and Goff, J. C., 2006. Geology of Iraq. Dolin, Prague and Moravian Museun, Berno. 341p

Hsü, K. J. Jenkyns, H. C., 1979. Pelagic sediments, on land and under the sea: proceedings of a symposium International Association of Sedimentologists, European Geophysical Society, Wily S

Karim, K. H., Ismail, K. M., Ameen B. M., 2008. Lithostratigraphic study of the Contact between Kometan and Shiranish Formations (Upper Cretaceous) from Sulaimani Governorate, Kurdistan Region, NE-Iraq. Iraqi Bulletin of Geology and Mining. Vo.4, No.2.

Karim, K.H.(2013a).New geologic setting of the Bekhme Formation, 1st Geological Conference of Kurdistan, Journal of Zankoy Sulamani (JZS), Vol.15, No.3.

Karim, K.H. Al-Hamadani, R.. K. and Ahmad S. H. (2013a). Relations between deep and shallow stratigraphic units of the Northern Iraq during Cretaceous. Iranian Journal of Earth Sciences, vol.4.No.2.

Karim, K.H. and Taha, Z.A. 2009. Tectonical history of Arabian platform during Late Cretaceous An example from Kurdistan region, NE Iraq. Iranian Journal of Earth Sciences,Vo.1. No.1, p. 1-14.

Karim, K.H., Salih, A.O and Ahmad, S.H., 2013b. Stratigraphic Analysis of Azmir – Goizha anticline by Nannofossils. Journal of Zankoy Sulaimain (JZS), Part A, Vol.15, No.2, pp.103-124.

Karim, K.H. 2004. Basin analysis of Tanjero Formation in Sulaimaniya area, NE-Iraq. Unpublised Ph.D. thesis, University of Sulaimani University, 135p.

Lawa, F. A., Koyi, H. and Ibrahim, A. 2013.Tectono-stratigraphic evolution of the NW segment of the Zagros fold-thrust Belt, Kurdistan, NE Iraq. Journal of Petroleum Geology, Vol. 36(1).

Ma'ala, K. A. 2008. Geological map of Sulaimaniyah Governorate; sheet NI-38-3, State Company of geological Survey and Mining, Baghdad.

Taha, Z.A., 2008. Sedimentology of Late Cretaceous Formation from Kurdistan Region, NE−Iraq, Unpublished, M. Sc thesis, University of Suilaimani.150 pp.

Turgeon, S., Brumsack, H. J. 2006. Anoxic vs dysoxic event reflected in sediment geochemistry during the Cenomanian-Turonian boundary Event (Cretaceous) in the Umbria-Marche Basin of central Italy. Chemical Geology, 234, 321-339.

Sissakian, V. K., 2000. Geological map of Iraq, sheets No.1, Scale 1:1000000, 3rd edition, GEOSURV, Baghdad, Iraq.