



Age determinations of Cretaceous sequences based on calcareous nannofossils in Zagros Thrust and Folded Zone in Kurdistan Region-Iraq

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Article info

Original: 23 Feb. 2015
Revised: 24 June 2015
Accepted: 25 June 2015
Published online:
20 Sep. 2015

Key Words:

Kurdistan
Nannofossils
Cretaceous
Sarmord
Balambo
Shiranish

Abstract

The studied area is located in Northern Iraq in the Kurdistan Region, in the North-Western part of the Zagros Fold belt. This study concentrates on the biostratigraphic approach using nannofossil analysis to identify the age of the formations that have deposited during Cretaceous period in Kurdistan Region-Iraq. The sedimentary sequences in Kurdistan region exhibit many lateral and vertical environmental and facies changes. Previously most of the works to recognize the age of the formations were concentrated on the Foraminifera zonation. In the present study, attempts have been made to review the age of the formations and the contact between them by using nannofossil analysis technique. Nannofossils assemblage Chia Gara Formations show that conformable contact situation between Jurassic-Cretaceous. The contact is between Late Tithonian Chia Gara and Berriasian- Valanginian Balambo formations. In Kurdistan during Hauterivian-Barremian the outer shelf sediment of Sarmord Formation deposited that conformably overlay Balambo Formation. The Qamchuqa Formation is a heterogeneous group of limestone. The lower part is belongs to the Aptian to Albian periods, while The upper part of the Qamchuqa limestone is generally dolomitized, therefore, the existed nannofossils even within the locally thin marl layers are destroyed. The Dokan Formation, which appears along the Dokan dam, is a Cenomanian age. The Kometan Formation is represented an Early Turonian age. The top of the Kometan limestone is characterized by a hard ground most possibly indicating a hiatus. The sequence of marl-Limestone of Shiranish Formation we dated Early to Late Campanian. Toward north the Early to Late Campanian part of Shiranish Formation can be locally replaced by the reefal Bekmeh limestone Formation. Very rare nannofossils were found in the marly intercalations of the Bekmeh limestone indicating at least a Late Cretaceous age. The Shiranish/Tanjero formations boundary lies within the Upper Campanian. The age of Tanjero Formation ranges from Late Campanian to Late Maastrichtian.

Introduction

New dating of the Cretaceous formations in Kurdistan region was determined by calcareous nannofossils. The dating is achieved from the investigation of more than 500 samples that collected in different areas of Kurdistan region. The age of Mesozoic formations were already have been determined according to the publications from *Thierstein* (1971), *Perch-Nielsen* (1985), *Martini* (1971) and *Martini and Muller* (1986). The previous works were mostly dependant on foraminifera or macrofossils for dating the formations. However we try to use another chronological tool to identify the Cretaceous- Paleogene this appear regarded with Cretaceous rocks only, not exceeds to Tertiary period in Kurdistan region.

Location of the studied area

The studied area is located in Northern Iraq in the Kurdistan Region, which approximately corresponds to the North-Western part of the Zagros Fold belt. This study is mainly concentrated on the area that located between the longitudes $44^{\circ} 00' 00''$ E and $45^{\circ} 30' 00''$ E and the latitudes from $35^{\circ} 30' 00''$ N to $37^{\circ} 00' 00''$ N (Fig.1). As a preliminary phase, visited have been made to most parts of the Kurdistan Region, but the areas of interest were belonging to Erbil and Sulaimaniyah provinces (Fig. 1).

In the Sulaimaniyah province, this work is studied four main areas: (1) NE of Sulaimaniyah city, (2) NW of Sulaimaniyah city, (3) Dokan area and (4) Rania-Qaladize area. Regarding the Erbil province, the selected studied areas are located on the northern and eastern parts of Erbil Province (Bekhme, Bradost, Aqra, Shirin, Harir, Safeen, and Korek anticlines). The field work also covers the mountainous area that are located between Sulaimaniyah and Erbil provinces close to the Iranian border, known as Qandil area (Fig. 1).

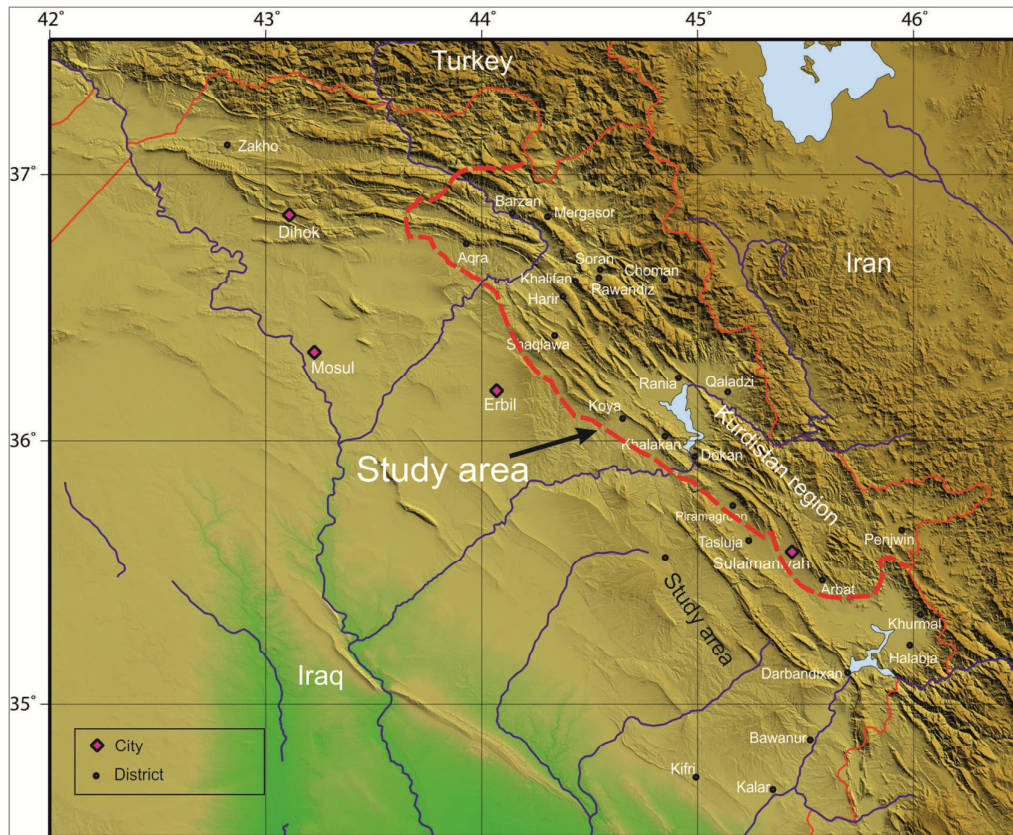


Fig. 1: Maps of Kurdistan Region shows the limit of the study area.

Fieldwork and methodology:

The main goals of this research are study the Cretaceous successions that crop out in part of the Kurdistan region. We collected more than 500 samples from different out crops of the formations in the different location (Fig.2), and also we try to concentrate on the physical properties of the formations and accurately determine the age of these stratigraphic sequences through used the analysis of the interval between the samples.

The term calcareous nannofossil is usually defined as including all calcareous fossils smaller than 30 microns exist in marine environment. The nannofossil includes a various range of calcareous small organisms, such as *ascidian spicules*, *calcispheres* (calcareous *dinoflagellates*) and *juvenile foraminifera*. The main significant and predominant groups are the remains and probable remains of *haptophyte* algae (Bown and Young, 1998).

Most of the Cretaceous nannofossil species were extinct in the Cretaceous-Tertiary boundary. The nannofossils have fluctuated also in Tertiary. Because of their widespread distribution and quick revolution the study of nannofossil is important tool for biostratigraphy (Aubry, 1985; 1987). Most of the outcropping stratigraphic sequences in Kurdistan range in age during Cretaceous are marine therefore the identification of the age using nannofossils is obtains good results.

The only destruction to use this relevant tool is that the nannofossils are often badly preserved in the high re-crystallized dolomite and limestone. Unfortunately some of the Late Cretaceous sequences such as Qamchuqa and Bekhme formations are massive and hard reefal dolomitic limestone. Therefore they are still poorly dated. However some soft formations such as Shiranish and Tanjero are widespread and were well dated.

The nannofossil occurs in virtually any Mesozoic marine sediment with in fine carbonate fractions, which have not undergone metamorphism, severe diagenesis or weathering. The most favorable lithology are marly and chalky facies, but muddy sand and silt, including glauconitic sands, can often contain good assemblages. The nannofossils are poorly preserved or completely absent in the coarse clastic sediments. More than 100 samples did not contain any or rare nannofossil and could not be used for identification the age of the sequence.

Stratigraphy and age determination of Cretaceous sequence in Kurdistan-Iraq:

The Kurdistan territory is an area of deposition of thick sequences of marine and continental facies, especially since the opening of Neo-Tethys until the final phase of the Arabian-Eurasian collision. The Cretaceous sequence in Kurdistan deposited during rifting, subduction and obduction (formation of the foreland basin) of the Arabian- Eurasian plates.

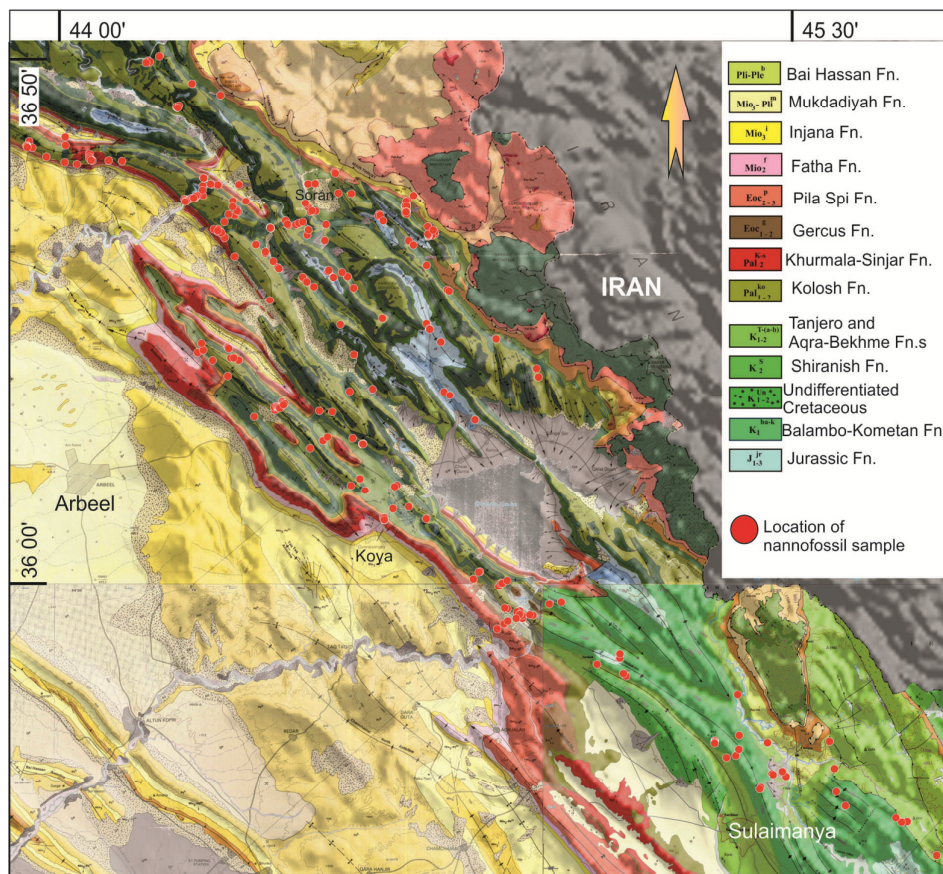


Fig.2: General Geological Map of Kurdistan Region (Sissakian, 1997), the red points are the location of Nano-fossil samples.

The Cretaceous sequence consists of Megasequences AP8 and AP9 (Sharland et al., 2001). The Megasequence AP8 starts from **Late Tithonian** to **Early Turonian** and the Megasequence AP9 from Late Turonian to Danian (Jassim and Goff, 2006). In Iraq and especially in Kurdistan, three major periods of basin development and tectonic activities can be identified during the Cretaceous: (1) Berriasian-Early Turonian; (2) Late Turonian-Early Campanian; and (3) Late Campanian-Maastrichtian (Jassim and Goff, 2006). The total thickness of this sequence exceeds 3000 m. Lateral and vertical facies variation can be recognized during the Cretaceous in Kurdistan.

Chia Gara Formation

The Chia Gara Formation was first defined by *Wetzel* (1950 in *Bellen et al., 1959*), in the Chia Gara anticline. The Formation is composed of a succession of thin bedded limestone and shale (Fig. 3). The depositional environment is deep marine (*Al-Qayim and Saadalla, 1992*) or deep outer shelf to carbonate slope environment (*Mohyalidin, 2007*). Depend on the *Buday (1980)* the Chia Gara Formation started from Middle Tithonian up to Berriasian in age.

In our study we concentrate on upper part of the formation and the upper contact situation.

The Jurassic/Cretaceous boundary lies within the upper part of Chia Gara Formation. Because (1) the upper part of it was dated Berriasian by the occurrence of *Nannoconus colonii* together with *Polycostella beckmannii* & (2) There is no lithological change at the Jurassic/Cretaceous boundary (Fig. 3)

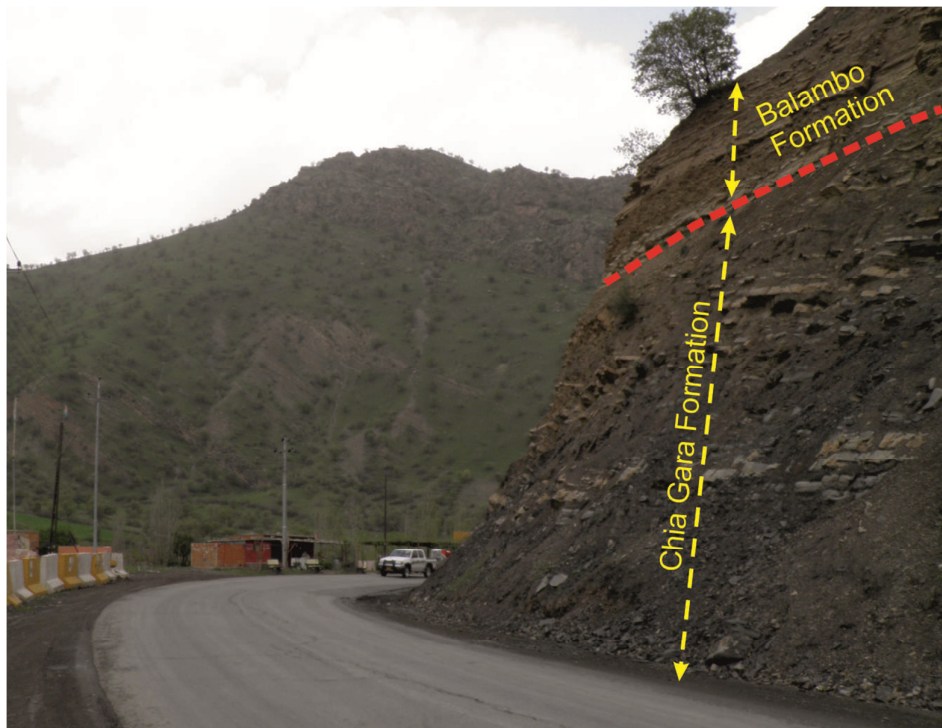


Fig. 3: Tithonian – Berriasian Sequences open marine facies of Chia Gara and Balambo Formations. The figure show the Jurassic –Cretaceous boundary in the upper part of Chia Gara Formation. The Road is Soran-Choman main road, closed to Barsarin village.

Balambo Formation

The Balambo Formation consists of alternating limestone beds with belemnites and marls (Fig. 4). These sediments were deposited in a deeper more open marine environment (*Buday, 1980; Jassim and Guff, 2006; Al.Dulaimi and Mahdi, 2008; Ghafor, 1993 and Ghafor et.al, 2004*) with common nannofossils and well diversified assemblages. This formation is of Berriasian-Valanginian age with the following assemblages: *Calcicalithina oblongata*, *Bipodorhabdus colligatus*, *Cruciellopsis cuivellierii*, *Cyclagelosphaera deflandrei*,

Ellispogelosphaera communis, *Micrantholithus obtusus*, *M.hoschulzi*, *Nannoconus colomii*, *N. steinmannii*, *Tubodiscus verena*, *Watznaueria barnesae*. In some layers nanofossils are strongly re-crystallized and fragmented by diagenesis. The lower contact of the formation with the Chia Gara Formation show the conformable contact because there is no any interruption in the time and environments.



Fig. 4: Rhythmic alternation between thin papery Marl and Limestone of Berriasian-Valanginian Balambo Formation in the core of Azmar anticline northeast of Sulaimaniyah city.

Sarmord Formation

The Formation is composed of marl and marly limestones. The Sarmord Formation mostly appears in the cores of the anticlines such as the Piramagroon, Surdash, Bekhme and Korek Anticlines. In the center of Kurdistan the Sarmord Formation is intercalated between the overlying carbonate of the Qamchuqa Formation of mainly limestones and the underlying Balambo Formation.

The Sarmord Formation stratigraphically located between deep open marine carbonate sequence of Berriasian- Valanginian of Balambo Formation and thick massive reefal limestone of Qamchuqa Formation. The formation is predominantly a marly series with locally shallower limestone layers within the upper part. The sediments are rich in well preserved nanofossils. Depending on the time of deposition, we suggest to divided the formation into two part (1) Hauterivian part and (2) Barremian part. The Hauterivian part of Sarmord Formation is characterized by following assemblage: *Calcicalithina oblongata*, *Bipodorhabdus colligatus* (lower part) *Cruciellipsis cuivellierii*, *Ellispogelosphaera communis*, *Lithraphidites bollii*, *Micrantholithus obtusus*, *M. hoschulzii*, *Nannoconus bucheri*, *N. colomii*, *N. kamptnerii*; *N. steinmannii*, *Watznaueria barnesae*, and the absence of *Cyclagelosphaera deflandreii*.

The second part is Barremian assemblages consist of the species: *Calcicalithina oblongata* (lowermost part), *Ellispogelosphaera communis*, *Micrantholithus obtusus*, *Nannoconus bucheri*, *N. colomii*, *N.eleogatus*, *N. circularis*, *N. grandis*, *N. kamptnerii*, *N. steinmannii*, *Watznaueria barnesae*. The sediments of the Sarmord Formation were deposited in a relative shallow water depth in an open marine environment (about 300 to 500 m). *Nannoconids* are common within the formation. Nanofossils are poorly preserved within the limestones due to diagenesis.

Qamchuqa and Dokan Formations

The Qamchuqa Formation is a heterogeneous group of limestones. The lower part consists of well bedded black limestones with chert nodules that intercalated with very thin black marly layers rich in organic matter (Fig. 5). These limestones are most possible belonged to Aptian to Albian age. The lower part of the Qamchuqa Formation is not developed everywhere. Very often the thickly bedded partly reefal limestones of the upper part are overlying directly the marls of the Sarmord Formation. This might indicate the existence of horst-graben structures at Early Cretaceous time.

Within the thin marly layers of the Aptian-Albian limestones, few nannofossils, like *Eprolithus floralis*, *Ellipsogellosphaera communis*, *Nannoconus circularis*, *Rucinolithus irregularis*, *Watznaueria barnesae* are found within the Aptian part, with additional *Prediscosphaera cretacea* and *Eiffellithus turrieiffeli* in the Albian. The upper part of the Qamchuqa limestone is generally dolomitized. Therefore all nannofossils even within the marly intercalations are destroyed. Only along the Dokan Dam, we record Cenomanian age in the 3-5 meter thick of well bedded limestone. This sequence is conformably located the reefal Qamchuqa Formation. These beds are represents the Dokan Formation, due to these result indicate (1) the Dokan Formation developed in restricted area (Dokan area) and (2) the upper most part of Qamchuqa Formation is Lateral equivalent of Dokan Formation. The nannofossil assemblage in the upper most Qamchuqa & Dokan formations are: *Eprolithus floralis* (common), *Eiffellithus turrieiffeli*, *Prediscosphaera cretacea*, *Lithraphidites alatus*, and *Watznaueria barnesae*. However in some area the upper most part of Qamchuqa Formation deposited in the Cenomanian period. That mean the age of upper part of Qamchuqa Formation is most possibly Albian - Cenomanian

Kometan Formation

The Kometan Formation is represented by a white silicified well bedded limestone with chert nodules and very thin brown marly layers rich in organic matter and pyrite (Fig. 6). The bedding planes are characterized by an enrichment of chert nodules and stylolites due to compaction. The Kometan limestone in this typical facies is very well developed in the Dokan lake area (Fig. 6). It is missing in many parts of Kurdistan, where the Qamchuqa limestone is directly overlain by the Shiranish Formation or the time equivalent Bekmeh Formation. This might be due to non-deposition of Kometan Formation on paleo-highs. Samples taken from the very thin marly intercalations indicated an Early Turonian age for the Kometan Formation. The following nannofossils assemblages were observed: *Eprolithus floralis*, *Eiffellithus turrieiffeli*, *Ellipsogellosphaera communis*, *Watznaueria barnesae*, *E. eximius*, *Micula staurophora* (the two latter species are very rare, they have their first appearance within the lowermost Turonian).

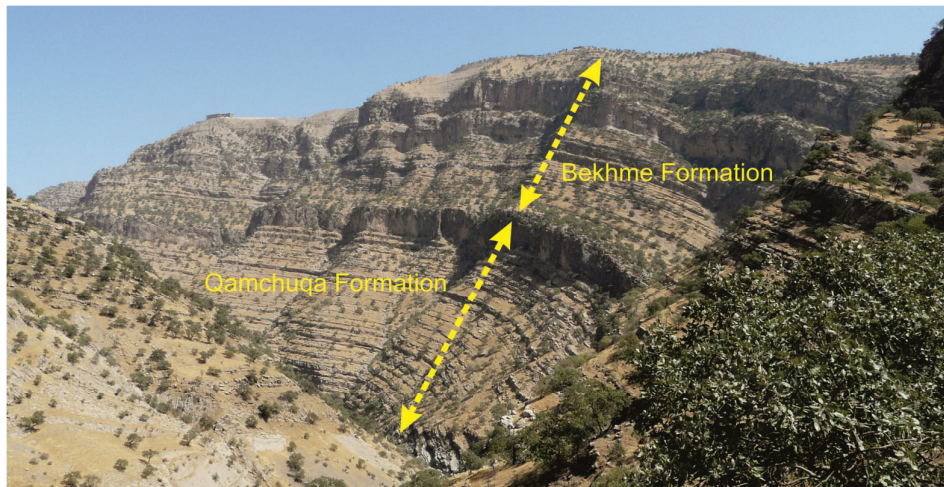


Fig. 5: Qamchuqa and Bekhme formations that form high cliffs (more than 1000m thick) in the Barzan area close to Dore Village. The Bekhme Formation disconformably overlay the Qamchuqa Formation.

The top of the Kometan limestone is characterized by a hard ground possibly indicating a hiatus. Locally it is overlain by a glauconitic sand of Early Campanian age. No sediments of Late Turonian to Santonian age were dated during this work in the study area. This time interval corresponds most probably to a tectonic event with reorganization of the plates. This hiatus was observed in many parts of this region.

It is the widespread Turonian Formations of the northern and central Iraq (Buday, 1980).



Fig. 6: Outcrops of the Turonian well bedded thick limestone Kometan Formation. The beds affected by highly fracture and faults. Location is the main road of Khalakan-Dokan main road, close to the Dokan Dam.

The formation has been laid down in different environments. The type Kometan Formation included beds of a deeper neritic globigerinal open marine facies, outer shelf or basinal (Buday, 1980; Jassim and Goff, 2006). The lateral facies change of the Kometan Formation in the north possibly is the Bekhme Formation (Karim, 2014). In the center of Iraq (Mesopotamian zone) the Kometan Formation is equivalent to Khasib, Tanuma and Sa'di formations (Buday, 1980; Jassim and Goff, 2006; Al-Qayim, 2010). The Mergi limestone Formation in the Shiranish area (Northern Iraq) is an isolated remnant of neritic limestone of Turonian age, which was perhaps deposited in lateral continuity with the Kometan Formation (Bellen et al, 1959). In the extreme eastern (Halabja area) the Kometan Formation passes into the uppermost Balambo Formation (Dunnington et al., 1958, Al-Naqib, 1967).

Bekhme and Aqra Formations

The Bekhme Formation was first introduced by *Wetzel* (1950 in Bellen et al., 1959). The type section is in the Bekhme Gorge in the core of the Bekhme Anticline on the Greater Zab River. The thickness of the Bekhme Formation in the type section and in the Gali Dore is about 300 m (Fig. 5). The lower contact with the underlying Qamchuqa Formation is questionable. A sub-areal conglomerate layer has been designated at the base of the Bekhme Formation indicating an unconformity (Bellen et al., 1959; Buday, 1980; Al-Karadaghy, 1989; Al-Qayim and Shaibani, 1995; Omar, 2006; Jassim and Golf 2006). However, *Karim and Ameen* (2008) believed that the contact is mostly conformable, and there is no sub-aerial erosion at the contact between the Qamchuqa and Bekhme Formations.

The platform limestones of the Bekmeh Formation directly overly the Qamchuqa Formation (Cenomanian). The age of Bekhme Formation is most possibly Early Campanian because (1) the formation is equivalent to lower part of Shiranish Formation (2) the Late Campanian Shiranish Formation conformably overly Bekhme Formation and (3) gap of Coniacian – Santonian occurred between Bekhme and Qamchuqa Formations.

The Bekmeh limestones and the intercalated marls are very poor in nannofossils like *Micula staurophora* and within the upper part *Quadrum gothicum*. The marls beds just above the Bekhme Formation contain Late Campanian nannofossil assemblage: *Broinsonia parca*, *Eiffellithus eximius*, *Micula staurophora*, *Quadrum gothicum*, *Q. trifidum*, *Reinhardtites anthophorus*, *Watznaueria barnesae*. The same assemblages were observed in the marls overlying the slope deposits.

The Aqra Formation first described by *Bennet* (1945 from Bellen et al.) in Aqra city along the Geli Sheikh Abdul Aziz (Bellen et al, 1959). The thickness of the Aqra Formation in the type section is 740 m (base of

the Formation is not seen). It is composed of a reefal limestone complex with massive rudists-shoal reefs, detrital fore-reef limestone, locally dolomitized, siliceous and impregnated with bitumen (Fig. 7). The Aqra Formation forms the core of many anticlines in the western High Folded Zone such as Aqra Dagh, Jebel Gara, Ser Amedia and Shaikhan. The Aqra Formation deposited in reef, fore-reef and back- reef environments (Buday, 1980; Lawa, 1983; Al.Ameri and Lawa, 1986; Zebari, 2010).

The lower contact of the Aqra Formation with the Bekhme Formation is not clear, possibly disconformable by the presence of the hardground between them (Zebari, 2010), but the upper contact is disconformable with Khurmala Formation.

The reefal Aqra limestone with patch reefs of rudists and the corresponding fore- and back-reef facies is locally predominant only in the Aqra area (Fig. 7). The age of the Aqra limestone is Early Maastrichtian to Late Maastrichtian. Locally it is covered by Late Maastrichtian marls. The Early Maastrichtian is characterized by the presence of *Quadrum gothicum* and *Q. trifidum* but without *Eiffelithus eximius*, *Broinsonia parca* and *Reinhardtites anthophorus*. The Upper Maastrichtian is indicated by the presence of *Micula murus*. The occurrence of limestone beds within the Late Maastrichtian Tanjero Formation are considered to be equivalent with the Aqra limestone.

The Bekhme & Aqra Formations described as two independent unites, partly or slightly different age, but where the Aqra Formation lies directly above the Bekhme Formation without Shiranish or Tanjero Formations. However Buday (1980) used term Aqra/Bekhme due to the difficulty to distinguish the Bekhme Formation from Aqra Formations, especially where the Aqra Formation overlies the Bekhme Formation, and both are composed of limestone deposited mostly in reef, fore-reef environment. They are represents an elongated, bank-type reef complex (Al-Qayim, 1989).

The term Bekhme/Aqra Formations or combination of these two reef formations as one unit is not need. Because the Bekhme Formation are well developed during Early Campanian in the North of Kurdistan and restricted between Qamchuqa, Shiranish & Aqra formations. However the Aqra Formation is less geographically developed and it is Maastrichtian reef stratigraphically locate between Bekhme & Sinjar formations.



Fig. 7: Highly folding and fractures containing bitumen of massive limestone Aqra Formation in Gali Abdul-Aziz gorge.

Shiranish Formation

In the areas where the Kometan limestone developed the Early – Late Campanian Shiranish Formation disconformably overlay it. However toward North the lower part of Shiranish Formation can be replaced by the Bekmeh limestones.

Locally it is possible to observe glauconitic sand with highly bioturbation of about 5-20 cm at the base of the Shiranish Formation indicating the hiatus, which represents the time interval of Late Turonian to Santonian. Generally the lowermost part of the Shiranish marls overlying the Qamchuqa or Kometan Formation are strongly indurated. They are getting softer within the upper part of the Formation, where marly limestone layers become more frequent. The marls of the Shiranish Formation are generally rich in nanofossils. They are re-crystallized and broken by diagenesis within the indurated sediments. A layer of intra-formational mud pebbles was observed at several places. This layer marks more or less the Early/Late Campanian boundary and might be related to the transgression at that time.

The nanofossil assemblages of the Early Campanian are marked by the presence of *Eiffelithus eximius* (common), *E.turrisieffeli*, *Broinsonia parca*, *Cribrosphaerella ehrenbergerii*, *Lucianorhabdus cayeuxii*, *Micrantholitus decoratus*, *Micula staurophora*, *Prediscosphaera cretacea*, *Reinhardtites anthophorus*, *Watznaueria barnesae*. The assemblages of the Upper Campanian consist of the same species with additional *Quadrum gothicum* and *Q. trifidum*, *Eiffelithus eximius* becomes very rare.

The thickness of the Shiranish Formation is variable from place to place depending on the degree of the subsidence of the basin; the average thickness varies between 20 to 250m. The Shiranish Formation is widely distributed in Kurdistan region and towards the West and Southwest of Iraq. The lower contact situation of the formation is change from the locality to another. In Sulaimaniyah, Rania, Dokan and Balakaiaty areas the Early Campanian marly limestone beds disconformably overlay the Kometan Formation. In the Safeen, Shakrok and Harir anticlines the Late Campanian marl and marly limestone beds disconformably overlay the Cenomanian reef of Qamchuqa Formation. However in the Bekhme, Shirin, Korek and Bradost anticlines the Late Campanian marly limestone of Shiranish Formation conformably overlay the reef of Bekhme Formation. The age of Shiranish Formation depend on the nanofossil analysis is Early – Late Campanian where overlay Kometan Formation. However the age reduces to only Late Campanian where overlay Bekhme & Qamchuqa Formations.

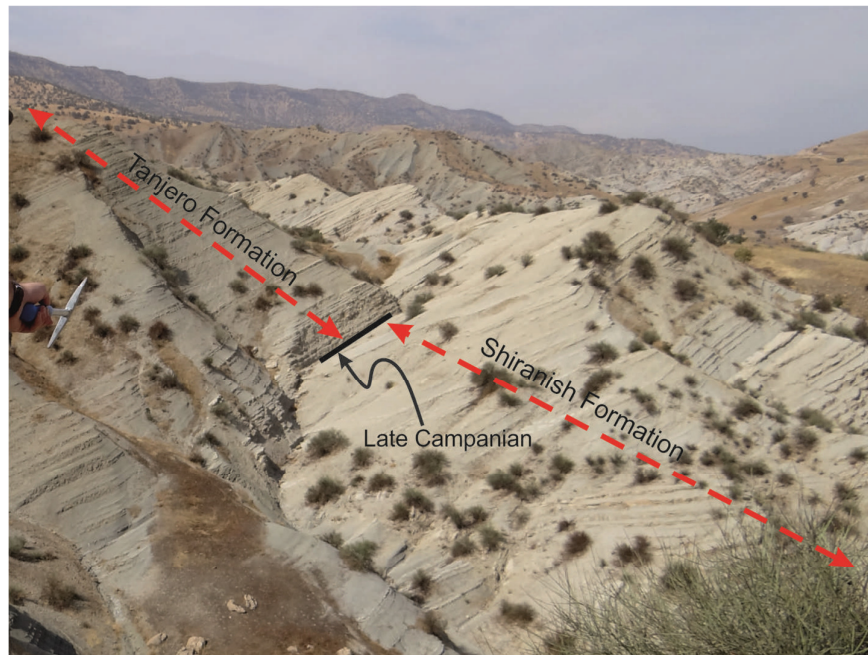


Fig.8: Thick sequence of foredeep turbidity facies of Tanjero Formation conformably overlay open marine Shiranish Formation. The contact is sharp and we date a Late Campanian.

Tanjero Formation

The Tanjero Formation was first described by *Dunnington* (1952 from *Bellen et al.*, 1959). The type section is located southeast of Sulaimaniyah near the Halabja town. In the type locality, the Formation is composed of silty marls, siltstone, sandstone, conglomerates, and sandy or silty organic detrital limestones, with intercalations of organic reef and shoal-type limestones. *Karim* (2004) divided the Tanjero Formation into three parts. (1) Lower part composed of thick succession of conglomerates. (2) The middle part is composed of calcareous marl alternated with sandstone and conglomerates. (3) The upper part is composed of beds fossiliferous limestone alternating with black silty calcareous shale or marl. The thickness is about 50-200 m. The boundary Shiranish/Tanjero Formation lies within the Upper Campanian (Fig. 8). Locally this boundary is easy to recognize in the field by a distinct color change from light gray marls to dark brownish siltstones. However, this color change cannot be observed everywhere. This boundary can be also marked by the occurrence of some fine grained sandstone layers. This facies change might indicate the obduction of the ophiolite.

The Tanjero Formation consists generally of thinly bedded dark siltstones with intercalations of thin light calcareous sandstones. The age of this formation ranges from Late Campanian to Late Maastrichtian. The Campanian/Maastrichtian boundary is marked by the extinction of *Eiffellithus eximius*, *Broinsonia parca* and *Reinhardtites anthophorus*. The Middle-Upper Maastrichtian can be determined by the presence of *Lithraphidites quadratus*, *Micula murus*, *M.prinsii* and *Ceralithoides kamptnerii*.

The overlying formations are the Red beds or Kolosh Formations. The contact with the Red bed series is gradational like in Chwarta area (*Lawa et al.*, 1998); or gradational and unconformable in different localities like in the Chwarta and Qandil area (*Karim*, 2004). The upper contact of the Tanjero Formation with the Paleocene Kolosh Formation is a dis-conformable (*Bellen et al*, 1959; *Buday*, 1980; *Jassim and Goff*, 2006). While *Sharbazheri et al.* (2009) from the study of the Foraminifera bio-zonation found a conformable contact. But depend on the reworked nannofossil assemblage in the lower part of Red bed indicate disconformity of Paleocene to Late Oligocene periods. While the contact Tanjero Formation with Kolosh Formation is seem to be conformable by recording the Late Maastrichtian in the upper part of Tanjero Formation and Early Paleocene in the lower part of Kolosh Formation.

Conclusions

The new dating based on calcareous nannofossils is allowed to get more precise ages for the different formations of Kurdistan region. The Jurassic/Cretaceous boundary identified as a continuous deposition without any interrupter and gaps between Jurassic and Cretaceous periods. The Early Cretaceous sequences they are carbonate domain. From lower starting from basinal open sea Berriasian-Valanginian of Balambo Formation, open marine outer shelf Hauterivian-Barremian of Sarmord Formation and ended by shallow reefal Aptian-Cenomanian of Qamchuqa Formation. The dense silicified white limestone of the Kometan Formation is overlying conformably the Qamchuqa limestone and is of Early Turonian age. The existed hiatus between Kometan and Shiranish formations is representing the time interval of Late Turonian to Santonian in Sulaimaniyah and Dokan area. While in Safeen, Shakrok and Harir extend to Late Campanian. Late Campanian-Maastrichtian age of the foredeep Tanjero Formation indicate starting of the Arabia-Eurasia obduction in extreme northeastern of Kurdistan region.

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