



## Relations between Deep and Shallow Stratigraphic Units of Northern Iraq during Cretaceous

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### Abstract

The study area includes Sulaimani, Erbil and Dohuk Governorates where Cretaceous rocks are well exposed in the High Folded Zone of North and Northeastern Iraq. This area is part of the northwestern boundary of the Arabian platform near the Iranian border. In these governorates, the study tries to clarify the relationship between deep and shallow stratigraphic units (formation or facies) during the Cretaceous period. The results of the present study are mainly dependant on the field lateral tracing of the lithologic changes and paleontological evidence for indicating the new age termination of the units. The results shown are a generalized and simple model of temporal and special relations between Cretaceous deep and shallow water formations. The Balambo (Kazhdumi in Iran), Kometan (Ilam), Shiranish-Tanjero (Gurpi) Formations (as deep facies) are indicated as lateral equivalents of shallow facies of Qamchuqa (Sarvak and Dariyian), Bekhme (has no equivalent in Iran yet) and Aqra Formation (Seymare or Tarbur) respectively. On the model, the transition zone is indicated where the deep facies, from the southeast, change to shallow ones in the northwest. The shallow facies consist of coarse grain limestone with fossils, skeletons, bioclasts and intraclasts. The deep facies are fine grain pelagic limestone with microfossils (panktonic forams and nanofossils) whiles the transitional facies (zones) generally consist of a mixture of the two as interfiguring relation between the deep and shallow facies. As the changes of the lithology of transitional zones are relatively sudden, they are not designated as formations and not defined previously.

**Keywords:** Shiranish-Tanjero Formations, Stratigraphic units, Arabian platform, Sulaimani, Iraq.

### 1. Introduction

The studied area is located in the Dohuk, Arbil and Sulaimaniya Governorates (Fig.1) in the High Folded Zone of Buday (1980). In this area extensive studies have been conducted from the 1950's till now. These studies document the relations (lateral lithologic change) between Early Cretaceous deep Balambo and shallow Qamchuqa Formations [1, 2]. The former formation consists of about 600m of grey, massive detrital and biogenic dolomitic limestone of reefal origins while the latter is made up of yellowish white and well bedded pelagic limestone. The same relation is cited between the Shiranish Formation (marlstone of Campanian-Maastrichtian) and the Aqra Formations (Massive reefal limestone of Late Campanian-Maastrichtian) by Buday (1980), Al-Ameri and Lawa [18]. The lateral lithologic changes between other units are still obscure. The present study tries to establish and define new relations between all Cretaceous deep and shallow water formations in northeastern Iraq and modify the previously cited relations.

The establishment includes combining new and old relations in a simple and generalize model that change the previous idea about the geology of the area in Dohuk, Arbil and Sulaimaniya Governorates. The model and included relations show temporal and spatial lateral distributions which are ascertained by finding transitional zones (common lithologies) between the studied formations (Fig.2). The establishment of the discussed relations was mainly dependant up fieldwork during which the lateral tracing of the relation was conducted and ascertained. The establishment was achieved with the aid of paleontologic evidence. All the previous studies are reviewed and checked in the field to indicate whether or not there are any ideas that contradict the results of the present study. The study includes large areas of northern Iraq in the Kurdistan region about 250 kms long and 50 kms wide.

### Discussion

The deep facies of the Balambo Formation (Early Cretaceous) in the east change laterally to shallow facies in the Qamchuqa Formation in the west. The transition zone between the Balambo and Qamchuqa formation [3, 4] can be seen in the area to the west and northwest of Sulaimaniyah City (Fig.1D). The facies of the transitional zone are generally intermediated between both formations, which are neither deep nor

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shallow. In some places this can be seen as an alternation of coarse and fine detrital limestone.

No relations have been established previously between the Kometan (Turonian–Early Campanian) and Bekhme Formations (Late Campanian–Maastrichtian) which are designated as formations of different ages. In the present study, a close relation is established between the Kometan and Bekhme Formations and the age of both formations were changed to Turonian–Early Campanian. In the model, Kometan Formation, in the east, changes to Bekhme Formation in the west. The transition zone of these two units can be seen in the area between Dokan and Smaquilly Gorge, where the Kometan Formation gradually changes to a massive Bekhme Formation. The transitional zone can be seen as an alternation between white, fine grained beds and grey coarse grained ones (Fig.2). The best places to see the transition zone are the eastern end of Makok Mountain about 3 km southwest of the town of Ranyia (Fig.3) and the area around the Hezob bridge at 36° 10' 18.48" N latitude and 44° 41' 12.88" E longitude. Another location of the transition zone is the area around Sarochawa village about 20km northwest of the town of Ranyia where the same features of the latter mountain can be seen. It is important to note that, at a few places to the west of the transition zone, the Kometan Formation does not change to the Bekhme Formation totally but remains in some places with a reduced thickness. Such are the places around the area of Shaqlawa [5] and about 4 km to the south of the town of Khalyfan. In the Bekhme Gorge, Ameen and Karim [6] correlated the lower part of the Bekhme Formation with the Kometan Formation and changed the unconformable contact between the Bekhme and Qamchuqa Formations to conformable.

The relationship between the Kometan and Bekhme Formations can be seen in figure (1B) in which the facies map of Dunnington [1] of Turonian–Early Campanian (Fig.1C) is modified to show a lateral facies change of the former formation from the southeast to the latter one in the northwest (see the green circle in the figure1B). Previously, Dunnington (1958) Buday (1980) and Jassim and Goff [7] considered the Bekhme Formation to be the age equivalent of Tanjero and Shiranish Formations.

The same relation of the above formations can be established for the Shiranish and the lower part of the Aqra formations as well. When one walks on the outcrops of the Shiranish Formation from Bekhme Gorge (southwestern outlet) to Zanta Gorge, a gradual change of marly limestone to fossiliferous limestone of Aqra Formation can be seen. From the former gorge, the upper part of the Aqra Formation contains two interfingers (Fig.4). The two interfingers contain large omphalocyclus foram which are found only in this formation (Fig.8) (see section of paleontological evidence). Accordingly, there are two main features of

transition zones, the first is gradual lithologic (or facies) change (Fig.5) and the second is interfingering between shallow and deep facies (Fig.4).

On Google Images Earth, the stratigraphic position of the Shiranish Formation shows gradual thickness reduction in an expanse of the lower part of the Aqra Formation. With this reduction, the white color succession (Shiranish Formation on Google Earth) can be observed to change to a grey succession of the Aqra Formation. Near Bujeel town, the transition zone becomes totally resistive and covers (as Aqra Formation) the peak of the Perat Mountain (anticline). At the northeastern outlet of the Zanta Gorge, the equivalent of the Shiranish Formation can be distinguished, which consists of approximately 150 m of well bedded grey to bluish white limestone succession which is occasionally fossiliferous (Fig.5).

The same previous relationships are true for the Tanjero Formation (maastrichtian sandstone and calcareous shale), which changes to the upper part of the Aqra Formation. The change occurs in a shorter distance than other formations. In Bekhme Gorge, the Tanjero Formation exists mainly as soft green marl or calcareous shale (with thin interfingers of Aqra Formation) between Shiranish and Tanjero Formations, which is located at the lowest elevation forming a small valley. Toward the west, the soft part becomes resistive (changes to resistive limestone) and near Bujeel it climbs the Perat Mountain up the peak.

The southwest outlet of the Zanta Gorge contains large foram of *luftusia* and finally, in Aqra, changes totally to the typical lithology of the Aqra Formation. The change of the Tanjero to Aqra Formation agrees with the conclusion of Walker et al. [8] who clarified that the a basinal deep water shale (calcareous shale of Tanjero Formation in Bekhme Gorge) will always separate the terrigenous depocenter (Tanjero Formation in Dokan area) from the carbonate depo-center (Aqra formation near the town of Aqra) . It was added that the carbonate depo-center tends to remain nearly stationary for long periods. It was further added that each basin will be filled slowly by shale deposition and will be flanked on both sides by thick, potentially more porous carbonates and coarser terrigenous clastics.

#### **Paleontological study**

Many detailed studies have been conducted on the Aqra and Bekhme Formation such as ([9, 10, 11 (they are detailed MSc thesis), 12, 7]. These studies have not shown any direct evidence to indicate the age of the latter formation. Even Bellen et al. [2] has recorded many fossils in the Bekhme Formation but today not one of them is used for age determination because they all have a long range of occurrence.

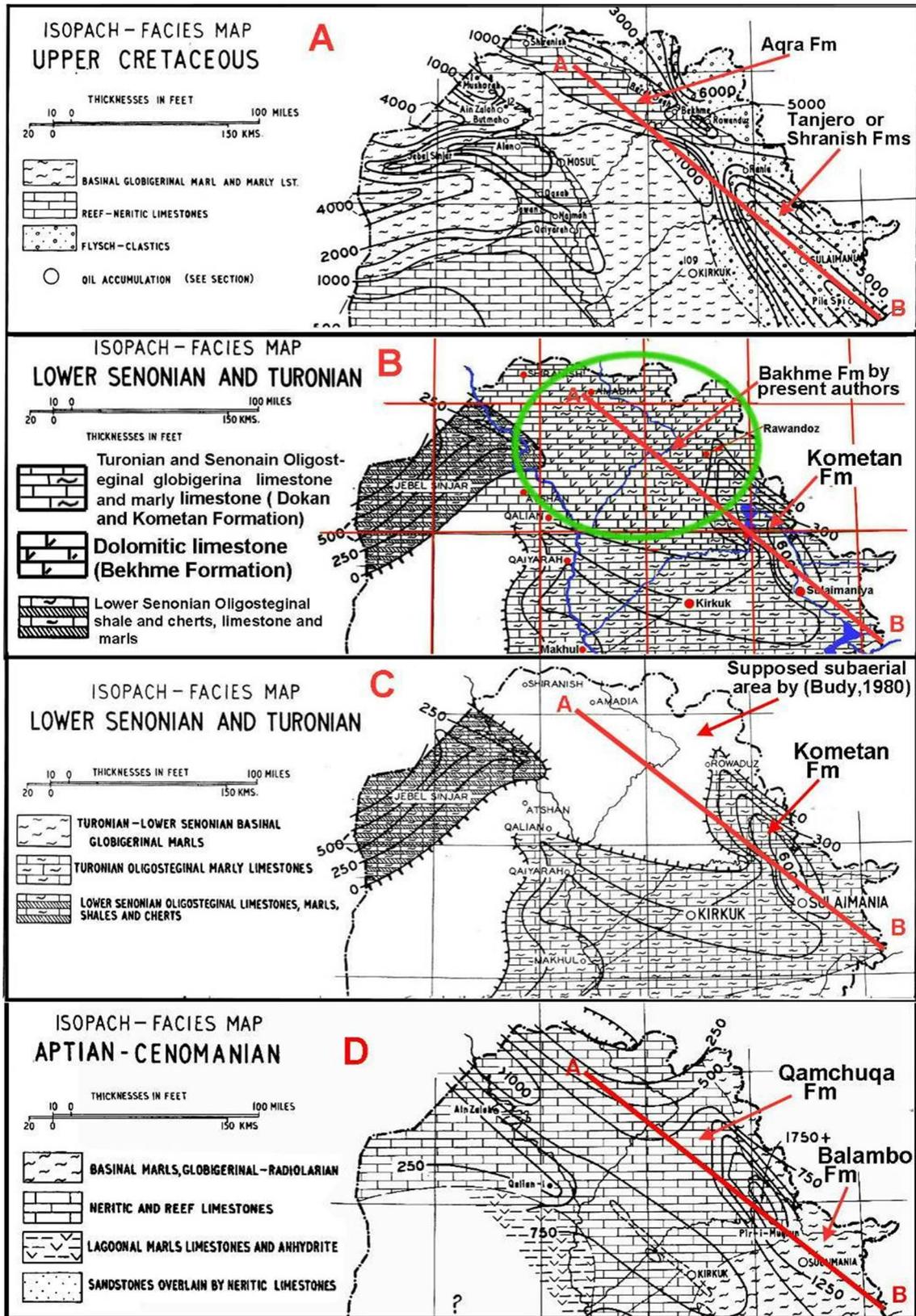


Fig. 1. A, C, and D facies maps of Cretaceous [1] shows the study area which is located along and around the red line (AB). The line is the direction of the geologic cross section in figure 2. In this study, the map (C) is modified to the map B which shows a lateral facies change of the Kometan Formation to the Bekhme Formation (green circle).

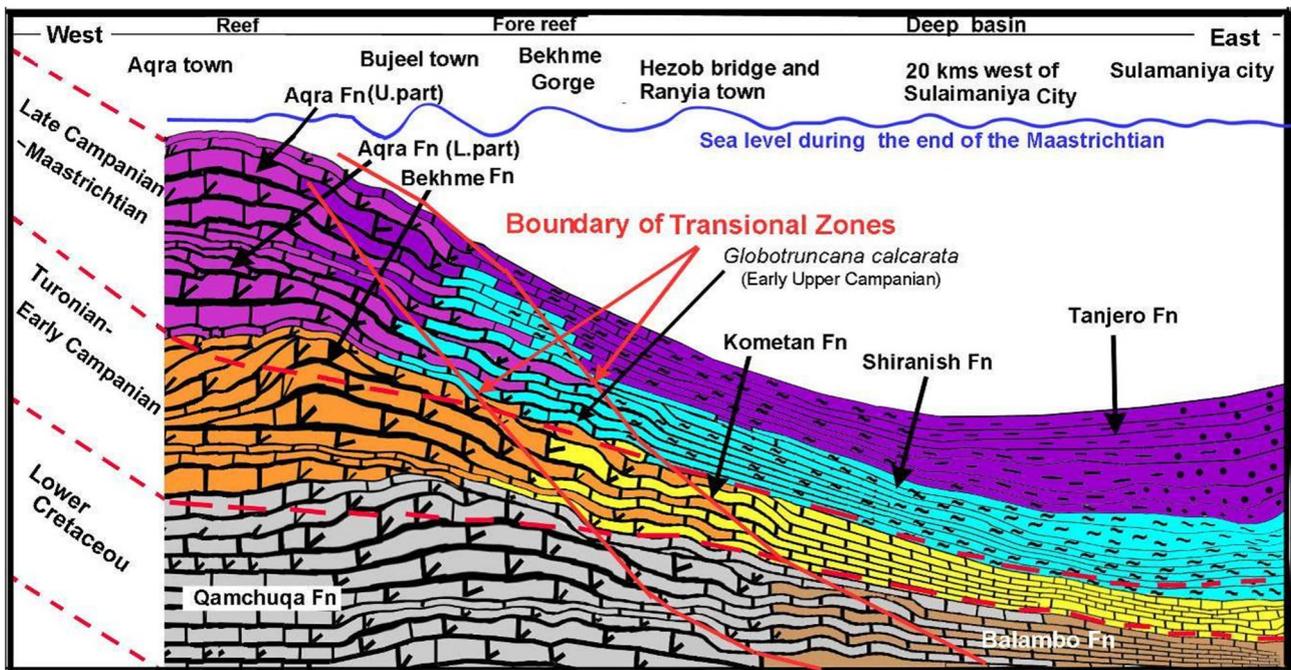


Fig. 2. Geologic longitudinal section along the transect line AB (see facies maps A, B, C and D in the fig.1) shows relation between the shallow and deep formations. This diagram is based on fieldwork done between the city of Sulaimaniya and the town of Aqra. It shows spatial and temporal relations between Cretaceous formations. It appears that the geologic relations between the Balambo and Qamchuqa formations are applicable for other units of Upper Cretaceous rocks. The dashed red lines are isochrones datums.

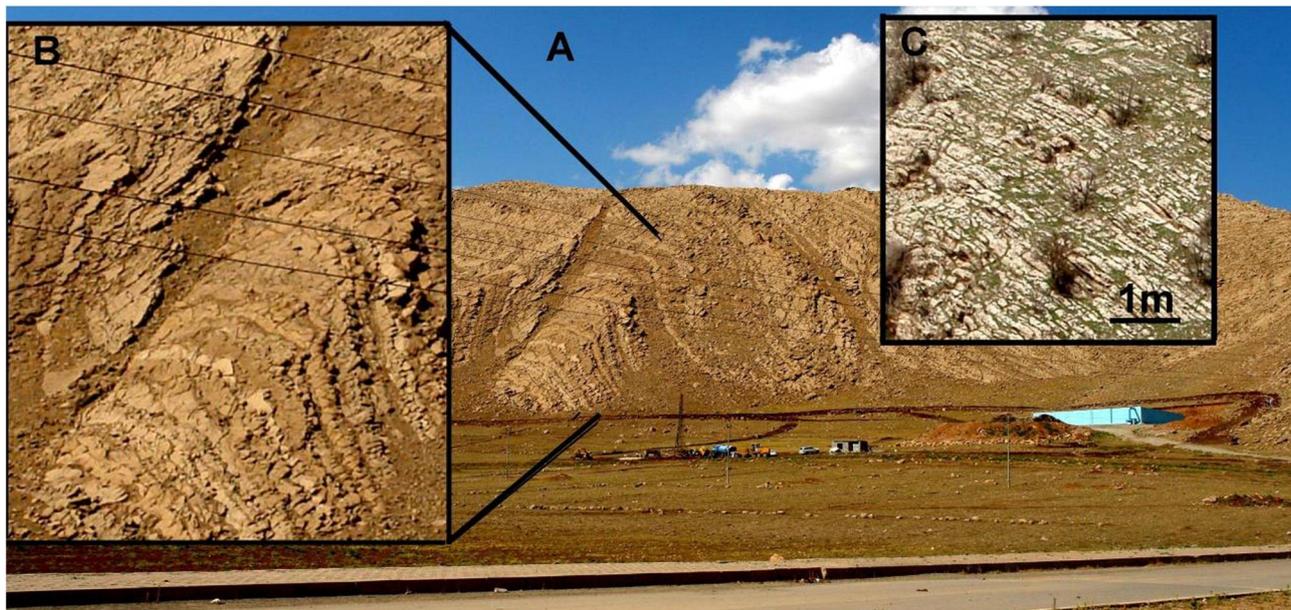


Fig. 3. A) Shows a lithology which is intermediate between the Kometan and Bekhme Formations (transitional zone between the two formations is interfingers of shallow and deep facies) about 3 km to the west of the town of Ranyia (southeastern end of Makok Mountain), with the rack being approximately 7m high. B) Enlarged interval between the two lines. C) Kometan formation in the Dokan area.

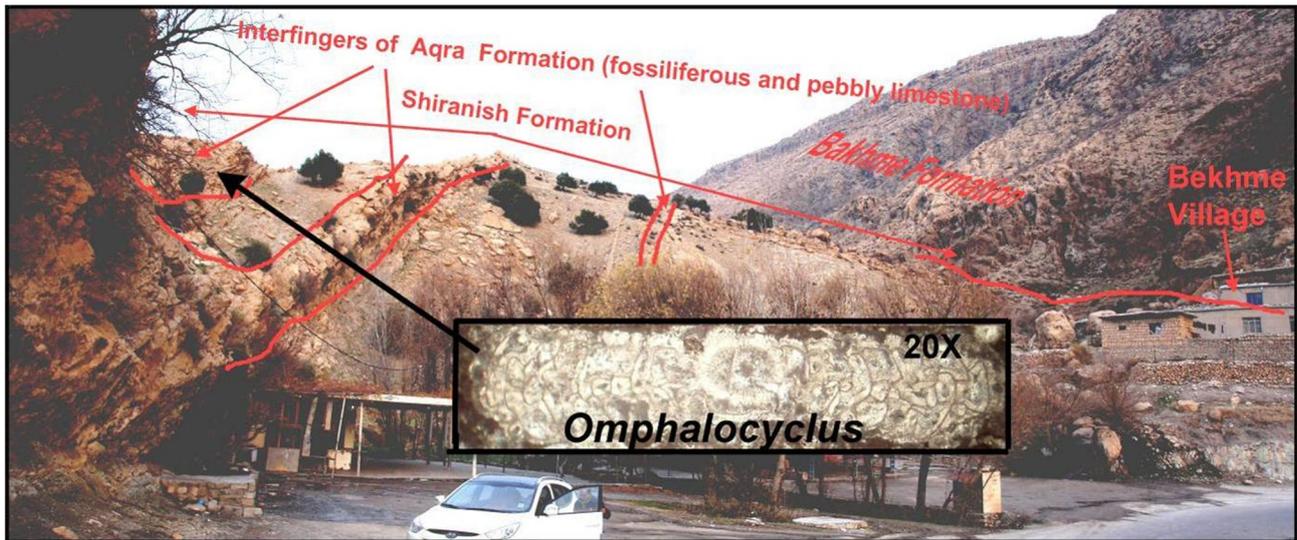


Fig. 4. Southeastern outlet of Bekhme Gorge (directly to the west of Bekhme village) showing the upper part of the Shiranish Formation that contains two interfingers of Aqra Formation which contain *Omphalocyclus*. This interfingering is a common feature of the transition zone.



Fig. 5. Bluish white to grey succession which represents the transitional zone between Shiranish and the lower part of the Aqra Formation at the northeastern inlet of Zanta Gorge about 7kms to the southeast of Aqra. The beds of the succession are occasionally fossiliferous and are located under the Tanjero Formation or its equivalent.

In the present study, no fossils are found in the Bekhme Formation for age determination due to intense dolomitization and recrystallization. Therefore, efforts have been directed toward the base of the Shiranish Formation which overlies the latter formation. The samples of the Shiranish Formation in Bekhme Gorge gave the age of early upper Campanian (Fig.6, 7 and 9). The efforts of this study have therefore been successful in proving that the previous age determination of the Bekhme Formation (Late Campanian-Maastrichtian) is not accurate. The age of the Bekhme Formation is older than Late Campanian (Middle Campanian and older). For this age

determination, a section of the boundary between the Shiranish and Bekhme formations was taken that overlies a section of this latter formation at Bekhme Gorge. The section is located at the end of a tunnel that passes through the northeastern limb of the Perat anticline. Directly to the east of the northeast outlet of the tunnel, a well exposed section can be seen along the road cut (Fig.6). The latitudes and longitudes of this section are  $36^{\circ} 41' 45.20''$  N,  $44^{\circ} 17' 09.55''$  E.

The main sedimentological feature of this section is a glauconitic bed that is located between the two formations. It is about 10cm thick and contains grass green disseminated glauconite grains (Fig.2). R.

Wetzel, 1950 (in [2]) cited abrupt contact between the two formations which is marked by condensation of planktonic foraminiferal fauna and by glauconite concentration, doubtfully conformable. A sample of the base of the Shiranish Formation that was taken directly above the glauconitic bed, showed *Globotruncana calcarata* which is an index fossil of the early upper Campanian (Fig.7 and 9). An other index fossil of the Late Campanian-Maastrichtian is omphalocyclus (Fig.8) which is not found in the Bekhme Formation in any of the aforementioned studies but was found inside a fossiliferous limestone in the upper part of the Shiranish Formation at the Bekhme Gorge. This latter limestone is an interfinger of the Aqra Formation in the upper part of the Shiranish Formation or in the lower part of the Tanjero Formation.

If the age of the Bekhme Formation (as a reefal facies) was late Campanian- Maastrichtian as mentioned

before, it must contain very clear and abundant fossils such rudists, loftusia, omphalocyclus . This is because the rock of the latter age contains these fossils in Iraq, Iran, Turkey Oman and Greece (see [13, 14, 15]). Unfortunately these fossils are not found in the Bekhme Formation. The occurrence of the Glauconitic beds below the *Globotruncana Calcarata* Zone, convince one that the age of the top of the Bekhme Formation is far older than Middle Campanian. This is because the glauconitic bed is always responsible for the non-deposition and disappearance of what may coincide with the Middle Campanian. The evidence for this assumption is the study of Al-Badrani *et al.*[16] who concluded (by Nannofossils biozonation) that the lower part of the Shiranish Formation has the age of Early Campanian in a section near the city of Sulaiminyia.

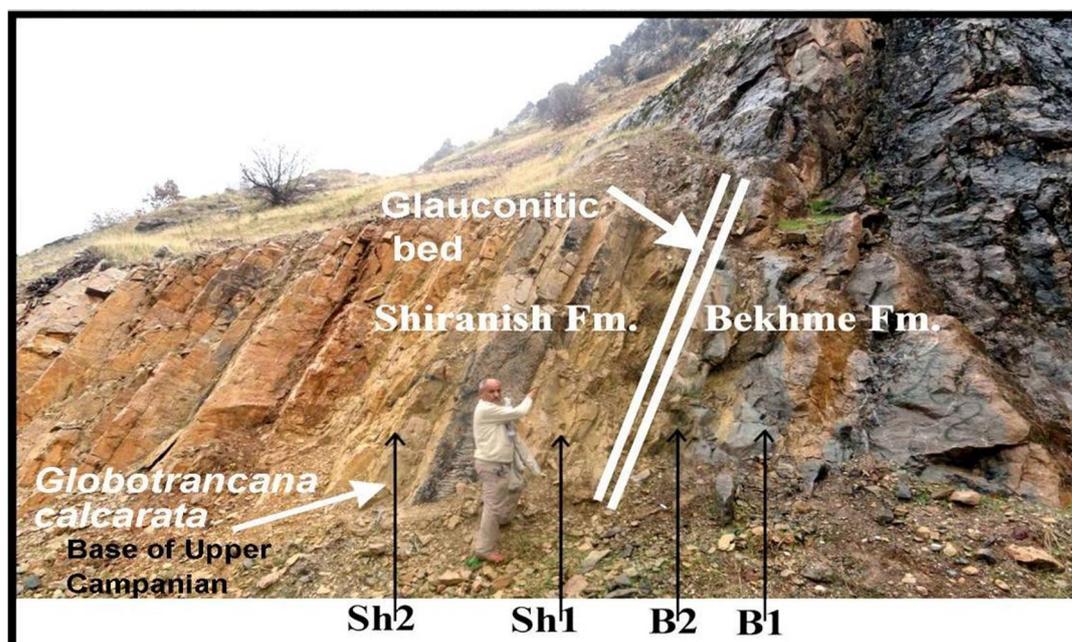


Fig. 6. Contact between the Bekhme and Shiranish Formation at northeastern outlet of the Bekhme Gorge, shows inspected samples and location of *Globotruncana (Radotruncana) calcarata* (Early Late Campanian).

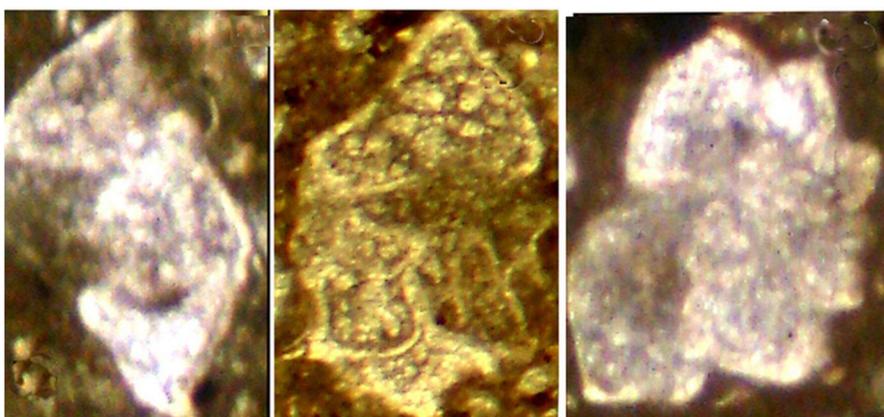


Fig.7. Different section of *Globotruncana calcarata* which is an index fossil of the base of Early Late Campanian found in the base of the Shiranish Formation in Bekhme Gorge, S.No. Sh2, 50X, normal light.

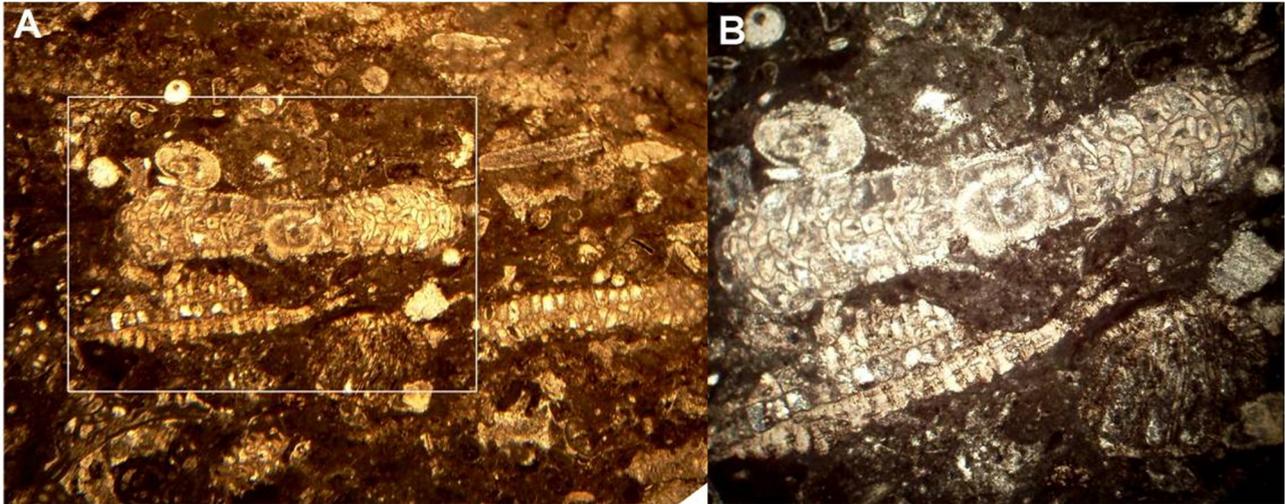


Fig. 8. Omphalocyclus in the Aqra Formation (located in the upper portion of the Shiranish Formation) in Bekhme Gorge which is not found in the Bekhme Formation in the present study nor in all previous ones. No. A3, 10 X, normal light.

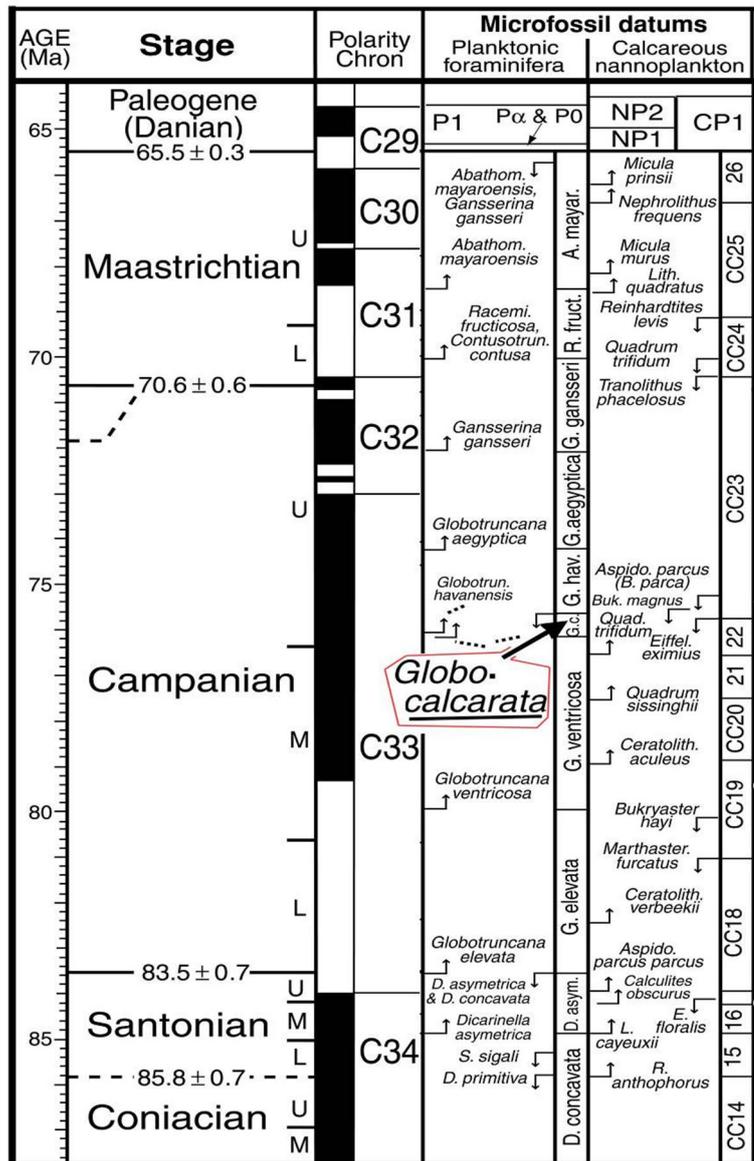


Fig. 9. Biozonation of the Late Cretaceous [17] in which the Early Upper Campanian is represented by *Globotruncana calcarata* (indicated by black arrow).

## Generalized Model

In figure (9), a simplified graphical model is drawn to show generalized spatial and temporal lateral relations between deep and shallow Cretaceous formations. This model is based on fieldwork and lateral tracing in addition to palaeontologic evidence. The transition zone of these related formations is indicated and located between the red dashed and bold green lines. All transitional zones of different ages and different formations are connected. The relations show that the facies changes (in the transitional zones) occur relatively suddenly which resemble steps and ascend toward the west. It can be seen that there is no prominent unconformities between the different formations because the main tectonic was far from the studied area and located inside Iran to the northwest during the Cretaceous period. The continuous shallowing by reef growth and sediment fill is compensated by subsidence at the end of each reef building phase. In addition to reef growth, the area as Cretaceous forbulge is most possibly uplifted by the tectonic load of the Iranian plate.

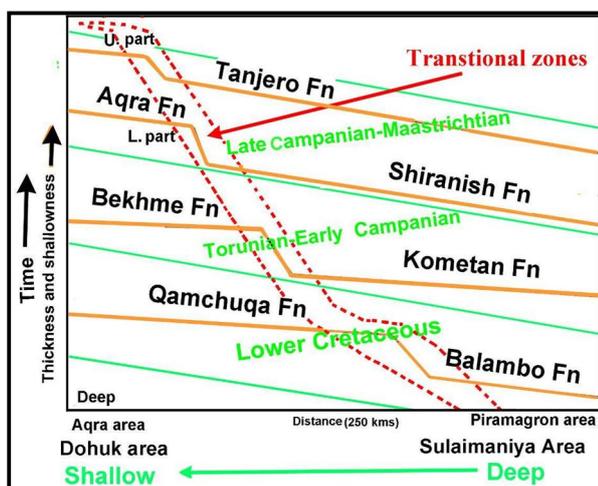


Fig. 10. A simplified model shows generalized spatial and temporal relations between deep and shallow Cretaceous formations (based on fieldwork). The shallowness is compensated by subsidence, therefore no unconformities are seen in the area.

## Conclusions

- Generalized relations of deep to shallow facies changes were established across Sulaimaniyah, Erbil and Dohuk Governorates during the Cretaceous for the first time.
- Their relationship are organized in a simple graphical model of temporal and spacial relations between the Cretaceous Balambo, Kometan, Shiranish (with Tanjero) Formations (as deep facies) which are indicated as lateral equivalent facies of the Qamchuqa, Bekhme and Aqra Formation respectively.

- On the model, the transition zone is indicated where the deep facies from the east, change relatively suddenly to shallow ones in the west.
- The paleontological evidences used for the first time to show that the previous age determination of the Bekhme Formation was not accurate and its top is older than Late Campanian.

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