

The Significance of Diachronous Age as an Indicator of the Southeast Advance of the Zagros Orogenic Belt During Campanian, NE. Iraq

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ABSTRACT

The contact between Bekhme and Shiranish Formations is studied paleontologically in Bekhme gorge and Rawanduz area. The nannofossils are used to prove that the age of the base of the Shiranish Formation is lower late Campanian and middle Campanian in Bekhme gorge and Rawanduz area respectively. The older age of the Rawanduz area is attributed to early drowning (flexing downward) of the forebulge of the Arabian platform due to southwest propagation of tectonic load of the Zagros Orogen during early stage of collision of Afro-Arabian and Iranian plates by which the Tethys ocean closed later.

Keywords: Bekhme, Shiranish, Late Cretaceous, Nanofossil, Rawanduz Area.

أهمية العمر المتزامن كدليل للتقدم التكتوني نحو الجنوب الشرقي خلال الكامبانيان،
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الملخص

تم دراسة الحد ما بين تكويني شيرانش وبخمة من الناحية الاحاثية في منطقتي بخمة وراوندوز. استخدمت حشود متحجرات النانو الكلسية التي اثبتت بان قاعدة تكوين شيرانش هي اسفل الكامبانيان المتأخر و الكامبانيان الاوسط لمنطقتي بخمة وراوندوز على التوالي. إن العمر الأقدم في راوندوز يشير إلى الانغمار المتعاقب (الانغمار غير التزامن) للمنصة العربية تحت تأثير تقدم الحمل التكتوني لزاكروس خلال المراحل الأولية لتصادم الصفائح الافرو-العربية و الايرانية خلال الانغلاق التدريجي لمحيط التيثس الجديد.

الكلمات الدالة: تكوين بخمة، تكوين شيرانش، الكريتاسي المتأخر، متحجرات النانو، منطقة راوندوز.

INTRODUCTION

According to Bellen *et al.* (1959) the type section of Bekhme Formation was defined by Wetzel in 1950 and located in the Bekhme Gorge in the High Folded Zone (Figs.1 and 2). It consists of carbonate rocks of detrital and biogenic limestone which are intensively and coarsely dolomitized. The latter author cited that the overlying formation is Shiranish with abrupt contact which is marked by condensation of planktonic foraminiferal fauna and by glauconite concentration, doubtfully conformable. He further mentioned that the age of Bekhme and Shiranish Formations was Upper Campanian–perhaps Lower Maastrichtian and Late Upper Campanian–Maastrichtian respectively. The aim of study age of the lower part of the Shiranish Formation in the Bekhme gorge and northwest of Rawanduz town (southwest of Diana town) by studying the nannofossils and using as Indicator of the southeast advance of the Zagros orogenic belt during campanian.

METHOD OF THE STUDY

Five and three samples were taken from the boundary between Bekhme and Shiranish Formation at Bekhme Gorge and Rawanduz sections respectively. These samples are inspected under hand lens in the field and smear slides are prepared for nannofossils identification by using more than 1000 power magnification. The slides were prepared by placing a small portion of the sample on a glass slide and mixed thoroughly with distilled water to make a paste. Spatula was used to make very thin and even laminae (smeared sample) on the glass slide. The slide was dried on a hot plate and covered with glass cover slide by using Canada balsam and examined with transmitted light microscope (Armstrong and Brasier, 2005).

For the achieving the identification and age determination of the nannofossil the studies of Perch-Nielsen (1985), Gradstein, *et al.*, (2004). Hadavi *et al.*, (2008), and

Shamrock and Watkins (2009) were used. The inferred age was compared with the age of the underlying Bekhme Formation.

In past and during the fifties of the last century, the Campanian was divided into three (early, middle, later) ages or parts of nearly equal durations. The age determination of the Bellen *et al.*, (1959) are based on this tripartite division while in some recent studies, two (early and late) divisions are used. In the present study the tripartite division is used and when the two divisions of some authors are used, the absolute age is converted to its equivalent in the three part divisions.

DESCRIPTION OF STUDIED LOCALITIES

1- Bekhme Gorge section (or Bekhme section).

This section represents the boundary between Bekhme and Shiranish formations and located at the end of the tunnel that passes through northeastern limb of Perat anticline. Directly to the east of the northeast outlet of the tunnel, a well exposed section of the boundary can be seen along the road cut (Fig.3). The latitudes and longitudes of this section are $36^{\circ} 41' 45.20''$ N, $44^{\circ} 17' 09.55''$ E. At this area, the Perat anticline is trending northwest–southwest and cut transversally by Greater Zab River and consequently Bekhme gorge is formed which has two and four kilometers of width and length respectively. The anticline is asymmetrical and its southwestern limb is steeper than the northeastern one. In the gorge, Balambo, Qamchuqa and Bekhme Formations are exposed while along its two limbs Shiranish, Aqra, Tanjero and Kolosh Formations are outcropping.

The main sedimentological feature of this section is a glauconitic marly limestone bed which is located between the two formations. It is about 10cm thick and contains grass green disseminated glauconite grains (Fig. 3). Wetzel (1950 in Bellen *et al.*, 1959) cited an abrupt contact between the two formations which is marked by condensation of planktonic foraminiferal fauna and by glauconite concentration, doubtfully conformable.

2- Rawanduz town section (or Rawanduz Section).

This section is located between Rawanduz and Diana towns, directly to the west of the Kawlokan Bridge on the western bank of Rawanduz stream (Figs.1 and 2). The latitudes and longitudes of this section are $36^{\circ} 37' 25.20''$ N, $44^{\circ} 32' 01.13''$ E. The section is near the plunge of Handreen and Bradost anticlines. In the area the oldest formation is Qamchuqa Formation which is overlain by Bekhme Formation. The later formation is underlying Shiranish Formation with very clear sharp contact in

which there are sporadic limestone gravels (or gravel sized clasts or intraformational conglomerate) in a bed of marly limestone about 30cm thick. The bed is directly overlying the Bekhme Formation at the base of Shiranish Formation (Fig. 4). The surface of the last bed (directly below the conglomerate) is irregular and shows some sign of submarine erosion and possible etching. Due to high thickness, hardness and massiveness of Qamchuqa and Bekhme Formations, the mass-wasting is not common; therefore chemical and stream vertical erosion are active. This absence of mass wasting, formed many vertical sided gorges in many areas such as those that surround Rawanduz town and by which the city looks like large man made castle.

Age of the Base of the Shiranish Formation at Bekhme Gorge

The samples of this section contain *Globotruncanita calcarata* (Cushman) which is found at the base of Shiranish Formation in a bed directly overlains the glauconitic bed that is directly above Bekhme Formation, The bed consists of a pale yellow to grey marly limestone. This fossil has short range and determined, in recent study, as index fossil of lower Late Campanian with some controversy as cited below.

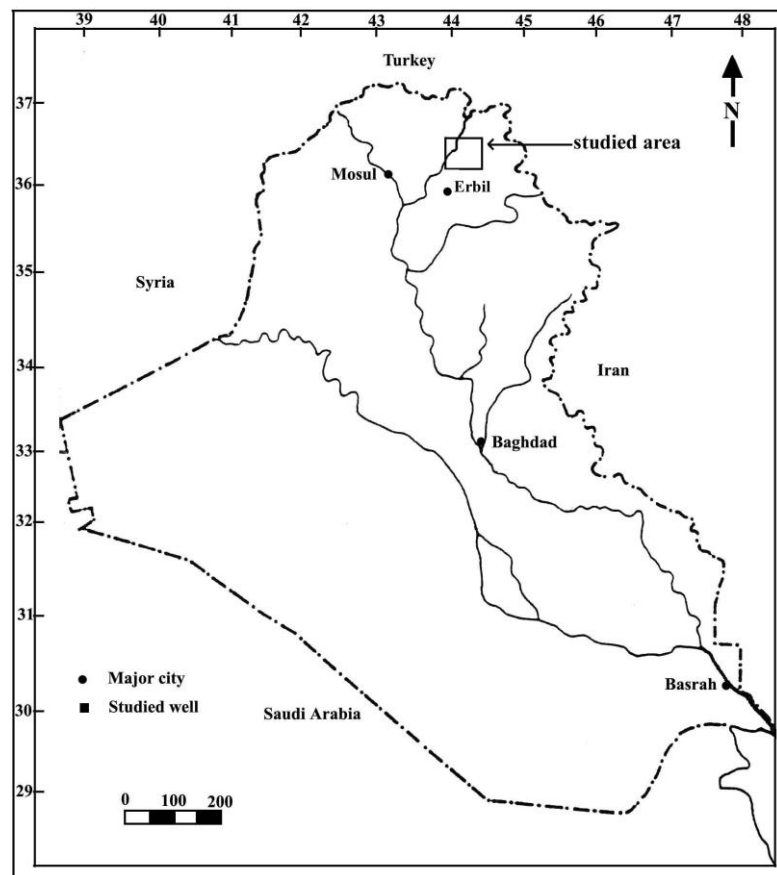


Fig. 1: Location Map of the Studied Area.

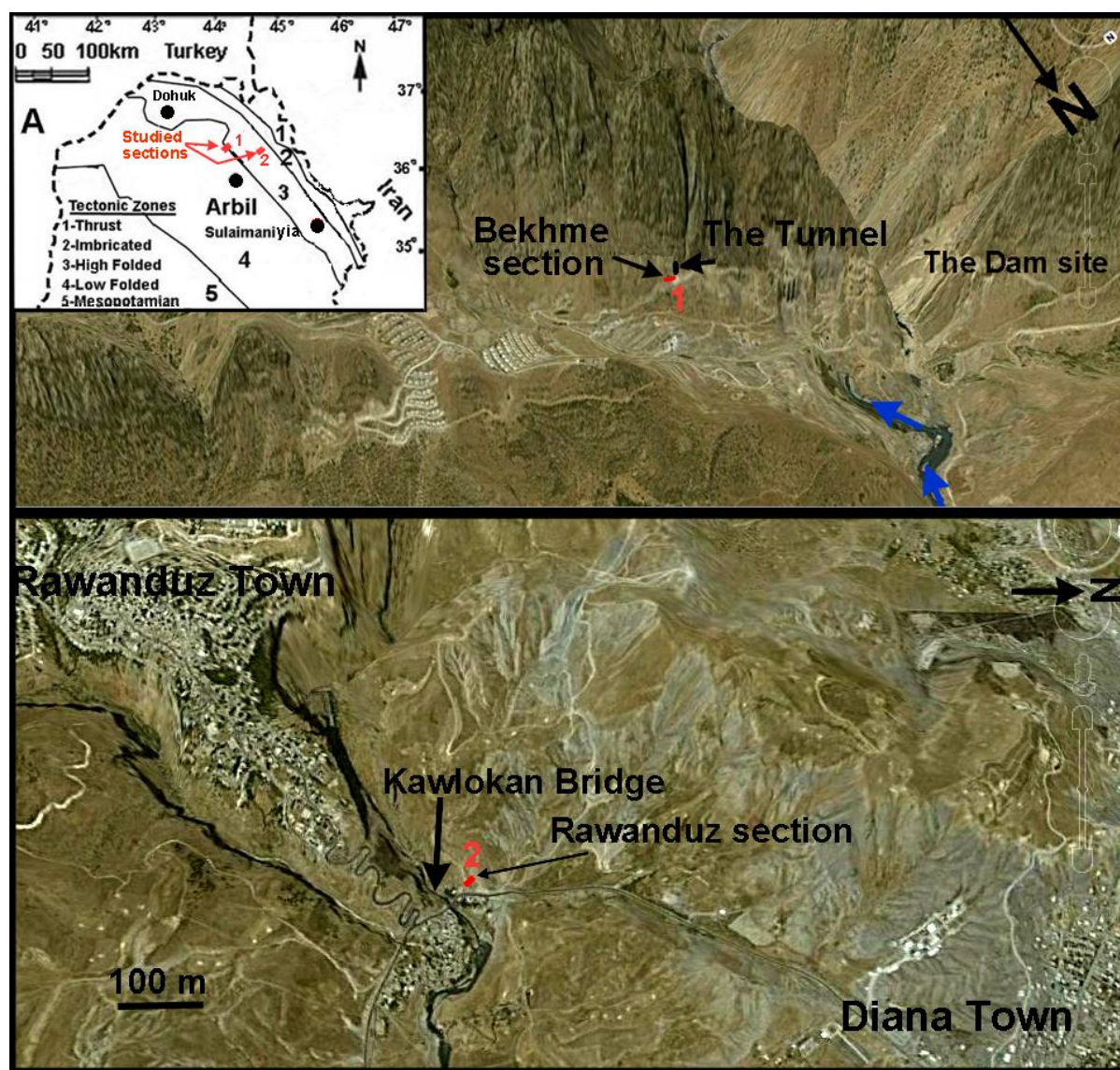


Fig. 2: Google Earth Image on Which the location of the Two Studied Sections are Shown.

Sliter (1968), El-Nady, (2006) and Al-Mutwali *et al.*, (2008) indicated the age of this species as late Campanian while Darvishzad and Abdolalipour (2009), Özer and Toker (2009) ; Gradstein, *et al.*, 2004, Georgescu (2007), Sari (2006), (Fazli, *et al.*, 2010), (Falzoni, and Petrizzo, 2011), Erba, *et al.*, (1995), Abdelghany (2003) stated a lower Late Campanian age for this fossil. In Tibet and Turkey, the age of this fauna is assigned as middle Campanian by Li *et al.*, (2011) and Ozcan, (2007) respectively. The same age (Middle Campanian) is stated by Petrizzo *et al.*, (2011). Odin *et al.*, (2001) aged it as middle part of late Campanian. In Bulgaria Valchev and vd Dimitrova, (2007) and Robaszynski, (2006) referred to it as fauna upper late

Campanian. In the present study, the age is determined as lower late Campanian as mean value for the all above ages (Fig. 7).

The same section is studied for nannofossil and within the collected samples two of them contain index nannofossils such as *Aspidolithus constricts*, *Eiffellithus eximius*, *Glaukoithus diplogramus*, *Microrhabdulus decorates*, *Micula decussata*, *Quadrum sissingh*, *Micula cf. swastika* *Pervilithus varius*, *Tranolithus phacelosus* and *Watznaueria barnesae*. These species gave the age of lower late Campanian (Fig. 7).



Fig. 3: Outcrop of the Contact Between Bekhme and Shiranish Formations at Northeastern Outlet of Bekhme Gorge (Immediately at the Northeastern End of the Tunnel).

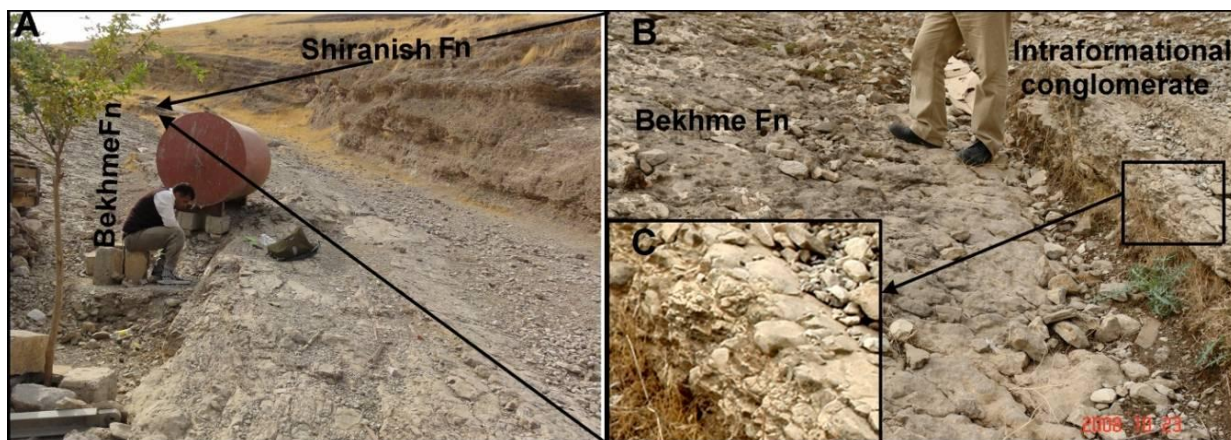


Fig. 4: Outcrop of the Contact Between Bekhme and Shiranish Formations at Rawanduz Area (A and B). the Contact Contains Intraformational Conglomerate (C).

Age of Base of the Shiranish Formation at Rawanduz

As mentioned before, the Rawanduz section does not contain glauconite bed but instead it contains an intraclastic (intraformational conglomerate) bed between Bekhme and Shiranish Formations at the same stratigraphic position (directly above Bekhme Formation). The intraclastic bed is about 30cm thick and consists of marly limestone that contains clasts of gravels of limestone (Fig.4). It is possible that these clasts were ripped up from underlying beds of Bekhme Formation during its drowning. During onset of drowning, the partially lithified sediment of the Bekhme Formation was opened to strong wave of the open sea and consequently the reworking of the intraclasts had taken place.

For the age determination of the base of the Shiranish Formation in the Rawanduz section, the bed that is located directly above the intraclastic bed was sampled (Fig. 4). The samples were studied for nannofossil age determination and gave Middle Campanian. This age is represented by the occurrence of index nannofossils of *Aspidolithus parvus*, *Micula decussata* and *Quadrum cf. sissingh*. These fossils gave the age of the base of the Shiranish Formation as Middle Campanian or younger (Fig. 6).

DISCUSSION OF THE AGE

There are differences by about 1.5 million years between the base in Bekhme and Rawanduz sections as they have the age of lower late Campanian and Middle Campanian respectively (Fig. 7). The younger age of the Bekhme section could be attributed to what mentioned by Bosence (2005), That due to progressive advance of the orogenic wedge, the platform (Bekhme gorge) at any one site will drown within a few million years but the composite platform (platform in Rawanduz and Bekhme area) is diachronous, becoming younger towards the foreland (toward the southwest). The same migration of drowning is clarified by Dorobek (1997), as shown in the (Fig. 8).

The figure can be applied to the Bekhme Formation in Rawanduz area (T₁ RAMP) and in the Bekhme Gorge Formation (T₃ RAMP). The covering of Arabian platform (Bekhme Formation) by Shiranish Formation agrees with the literature in Europe such as Sinclair (1997), who mentioned examples from Tertiary foreland platform of Alps where the upper surface of the carbonates ramp is a sharp or transitional passage into deeper-water globigerinid marls. He added that the high rates of siliciclastic supply sourced from the advancing orogenic wedge, onlap, overlie and bury the platforms at the base of the foreland basin fill (Bekhme Formation at Rawanduz area).

The early drowning of the Rawanduz area (T₁ RAMP) is due to its closeness to the frontal part of the Iranian Plate that overridden the Arabian plate. The area had

subsided earlier and received clastic sediments of marl (hemipelagite or distal turbidite) while the Bekhme gorge (T₃ RAMP) remained shallow and depositing reefal limestone or starved from sedimentation as shown by glauconitic bed (Fig. 3). The delay of subsidence was lasted for about 1.5 million years during which the deepening of the Rawanduz area forced the sediment influx to settle there and did not reach Bekhme gorge, which was in higher submarine topography (forebulge), (Znad, 2013)

It is possible that the submarine erosion (as an event) in the Rawanduz section (as indicated by intraformational conglomerate) is a hiatus that is equal in duration to non-deposition (glauconitic bed) in the Bekhme Gorge. This means that the two events are diachronous like the drowning of the platform in the two studied sections.

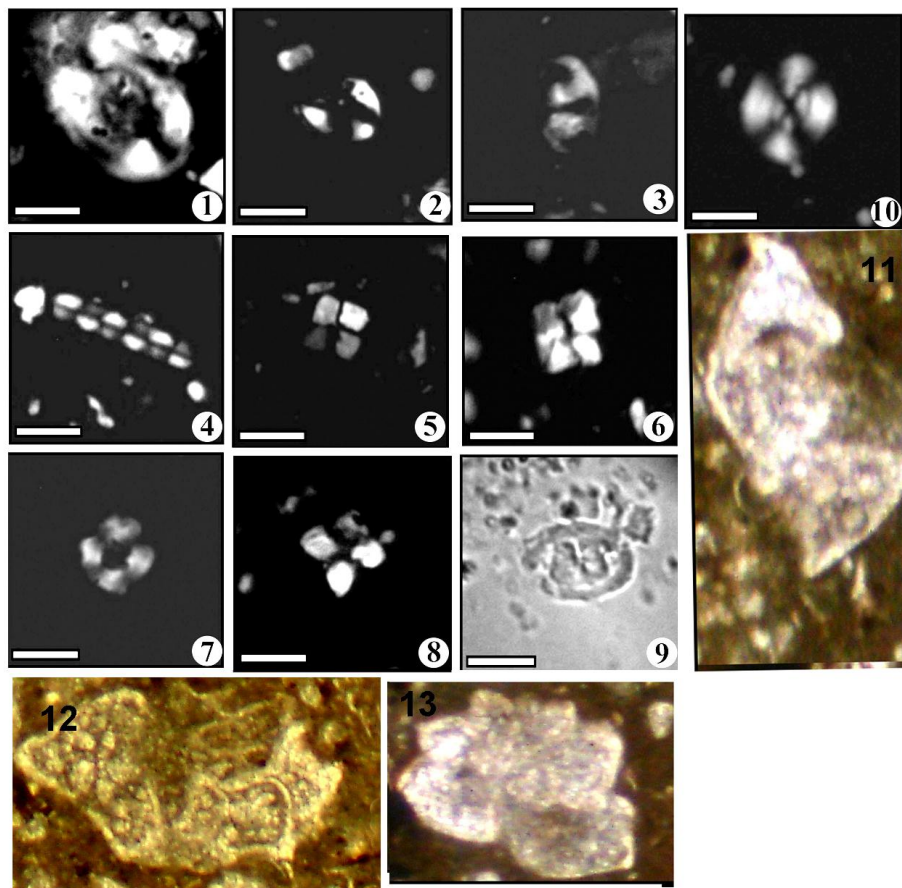


Fig. 5: Species of Nannofossils in Shiranish Formation Directly above Bekhme and Shiranish Formations at the Northeastern Outlet of Bekhme Gorge that Indicate Lower Late Campanian: 1- *Aspidolithus Parcus*, 2- *Eiffellithus Eximius*, 3- *Glaukoithus Diplogramus*, 4- *Microrhabdulus Decoratus*, 5- *Micula Decussata*, 6- *Micula cf. swastika*, 7- *Pervilithus varius*, 8- *Quadrum sissingh*, 9- *Tranolithus Phacelosus* 10- *Watznaueria Barnesae* 11, 12, 13- Foraminifera Species, bar is (5) micron.

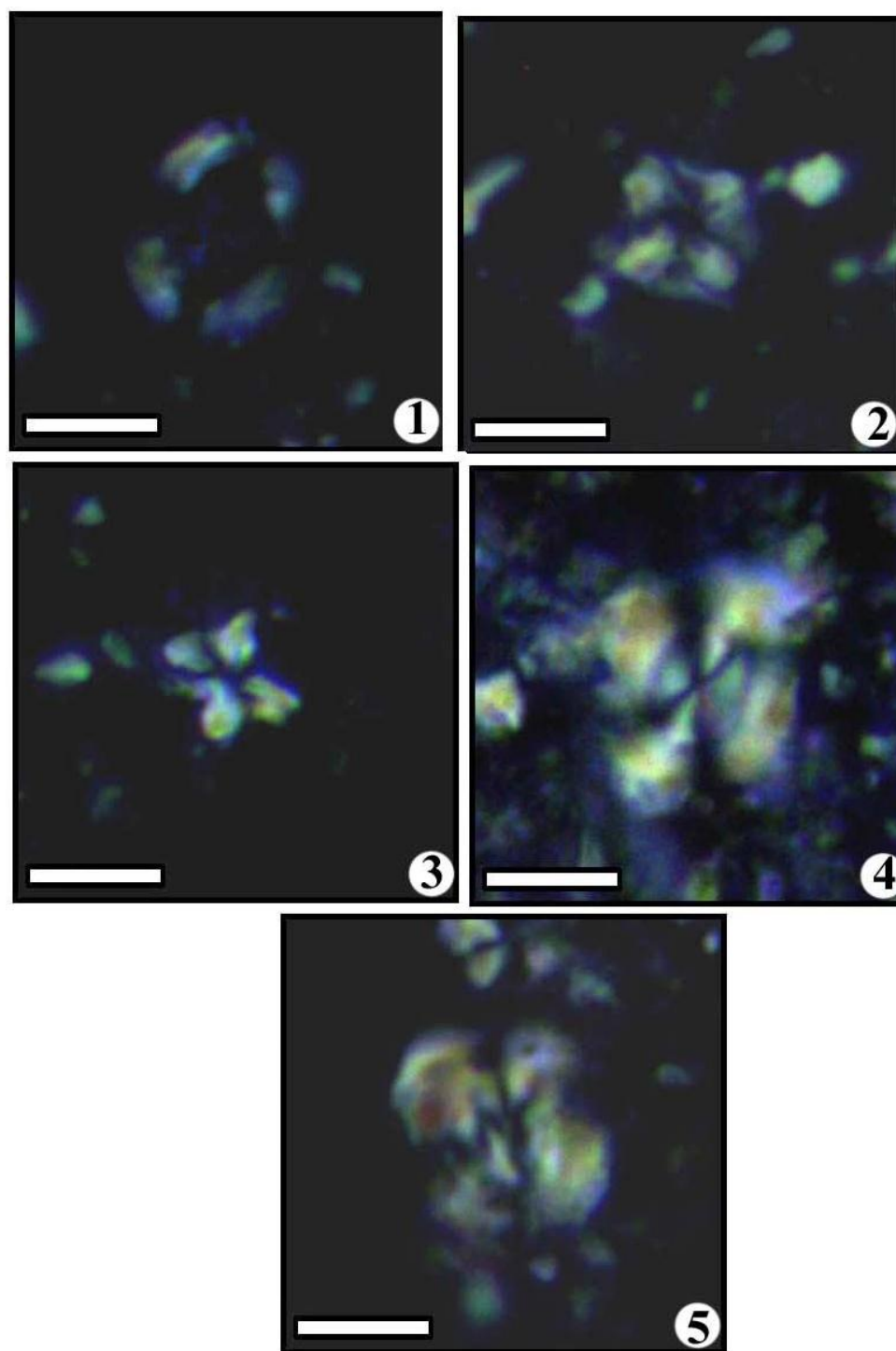
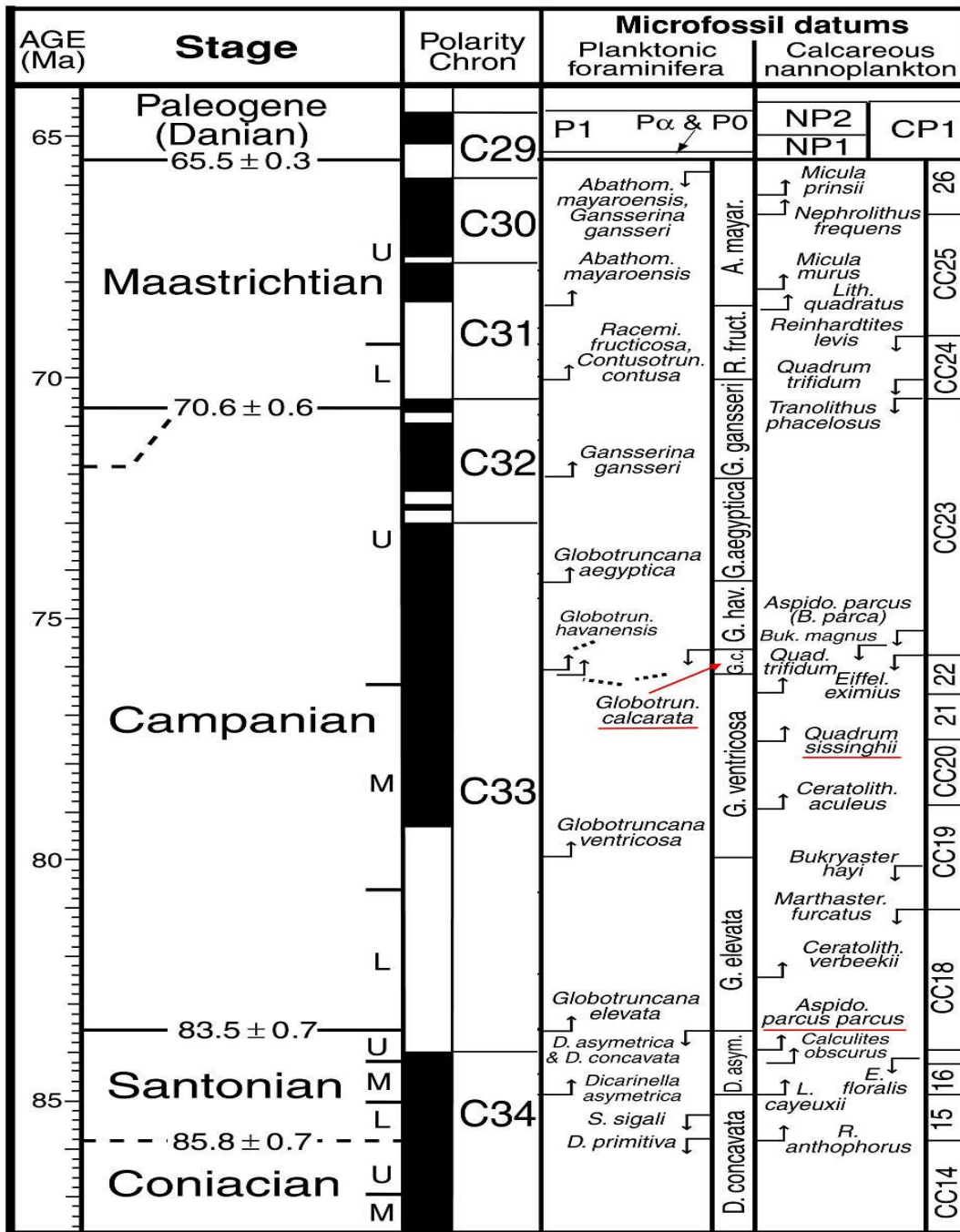


Fig. 6: Species of Nannofossils of Shiranish Formation Directly Between Bekhme and Shiranish Formations at Rawanduz Area, These Fossils Give the Age of Middle Campanian: **1-** *Aspidolithus Constricts*, **2-** *Micula cf. decussata*, **3-** *Quadrum cf. Sissingh*, **4, 5-** *Watznaueria Barnesae*, bar is (5) micron.

Fig. 7: Biozonation of the Late Cretaceous (Gradstein *et al.*, 2004).

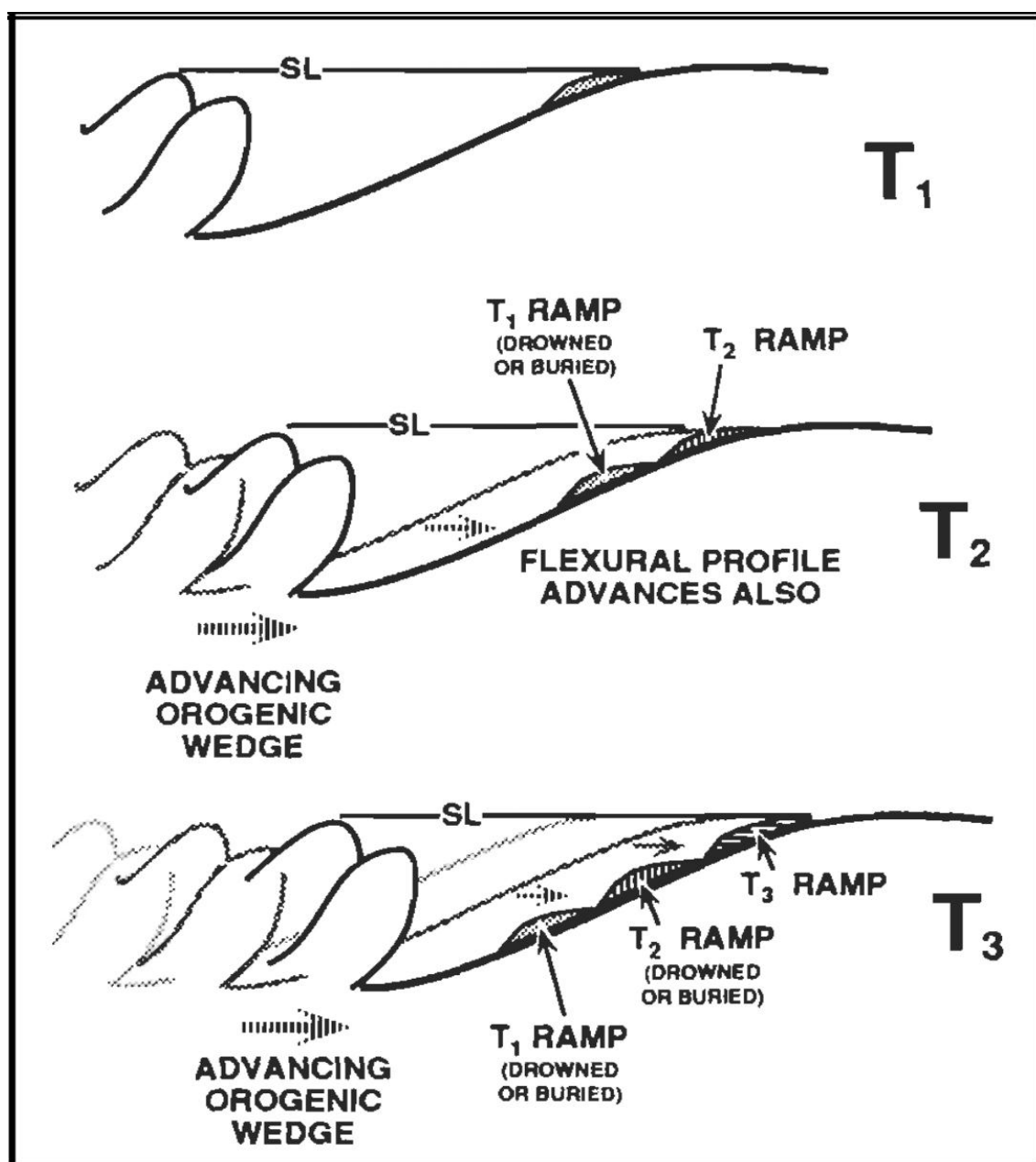


Fig. 8: Gradual (Diachronous) Drowning of Forebulge (Dorobek, 1997) which can be applied to the Arabian Platform (Bekhme and Qamchuqa Formations) in the Studied Area (Rawanduz and Bekhme Gorge, T_1 , T_2 and T_3 Ramps).

CONCLUSION

This study has the following conclusions:

- 1- The nannofossils age determination of the base of Shiranish Formation at Bekhme gorge and Rawanduz area gives lower Late and Middle Campanian age respectively.
- 2- The difference in age is about 1.5million year which could be attributed to earlier drowning of Arabian platform in the Rawanduz area than the Bakhme gorge.
- 3- The effect of tectonic migration was reached in Rawanduz area earlier than Bekhme Area.
- 4- These ages are new and in contract to with previous studies.

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