Stratigraphic Analysis of Azmir-Goizha anticline by Nannofossils

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Abstract:

The Azmir-Goizha anticline elongates directly to north and northeast boundary of Sulaimani city, Kurdistan Region, NE-Iraq. The anticline is originally consisted of two main connected anticlines (Goizha and Azmir anticlines) at southwest and northwest respectively with many other smaller ones. The anticline has the length, width and elevation of about 10, 4 and 1.6 kms (amsl) respectively. It elongates from Weladar village, from southeast to Khamza village at the northwest. The anticline is relatively complex and during the last decade, many structural, paleontological and stratigraphical studies were conducted on it but without utilizing them for accurate solving complexity. The present study tries to use the field study and nannofossils aging for simplifying and showing actual geologic setting of the anticline. The previous occurrence of 63m of Dokan Formation and its unconformable lower boundary are refused. On the basis of clear stratigraphic horizon, the geological map of the anticline is completely and new stratigraphic units are shown. The map shows that the anticline is mainly covered by Balambo Formation instead of previous Kometan Formation. Moreover, the Sarmord Formation is identified for the first time in the area and differentiated from Balambo Formation. Sarmord Formation crops out and occupies the core of the anticline which can be seen from Khamza to Weladar villages at the northwest and southeast of the studied area respectively. For the first time, the equivalents of Gulneri and Dokan formations are shown and discussed in the area.

Keywords:

Introduction

The Azmir and Goizha are two connected mountains that located to the north and northeast of Sulaimani city respectively. In the present time, the boundaries of two mountains are nearly coinciding with boundary of city (Fig.1). The two mountains are forming a large northwest-southeast mountain range looking over the city and have important location and beautiful scene due to these, it used as picnic area for people and foreign visitors of the city. Therefore, hundreds of geologists visit the two mountains annually and they ask many questions about the geology of the mountain. Before the present study, the accurate answering of these questions was not possible due to its complex geologic setting and insufficient geologic studies. In the present study, the authors think that it perfectly and simply is possible to answer them.

Bellen et al. (1959) referred to the problem of mapping of the studied area and mentioned the below important sentences " *toward eastwards into the region of continuous "basinal" sedimentation* (including the present studied area) *the Kometan, Gulneri and Dokan formations are all represented by contemporaneous sediments, in somewhat similar fades, which are included within the Lower Cretaceous to Turonian, Balambo formation. In order to avoid confusion Dokan, Gulneri and*

Kometan formations are recognized only in the areas in which the limiting unconformities are present (Dokan and Piramagroon areas where Qamchuqa Formation does occur). In contrary to the ideas of Bellen *et al.* (1959) and other previous studies, the main aim of the present study is to separate these formations and showing their distribution on maps and on geologic cross-section in addition to their relation to the structure and geomorphology of the area. The equivalent of Gulneri, Dokan and Sarmord formations are discussed in detail in term of location, lithology and thickness. These equivalents are referred to, in the text, as EOGF and EODF respectively.

Structurally, each of the two mountains consists of many anticlines which are very close to each other and all named, in the present study, as Azmir-Goizha anticline. This anticline is surrounded by smaller anticline from northeast and southwest. In the literature the anticline is referred to as Azmar, Azmir, Azmur, Goizha or Jebel Azmer anticline or mountain. Historically, the development of the anticline was controversial, Lawa (2004, p.213 and 222) in his model for basin analysis of Kolosh Formation showed that the anticline was source area for the formation during early Paleocene and called it "Azmer Orogenic belt". Al-Hakari (2011) showed by correlation chart same idea of Lawa (2004) that Azmir-Goizha anticline was uplifted and acted as terrestrial land between Red Bed Series and Kolosh Formation during Paleocene (Fig. 2) .

In contrast of the ideas of the above latter two authors, Karim 2004 and Al-Barzinjy, 2005 concluded that the anticline was not existed during Maastrichtian and Paleocene respectively and it covered by marine water in which both aforementioned units are deposited concurrently as lateral facies changes. Karim *et al.* (2008) concluded, on the basis of sedimentology and hydrodynamic of the Zagros foreland Basin, that the first development of the anticline had occurred during Middle Eocene and prevented the influx of the clastic sediments to reach Pila Spi basin (Fig.3). Aziz and Lawa, 2000) called the anticline "Azmer anticlinorium" and Al-Al-Hakari (2011) used the same name too. Ibrahim (2009, p.137 and 143) gave two different ages in two different pages for the first development of the anticline which was the age of Paleocene and Upper Eocene (Fig.4).

Methodology

The study depends both on the field work and microscopic study of the sample by which the lithology and fossils of the samples are studied. For nannofossils analysis, fifteen samples are prepared and sent to England and Romania for age determination. The previous studies reviewed and used to find reliable marker bed or beds for mapping and the best one was the beds that discussed in detail by Taha and Karim (2009). In their study, the unconformable upper and lower boundaries of the Gulneri Shale are changed to conformable ones and the lithology is changed from shale to marl and marly limestone. Moreover, they modified the isolated and euxinic basin of Gulneri formation to large and open one in which Kometan, Gulneri and Balambo (Qamchuqa) formations are deposited. This latter study predicts that EOGF must be present in the basin of Kometan and Balambo formations. During the field work the EOGF is found which is consist of a soft marly limestone and located between latter two formations. The nannofossil analysis proved that the soft lithology has same age of Gulneri Formation (Turonian). Many sequence stratigraphic models (such as Karim, 2004, Karim and Surdashy, 2006) are used for checking all new ideas of the present study.

Since the lithology of Kometan and Balambo formations are very similar in the studied area, therefore, the soft lithology (EOGF) was very helpful for mapping and differentiating the latter two formations. In the field it appears as dark line (or ribbon) along the slopes of the Azmir on the both limbs of the anticline and has the width of about 2-5meters which depend on the slope and apparent and true thickness. This ribbon is used for checking and correction of all five strike slip faults and geological maps that are drawn by Al-Hakari (2011) and Omer (2011) (Fig.5). GPS are used to locate the position of anticlines with the measurements of the attitude of the beds and the thicknesses for indicating the type degree and type of folding.

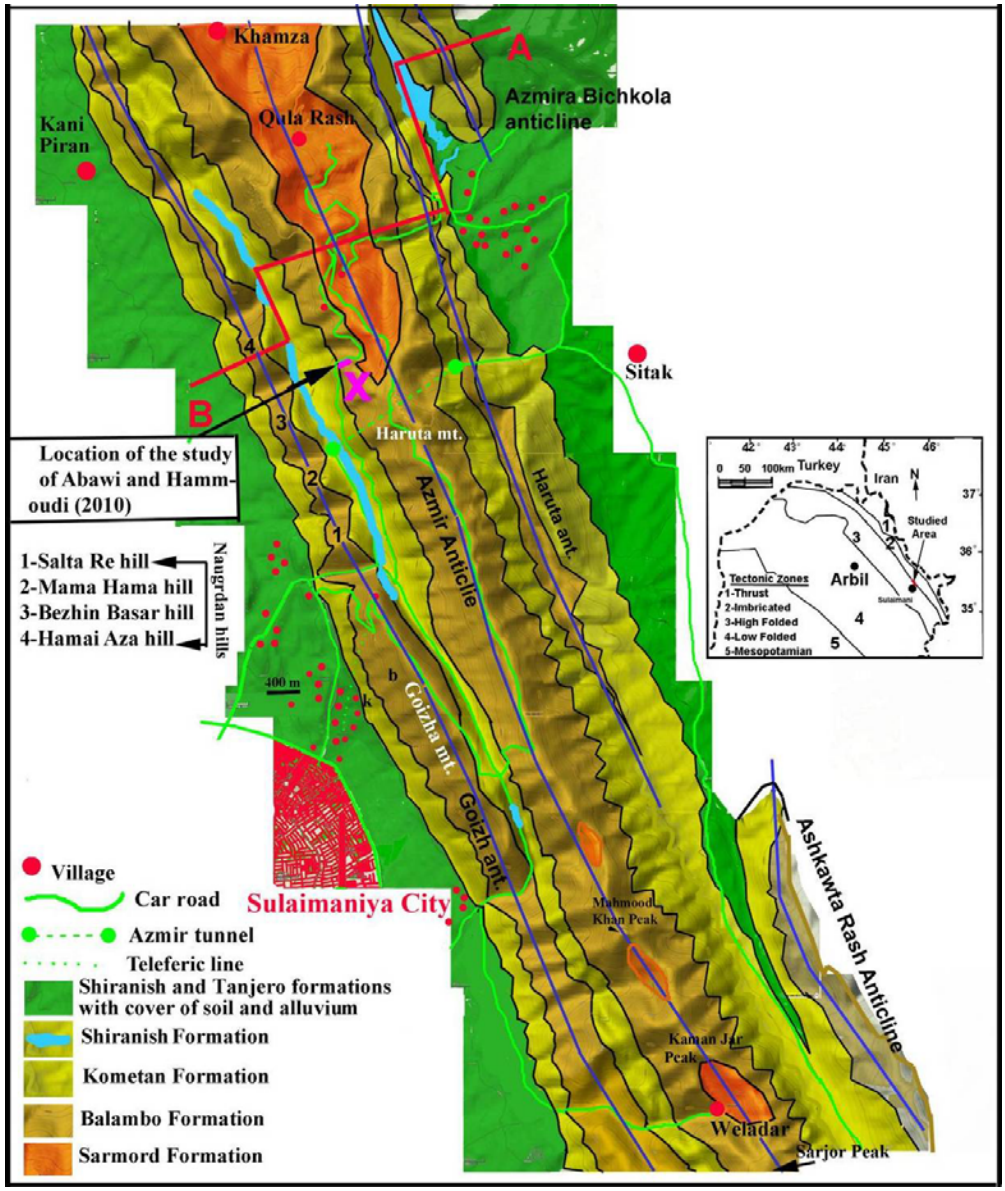

Fig.(1) Geological map of Azmir-Goizha anticlines which is the most detail map that is drawn till now.

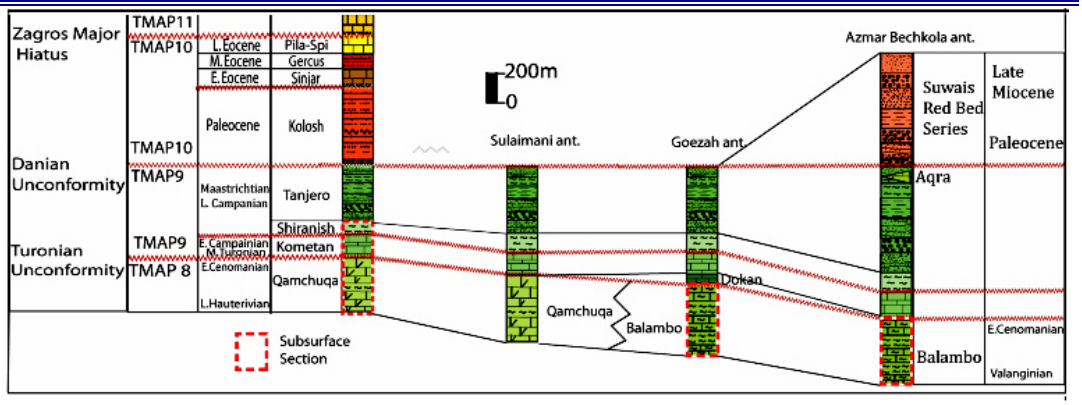

Fig.(2) Correlation of the Cretaceous formations (Al-Hakari, 2011) which shows that Dokan Formation is not deposited except in one section (Goizha anticline).

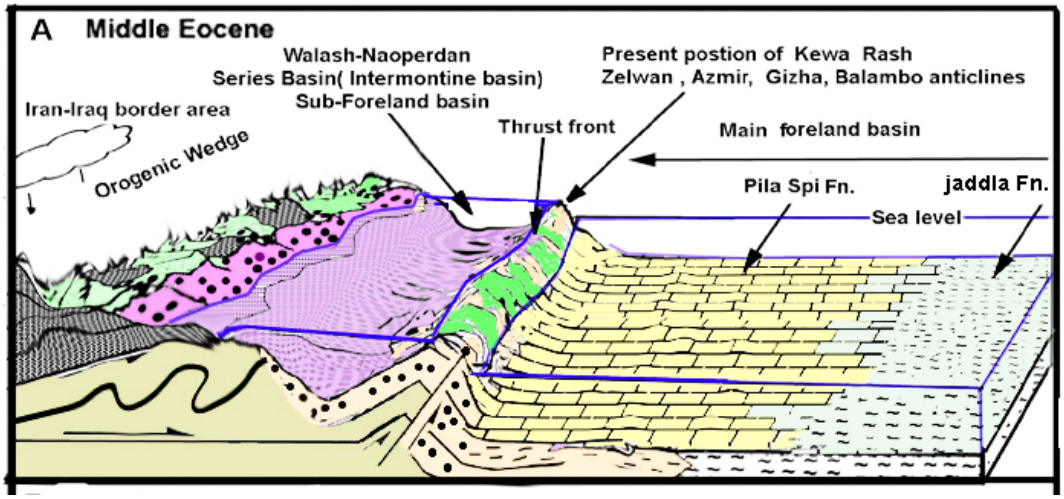

Fig.(3) Geological cross section of the northeastern Iraq during Middle Eocene in which the first uplift of Azmir anticline was started (Karim *et al.*, 2008).

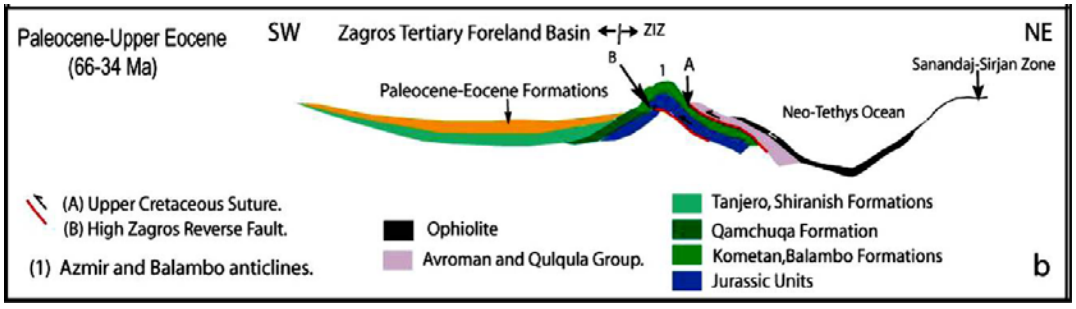

Fig.(4) schematic geological cross section of Azmir anticline which started during Paleocene- Upper Eocene (66-34Ma) (Ibrahim, 2009).

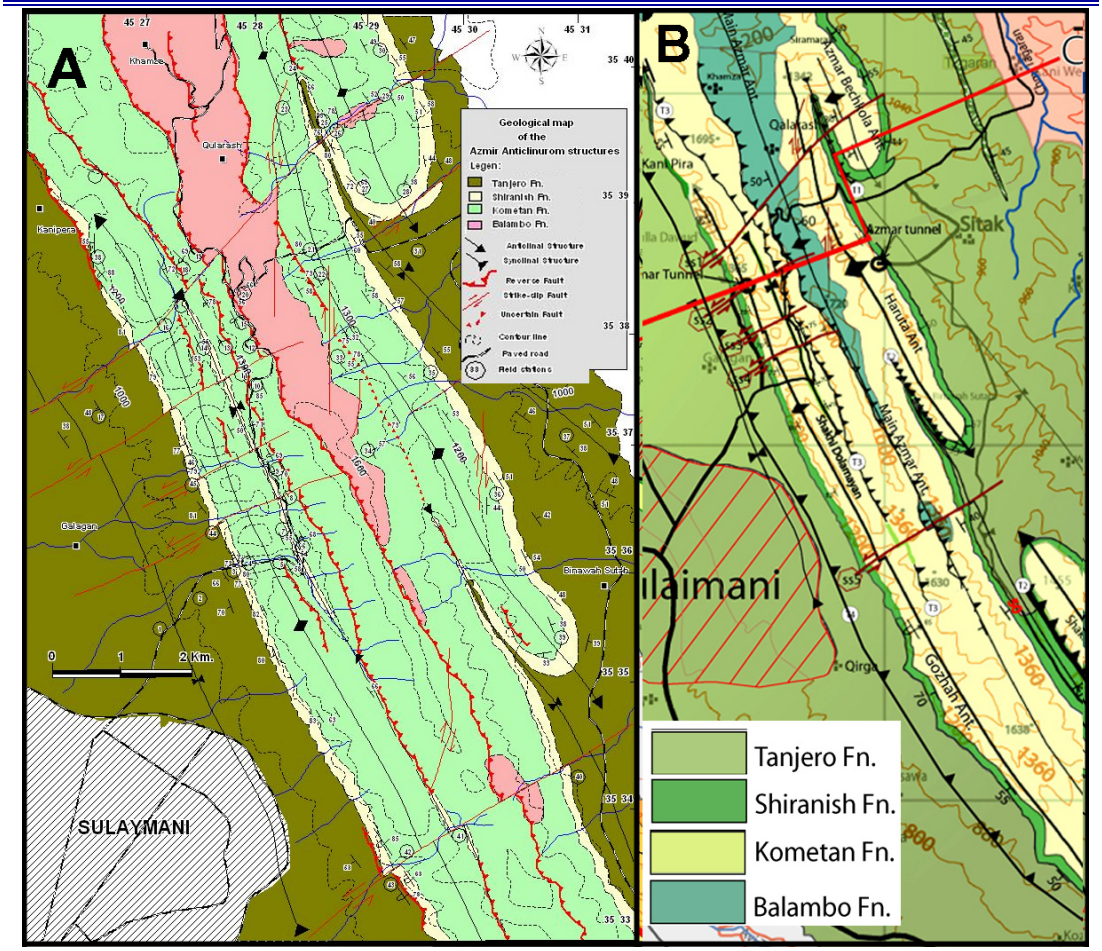

Fig.(5) Geological map of the studied area, A) Omer (2011) B) Al-Hakari (2011)

Discussion

All the previous studies agreed that the anticline is covered by Kometan and Balambo formations but without differentiating them and indication of the boundaries. The Shiranish and Tanjero formations occur around the anticline mostly in the complementary synclines and along both lower limbs. The main problem in the area is the separation of Kometan and Balambo Formations. Another problem is the indication of the presence or absence of Dokan Formation which proved to occur in the area by Abawi and Hammoudi (2010) and the Sarmord Formation which recorded in the nearby areas such as core of both Piramagroon and Sara anticline which are about 13 and 30 kms far from the Azmir-Goizha anticline respectively. The question, why it is not recorded in the studied area and what is the equivalent lithology of the Sarmord Formation on the surface? it is important to answer it in this study.

Age equivalent of Dokan Formation (EODF)

The Dokan Formation proved to exist, in the studied area by Abawi and Hammoudi (2010) in which they recorded a succession of 63 meters thick of the upper part of Balambo Formation and assigned it as Dokan Formation. They also

recorded a major hiatus between the lower (Balambo Formation) and upper (Dokan Formation) units of the succession (Fig.6). They added that due to this unconformity and the lithological differences there is strong reason to characterize the upper part (63 m) of the Balambo as the Dokan Formation. They further added that it consists of light brown and white massive not well bedded limestone.

In the present study, after great effort the studied section that sampled by the above two authors is found and indicated by GPS and plotted on the map. The GPS reading of the top of the section is: 35^{o} 37^{-} $36.30^{=}$ N and 45^{o} 27^{-} $57.63^{=}$ E at the elevation of 1348 meters on the eastern side of the paved road between Sulaimaniya city and Chwarta town (Fig.1 and 7 and 8).

After the inspection of the section, the below seven points are necessary to be mentioned. The first is the massiveness of the section may be due to its location which is located along the recently excavated road sides. This excavation increased fracturing by further artificial discontinuities and the bedding is not clear especially the differential weathering was not affected on it. The second is that along the 63 meters there are three fold which mean the section is repeated six times and the Dokan Formation (if exists) its thickness is extremely exaggerated Fig.(8). The third point is that the lithology of claimed Dokan Formation is very similar to either Kometan or upper part of Balambo Formations and is located below the marly limestone (age equivalent of Gulneri Formation). The fourth is that the beds consist of white to milky fine grained limestone which is well bedded and the thickness of beds ranges 10-30 cm except one bed which has the thickness of 60 cm (Fig.7 A and B). The fifth is the previous recorded (by latter authors) light brown color, massiveness and absence of oligostigina fossils (as appear from their thin sections) don't agree with the original description of the formation by (Bellen et al., 1959). The sixth is that the major hiatus is not found in ten of sections in the studied area. The seventh point is that the Dokan Formation, in all sections (including that of Abawi and Hammoudi, 2010) on the Azmir-Goizha anticline occur on smooth slopes and partially covered that resemble the underlying Balambo Formation only one bed (60cm thick) can be seen and differentiated from the later formation (Fig.7; 8A and B). The present authors think that the claimed Dokan is identical to underlying Balambo Formation in color (white), bedding pattern (alternation of well bedded limestone), lithology (fine grained limestone) and nearly absence of oligostegina (calcisphere) which according to Bellen et al. (1959) must be of great abundance. These characteristics are consistence and inspected in tens of sections. Therefore, it is better to be combined with Balambo Formation. In the studied area the thickness of the Equivalent of Dokan Formation (EOGF) (if exist) is not more than 80 cm which clearly can be seen as white thick bed in the figure (7; 8A and B).

Al-Hakari (2011) in his correlation chart of the Azmir Goizha anticlines indicated the Dokan Formation on Goizha anticline while he changed it to unconformity on Azmira Bechkola and Sulaimani anticlines (Fig.2).

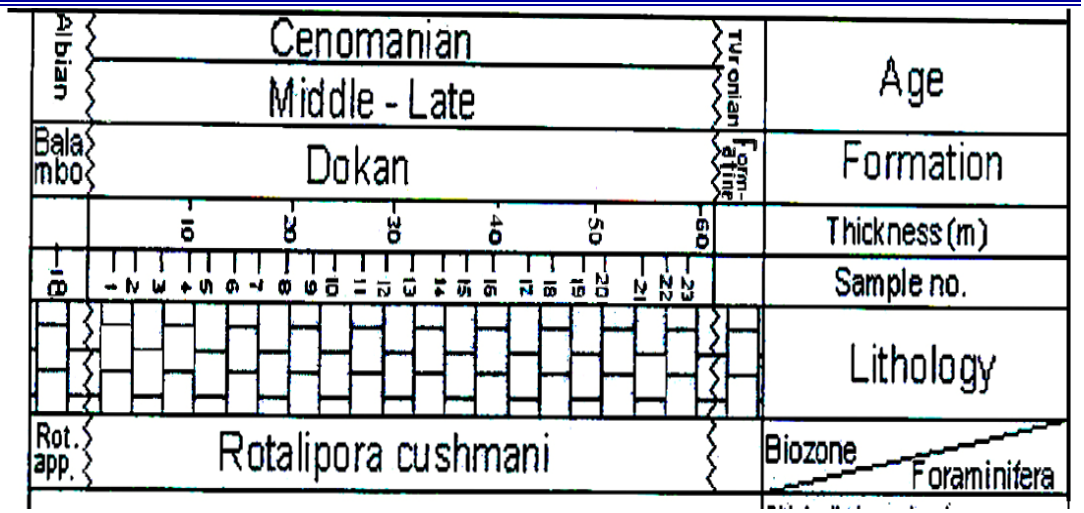

Fig.(6) Stratigraphical column of the sampled section of Abawi and Hammoudi (2010). The GPS reading of the top of the section is: 35° 37' 36.30" N and 45° 27' 57.63" E

Age equivalent of Gulneri Formation (EOGF)

The role of the equivalent of the Gulneri Formation (EOGF) is discussed in the section of methodology, therefore, in this section; the lithological changes in different sections will be shown. Taha and Karim (2009) changed the lithology of the formation from black shale to marl and marly limestone while Lawa and Gharib (2010) referred to it as condensed section of black shale and considered it as sequence boundary type 2. As mentioned before, the equivalent of this formation is not found previously in the studied area and even EOGF (Marly limestone) is part of the section of the Abawi and Hammoudi (2010) but it is neither mentioned nor drawn in their stratigraphic column (Fig.6).

Al-Hakari (2011) has wrote a section under the title of Turonian unconformity and showed its position by photo (Fig.10B) and he cited many references to confirm existence of this unconformity and absence of the formation in the studied area. About this unconformity, he cited from Lawa and Gharib (2009) that "*in the Imbricated zone (Azmar structure) it is seen between Balambo (Hauterivian-Cenomanian) and Kometan (Late Turonian-Coniacian) formations with remarkable disappearance of Gulneri Formation*".

He further cited the below paragraph: *This unconformity is between (TMSAP-8 and TMSAP-9) and indicated as unconformity called (Pre Aruma) within the Arabian Plate Tectonic Megasequences (Sharland et al., 2001 and Al Hussaini and Matthews, 2008). This unconformity resulted from the Ophilolites- Qulqula Obduction is displayed between different time-equivalent formations from the High Zagros towards the platform. Whereas in the Zagros High Folded Zone (Surdash and Piramagroon anticlines), it is seen between Qamchuqa Formation (Barremian Cenomanian) and Kometan Formation with disappearance of Dokan and Gulneri formations. During the early Turonian the Qulqulqa Radiolarian and Main igneous complexes were uplifted and act as Hinterland for Kurdistan Foreland basin (Lawa et al., 2011). Homke et al., (2009) also referred to such condition in the eastern".*

Al-Qayim et al (2012, p.143) referred to this unconformity and about Kometan Formation mentioned these sentences *"the best outcrop in the study area, however, is exposed around Azmur Mountain of Traverse 1 area* (Diri village –Azmur anticline), *which unconformably overlies the Dokan"*. In the same paper, Al-Qayim et al. (2012, their fig.11, p.118) showed by chronostratigraphic column that the Qulqula Conglomerate Formation was equivalent in age (Early Campanian-Mastrichtian) to Tanjero and Aqra-Bekhme formations. This age is opposite to that mentioned by Al-Hakari (2011) and (Lawa et al., 2011 *in* Al-Hakari, 2011).

The result of the present study and that of Taha and Karim (2009) don't aid the presence of the Turonain unconformity in Kurdistan that mentioned by above authors. In the studied area, the upper part of Balambo Formation and lower part of Kometan Formation are very similar in lithology and bedding patterns Fig.(7; 8A and B). Its color is different in different sections such as light pink, light brown, bluish grey or black. The EOGF (with EODF) exists between both units and has the thickness of 2-2.5m and its location can be identified in the field from few kilometers and even on Google earth image. It appears as partially covered dark ribbon in lighter background which has the width of 2.5 to 5m (depending of outcropped true or apparent thicknesses). The darker color is due to its content of light pink, light brown, bluish grey or black marly limestone and its relative softness as compared to other two overlying and underlying formations. In many place along the southwestern and northwestern limbs of Azmir-Goizha anticline, the EODF can be seen clearly too which appear as white bed directly below EOGF (Fig.7; 8A and B). Four sections are inspected and the nannofossils analysis for five samples of the EOGF gave the following fossils: *Eiffellithus eximius, Prediscosphaera columnata, Eprolithus rarus, Watznauria barnesae, Eprolithus moratus* which gave the age of Turonian in general (Fig.11).

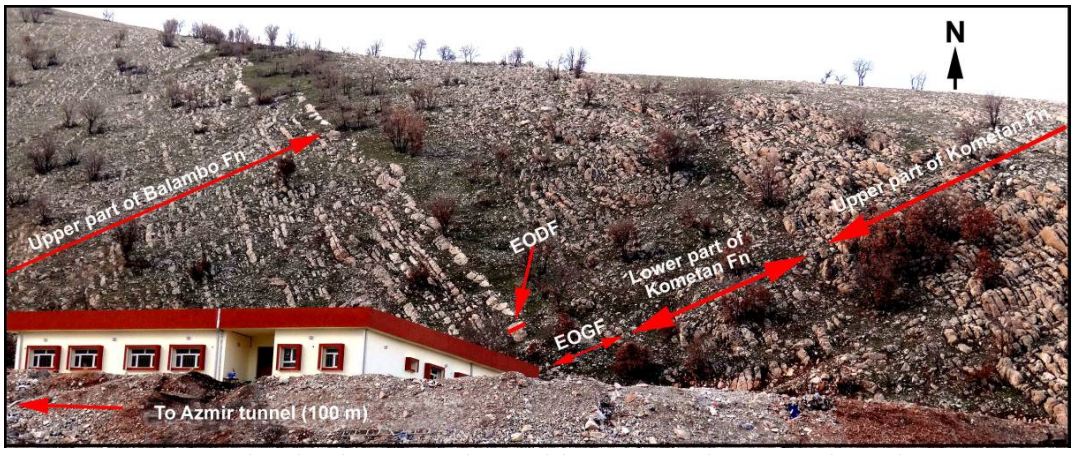

Fig.(7) Kometan and Balambo Formations with EOGF and EODF along the northeastern limb of Azmir-Goizha anticline near out let of Azmir tunnel.

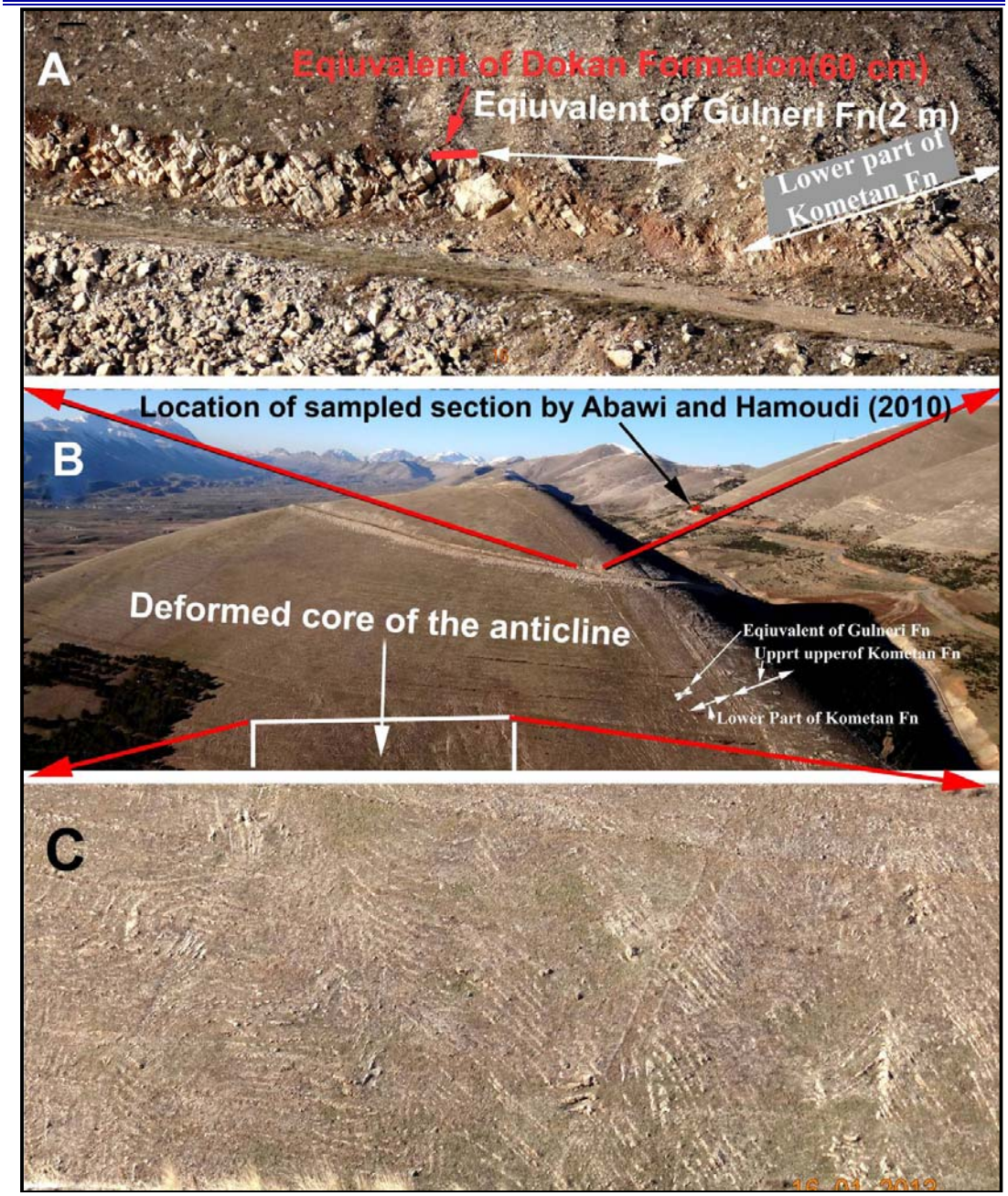

Fig.(8) A, B) EOGF and EODF along the Salta Re Hill (Naugirdan hills). According to Al-Hakari, 2011 it is part of Goizha anticline. C) Deformed core (Balambo Formation) of the above mentioned hill.

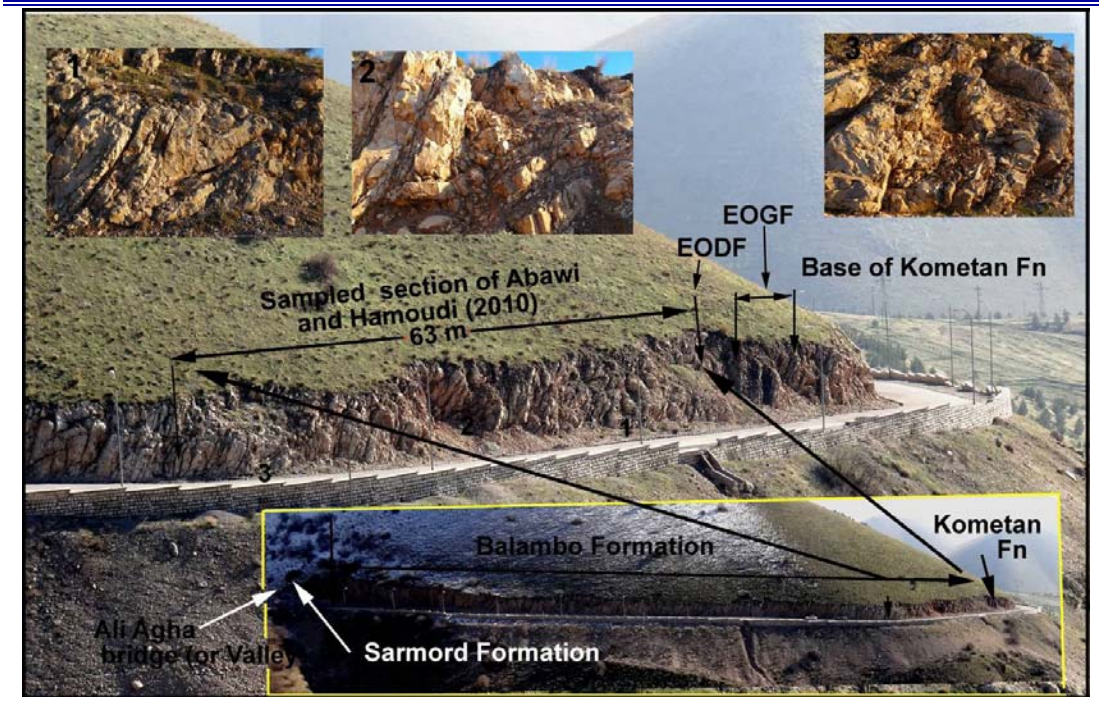

Fig.(9) Ali Agha bridge (or valley), southwestern limb of Azmir anticline shows Balambo Formation , EODF and EOGF. The numbers 1, 2 and 3 indicate position of the folds along the sampled section (63 m) of Abawi and Hamoudi (2010).

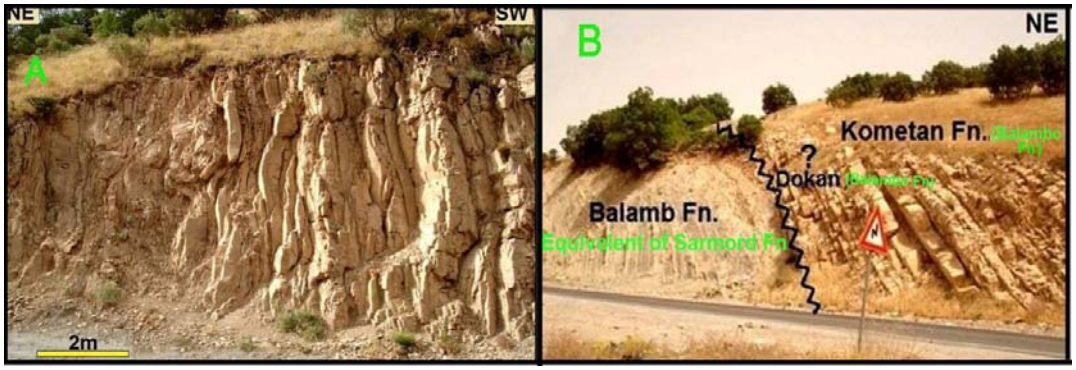

Fig. (10) Due to complexity of the studied area the confusing is clear in the identification of the Formation. A) Vertical beds Balambo Formation which is identified by Al-Hakari (2011, p.83) as Kometan Formation on the eastern side of the paved between Sulaimani city and Chwarta town. B) A published photo (by the latter author) shows Turonian unconformity, Balambo and Kometan Formations. In the present study they are changed to conformity, Sarmord and Balambo Formations respectively as shown by green fonts.

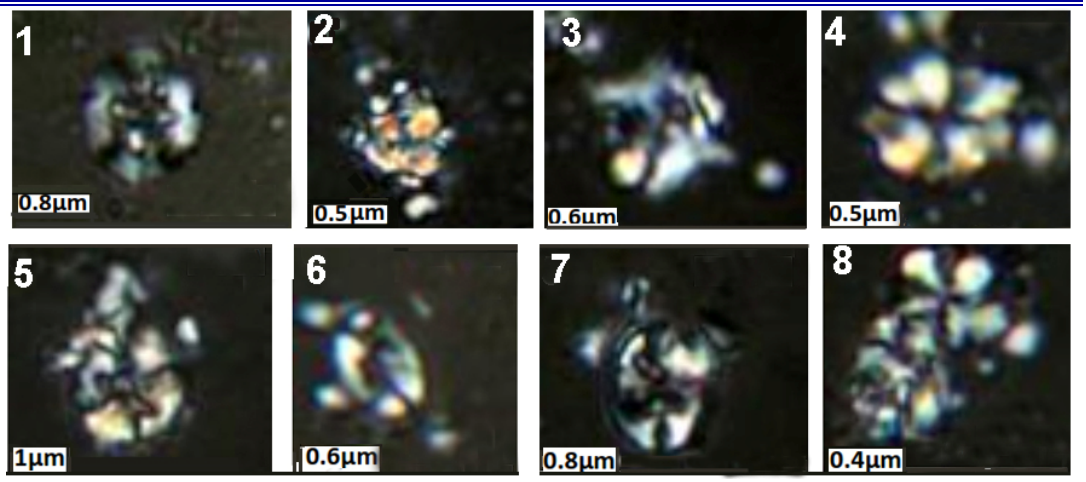

Fig. (11) Species of nannofossils in the Equivalent of Gulneri Formation (EOGF) which gave the age of Turonian. 1-*Retecapsa angustiformata* (S. 2MBK), 2-*Radiolithus planus* (S. 2MBK), 3- *Prediscosphaera columnata* (S. 1 MBK), 4-*Eprolithus moratus* (S.5 MBK), 5-*Eiffellithus eximius* (S.4 MBK), 6- *Eiffellithus gorkae* (S.4 MBK), 7- *Eiffellithus turriseiffelli* (S.4 MKB), 8-*Eprolithus Moratus* (S. 4 MBK)

Thickness problem of Balambo Formation on Azmir-Goizha anticline (AGA)

Omar (2011), in the studied area, mentioned that mostly the Upper Balambo Formation is widely exposed and consists of thin beds of shale, interbedded with medium to thick bedded limestone and marl, he added that the thickness of the formation is about 400 m. From his description it is clear that he measured the thickness that is identified (in the present study) as Sarmord Formation. The present authors think that the thickness of the Balambo Formation is never measured accurately in the studied area and its measurement is very difficult due to three facts. The first is its deformation which in interval of 100m shows several folds (Fig.8C). The second fact is lithological change and repetition by facies change and deformation which are difficult to differentiation by most geologists. It changes from fine grain fossiliferous limestone (under hand lens) to re-crystallized non-fossiliferous dolomitic limestone at the base (Fig.10A). In some place, it may contain interfinger of limestone or dolomite of Qamchuqa Formation which due to the closeness (less than 12kms) of the studied area to the depositional area of the latter formation. According to Ameen (2008), the northwestern part of Azmir-Goizha anticline is located in the transitional zone (inter-fingering of lithologies of both formations) between Qamchuqa and Balambo formations. The former and latter formations were deposited on the shelf and basin of Early Cretaceous basin respectively. The unconformity that concluded by Abawi and Hammoudi (2010) between Balambo and (claimed) Dokan formations may be due to either deformation (repetition) or absence of index fossils in the recrystallized intervals not to missed lithology (unconformity) of the related age. Especially toward the bottom of their section the dolomite clearly increase and lithology changes from milky fine grained limestone (at the top) to brownish grey dolomitic limestone at the bottom (Fig. 10A). The best way to

measure the thickness is to estimate it indirectly by available models of carbonate dominated basins.

Tens of papers and books are published that contain many sequence stratigraphic models of carbonate platform in which shallow (like Qamchuqa Formation) and deep (Balambo Formation) facies are deposited. In these models the time equivalent facies are indicated by time lines by which the thickness ratio of platform to basin are shown (Miall, 2010, Louks and Sarg 1993 (Fig.12), Karim and Taha, 2009, Ameen, 2008), Ameen and Karim, 2009). This ratio is about 1/3.5 and if it is applied for the Qamchuqa and Balambo Formations the thickness of the latter formation will be 228m when the thickness of Qamchuqa Formation is 799 m that is given by Bellen et al. (1959) is used.

The thickness of Qamchuqa Formation is relatively accurate and realistic as the measured section consists of massive and non-deformed limestone and dolomite successions in the type locality. The thickness of about 228 is seems true for the studied area for that part of Balambo Formation that is time equivalent to Qamchuqa Formation. This thickness, when checked, the repetition by both folding and the position of the measured section within Early Cretaceous Basin must be considered. This consideration is important because, toward the northeast and east the thickness of the formation decrease due to increased of both distance from Qamchuqa Formation (as main source for influx of the lime mud) and depth. With this addition, the total thickness of the formation become about 683 meters. The problem is that in all previous studies, the cropped out thickness of the Sarmord Formation (455 m thick at its type section) was included with thickness of the Balambo Formation in the studied area and surrounding ones, (see Omer, 2011; Al-Hakari, 2011; Lawa and Aziz (2000, in Aziz and Lawa 2001) (Fig.14 and 15) and Al-Qayim *et al*. 2012, p.114).

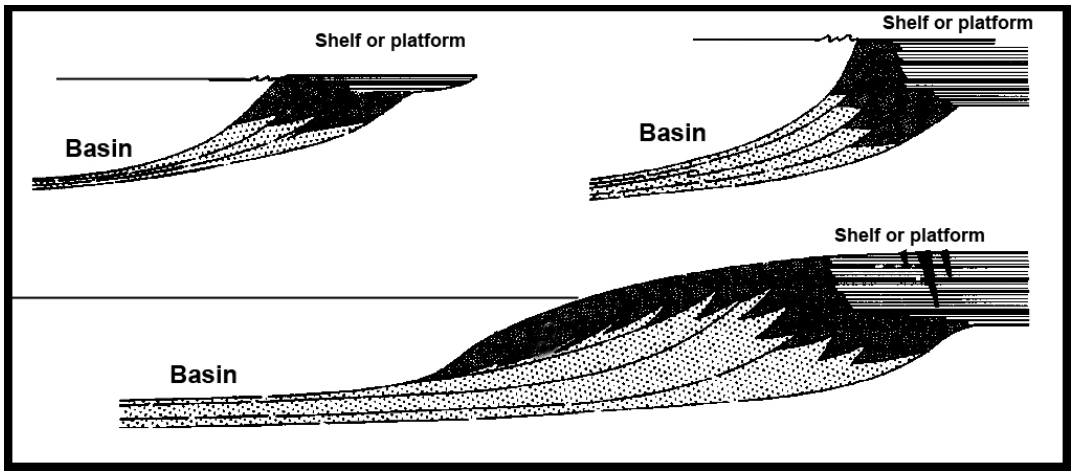

Fig.(12) The ratio of the thickness of the sediment of basin (Balambo Formation) and shelf (Qamchuqa Formation) can be estimate from the above models (Louks and Sarg, 1993).

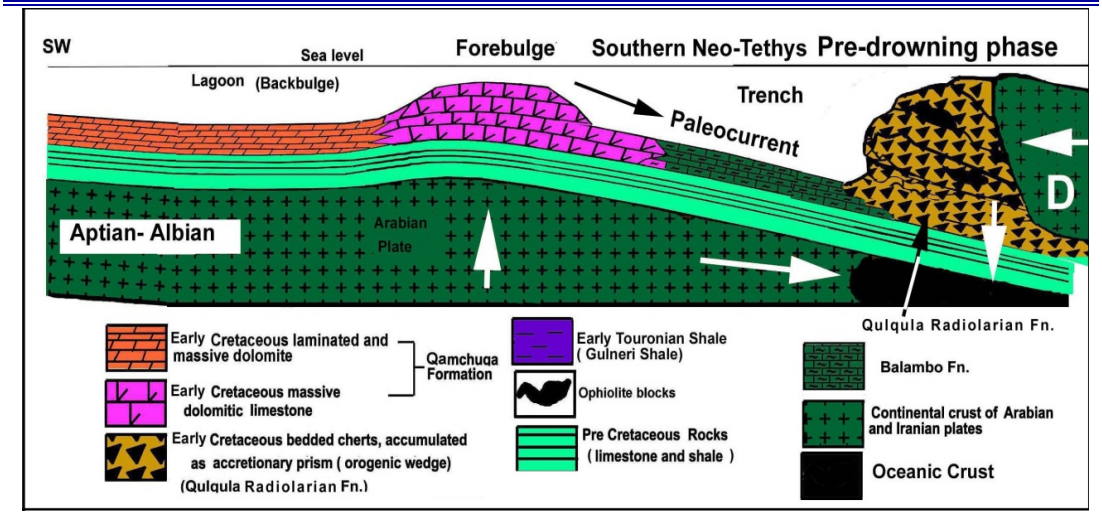

Fig.(13) The thickness estimation between Balambo (deep water facies) and Qamchuqa (shallow water facies) formations which can be used for estimation of the thickness of latter formation in the studied area (Ameen, 2008 and Taha and Karim, 2009).

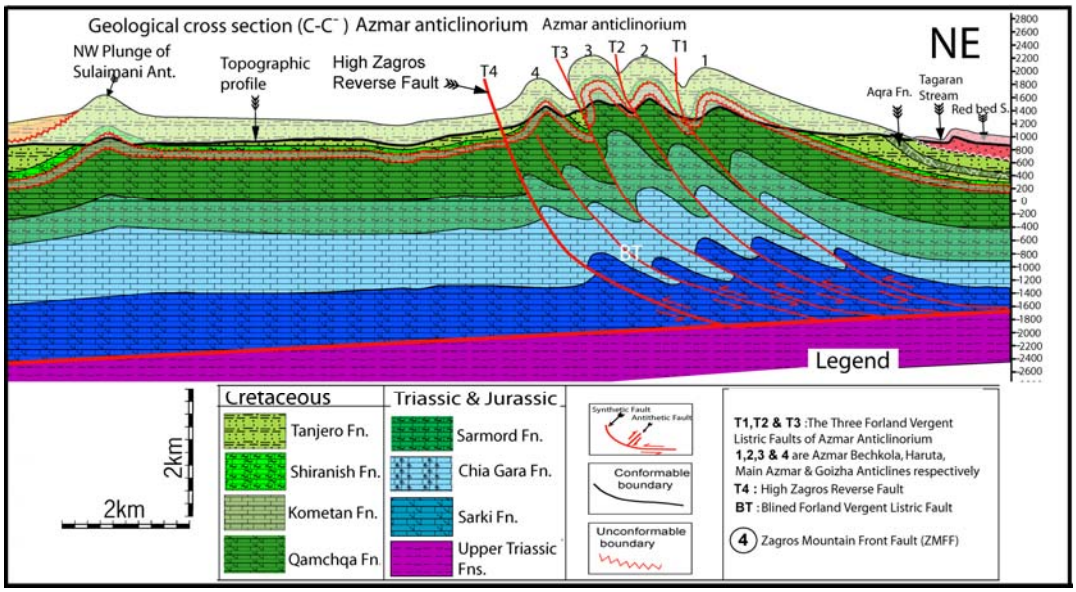

Fig. (14) Geological cross section across Azmir-Goizha anticlines of Al-Hakari (2011) in which two unconformities are shown and neither Balambo nor Sarmord formations are shown on the surface.

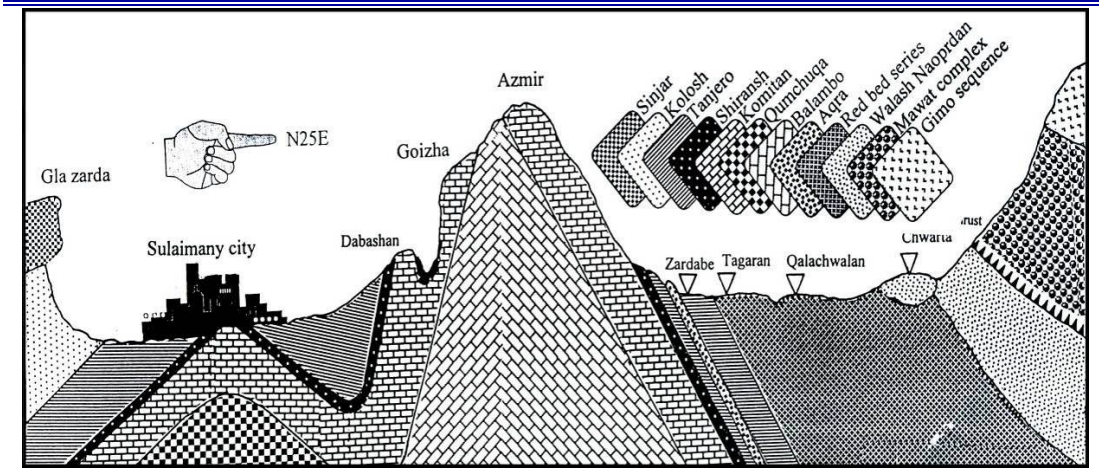

Fig.(15) Geological cross section across Sulaimani city and Chwarta Town (Lawa and Aziz, 2000 in Aziz and Lawa, 2001).

Sarmord Formation

In the studied area, the Sarmord Formation is recorded for the first time and separated from Balambo Formation. it is consists of brownish marly limestone and greyish to bluish marl (Fig.16) which is nearly similar to the lithology of its type locality at Qamchuqa valley (Fig.17 A, B and C and 18 A, B). The definition of the type locality contains neritic limestone, therefore the occurrence of some beds of marly limestone or limestone, in the studied area, is agree with original description by Wetzel (1950 in Bellen et al., 1959).

In the type locality, according to Bellen et al. (1959) the age of the formation is Hauterivian-Barremian while Qaradaghy (2007) inferred the age of Berriasian-Aptian for the formation in the type locality. In the studied area, due to intense deformation, the accurate biozonation is not possible. Many samples of the marl and marly limestone are cooked for extraction of planktonic forams but it is appeared that they are barren from these fossils. Therefore, samples are sent to many nannofossils experts in many countries for age determination of the formation.

The defined Balambo Formation on the Azmir anticline by Al-Qayim *et al.* (2012, p.142 and their fig.25a) is same as the Sarmord Formation of the present study. They defined outcrops of the Balambo Formation as *"The formation* (Balambo Formation) *crops out extensively in the study area, especially at the south western part of Traverses 1 and 2. The exposed section of the formation in this area is about 225 m* (Upper part of Sarmord Formation in the present study) *and generally consists of well bedded Argillaceous gray limestone, shale with occasional black chert horizon. These sequence show alternation of thinly-bedded globigerinal limestone and marlstone."*

The argilliceous grey limestone and marl (or shale) in above paragraph is same as and marly limestone and marl of present study respectively. Therefore, the present study recommends separating the Sarmord and Balambo formations from each other which give the area more simple and understandable geologic setting.Moreover, it can be connected with the type section by elongation of its outcrops from Qaywan, Sangir, Maloma, and Chokhmagh, Sargelu villages to Sarmord village immediately adjacent to

the type section. The nannofossil analysis by Daoud *et al.* (2010) gave the age of Upper Barremian for marly part of Balambo Formation (upper part of the present Sarmord Formation). This age is the age of upper part of the formation in type locality (Bellen *et al.*1959) while the lower part is not exposed in the studied area. To inspect the lower part, the sampling is extended to the Qayiwan valley which is located directly to the northwest of the studied area and contains possible outcrops of the lower part. The following species are found in the lower part of the formation in the core of Qaywan anticline (mountain) at the location of (N 35° 42' 34.4" E 45° 25' 18.8"): *Calcicalathina oblongata, Cruciellipsis cuvillieri, Cyclagelosphaera deflandrei, Ellipsogelosphaera communis, Micrantholithus obtusus, M. hoschulzii, Nannoconus colomii, N. steinmannii, Stephanolithion laffittei, Tubodiscus verenae, Watznaueria barnesae* which gave the age of Valanginian.

In the upper part of the formation at peak of Qayiwan anticline on the road the sample gave the age of Barremian at the location of N 35° 41' 54.5" E 45° 24' 55.6" which contain the following species: *Calcicalathina oblongata, Cyclagelosphaera deflandrei, Ellipsogelosphaera communis, Micrantholithus obtusus, M. hoschulzii, Nannoconus colomii, N. steinmannii, Tubodiscus verenae?, Watznaueria barnesae.*

Other samples that are sent to Romania gave the age of Upper Berriasian, Lower Valanginian, Lower Hauterivian and Upper Barremian (Fig. 19).

Fig. (16) Outcrop of Sarmord Formation in the east of Weladar village on the summit of Sarjor mountain at southeast of end of the studied area which assumed to be Balambo Formation by the previous studies.

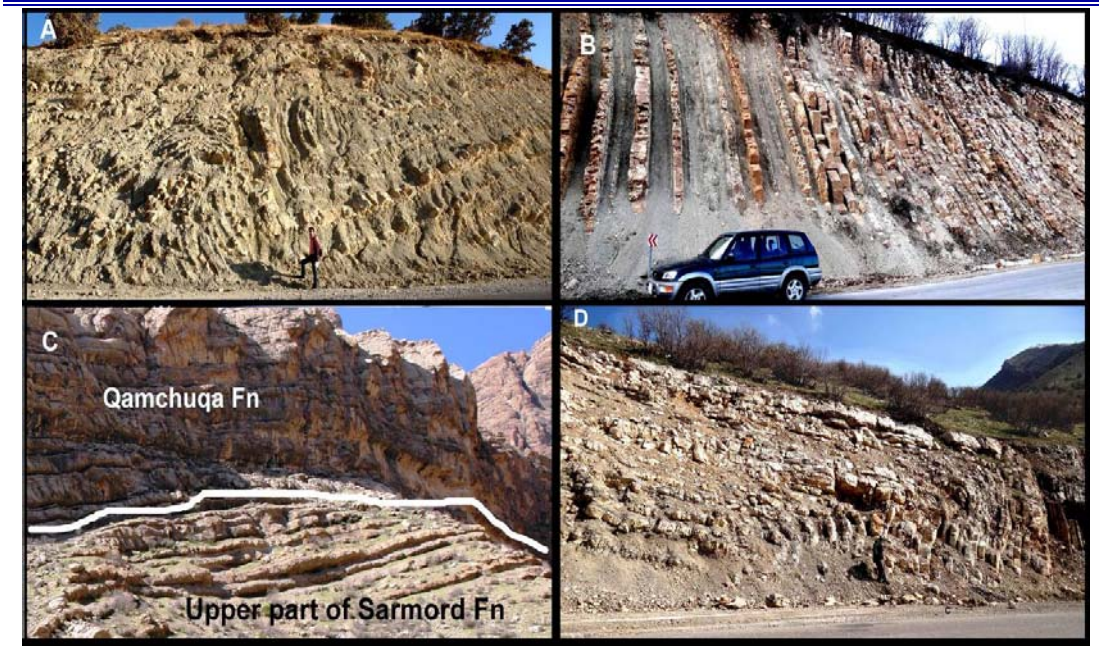

Fig.(17) A and B) Outcrops of Sarmord Formation in the northeast of Azmir-Goizha anticline (locally called Qaywan anticline) which assumed to be Balambo Formation by all previous studies and in the present study, nanofossils prove Early Barremian age of this location. C) Upper part of the formation at its type area which can be compared with those of the studied area. D) Balambo Formation, Azmar Mountain (Al-Qayim *et al*, 2012, fig.11c and 25a) which changed to Sarmord Formation in the present study. The section consists of alternation of marl and marly limestone (Note: The mountain is Qaywan not Azmar (Azmir)).

Fig.(18) Comparison of outcrops of Sarmord Formation (alternation of marl and marly limestone) in the Zewe (A) and Qaywan (B) Valleys at 35^{o} 44^{-} 41.80$^{=}$ N, 45^{o} 15^{-} 05.76$^{=}$E and 35^{o} 42^{-} 34.26$^{=}$N, 45^{o} 25^{-} 09.49$^{=}$ E respectively.

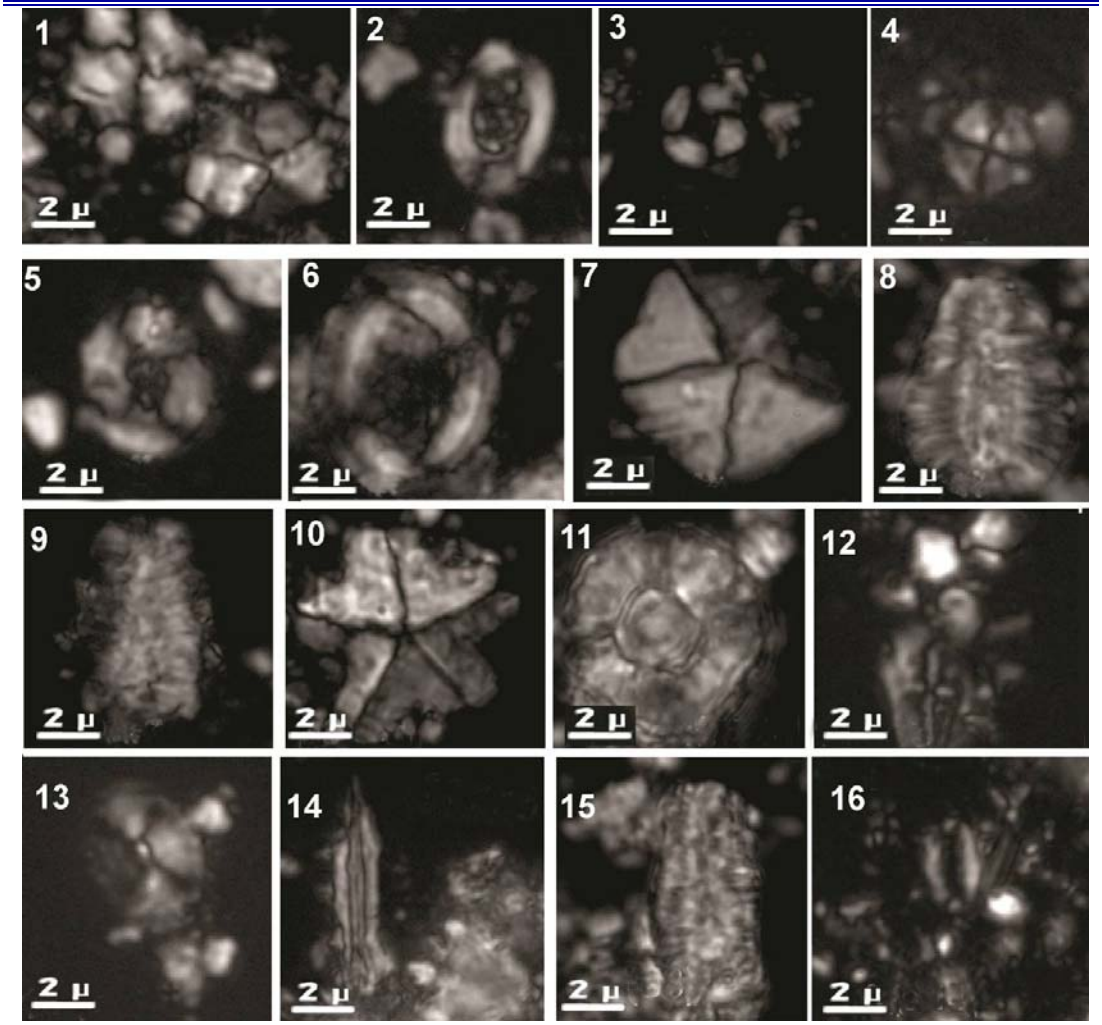

Fig. (19) Extracted nanofossils in the fives samples of Qaywan valley where both age and lithology prove occurrence of Sarmord Formation. The ages that are indicated by these fossils are upper Berriasian, Lower Valanginian, Lower Hauterivian and Upper Barremian. **1**-*Carinolithus magarensis* (s1), **2**-*Crepidolithus granulates*(s1); **3**-*Diazomatolithus lehmanii* (s1), **4**-*Discorhabdus ignotus* (s1), **5**-*Helenea chiastia* (s1); **6**-*Manivitella pemmatoidea* (s1); **7**- *Micrantholithus hoschulzii* (s1); **8**-*Nannoconus steinmannii minor* (s1); **9**- *Nannoconus kamptneri* (s2); **10**-*Micrantholithus obtusus* (s3), **11**- *Nannoconus* sp. (s3); **12**- *Staurolithites* sp. (s3); **13**-*Haquis ellipticus* (s3); **14**-*Lithraphidites carniolensis* (s3); **15**-*Faviconus multicolumnatus* (s3); **16.** *Rhagodiscus pseudoangustus* (s14).

Unconformities in the studied area

Lawa and Gharib (2010) summarized five sequence boundaries (unconformities) of type 1 or 2, in the study of the Cretaceous sequence stratigraphy (including the studied area). These boundaries are; 1-Intra-Barremian (S.B.T.1), 2- Upper Early to Middle Cenomanian (S.B.T.2), 3- Upper most late Cenomanian (S.B.T.2), 4- Middle Campanian (S.B.T.2), and 5-late Maastrichtian (S.B.T.1). In the present

study, the evidence of these boundaries is not observed.

In the present study, many sections are inspected for finding major hiatus and unconformities that are recorded by Abawi and Hammoudi (2010) between Dokan Formation and Balambo Formation during Early Cenomanian. In all sections, erosional surface or plaleosoil or conglomerate is not found in the interval studied by them, even bioturbations and amalgamations have not seen. The relatively long duration of hiatus during Early Cenomanian (2.3 m.y) must had left clear signals of large unconformity. The problem is that they gave not detail about the method of finding the two unconformities (at the top and base of the sampled section) (Fig.6). It is not known if they indicated them on basis of previous studies or by biozonation. But if they found them by biozonation aging, the following problems arise. The first is that the sampled section, according to all evidenced is located in deep basin (deep part of continental margin of Neotethysis ocean) so how did unconformity can be occurred in the deep basin. These two unconformities are cited by Bellen et al. (1959) in Dokan area but they refused by Taha and Karim (2009). The second is a presence of three folds along the section which give repetition or removal of some interval, so the folding gives apparent unconformities not true ones (Fig.9). The third is the recrystallization and dolomitization which are destroying fossils in some interval. The fourth problem is that the two unconformities are located outside the interval of the 23 samples that are taken by the authors (as appear from figure 6) so the aging by foram is not known how it is done.

The upper unconformity also confirmed again (after its refusal by Taha and Karim, 2009) by Lawa and Gahrib (2009 in Lawa *et al*, 2013 and in Al-Hakari, 2011) who mentioned that in the High Zagros Fold-Thrust Zone, the unconformity occurs between the Dokan Formation (Cenomanian) and the Kometan Formation (late Turonian–Coniacian), and the Gulneri Formation (Late Cenomanian – Early Turonian) is absent.

Lawa *et al.* (2013) further stressed on this unconformity and mentioned that elsewhere, the unconformity occurs between the Qamchuqa Formation (Barremian–middle Cenomanian) and the Kometan Formation (late Turonian–Early Campanian), with the absence of the Dokan and Gulneri Formations (Fig.20 A).

Lawa *et al*. (2013.) cited the below paragraph "*The Turonian hiatus varies in duration according to the structural configuration of the basin, which was controlled by major north-south trending strike slip and oblique transverse faults. In some areas (e.g. the SE limb of the Safin Anticline), this hiatus lasted for 0.5 Ma (Lawa and Gharib, 2009). In the Qamchuqa section, it lasted 4.7 Ma (Lawa and Gharib, 2009).These estimates are based on the absence of planktonic foraminifera (Globigerinoides bentonensis and Dicarinella hangi, Whitnella archaeocretacea, Heterohelix moremani, and Helvetotruncana helvetica)"*. The absence of these fossils is not always the evidence of unconformity but may be due to crystallization (diagenesis) or environment (shallowness and absent of nutrient) or the manner of sampling. In the present study it is proved by fossils and by field evidence that both formations exist and there is no unconformity (Fig.20C and 21).

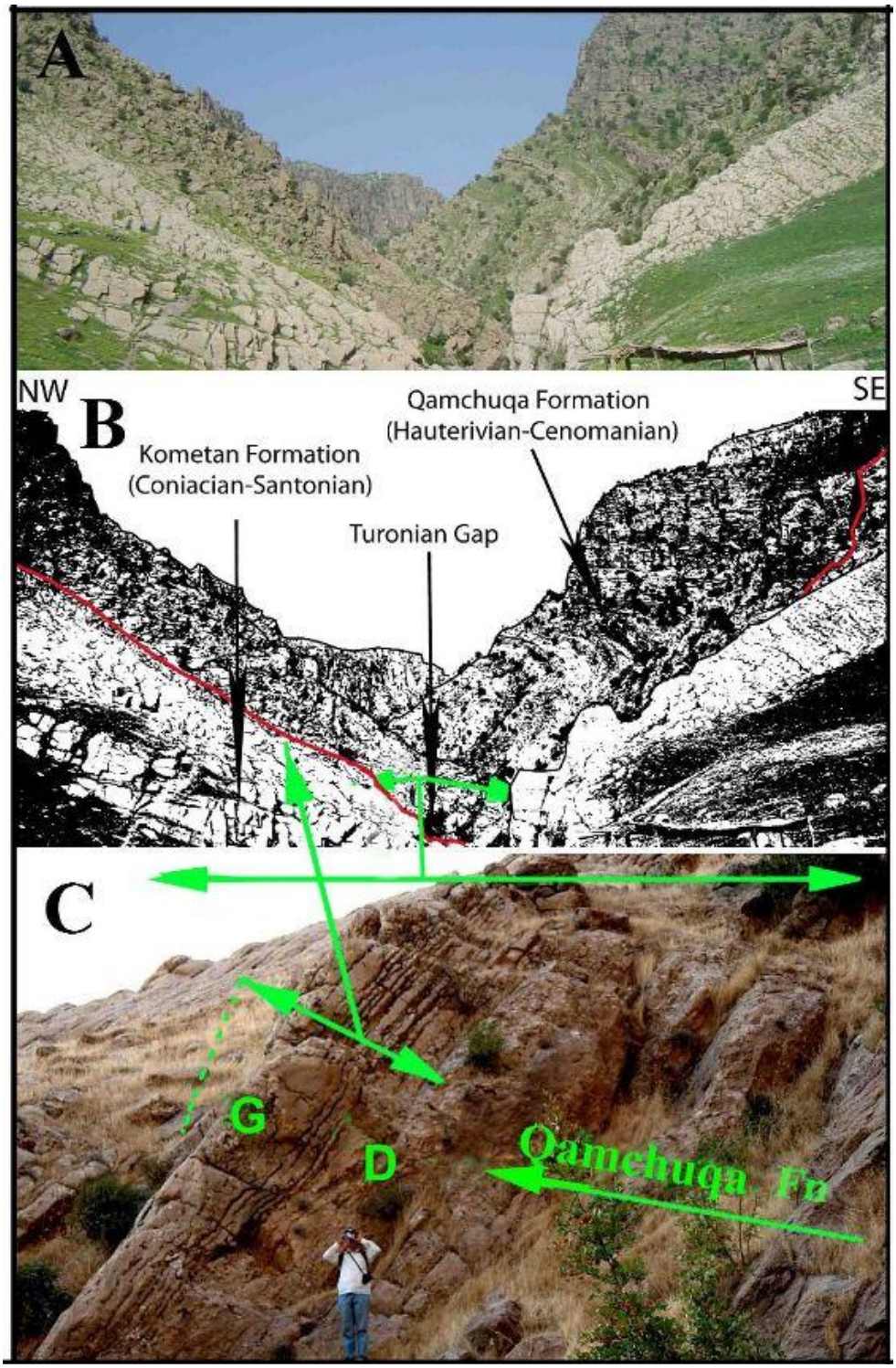

Fig. (20) A and B) photo of Lawa et al. (2013) for indication that Dokan and Gulneri formation are not present (Unconformity for 4.7 m.y) in the Tabeen Gorge 4km to the southeast of Surdash village. C) Photo of the same gorge of the present study which shows clearly that equivalents of both formations (EODF and EOGF) are existing and only the facies are changed which means that there is not unconformity. The EODG appear as highly deformed and thin bedded limestone under Kometan Formation.

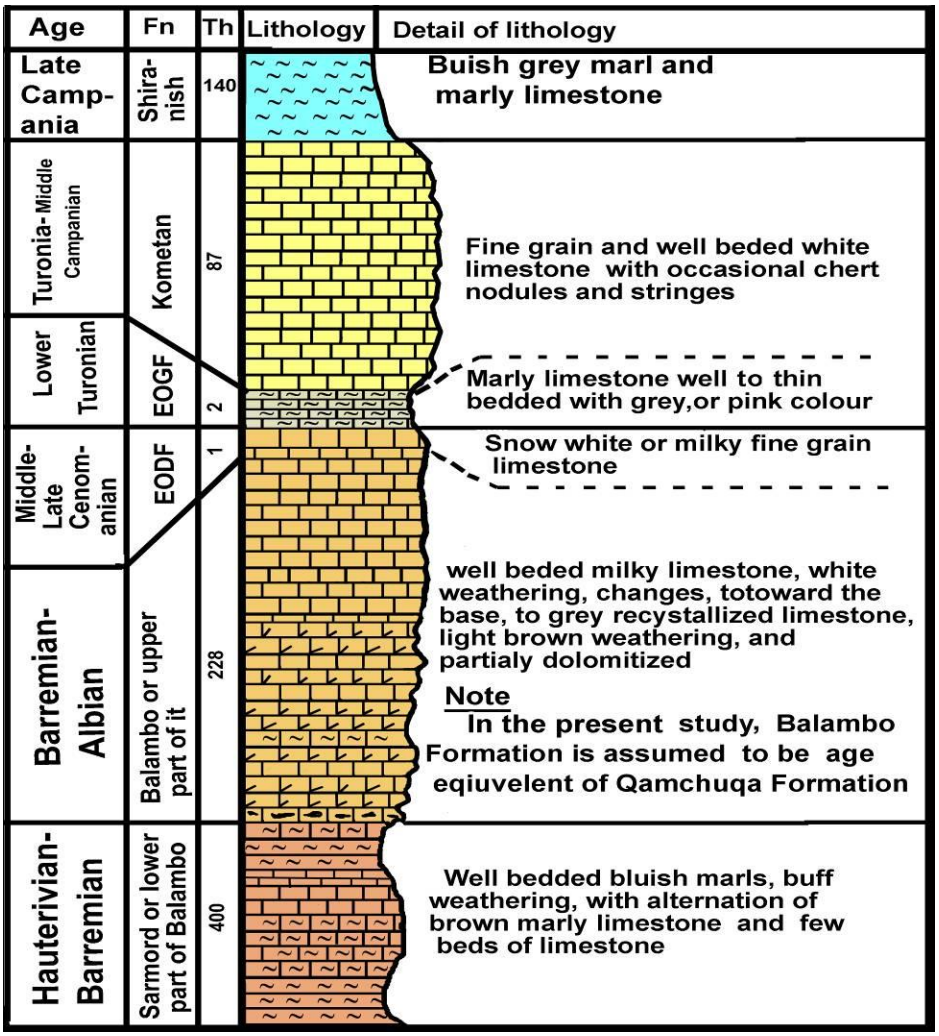

Fig. (21) Stratigraphic column of the studied area in which the ages are taken from Bellen et al. (1959), except that of Balambo Formation.

Conclusions

Thos study has the following conclusions

1-The detailed geological map of area of the Azmir-Goizha anticline is drawn for the first time on which both Kometan and Balambo formations are differentiated

2- The equivalent of both Gulneri and Dokan formations are recognized on the map for the first time which are located between Balambo and Kometan formations.

3- The outcrops of the Sarmord Formation is mapped, recognized and separated from Balambo Formation for the first time.

4- Refusing of the two previous unconformities. The first is located between Balambo and Dokan formations while the second is located between Dokan and Kometan formations.

5- There is no break in sedimentation, in the studied area, from end of Jurassic to the Maastrichtian.

6-The EOGF and EODF can be used as marker beds for accurate mapping

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