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LITHOSTRATIGRAPHIC STUDY OF THE CONTACT BETWEEN KOMETAN AND SHIRANISH FORMATIONS (CRETACEOUS) FROM SULAIMANIYAH GOVERNORATE, KURDISTAN REGION, NE IRAQ

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ABSTRACT

The contact between Kometan and Shiranish Formations (Cretaceous) are re-studied in the field and laboratory. The study elucidates the nature contact and discussed the previous ideas of unconformable contact. On the lithologic basis, the contact is described and analyzed in eight different sections and grouped into three types: obvious gradational, burrowed and glauconitic and sharp contacts. Following recent studies, the basin in which the representative sediments of these types are deposited is considered as foreland basin and the location of each section is indicated within it. The sections are interpreted to be deposited in the beginning of clastic influx into the basin at threshold time and space between pure carbonate sedimentation and mixed sedimentation of clastic and carbonate during and after drowning of the previous platform.

The first type of the contact (Obvious gradational) is interpreted to be deposited in front of major submarine fans which is supplied by regular but intermittent clay influx of highly diluted turbidity current. The second type (Burrowed-glauconitic type) is attributed to the areas between the fans, which is supplied by clear water and rich in nutrient, Fe, Mg and O2. This supply is most probably due to currents that are driven from the turbidity current when the basin was passing from deep water to shallower one. The pebbles and granules exist only in one section out of eight and they are intraformational clasts (not terrigenous) and formed by submarine erosion. The third sharp contact represents sudden and unusual event of clay influx of the turbidity current into the location of the sections so that the marl is deposited instead of pure limestone of Kometan Formation. This rapid deposition may be due to a sudden switching of submarine channel, large storm or tsunami. All evidences suggest that the contact is conformable and shows no any signs of subaerial erosion or long non-deposition but does not exclude short submarine erosions and slow rate of sedimentation across the contact.

االدراسة الصخارية الطباقية للحد الفاصل بين تكويني كوميتان و شيرانش(الكريتاسي) في محافظة السليمانية، اقليم الكردستان , شمال شرق العراق

كمال حاجي كريم ، خاليد محموداسماعيل و بختيارمحمد امين

الملخص

تم اعادة دراسة الحد الفاصل بين تكويني شيرانش وكوميتان (الكريتاسي) من الناحيتين الحقلية والمختبرية ولمحاولة توضيح الطبيعةالحد الفاصل و ماقشة فكرة سطح عدم التوافق(المقترح سابقا). وإعتمادا على الدراسة الصخارية تم وصف و تحليل الحد الفاصل في ثمانية مقاطع مختلفة ووهذة المقاطع قسمت الى ثلاثة انواع الرئيسية , وهي تدرج واضح و مثقب كلاوكونيتي و متعكراتي و فاصل حاد. إعتمادا على الدراسات الحديثة اعتبر حوض الترسيبي حوض مقدمة القارة (Foreland basin) وتم تحديد موقع كل من

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المقاطع داخل هذا الحوض و فسرت ترسيب الرسوبيات على إنه حدث في بداية تدفق ترسبات فتاتية الى الحوض في وقت و مكان العتبة بين الرواسب الكلسية النقية وترسيب كاربوناتية – فتاتية ممزوجة. النوع الأول من الحد الفاصل (تدرج واضح) فسر على إنه ترسب في موقع ما امام المراوح تحت البحرية الرئيسية التي زودت بكميات من الطين بشكل منتظم و بفترات متقطعة بواسطة تيارات العكرة الخفيفة جدا .أما النوع الثاني من الحد الفصل(مثقب –كلاوكونيتي) فهو واقع ضمن منطقة الواقعة بين المراوح حيث تكون المياه صافية ومحملة بالغذاء والعناصر اللازمة لتكوين الغلوكونايت و عيش الاحياء . و هذا المياه زودت بواسطة تيارات العكورة اثناء تحول الحوض من نوع العميق الى نوع اكثر ضحالة، أما انوع الثالث من الحد الفاصل (الفاصل الحاد) ترسب بسبب التدفق السريع و الغير إعتيادي للطين الى موقع المقاطع بواسطة تيارات العكورة مرسبة المارل فوق الحجر الجيري النقي لتكوين كوميتان.هذا الترسيب السريع و غير الاعتيادي ربما حدث نتيجة لتغيير مسار للقنوات تحت البحرية. كل الدلائل يشير الى سطح التوافق بين التكوينين حيث لم تضهر اية دلائل لتعرية تحت وعدم ترسيب طويل و لكن هذة الراسة ، لا تستبعد تعرية تحت مائية و عدم ترسيب قصير الامد عبر الحد الفاصل.

INTRODUCTION

Kometan Formation is first described by Dunnington (1953, in Bellen et al, 1959). It is exposed in High and Low Folded Zones with recording in the subsurface sections in the Mesopotamian Zone also (Dunnington ,1958 Buday, 1980, Buday and Jassim, 1987). The type section is located at 400m to the west of Kometan village in the Naudasht valley in the foothills of Qandil Mountain about 20 km to the north of Ranyia town in the Imbricated Zone (Fig.1). The formation is composed of well bedded, light grey or white limestone. It contains locally chert nodules or ribbons with rare pyrite concretions.

According to the above authors, the lithology of the Kometan Formation is relatively constant. To the west and southwest, it becomes marly and changes from purely globigerional limestone with subordinate oligostegial inlayers to prevalently oligosteginal facies. The thickness of the formation, in the High Folded and Imbricated Zones, reaches (100-120m). The lower and upper contacts of the formation are unconformable (Dunnington, 1953 in Bellen et al, 1959, Buday, 1980 and Al-Khafaf, 2005). In the type area, the first author mentioned that the upper contact is unconformable but without angular discordance. He further added that faunal and intense glauconization indicate depositional hiatus and probable erosion. In this contact, in addition to glauconite and faunal break he found polygenetic micropebbles.

In the recent years and during fieldwork, new observations are recorded in many different localities that show opposite observation to previous studies. The possible gradational contact can be seen as regular alternation of white limestone and bluish white marl. These two lithologies represent the transitional zone (5-10 m) between Kometan and Shiranish Formations. This zone changes upward and downwards to the typical marl or argillaceous limestone Shiranish Formations and downward to limestone of Kometan Formation as described by Bellen et al, 1959.

BOUNDARY ZONE

Six sections for the contact zone are studied in seven different localities, which are mentioned hereinafter.

- **Gradational contact**

This is type of contact is exposed in three section, the Chaq Chaq, Azmira Bichkola and Amir Tourism valleys.

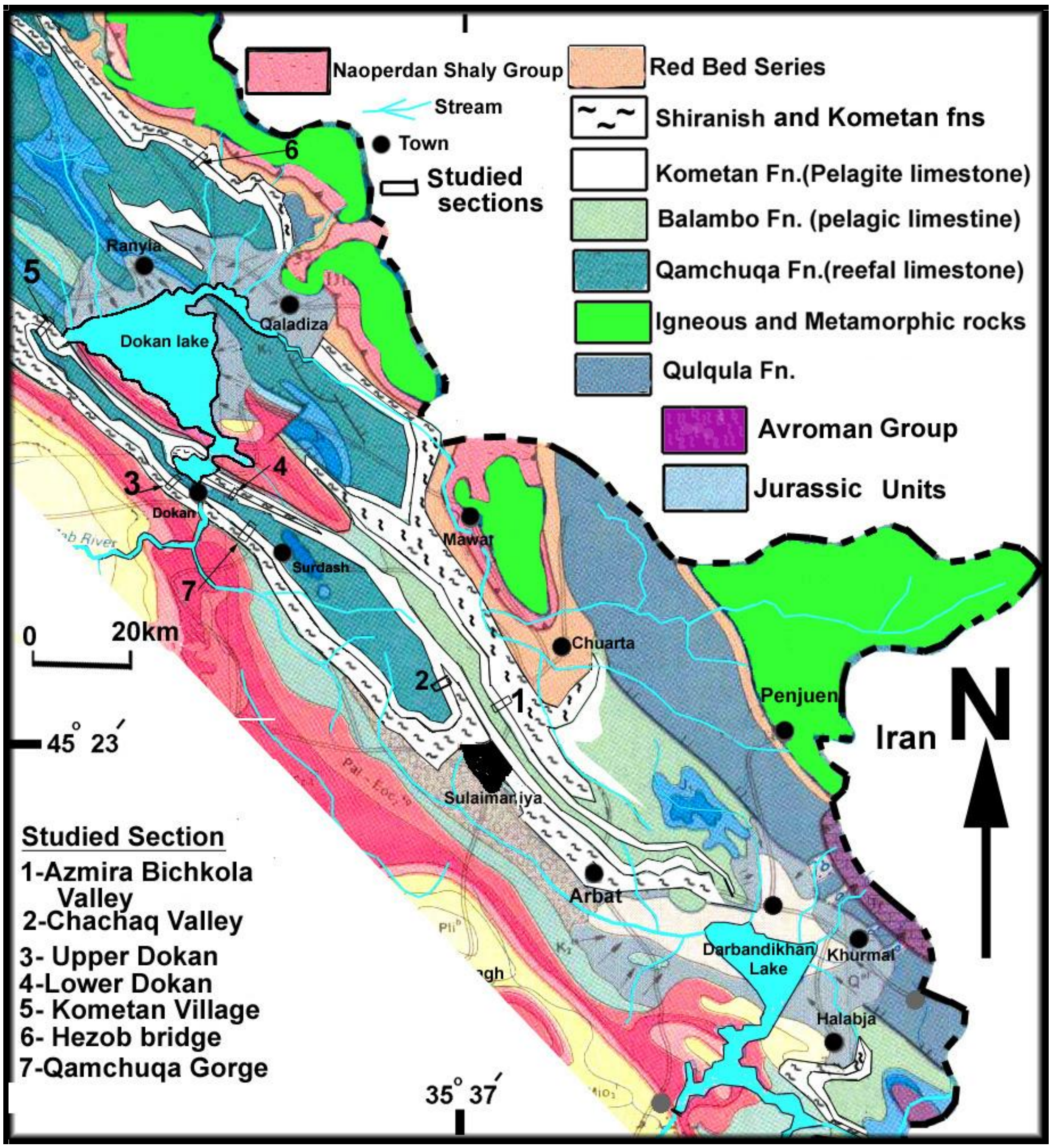

Fig.1: Geological map of the studied area (modified from Sissakian, 2000)

- **Chaq Chaq valley** section is located 10km to northwest of Sulaimaniya city and about 3 km south of Lower Hanaran Village in the intersection of latitude N 35^{o} 39^{-} $46^{=}$ and longitude E 45^{o} 24^{-} $33^{=}$ (Fig.1, section 2). The contact is exposed clearly at the right bank of the perennial stream that discharges the runoff of the valley. At this place, the gradational contact is very well developed and shows no signs of break in sedimentation or erosion. The contact has a thickness of about 10m and consists of alternation of beds of white limestone and bluish white marl (Fig.2).

- **Azmira Bichkola valley section,** is located at 15 km to north of Sulaimaniya city and 4 km to southwest of Tagaran village at the intersection of N latitude35^{o} 38^{-} $42.76^{=}$ and E longitude 45^{o} 04^{-} $01.19^{=}$. In this locality, the contact is exposed along the bank of intermittent stream in valley bottom. The same type of gradation occurs also but it is slightly covered by soil (Fig.3A).

Fig. 2: Gradational contact between Kometan and Shiranish formations in the Chaqchaq Valley. The contact is represented by alternation of grey marl and fine crystalline limestone. The marl increases toward Shiranish Formation.

The GPS reading of the location is: E: 35^{o} 39^{-} $45.25^{=}$ N: 45^{o} 24^{-} $33.12^{=}$.

Fig.3: A) Azmira Bichkola Valleys, the contact is represented by rhythmic alternation of grey marl and fine crystalline limestone. The marl increases toward Shiranish Formation. The GPS reading of the location is: E: 35^{o} 39^{-} $52.32^{=}$ N: 45^{o} 29^{-} $22.16^{=}$.

B) Gradational contact between the two formations on the right side of the paved road to Chwarta town, 50m to the northwest of small pond that is built at the mouth of Azmir tourism valley. No conglomerate, erosinal surface and glauconite are found in both sections.

- Azmir tourism valley section is exposed on the right side of the paved road between Sulaimanyia City and Chwarta town, about 50m to the northwest of a small pond built at the outlet of Azmir tourism valley (Fig.1,section 8). The boundary is gradational also as can be seen in the Fig. (3B).
In the aforementioned three sections, neither glauconite nor micropebbles are seen in the contact zone. Conversely, in these localities, there is a glauconitic bed about 30 m above the contact inside the Shranish Formation. In these three sections, there is transition zones (5−30) m thick between the two formations.

▪ Burrowed−Glauconitic contact

This type of the contact is observed in two sections, Upper and Lower Dokan sections
-Upper Dokan section is located about 3km to the east of the dam site near the tourism village (Fig.1, section 4) at the intersection of latitude N 35^{o} 56^{-} 09.11$^{=}$ and longitude E 45^{o} 01^{-} 32.62$^{=}$. The section is along the lower part of the northwestern limb of Sara Anticline. In this locaty the contact is sharp, which is manifested by sudden change of limestone beds of Kometan Formation to glauconitic sandstone bed (about 20 cm) at the base of Shiranish Formation (20cm (Fig.4 A and B). However, the contact shows no sign of erosion except some burrowing on the surface of the last layers of the Kometan Formation. Therefore, the contact is considered to be neither gradational nor unconformable; there is only slow rate of sedimentation or condensed section, which is not assigned as unconformity from sequence stratigraphy point of view, as cited by Vail, *et al* (1977), Loutit *et al* (1988), Haq, (1991), Emery and Myers (1996). But, the opposite ideas of the previous authors may be attributed to misleading of the limestone clasts and diagenetic nodules with terrigeneous clast as it on will be discussed later on.
-Lower Dokan sections, is located 500m to the south of the Dokan dam on the right side of the paved road that leads to Koyia and Arbil cities (Fig.1, section3) at the intersection of latitude N 35^{o} 56^{-} 57.43$^{=}$ and longitude E 45^{o} 56^{-} 54.38$^{=}$. The glauconite beds are exposed along the road cut and are about 1.5m thick (Fig.5A). The beds consist of glauconitic limestone and some of the layers contain burrows. This section resembles that of the Upper Dokan section except that it contains two types of gravel-sized grains. These grains are assumed as micropebbles by Bellen et al, (1959) and Buday (1980).

The first type consists of platy angular clasts (pebble sized) of Kometan Formation as they have same color and lithology of most upper part of Kometan Formation. Field and lab inspection showed that they are rip-up clasts (intraformational conglomerate) formed by submarine physical or bioerosion. Karim *et al* (2001) found burrows and boring below the glauconite beds in the same section.

The second type is green or brown color pebble-sized grains, which have botryoidal and smooth surfaces. The pebbles have different sizes and shapes such as rod, platy, oval and irregular, which are covered by either green or brown color coating about 1mm thick (Fig.6A). They resemble nodules that can be seen in Kometan Formation and studied by Al-Barzinjy (2007) that show flattened and ramulose nature (Fig.6B). The lithology of the nodules are grey limestone some of them slightly siliceous. These pebbles are neither terrigenous nor depositional because the elongated pebbles are stand both vertically and horizontally on bedding planes and do not show any accumulation but distributed randomly (Fig.6A). Conversely, they are diagenetic in origin and the green color is nothing except the glauconite coating (brown when oxidized). Therefore, this section can be assigned neither as gradational nor unconformable. However, there is short break (hiatus) without emergence or subaerial erosions in this section. The trace fossils content of the Lower Dokan Section is studied in details by Karim *et al* (2001).

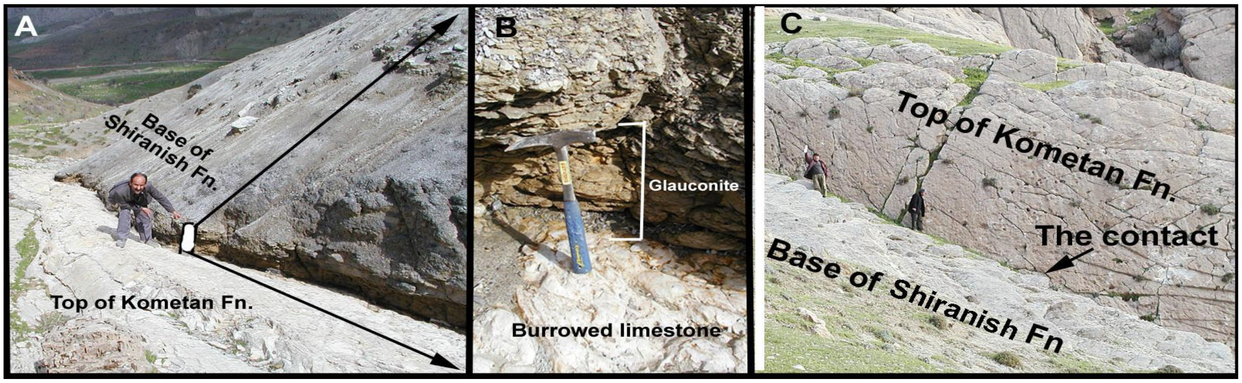

Fig. 4: Contact between Kometan and Shiranish formations.

A: It Upper Dokan (Jublakh village). The contact is sharp between the two formations.

B: The close up of the previous photo shows 20 cm glauconite bed at the base of Shiranish Formation and burrowed limestone at the top of the Kometan Formation.

GPS readings of both locations are: E: 35^{o} 56^{-} 09.1$^{=}$ N: 45^{o} 01^{-} 32.62$^{=}$. E: 35^{o} 53^{-} 50.88$^{=}$ N: 45^{o} 00^{-} 47.73$^{=}$, respectively.

C: Qamchuqa Gorge section shows sharp contact without glauconite and burrows.

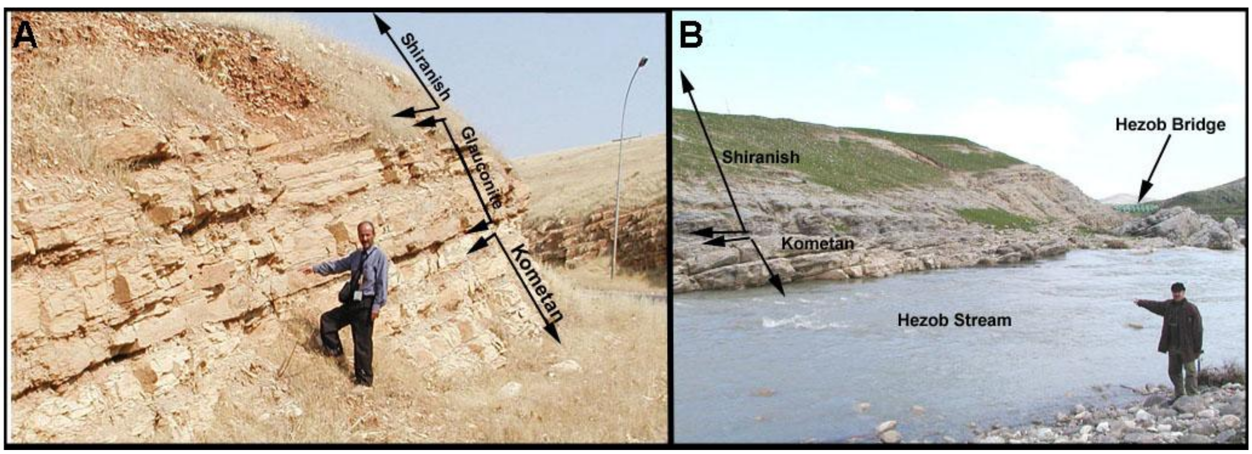

Fig. 5: The contact between Kometan and Shiranish formations. A) Along road cut in the Lower Dokan section. Hezop stream. B). GPS readings of both location are: E: 35^{o} 56^{-} 57.43$^{=}$ N: 44^{o} 56^{-} 54.38$^{=}$. E: 35^{o} 56^{-} 55.59$^{=}$ N: 44^{o} 56^{-} 49.15$^{=}$ respectively.

-Hezob Bridge section is located 20 km southwest of Ranyia Town,(Fig.1, section5) directly 200 m to the west of the Hezob Bridge, the contact is exposed along the left side of the perennial Hezob stream (Fig. 5A). The contact is also gradational, the lithology consists of alternation of white fine crystalline limestone and bluish marly limestone beds. Toward the top, it changes to lithology of Shiranish Formation (Fig.7).

-Kometan Village section is the type section of the Kometan Formation, where the formation is first defined by Bellen *et al.* (1959). The section is located about 400m southwest of Kometan village at the Naudasht valley in the foot hill of Qandil Mountain in the intersection of latitude and longitude of N36^{o} 24^{-} 28$^{=}$ and E 44^{o} 48^{-} 18$^{=}$ (Fig.1, section6). In the description of this section, Dunnington (1953) in Bellen *et al*. 1959) indicated the contact as unconformable, which is manifested by a conglomeratic nature of the base in Shiranish Formation. In spite of these ideas, the field study by present authors showed that the contact is gradational; this is represented by alternation of marl and limestone beds. The contact is more or less similar to Hezob Bridge section. Recently Kometan Formation is studied micropaleontologically in the type section and in the Lower Dokan by Al-Khafaf (2005), he mentioned, under the effect of the previous studies, unconformable contact between the two formations while in the prepared biozontaion charts showed clear conformable contact between the two formations across which no boizones are missed (see discussion section, point 6).

- **Sharp Contact**

This type of contact is exposed in one section only:

-Qamchuqa Gorge section, it is exposed along the left side of the inlet of Qamchuqa Gorge, which is located 6km west of Surdash village (Fig.1, section7), directly northwest of the previous location of Qamchuqa village (now transferred to near Dokan town) at the intersection of latitude N 35^{o} 53^{-} 50.73$^{=}$ and longitude E 45^{o} 00^{-} 47.73$^{=}$. At this gorge, the contact is sharp and neither glauconite nor burrowing are seen (Fig.4C). The lithology changes suddenly from white fine crystalline limestone (Kometan Formation) to bluish white marl of Shiranish Formation (Fig.4C).

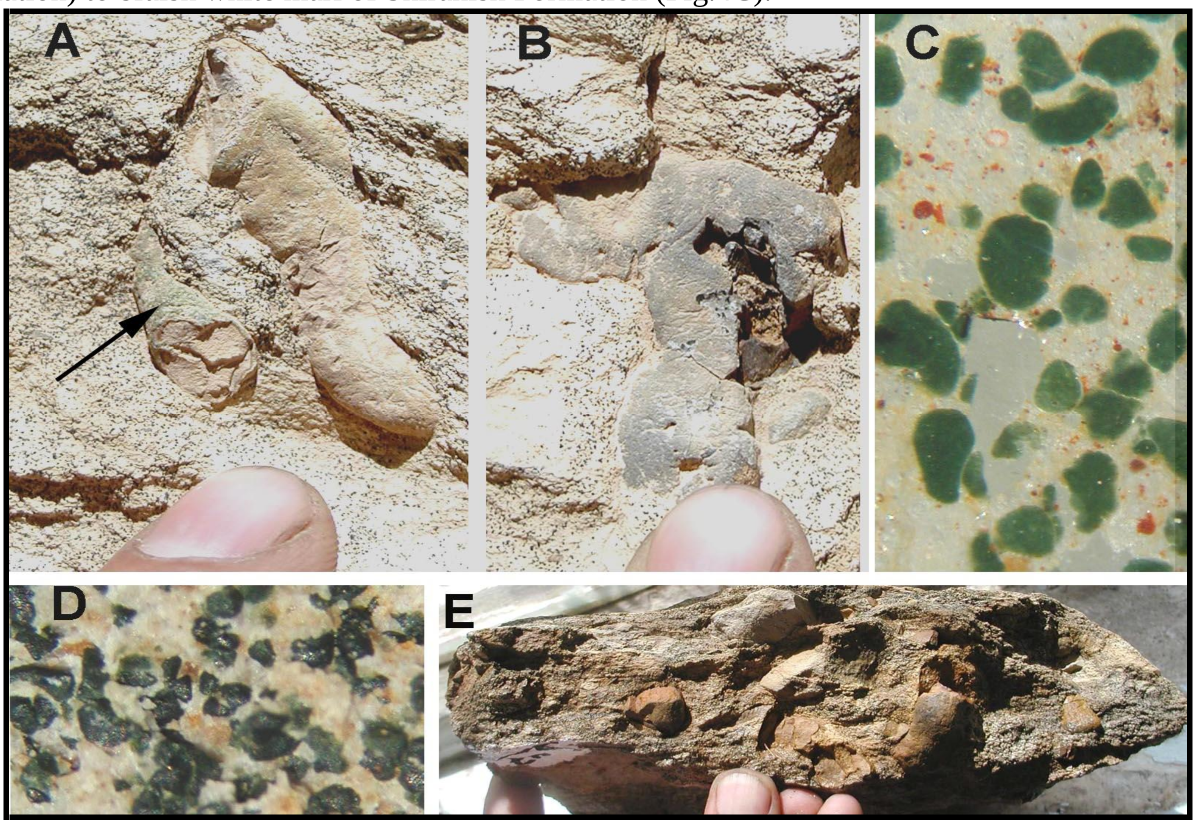

Fig.6: Different constituents of the lower Dokan section which assumed by Bellen *et al*.(1958) as conglomerate.

A: two elongated pebbles in the glauconite sand, the left one is coated with green pigment as indicated by arrow.

B: Chert pebbles which has the shape of chert nodules.

C: Glauconite as seen in thin section, S4, X20, PPL.

D: Same mineral as seen under binocular microscope, S4, X20. E: Hand specimen of pebbly and glauconitic limestone of lower Dokan section.

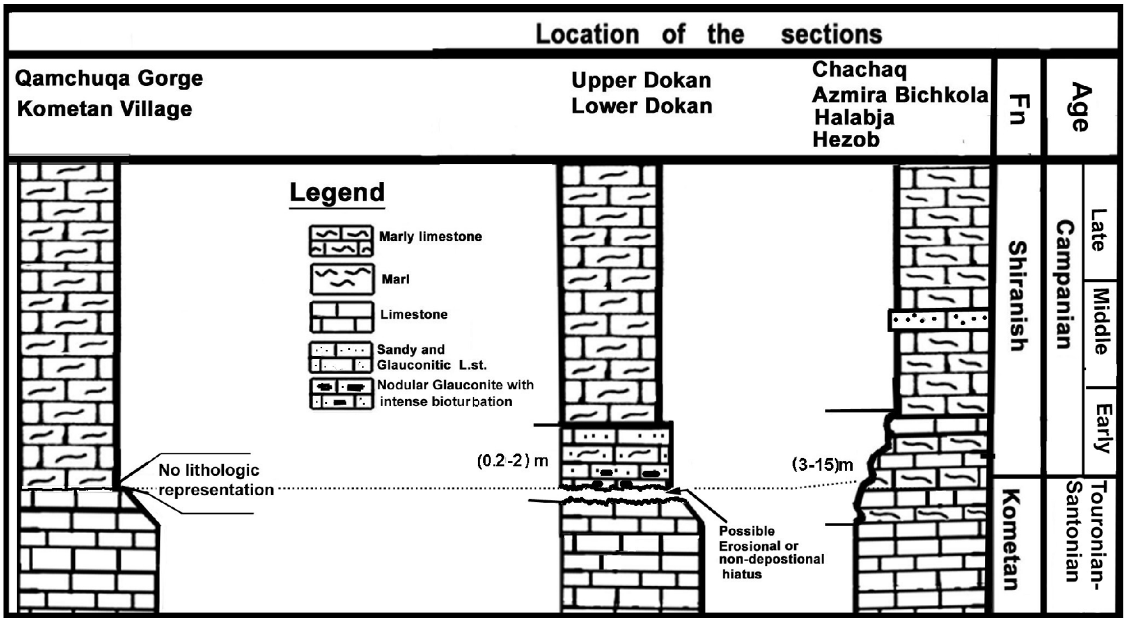

Fig.7: Stratigraphic column of the contact between Kometan and Shiranish formations in different areas Note: The location of the sections is shown on the top of each column, none of them shows unconformity except short submarine erosion in the Upper and Lower Dokan sections.

DISCUSSION

As aforementioned, from the eight sections only one section contains pebbles and granules grains which are not terrigenous and formed either by submarine erosion (for angular limestone clasts) as intraformational conglomerate or by diagenetic processes (for nodules). Moreover, from the aforementioned lithologic changes of the contact, the stratigraphic relations between the two formations could be inferred. This is based on the realization of the basin configuration, tectonics and environment of deposition, which can give reasons for the litholol gic changes across the contact. These changes, in this study, are not attributed to existence of an erosional gap (unconformity) or major non-deposition. Conversely, it returned to many factors or processes inferred in the recent years, which all prove the conformable contact between the two formations as follows:

1- In sequence stratigraphy publication by Vail *et al.* (1977), Loutit *et al.* (1988), Haq (1991), Emery and Myers (1996) the glauconite bearing bed or layer is called a condensed section which consist of thin marine stratigraphic horizons. They stressed that condensed sections are composed of pelagic and hemipelagic sediments characterized by very slow sedimentation rate and glauconite content (Fig.6D and C). They further added that within depositional sequence, the condensed section occurs partly at the top of transgressive systems tract and partly within high stand systems tract. The condensed sections represent the maximum landward extent of marine condition and flooding or subsidence, not uplift of the basin. Marine condensed sections are created by sediment starvation and thus characterized by apparent hiatus, thin zones of burrowed and somewhat lithified beds. Considering these facts (aforementioned authors), the condensed sections are not stand for unconformity because they are located at the middle of depositional sequence and unconformity is located at the top or bottom of the sequences. In this concept, Karim, and Surdashy (2006) has studied the sequence stratigraphy of Tanjero Formation and they put this latter and Shiranish Formation and in the same depositional sequence, which was deposited in the Zagros Early Foreland Basin. However, this does not mean that there is no more or less hiatus in sedimentation. This hiatus, in the case of the contact between Kometan and Shiranish Formations, was very short and existed only in some local places in one or two sections out of eight studied sections. This hiatus is most possibly attributed to submarine erosion during covering of the Kometan Formation with clastic sediments (marl or calcareous shale). The two sections that have condensed section are upper and lower Dokan sections. While in Chaqchaq and Azmira Bichkola valleys sections; the glauconite bed is located 30m inside the Shiranish Formation, not in the contact. In Sinjar area, Al-Anbaawy and Sadek, 1978 found 23meters of glauconitic limestone near the middle of the Shiranish formation. This aid that this mineral can be formed in any stratigraphic position (depending on the environment) and not necessary to be restricted to boundary of the formation and indicating to large unconformity as previously indicated Bellen *et al* (1959) and Buday (1980).

2-The sharp contact can be explained by the very recent studies of Karim (2004 and 2006) and Karim and Surdashy (2005a, 2005b and 2006). In these studies both, Shiranish and Tanjero formations are regarded as lateral facial change of each other, also interfingering, which have lateral and vertical gradation to each other. Both formations with the upper part of Kometan Formation are included in the one of the two depositional sequences in which Kometan, Shiranish and Tanjero were deposited. According to aforementioned studies, these formations are deposited in large Foreland basin, which occupied most of Iraqi land during Late Cretaceous. The foreland basin was bordered from north and northeast by a positive land of Iranian plate front (or foreland of Iranian Plate). From the foreland and hinterland the river driven influx of sediments were reached the coastal area of the foreland basin and there they were reworked by turbidity current and storm to deeper part of the basin (Fig.8).

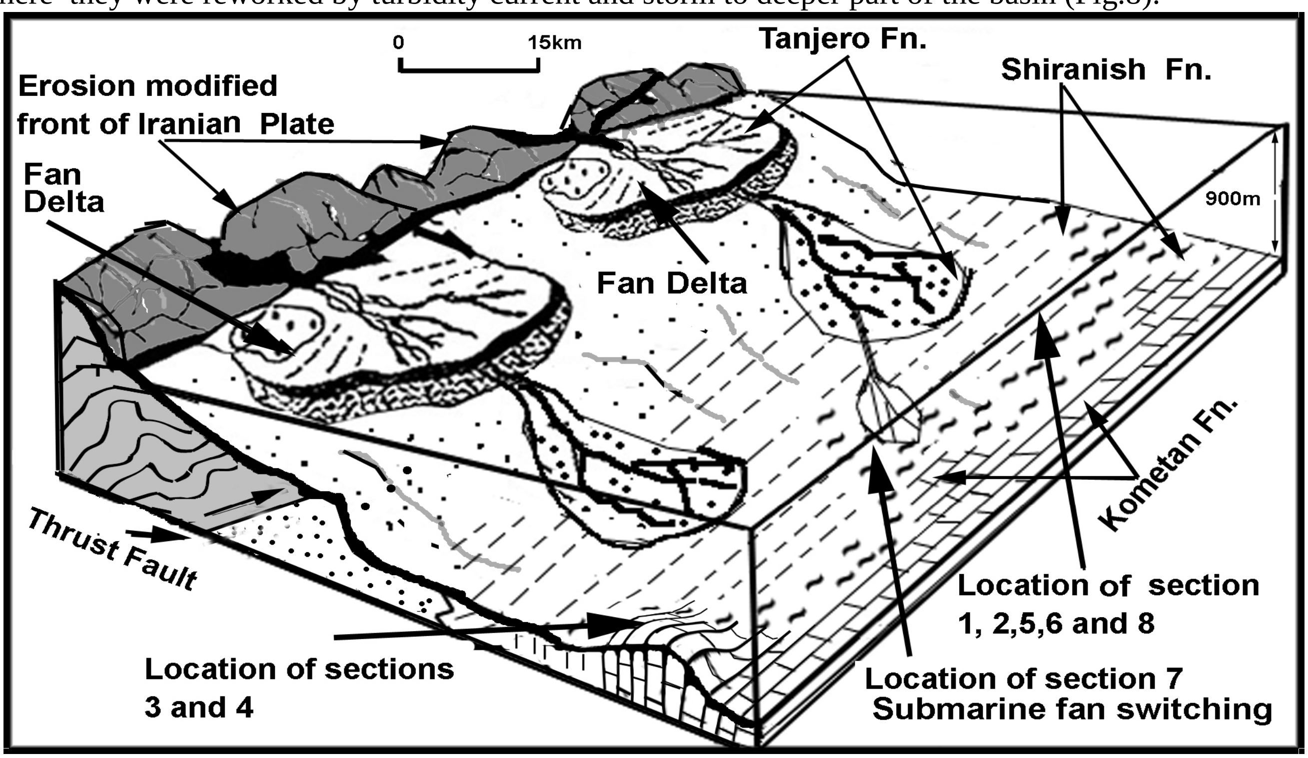

Fig.8: A paleogeographic model for interpreting the nature of the boundary and indicating it's location between Kometan and Shiranish formations during Lower Campanian in the newly developed foreland basin.

Considering, the foreland basin, turbidity current and nutrient influx, the three type of contact (sharp, gradational and burrowed-glauconitic) can be explained easily. Within the basin, the contact of the two formations represents the threshold time and place between possible deep marine carbonate dominated and clastic dominated environments, which are represented by Kometan and Shiranish (with Tanjero) Formations respectively. In this time and place, the sharp contact represents rapid and unusual influx of clay of the turbidity current into the basin so that the marl is deposited, as highly diluted turbidity current sediments, instead of limestone of Kometan Formation (Fig.7).

This rapid deposition (might be) due to sudden switching of submarine channel or events such as large storm or tsunami. The burrowed-glauconitic contact is standing for the places in the basin where Fe, Mg and nutrient rich currents were prevalent (Fig.8). These clay free current might be driven by turbidity currents. These currents formulated the nutrient and oxygen rich physicochemical milieu for survival of organism and diagenetic deposition of glauconite. The stratigraphic position of the glauconitic bed in the Shiranish Formation most possibly does not indicate maximum flooding surface.

This is because it is overlain and underlain by nearly same lithologies (marl or marly limestone) as in the Chaqchaq, Azmir tourism valley and Azmira Bichkola sections. Moreover, the bed is deposited in one systems tract, which according to Karim and Surdashy (2006) consists of lowstand systems tract. The granules and pebbles that exist with glauconite in the Lower Dokan section are most probably represent intraformational clast and formed by submarine erosion in local places because they exist only in one section. This is because limestone clasts are derived from the Kometan Formation (see discussion of lower and upper Dokan sections).

3- The gradational contact, in the Chaq Chaq and Azmira Bichkola valley, Kometan village, and Hezob bridge sections are located (with in the basin) in front of large submarine fans (outer fan) where frequently were supplied by clay during large events of turbidity current. From the current, marl is deposited while during quiescence limestone is deposited. According to Karim (2006b); Karim and Surdashy (2005a and 2006) with southwest advancing of Iranian Plate front, the basin becomes more and more closer to present position of the studied sections, the clay and sand increase gradually consequently Shiranish and Tanjero formations are deposited respectively (Fig.8).

4- According to Bellen *et al.* (1959) and Buday (1980), the lower and upper contacts of the Kometan Formation are characterized by existence of glauconite. This fact if is true, gives very important information and reasons that are concerned with the deposition of glauconite in the base and top of Kometan Formation. This is because; the glauconite indicates that during development of Kometan basin, the beginning and termination of this basin are passed through same depth of water and physicochemical condition. The basin developed, in some places, from shallow reefal environment of Qamchuqa Formation as seen in the field in Piramagroon area. It is logic that this beginning (contact with Qamchuqa Formation) is neither deep nor shallow but characterized by intermediate depth. Therefore, the ending (contact with Shiranish Formation) is also passed through this intermediate depth (as indicated by glauconite deposition). These facts indicate that it is possible that the glauconite, at the contact of the two formations, was not representing maximum flooding surface but returned to the generation of suitable environment when the environment changes from shallow to deep basin.

5- In literature, the citation of Emery and Myers (1996, p.101) about probability of development of condensed section by delta switching and on submarine highs is applicable for contact of the two formations in Dokan area (Fig.8). Einsele (2000) showed that glauconite is deposited in shallower seas than foraminera bearing lime mud (Kometan Formation.). According to the above facts, the expanded time stratigraphic column of Bellen *et al.* (1959) is modified to show the gradational contact of the two formations (Fig. 9 A and B). In the column, the three formations laterally and vertically change to each other and show conformable contact. Toward southwest Shiranish continuously replaced by Kometan Formation.

6- The aforementioned discussion about the interpretation of gradational contact is supported by the study of Al-Khafaf (2005) who has studied the biostratigraphy of Kometan Formation in Sulaimanyia area in the two sections, including the Lower Dokan section of the present study. He concluded that the age of Kometan Formation is Middle Turonian−Early Campanian. He also recorded the *Globotruncana ventricosa* index fossil of Middle Campanian that overlying *Glotrancanita elevata* Zone (Lower Campanian) inside Shiranish Formation. In his two biozonation charts no gap can be seen from Turonian to Middle Campanian (Fig. 10 and 11).Al–Jassim *et al.* (1989) have conducted biozonation of Kirkuk Well No. 166 and Qarachuq Well No.1. They record neither unconformity nor gaps in sedimentation from Turonian to Middle Campanian. Before these two latter study, the age of Kometan Formation was indicated as Turonian−Santonian by Buday(1980, p.174).

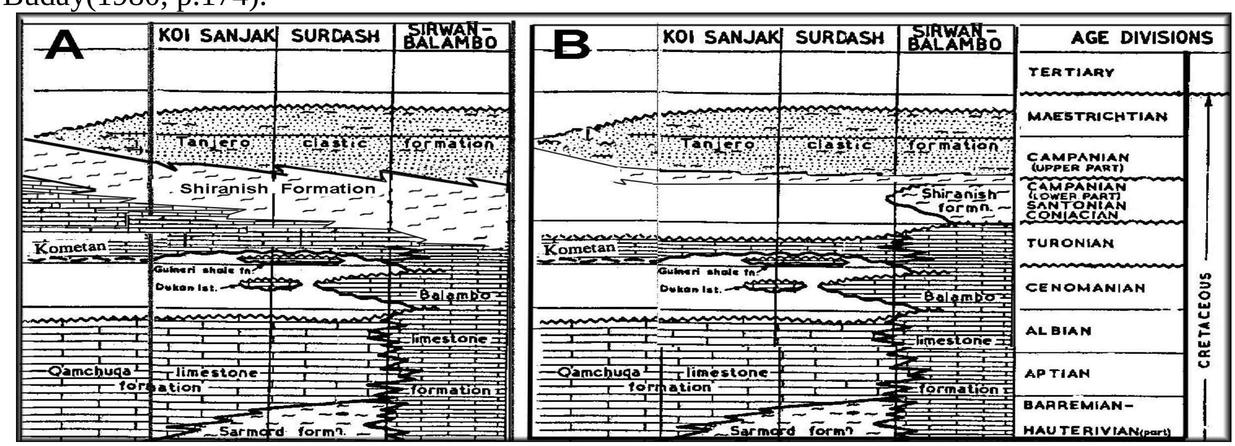

Fig.9: A) Time expanded stratigraphic column (Modified from Bellen *et al*(1959)shows the gradational contact between Kometan and Shiranish formations. B) Original column (Bellen *et al.* (1959).

Age			Planktonic foraminiferal Zones	Datum Markers
				⊥ *Globotruncana ventricosa*
Upper Cretaceous	Early Campanian		*Globotruncanita eleveta*	
	Santonian		*Dicarinella asymetrica*	T *Dicarinella asymetrica* ⊥ *Dicarinella asymetrica*
			Dicarinella concavata	⊥ *Dicarinella concavata*
	Coniacian		*Dicarinella primitiva*	⊥ *Dicarinella primitiva*
	Turonian	Late	*Marginotruncana sigali*	T *Helvetoglobotruncana helvetica*
		Middle	*Helvetoglobotruncana helvetica*	⊥ *Helvetoglobotruncana helvetica*

⊥ First Occurrence T Last Occurrence

Fig.10:Index fossils for Kometan Formation from Middle Turonian to Early Campanian in Sulaimanyia Governorate(Al-Khafaf, 2005)

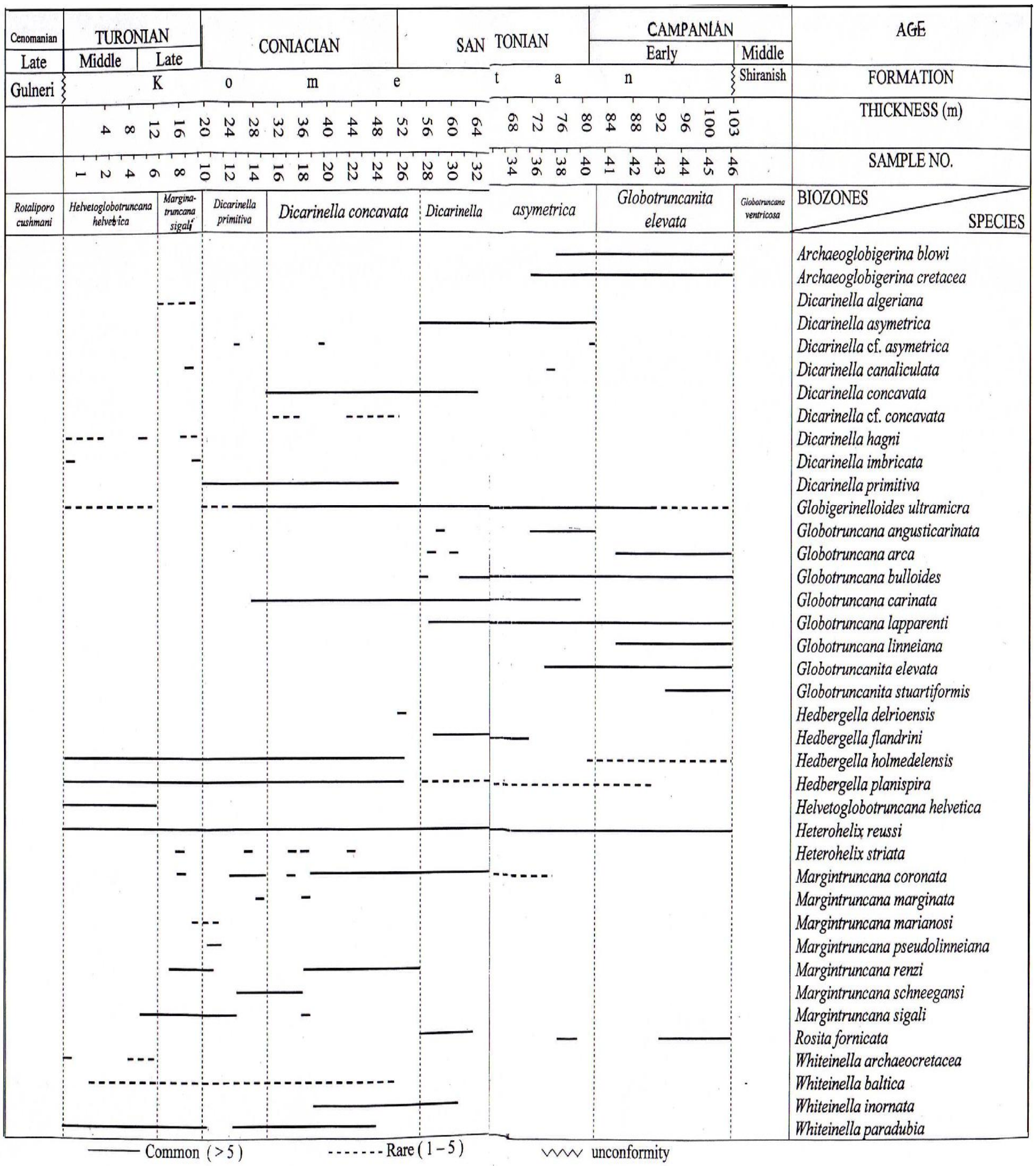

Fig.11: Biozonation chart of Lower Dokan section by Al-Khafa(2005) which shows continuation of sedimentation from Turonian until Middle Campanian across the boundary between Kometan and Shiranish formations .

CONCLUSIONS

This study has the following conclusions:

- This study inferred that the contact between Kometan and Shiranish formations is most probably conformable, but not every where, this depends on the basin configuration and show no sub-aerial erosion or major gap in sedimentations as mentioned previously. The existed gap in sedimentation is local and submarine only.
- Most of the sections show obvious gradational contact, only two of them show sharp contact and in two of them burrowing and glauconization is recorded.
- Among eight sections, only one contains rip–up clast and pebble-like bodies, which have intraformational and digenetic (nodules) origin, respectively.
- Depending on the recent studies, these sections are interpreted in term of the basin of deposition, which consisted of a foreland basin that existed in front of southwest advancing front of Iranian Plate.

REFERENCES

Al-Barzinjy, S. M., 2008. Origin of chert nodules in Kometan Formation from Dokan area, NE-Iraq. Iraqi Bulletin of Geology and Mining, Vol. 4,No.1, p.95-104.

Al–Jassim, J. A., Al–Sheikhly, S.S.J. and Al–Tememmey, F.M. 1989. Biostratigraphy of the Kometan Formation (Late Torunian–Early Campanian) in northern Iraq. Jour. Geol. Soci. Iraq.Vol.22, N.1, pp.53–60.

Al-Khafaf, A. O., 2005. Stratigraphy of Kometan Formation (Upper Cretaceous) in Dokan- Endezah Area, NE-Iraq. Unpublished MSc thesis, university of Mosul, Department of Geology, 79pp.

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

Buday, T. ,1980. Regional Geology of Iraq: Vol. 1, Stratigraphy: I.I.M Kassab and S.Z. Jassim (Eds) GEOSURV, Baghdad, 445pp.

Buday, T. and Jassim, S.Z., 1987. The Regional geology of Iraq: Tectonism Magmatism, and Metamorphism. I.I. Kassab and M.J. Abbas and Jassim, S.Z (Eds), GEOSURV, Baghdad, Iraq, 445 pp.

Einsele, G., 2000. Sedimentary Basin. 2nd ed. Springer Verlage, Berlin 792pp. Emery, D. and Myers, K., 1996. Sequence Stratigraphy. Blackwell Scientific Limited. 297pp.

Emery, D. and Myers, K. 1996**.**Sequence Stratigraphy. Blackwell Scientific Limited. 297pp.

El-Anbaawy, M. I. H, and. Sadek, A. 1978. Paleoecology of the Shiranish Formation (Maestrichtian) in Northern Iraq by means of Microfacies analysis and clay mineral investigation. Palaeogeography, Palaeoclimatology, Palaeoecology , 26(1979): 173-180.

Haq, B. U., 1991. Sequence stratigraphy, sea level change and significance for deep sea. Special Publs. Int. Ass. Sediment, 12(1). p.12-39..

Karim, K. H., Lawa, F.A. and Ameen, B. M., 2001.Upper Cretaceous Glauconite filled boring from Dokan area/ Kurdistan Region (NE-Iraq), Kurdistan Acadimician Journal (KAJ), Vol.1 (no.1) Part A.

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

Karim, K. H., 2006. Environment of Tanjero Formation as inferred from sedimentary structures, Sulaimanyia area, NE-Iraq. K AJ, Vol.4, No.1. p.16–43.

Karim, K.H. Surdashy, A.M.2005a. Paleocurrent analysis of Upper Cretaceous Foreland basin :a case study for Tanjero Formation in Sulaimanyia area, NE-Iraq, 2005, Journal of Iraqi Science, Vol. 5, No.1, p.30-44.

Karim, K.H. and Surdashy, A.M. ,2005b. Tectonic and depositional history of Upper Cretaceous Tanjero Formation in Sulaiumanyia area, NE-Iraq. Journal of Zankoy Sulaimani, Vo. 8 No.1. p.47–62.

Karim, K.H. and Surdashy, A. M., 2006. Sequence stratigraphy of Upper Cretaceous Tanjero Formation in Sulanmaniya area , NE-Iraq. KAJ, Vol.4., No.1.p19–43..

Loutit, T. S., Hardenbol, J., Vail, P. R., and Baum, G. R., 1988. Condensed section: The key to the age dating and correlation of continental margin sequences. In: sea level change: an integrated approach (Eds

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

Vail, P.R., Mitchum, R.M., Todd, R. G., Widmier, J.M. and Hatleid, W.G., 1977. Seismic stratigraphy and global changes in sea level. In: seismic Stratigraphy–Application to Hyrocarbon Exploration (ed. by C. E. Payton). Memoir of the American Association of the Petroleum Geologists, Tulsa, 26, p.49-62.