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LITHOLOGY OF THE LOWER PART OF QULQULA RADIOLARIAN FORMATION (EARLY CRETACEOUS), KURDISTAN REGION, NE IRAQ

[1]Kamal H. Karim[*], Habib R. Habib[**] and Sardar M. Raza[***]

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ABSTRACT

The lower part of the Qulqula (Radiolarian) Formation is studied in the Thrust Zone, Northeast Iraq (Kurdistan Region) near the border with Iran. The lower part consists of alternation of more than four detrital limestone successions (each about 25 m thick) with thick intervals of bedded chert and shale. The limestones are mainly of distinctly bedded and shallow marine in origin. The four successions have nearly the same lithology of peloid, ooid, lithoclastic and bioclastic grainstone and packstone, with rare mudstone and wackstone. The matrix consists mostly of blocky cement and minor amount of micrite (lime mud).

Previously mentioned, that the lower part of the Qulqula (Radiolarian) Formation overlies the Balambo and Kometan formations and a conglomerate bed (0.2–2 m thick) separates the two formations. In the present study, the origin of this conglomeratic bed is studied and inferred that it belongs to Tanjero Formation. It is found that, with the conglomerate, slices of the Shiranish Formation occur below the lower part of the Qulqula Formation.

The conglomerate is traced (surveyed) for about 30 Km continuously in the field, from Said Sadiq town to Chuwarta town. At 6 Km to the east of Chuwarta town, the conglomeratic bed combines lithologically and stratigraphically with the conglomerate beds of the lower part of Tanjero Formation (Maastrichtian). The lithology of both conglomerate are similar. Both of them consist of variegated chert and limestone clasts. Therefore, it is thought that has the same age and origin and belongs to Late Cretaceous Tanjero Formation. This is inferred by observing lateral combining and similar lithologies of the two conglomerates. The only difference is that the conglomerate of Tanjero Formation is characterized by better roundness and sorting than the concerned conglomerate in the present study. The difference is attributed to more closeness to the source area. The occurrence of Shiranish Formation and conglomeratic bed of Tanjero Formation below Qulqula Formation is attributed to thrusting of the latter formation above the formers.

صخارية الجزء السفلي من تكوين القولقولة الراديولاري (الكريتاسي المبكر) اقليم كوردستان، شمال شرق العراق

كمال حاجي كريم و حبيب رشيد حبيب و سردار محمد رضا

المستخلص

تم دراسة الجزء السفلي لتكوين القولقولةالراديولاري في المنطقة الفوالق الزاحفة في شمال شرق العراق شمال شرق مدينة السليمانية قرب الحدود العراقية – الايرانية . يتكون هذا الجزء من التكوين من اكثر من اربعة تتابعات اكلسية الفتاتية (يصل سمك كل واحد منهم الى 25م) و متبادلة مع نفس العدد من تتابعات الحجر الصواني المتطبق والطفل. تتالف التتابعات الاربعة من الحجر الكلسي المتميز بالطباقية ذات البيئة البحرية الضحلة. تتشكل جميع التتابعات من نفس الصخرية حيث تتكون من الحجرالجيري(الحبيبي والمرصوص) الدمالقي و السرئيي و الفتاتي الصخري مع قليل من الحجر الجيري الطيني و الواكي تتكون المادة الحشوية فيها اساسا من السمنت الكتلي و قليل من الميكرات.

ذكرسابقا وجود الجزء السفلي من تكوين قولقولة فوق تكوين بالامبو او كوميتان ويفصل بين هذين التكوينين و تكوين قولقولة طبقة من المدملكات ذات سمك (0.2–2) م. الدراسة الحالية سلطت الضوء على اصل طبقة المدملكات افوجدت بانها تعود الى مدملكات تكوين تانجرو (الماسترختيان).

[*] Assistan professor, Department of Geology, University of Sulaimaniyiah,

** professor Department of Geology, University of Baghdad

***Senor lecturer, Department of Geology, University of Sulaimaniyiah

كما لاحظت الدراسة وجود شرائح من تكوين شيرانش ضمن هذه المدملكات الواقعة تحت الجزء السفلي من تكوين قولقولة. و تم متابعة طبقة المدملكات هذه لمسافة 30كم وذلك بدءا من مدينة سيد صادق الي منطقة جوارتا. فوجد بانها ،الى الشرق من مدينة جوارتة، تندمج طباقيا و صخريا مع مدملكات الجزء السفلي من تكوين تانجرو . و تبين ان هذه المدملكات مشابهة صخريا لمدملكات تكوين تانجرو، اذ ان كليهما يتكونان من القطع الصوانية المتعدة الالوان والقطع الكلسية المختلفة. لذالك اعتبر هاتين الطبقتين لهما نفس الاصل وانهما ترجعان الى الماسترختيان(بسبب اندماجهما جانبيا مع مدملكات تانجرو) و تشابهما في الصخرية، مع اختلاف بسيط هو تميز حبيبات مدملكات تكوين تانجرو بتكورها و فرزها الجيدين مقارنتا بمدملكات اسفل تتابعات القلقلة و ذالك بسبب قرب الاولى و بعد الثانية من الصخور المصدرية. و يعزى وجود شرائح من شيرانش المتلاسنة مع المدملكات تحت تكوين قولقولة الراديولاريتي الي اندفاع تتابعات قلقلة فوق كلا من تتابعات شيرانش و تانجرو.

INTRODUCTION

According to Bellen *et al*. (1959) Qulqula Radiolarian Formation was first described by Bolton (1955), but a more precise definition and description was given by the same author in 1958. He mentioned that it consists of thick successions of bedded chert, shale and siliceous limestone. He also added that the contacts of the formation are hard to be determined, because of the complex structure of the outcrop areas, which are marked by intense folding, faulting and thrusting. Buday (1980) mentioned that, in the type area, the Qulqula (Radiolarian) Formation consists of three different members. The Lower Member consists predominantly of moderately thick bedded, oolitic and detrital limestones with thick beds of white chert. Both limestone and chert layers are interbedded with grey marly shale. The Middle Member is composed of thinly bedded, red, grey and green shale with intercalation of cherty radiolarian limestone and dark ferruginous shale. Moreover, he added that the Upper Member is dominated by thick sequence of dark red ferruginous-siliceous shale and ruby mudstone, with occasional beds of oolitic and detrital limestones. The author, mentioned the presence of contemporaneous synsedimentary effusion rocks, but they are not present in the type locality. Buday (1980) cited that the effusion rocks (volcanic rocks) are diabase, but their stratigraphic position is not clear enough. He also mentioned that limestone is very frequent in Kani Manga–Nal Parez area.

The present study deals with the lower boundary and Lower Member of the Qulqula (Radiolarian) Formation. The field study showed this part of the formation is well exposed throughout the Thrust Zone, usually forms ridges, along the northeastern side of Kurra Kazahaw, southwestern side of both Avroman and Qandil Mountains and north of Chuwarta–Mawat area. Among these areas, the present study is concerned with the area between Chuwarta and Said Sadiq towns only. In this area the lower part, as Lower Member of the formation, consists mainly of successions of black (light grey weathering) limestone. The number of these successions is more than four (Karim, 2003).

LOCATION AND GEOLOGICAL SETTING

The studied area is located within Sulaimaniyah Governorate in Northeastern Iraq near the border with Iran (Fig.1). It is elongated as a narrow belt between Chuwarta (from northwest) and Said Sadiq (from southeast) towns (Figs.2A and B).This area is located between latitudes N: 36^{o} 21^{-} $23^{=}$ and N: 35^{o} 25^{-} $48^{=}$ and longitudes E:45^{o} 10^{-} $04^{=}$ and E:46^{o} 02^{-} $41^{=}$. The studied area is located within the Zagros mountain belt in the Thrust Zone, Qulqula–Khuakurk Subzone (Buday and Jassim, 1987). The studied area consists of large horst (it is found in the present study) on which the Jurassic rocks are exposed near the northeastern boundary (Figs. 2A and B). This horst is bounded by two transverse normal faults from northwest and southeast. The former fault is described by Karim (2004). It is located to the east of Chuwarta town while the latter is found by this study; it passes through Said Sadiq town, and Kaolos village (Fig.2A and B). In Chuwarta-Said Sadiq area the Qulqula Formation

exhibits a reverse fault in the northeastern boundary of the studied area in stead of thrust fault, which exists outside the studied areas such as Mawat and Avroman areas (Karim and Baziany, 2007). The studied area is developed from the basin fill (Neo-Tethys) and deformed by colliding of the Iranian and Arabian Plates. Three sections are selected for detailed study of the lower part of the Qulqula (Radiolarian) Formation, these are:

1-Kaolos section

This section is located directly to the south of Kaolos village, at the extreme southeastern end of the studied area, a bout 15 Km to the north of Said Sadiq town at latitude N: 35° 29' 13.89" and longitude E: 45° 52' 1.47" (Fig. 2A).

2- Dostadara section

This section is located directly to the west of Dostadara village, in the middle of the studied area, about 12 Km to the northeast of Barzinja town (Figs. 2A, 2B and 3). GPS readings are latitude N 35° 34' 47.33" and longitude E 45° 46' 45.63".

3-Gali section

This section is located about 10 Km to the east of the Chuwarta area (Fig.2B). GPS readings are latitude N 35° 38' 54.08" and E longitude 45° 41' 13.67".

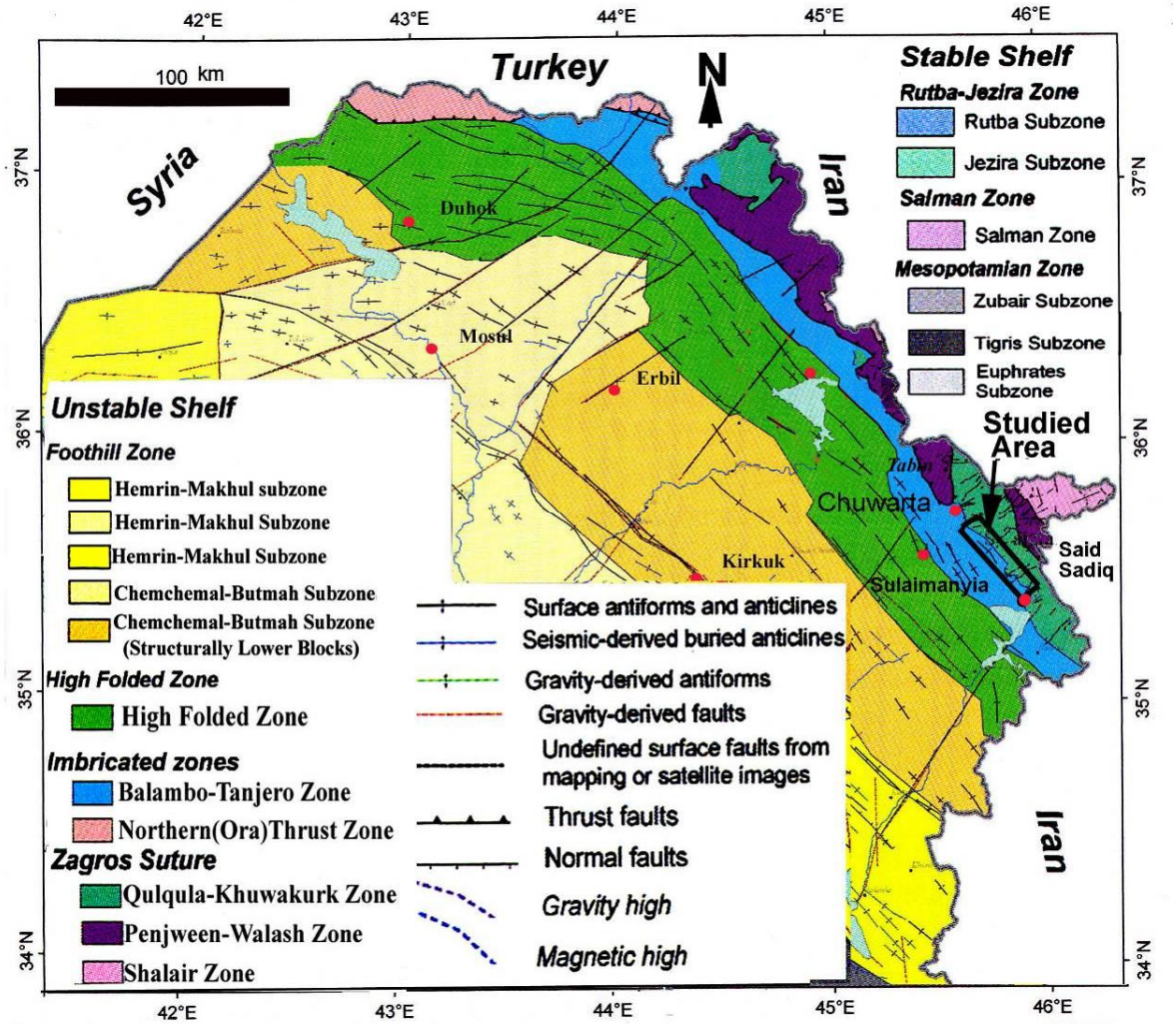

Fig.1: Tectonic map of Iraq (modified after Jassim and Goff, 2006) showing the studied area

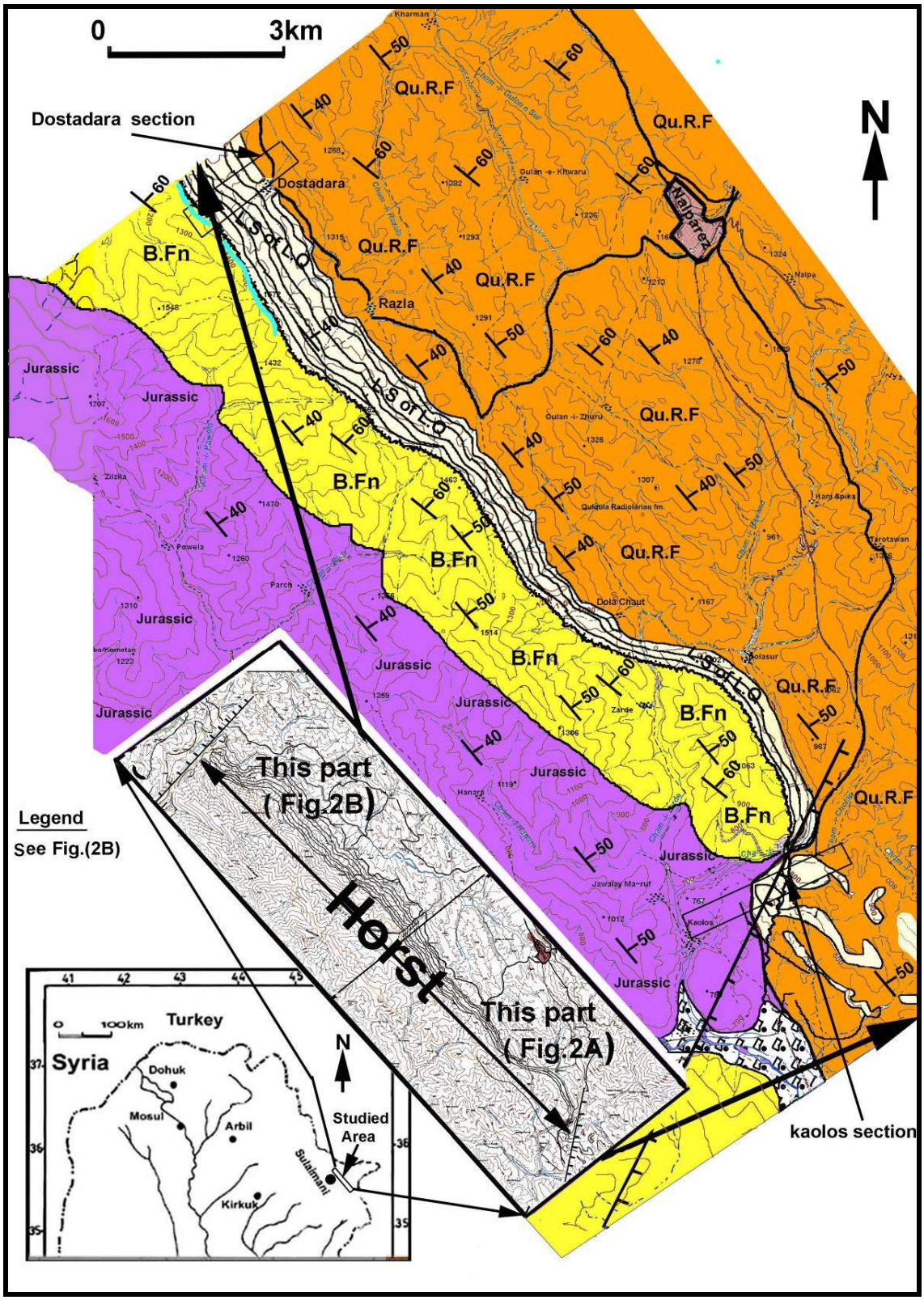

Fig. 2 A: Location and geological map of studied area (the southeastern part)

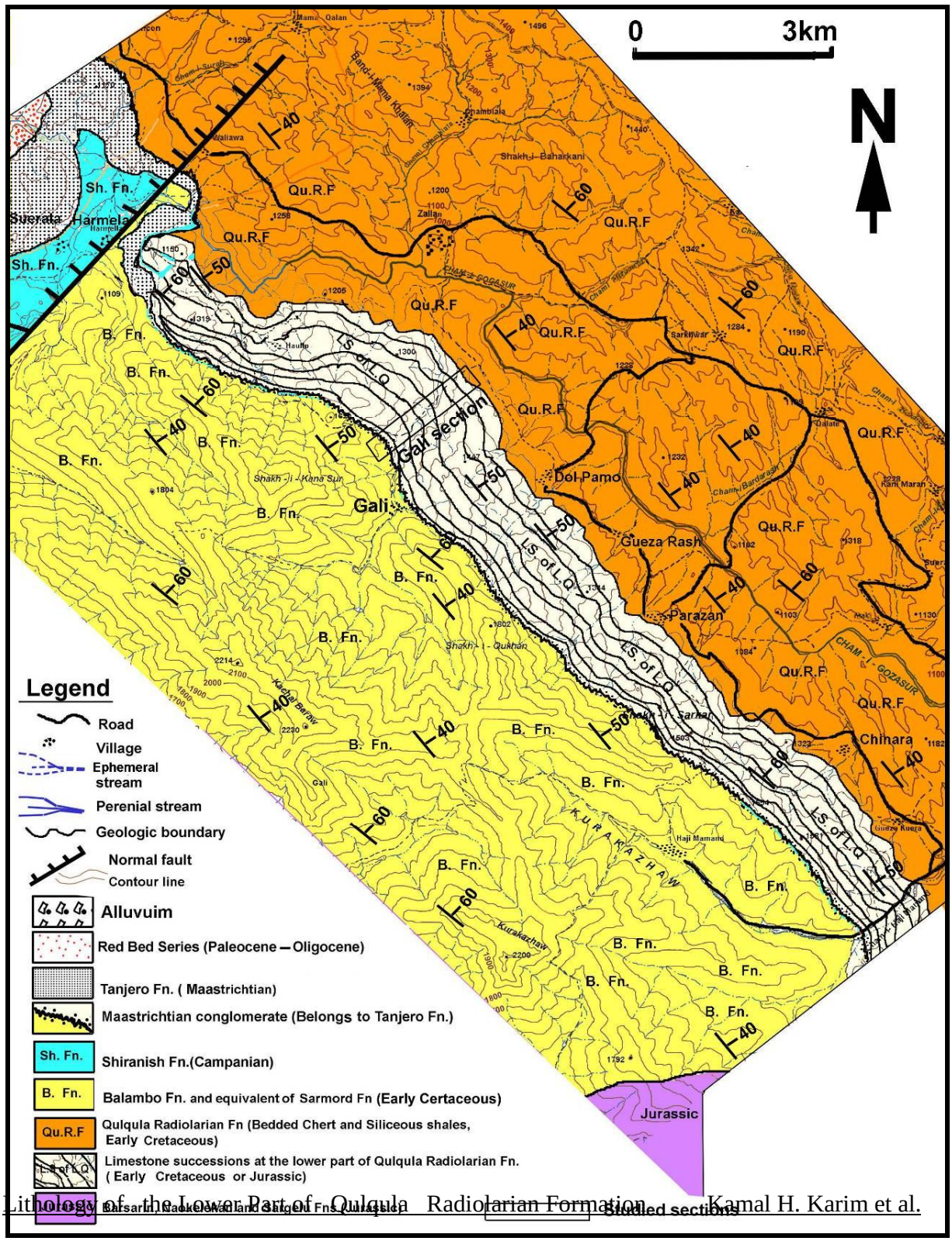

Fig. 2B: Geological map of the studied area (the northeastern part)

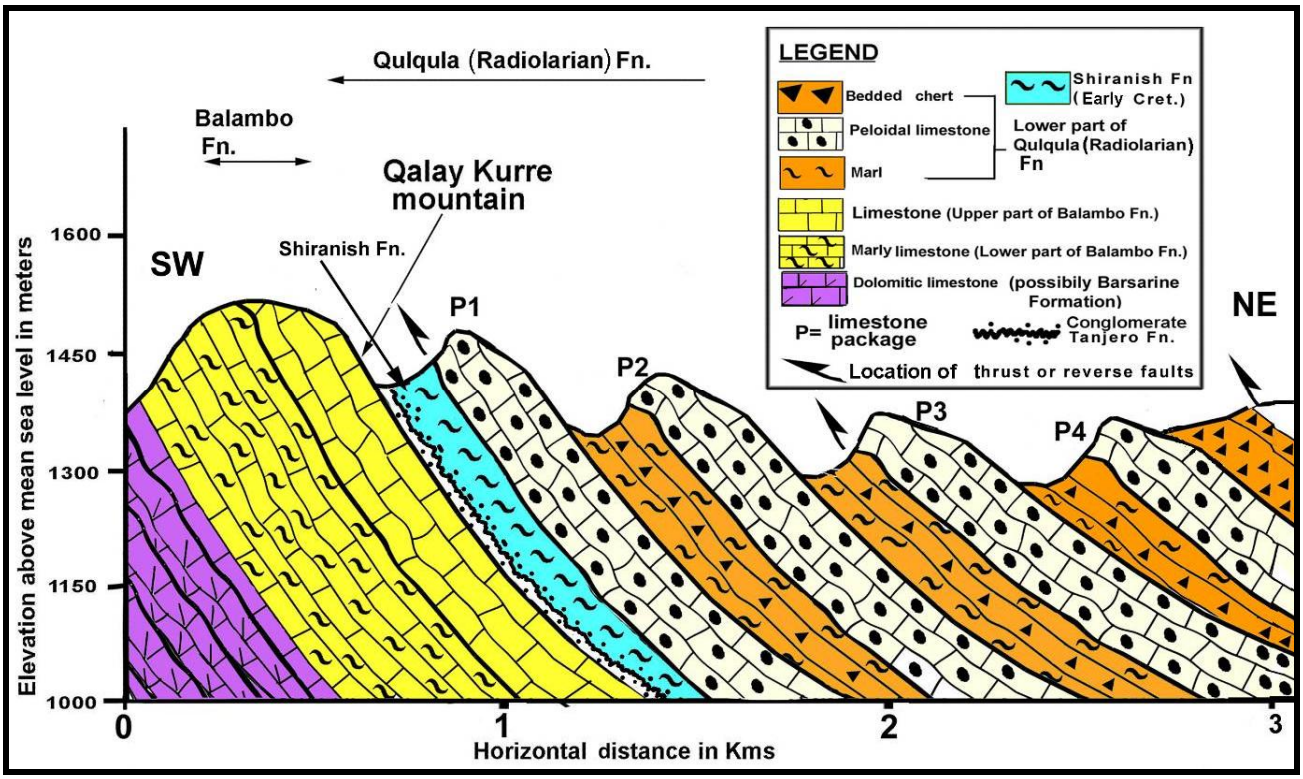

Fig.2C: Dostadara village geologic cross section, passing directly by the west of village section. (P1, P2, P3 and P4 represent limestone packages).

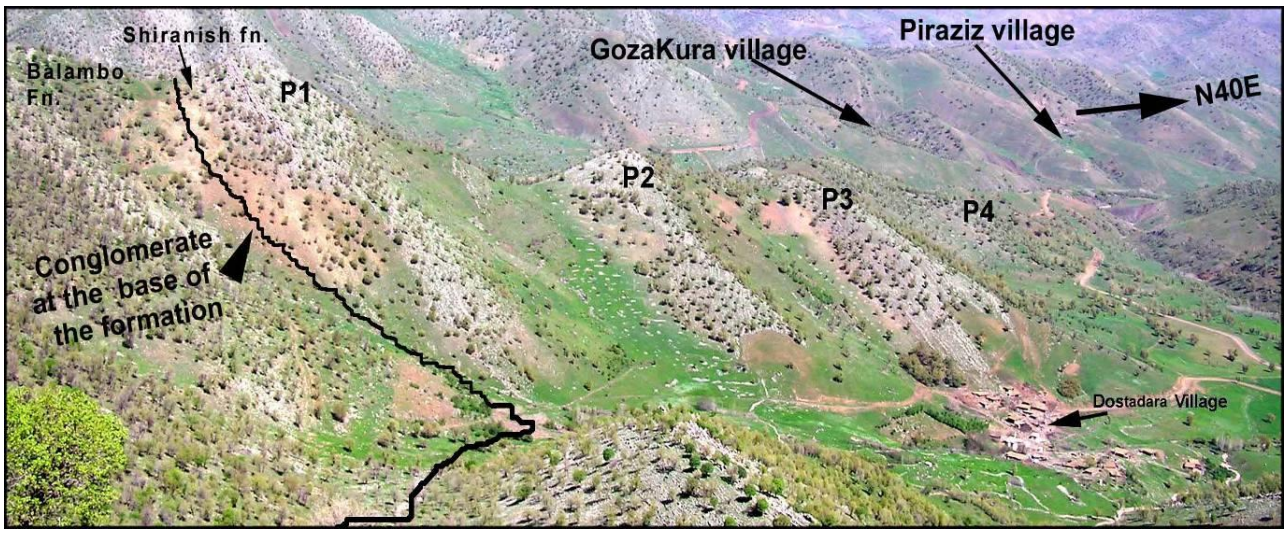

Fig. 3: Limestone packages (successions) at the lower part of Qulqula Formation, west of Dostadara village, N latitude 35^{o} 34^{-} $47.33^{=}$ and E longitude 45^{o} 46^{-} $45.63^{=}$
(P1, P2, P3 and P4 are representing limestone packages). The distance between P1 and P2 is about 400m.

LITHOLOGY OF THE LOWER PART OF QULUQLA (RADIOLARIAN) FORMATION

The succession the Qulqula (Radiolarian) Formation contains two different lithologies which can be observed in the field (Fig.4). These are: a conglomerate bed at the base of the lower part of Qulqula (Radiolarian) Formation and limestone successions at the lower part of the Lower Member of Qulqula Formation (Bolton, 1958), the details of these successions are:

- **Conglomeratic bed at the base of the lower part of Qulqula (Radiolarian) Formation**

A conglomeratic bed at in the base of Qulqula Formation with thickness of (0.2–2) meters (Karim, 2003). It consists of poorly sorted and sub-rounded gravels (with some boulders) of cherts and limestones (Figs.5 and 6). It extends between Chuwarta town, in northwest, and Said Sadiq town in southeast. It seems that the most problematic aspect of the Qulqula Formation in the nature of its boundaries. This is because presence of pure sedimentary conglomerate i.e: not tectonic in the studied area at the base of the formation, which extends almost continuously for about 35 Km in the area between Chuwarta and Said Sadiq (Fig.2A and B). On the basis of its deposition over the Balambo or Kometan formations, Karim (2003) stratigraphically aged its deposition to Late Cretaceous. Depending on the stratigraphic position of the conglomerate, he assumed that the overlying Qulqula (Radiolarian) Formation is autochthonous.

In the present study is re-studied in detail the ideas of the Karim (2003), in the field and the following points were proved. The **first** is that, it is true that the conglomerate is deposited during Late Cretaceous. This is proved by tracing the conglomerate towards northwest till it combined with a conglomerate that exists in the lower part of the Tanjero Formation, southeast of Harmella Village (8 Km southeast of Chuwarta town). The lithologies of both conglomerates are the same (gravel and boulders of variegated chert and oolitic–peloidal limestone). Therefore, the authors believe that the conglomeratic bed, although is located in the base of Qulqula Formation, but belongs to Tanjero Formation. This is because it laterally combines with conglomerate of Tanjero Formation and lithologic similarity with that of the latter formation. The Conglomerates, within this Tanjero Formation is studied in detail by Karim (2004 and 2006) and Karim and Surdashy (2005a and b), they called it Kato Conglomerate. According to those authors this conglomerate consists of chert and limestone gravels and boulders, with more than 500m of thickness.

The **second** is that, the age of Qulqula (Radiolarian) Formation is still controversial. According to Tahrani (2006) the age of this formation in Iran is ranges from Jurassic to Late Cretaceous. Karim (2003) suggested Turonian age, while in the present study no evidence of specific age was found, but Early Cretaceous age is preferred as an age of most parts of the Qulqula (Radiolarian) Formation.

The **third** is that, the Qulqula Formation is allochthonous and evidences could be seen showing more or less transportation. According to Aswad (1999), it is parautochtonous (partially transported) unit and comprised deepest marine sediments deposited parallel to the Arabian Shelf Carbonate and slightly dislocated by a reverse fault. The last two points are assumed as slight amendment for the previous idea of Karim (2003).

The **forth** is that, at the base of the Qulqula (Radiolarian) Formation not only comprise conglomerate of Tanjero Formation but also slices of friable bluish white marl occurs too. The slice has the thickness of about 30m located above the conglomeratic bed (Figs.7 and 8). It belongs to Shiranish Formation because it combines laterally with Shiranish Formation near the Harmela village (Fig.2B) and it shows nearly same lithology of Shiranish Formation when observed by microscope and hand lens.

It is worth to mention that according to Bolton (1955), Buday (1980) and Jassim and Goff (2006) there is another thick conglomerate (about 1200 m thick) at the top of the Qulqula (Radiolarian) Formation, which is called, by same authors, Qulqula Conglomerate Formation. This conglomerate is studied by Baziany (2007) and Karim and Baziany (2007), they suggested to abandon the formation because it is nothing except Red Bed Series.

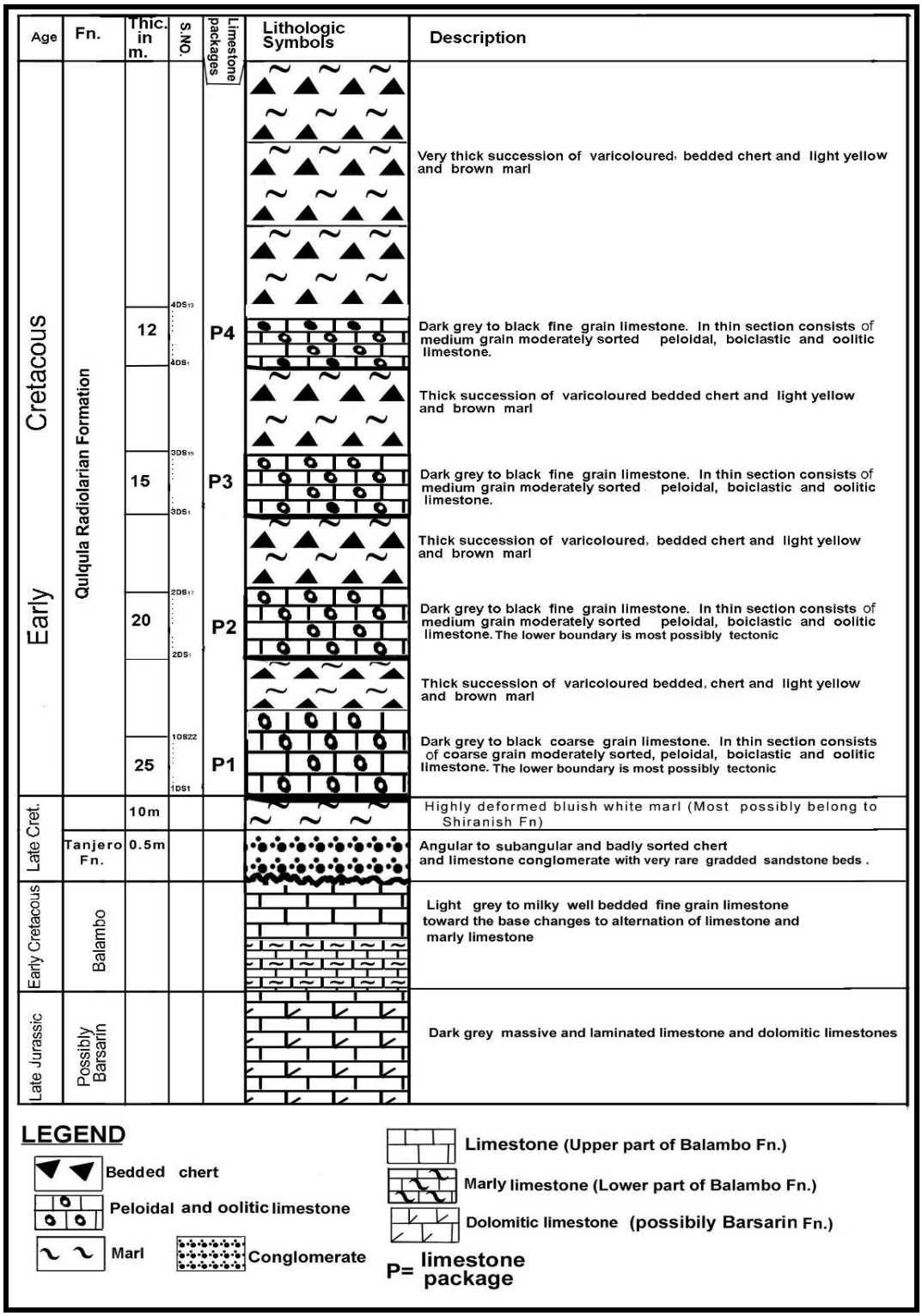

Fig.4: Stratigraphic column of the Dostadara section.

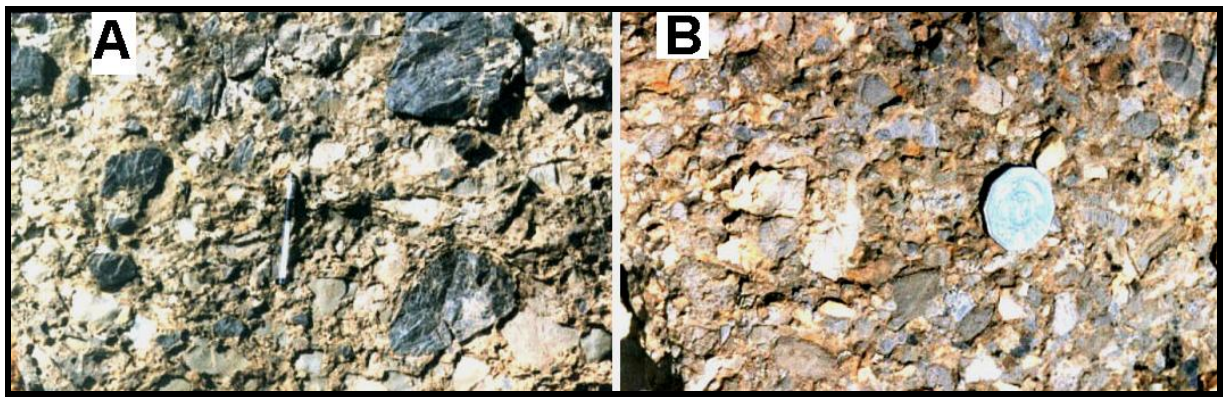

Fig.5: Texture and lithology of the conglomerate bed between Balambo and Qulqula (Radiolarian) Formations. A: Black chert and limestone clasts near Kaolos village. B: White chert and limestone clasts near Dostadara villages (from Karim, 2003).

Fig.6: The Conglomerate bed at the base of Qulqula Formation, exposed at 1 Km north of Kaolos village, (6 Km) north of Said Sadiq town.

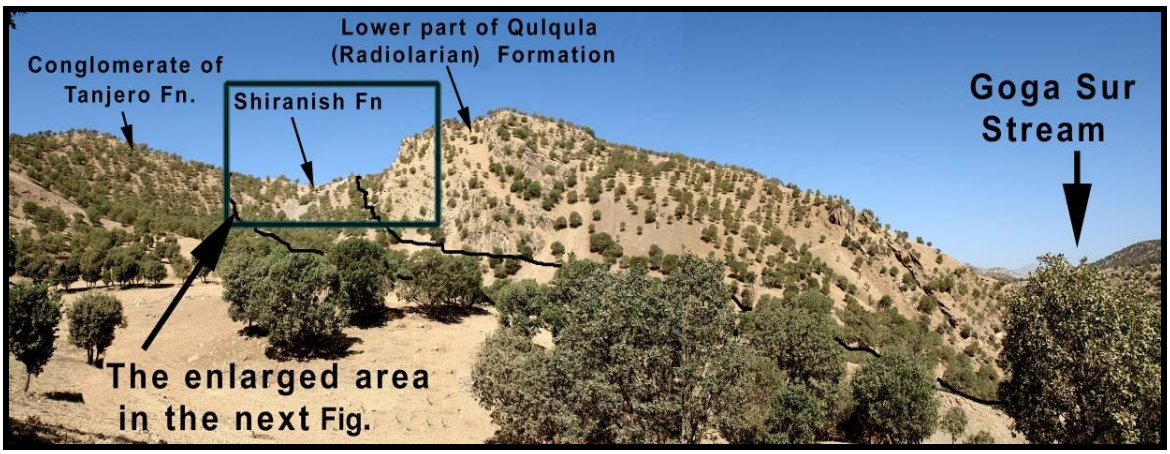

Fig.7: Qulqula (Radiolarian) Formation (Early Cretaceous) is overlying both Shiranish and Tanjero Formations (Late Cretaceous) due to thrusting, at 1Km west of Harmella village (8Km west of Chuwarta town).

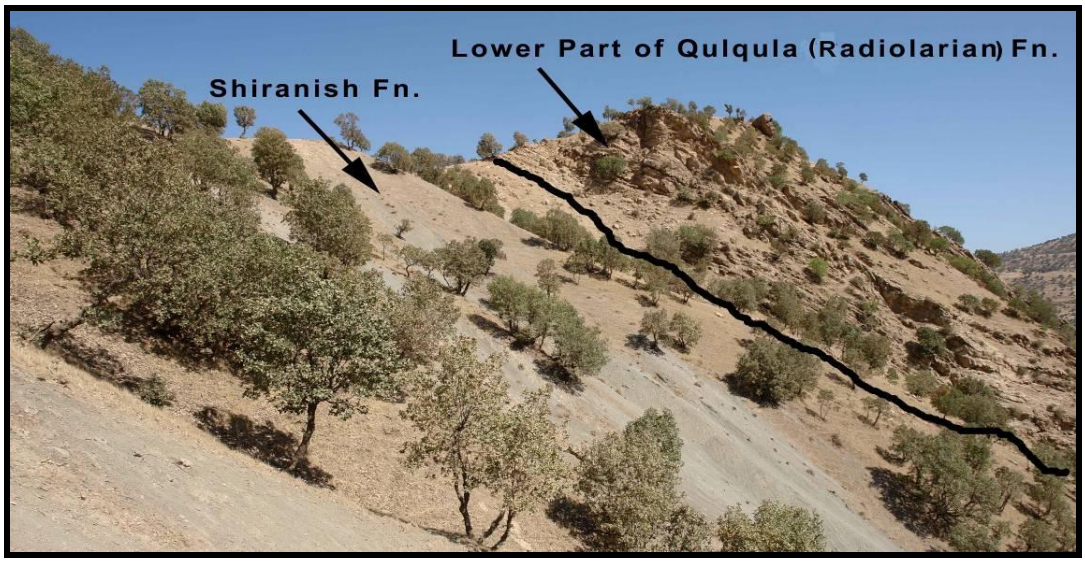

Fig.8: The enlarged area in the black parallelogram in the Fig.7 shows Qulqula Radiolarian Formation thrust over Shiranish Formation at 1km west of Harmella village (8km west of Chwarta town).

- **Limestone Successions at the lower part of the Qulqula (Radiolarian) Formation**

In the studied areas, the lower part of the formation consists of more than four limestone successions (or packages), which are located above the Conglomerate Bed or Balambo and/ or Kometan Formations. These packages (Lower Member, Bolton, 1958) are separated by thick interval of alternations of bedded cherts and marls (Fig.3). These limestone successions are well developed in the area between Chuwarta town and Razila village, where each packages has a thickness more than 25 meters. They crop out 3 Km to the south of Harmela village, near Chuwarta Town, and extend to Kaolos village, passing near by (to the south of) Dolpamo, Goezarash, Parazan, Chinara, Piraziz, Dostadara and Razla villages (Figs. 2A and B). Between Chuarta and Kalos villages, each succession consists of more than 50 beds (20–130 cm) of black and fine to coarse crystalline light grey weathering color limestone. Occasionally, the limestone beds contain nodules and strings of chert (Fig.9A).

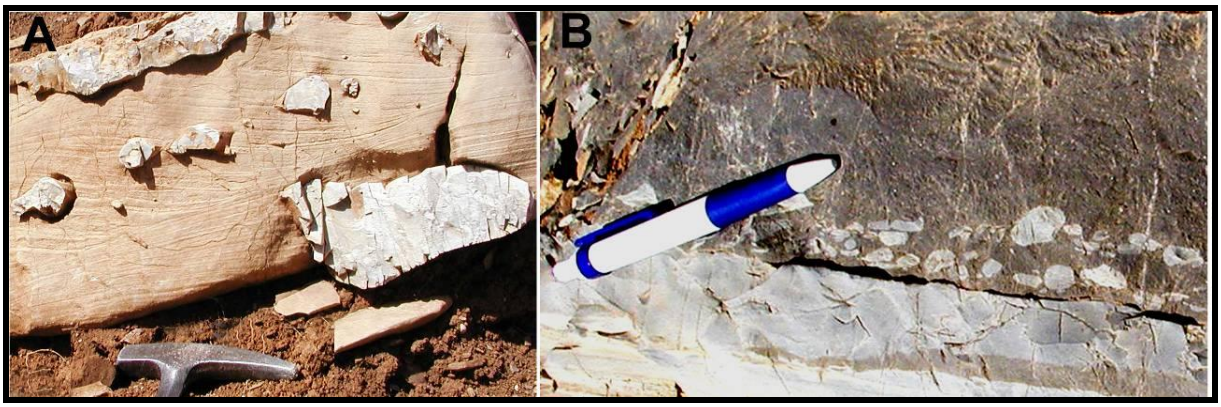

Fig.9: A) Cutting of the laminae (of a cross lamination) by chert nodules in the limestone succession of Qulqula Formation

B) Rip-up clasts found in the limestone member, 1 Km south of Razila village, 30 Km north of Said Sadiq town.

From Razla village to about (800 m) west of Kaolos village, the number and thickness of the limestone packages decrease to (2) and about (8 m), respectively. Near Kaolos village, the limestone packages disappear due to faulting (Fig.2A). Before disappearance, they become highly deformed and Sargelu Formation appears below them. The Sargelu Formation, in this locality, consists of thick sequence of black limestone containing Posidonia shell and their bioclasts.

CRITERIA FOR FINDING THE TOP AND BOTTOM OF THE LIMESTONE SUCCESSIONS

One of the difficulties that stand against this study was indicating whether these limestone successions are overturned or not, because the studied area is located in the Thrust Zone. This is very important for constructing the stratigraphic column and cross section within the studied area. To achieve these data, field study is conducted to indicate the top and bottom of the packages, by using sedimentary structures. Most outcrops almost devoid of sedimentary structures, the found useful sedimentary structures in the studied area are:

■Rip-up clasts

These clasts are intraformational and submarine eroded grains, which are removed from semi lithified substrata by current or wave. After removal, they are transported for short distance and then re-deposited with other sediments. The light grey sub-rounded clasts of the lower limestone bed can be seen in the upper layer of limestone of darker color (Fig.9B). These clasts were used for indicating the top and bottom of the beds. As the clasts are re-deposited in the overlying bed, therefore, the bed that is shown in Figs. (9B) is in the right depositional condition and not overturned.

■ Cross Lamination

Several small scale cross laminations are observed in medium and coarse crystalline limestone (Fig.9A and 10A). According to Pamela (2003), cross bedding exists in several environments; they are more common in river point bars, tidal channels, and delta and shelf environments. The acute angle between the underlying bed and tangential laminae is pointing towards the paleo-direction flow or sediments transport direction. The tangential laminae with the flat underlying laminae indicate the top of the strata (Fig.10A).

■Graded bedding

In the Qulqula Formation small scale graded bedding structures are found in two different lithologies. The first is found inside the limestone members (graded pebbly limestone) and the second is found in the pebbly sandstone inside the conglomeratic bed. Those that are associated with the latter, are associated with ripple marks (Fig.10B). In both lithologies, the graded bedding have erosional base and grading is normal type in which the grain size decreases upwards. These beds are deposited by either turbidity current or by storm generated geostrophic current. It occurs in both sandstone and pebbly sandstone as normal grading (fining upward).

■Channel gutter (small channels)

These structures consist of depressions with depth of few centimeters and with length of more than (5 cm). They are scored on the top of the limestone beds and filled with coarse sand sized to conglomeratic clastic limestone that show normal graded bedding and lamination (Fig.10C). The granules are rested at the lowest portion of the gutter. They are found in the limestone packages (limestone members) to the north of Said Sadiq, exactly at 2 Km south of Razila village at latitude N 35^{o} 33^{-} $23.23^{=}$ and longitude E 45^{o} 36^{-} $55.05^{=}$. These structures also show normal stratigraphic position

(not overturned) for the limestone packages. The channel gutters are most possibly formed on the erosional surface as the environment was of fairly high energy. This surface is observed in three thin sections in three different beds, as represented by samples 2Dos-1a and 3Dos-4b of the Dostadara section. In thin sections, the two different lithologies are separated by sharp boundary, the peloidal or lithoclastic grainstones which are located at the top, while the wackstone rested at the bottom of the oriented slide (Fig.11).

The aforementioned four structures show that most limestone successions (especially P1 and P3) are not overturned.

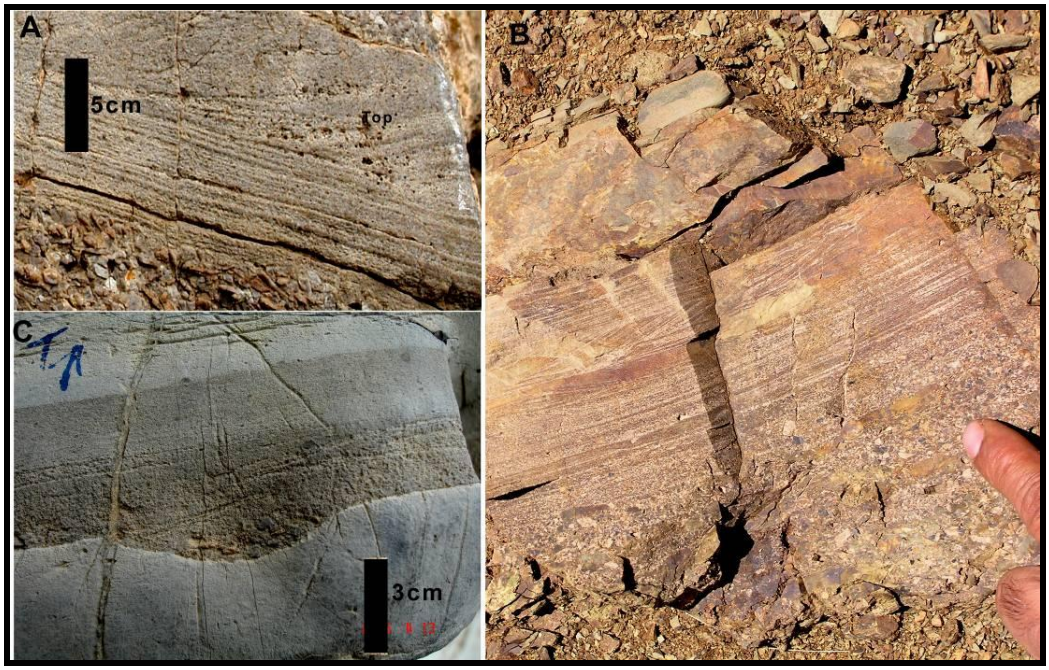

Fig.10: A) Cross lamination in limestone of P1, near Harmella Village, 12 Km east of Chuwarta town.
B): Graded bedding and cross lamination in a conglomerate at the base of Qulqula Formation, 2 Km to the southwest of Dostadara village, between Kaolos and Chuwarta.
C) Gutter cast, graded bedding and cross lamination in the limestone succession at the lower part of Qulqula Formation, between Kaolos and Chuwarta area, 2 Km to the southwest of Dostadara village

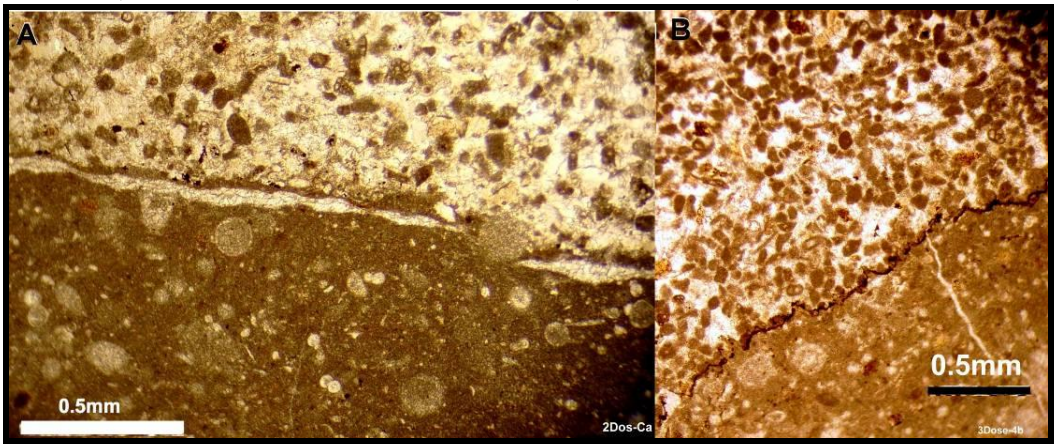

Fig. 11: Thin section of the sharp contact between bottom and top (wackstone and pelletal grainstone, respectively) of two limestone layer from Dostadara samples, A) 2 Dos-1a-P2;
B) 3Dos- 4b-P3.

PETROGRAPHY

Seventy samples were collected from three sections (Dostadara, Gali and Kaolos) and thin sections were prepared for petrographical study. The study showed that the limestone successions contain shallow environment detrital limestones, which mostly consists of peloidal packstone to grainstone, litho and bioclasts grainstone to packstone and ooid grainstone (Figs.12, 13 and 14). The bioclast allochems consist of fragments of coral, mollusk, algae and forams. The ooids are mostly superficial (i.e: few laminae arranged around relatively large nucleus of bioclasts or lithoclasts (Figs.15). The coral clasts are unusually small, while the individual coral is about (0.1 mm) in diameter (Fig.12). Nearly, all the clasts and skeletons suffer from more or less micritization process. Therefore, the details of most grains are destroyed, but some transitional phase of the processes can be observed in which the fossil skeleton can be identified. The different steps of micritization are so clear that the chart of Reijers and Hsu (1985) can be used for showing the different origins of peloids (Fig.16).

Among the three sections, the Gali section (12 Km east of Chuwarta Town) contains coarser grain limestone, especially the lithoclasts, while toward Kaolos section the constituents of the successions (packages) become finer and mostly change to fine pelletal limestone. The cement materials are mostly of blocky cement.

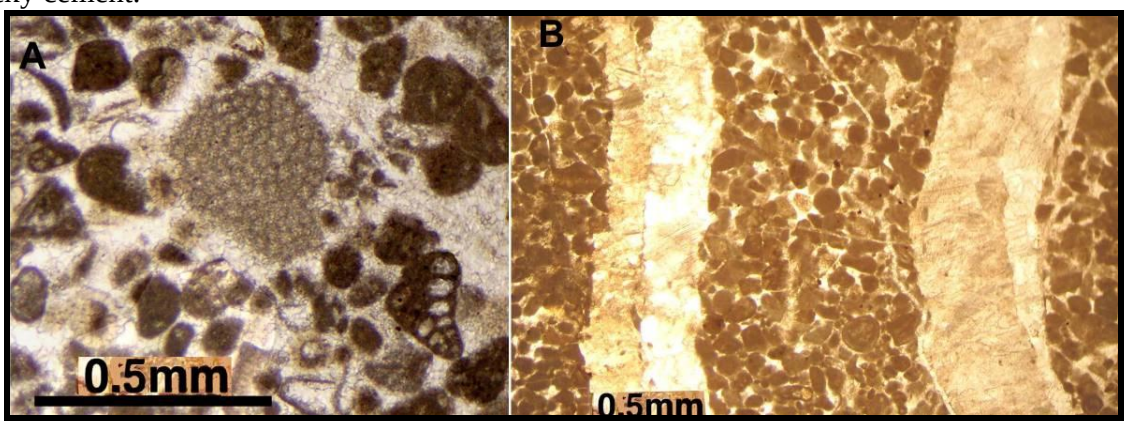

Fig.12: A) Clasts of scleractinian coral (center) and lithoclasts with one foram shell (lower left) in a grainstone limestone, sample: 1Dos-11a.
B) Peloid grainstone cut by two fractures that are filled with spary calcite, sample: 2Dos-9a

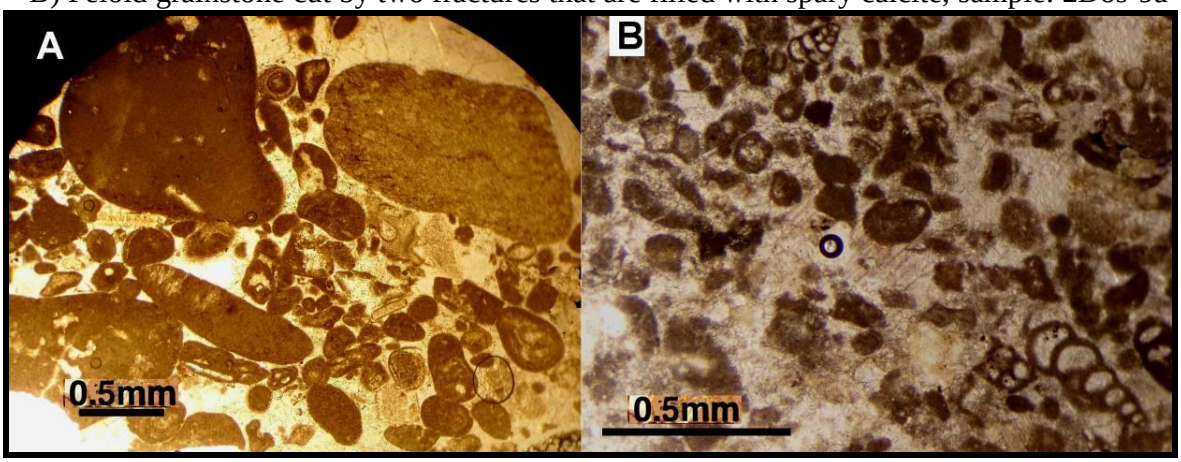

Fig.13: A) Badly sorted different lithoclast, 1Dos-20b, B): Subangular lithoclasts with foraminifera shells and peloids in a grainstone, sample: 1Dos-20d.

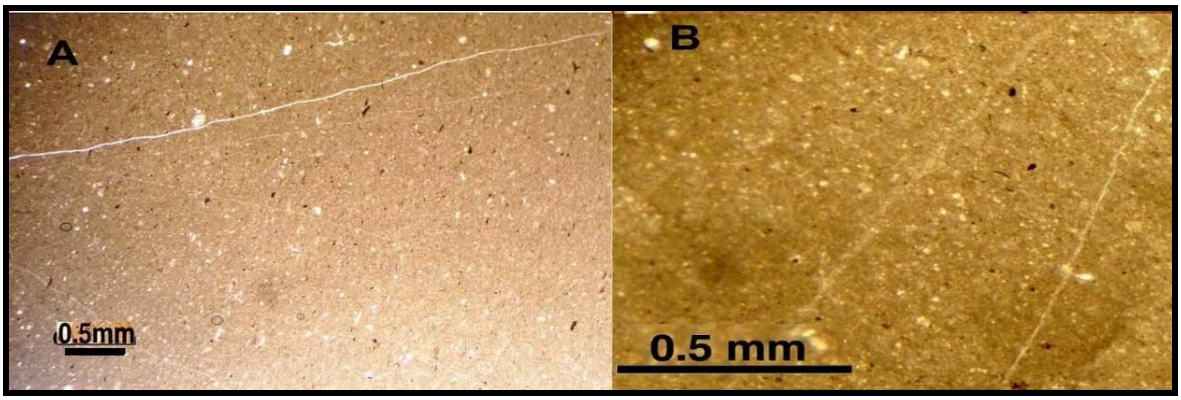

Fig.14: Mudstone lithofacies at the base of Dostadara section, samples: A) 2Dos-1, B) 1Dos-3b

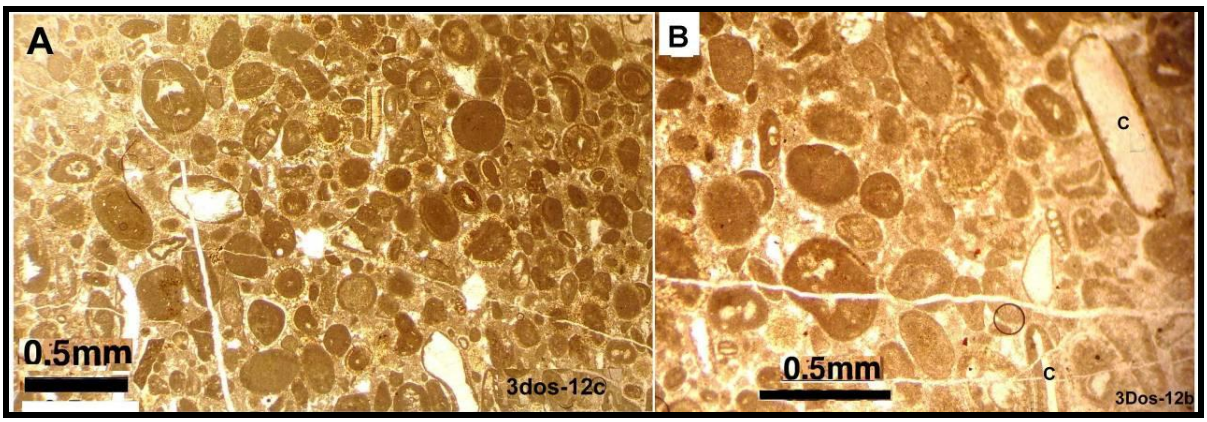

Fig.15: A) Ooids-peloids grainstone, which consists of spherical ooids (3Dos-12c). B) Superficial ooids, the oblate ooids are formed around bioclasts. Some unknown origin peloids can be seen. Dostadara section, sample (3Dos-12b).

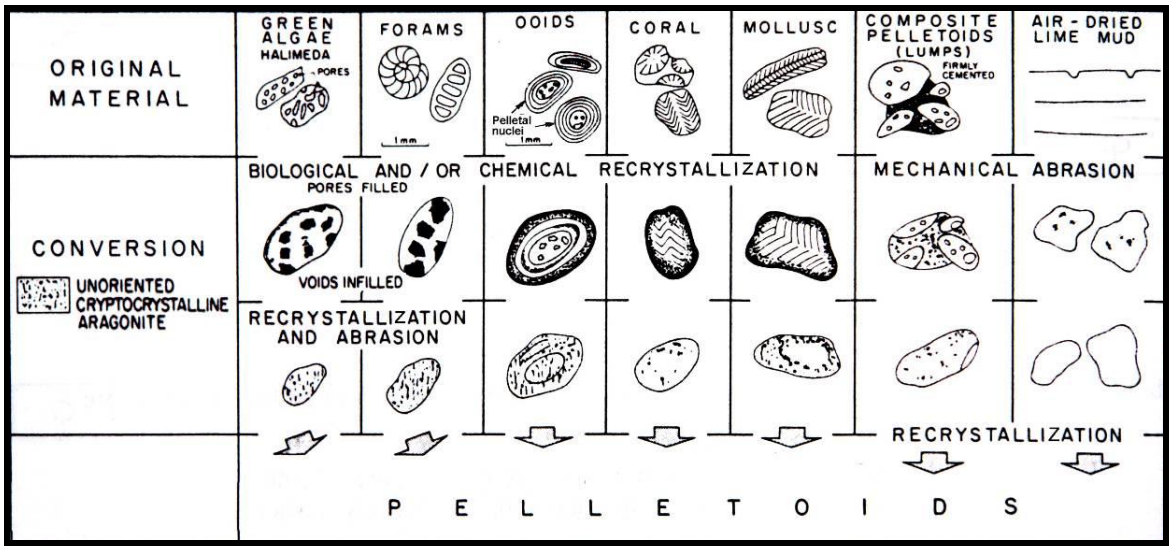

Fig.16: Different origins of peloids (Reijers and Hsu, 1985) which can be applied on the constituents of limestones of the Qulqula Formation.

CONCLUSIONS

This paper has concluded the followings:

- The Conglomerate bed that is located in the base of Qulqula (Radiolarian) Formation and in the top of Balambo Formation. This conglomerate bed is aged Late Cretaceous (Early Maastrichtian).
- The Conglomerate is traced for about 30 Km continuously in Said Sadiq–Chuwarta area; there it merges with the conglomerate of the lower part of Tanjero Formation (Early Maastrichtian) near Chuwarta town. Therefore, it belongs to conglomerate of lower part of Tanjero Formation.
- Slice of the Shiranish Formation occurs at the base of Qulqula (Radiolarian) Formation too, due to thrusting of latter formation over both Tanjero and Shiranish formations in addition to Balamno Formation.
- The Lower part of Qulqula Formation is composed of four limestone successions, which have nearly same lithologies. These lithologies constitute shallow marine detrital limestones which composed of peloids, ooids, lithoclast and bioclasts grainstone and packstone with rare mudstone and wackstone.
- Sedimentological study showed that most of the limestone successions have the same origin and most of them are not overturned but imbricated over each other.

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