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

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). The lower part consists of alternation of 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 followed for about 30 Km continuously, from Said Sadiq town to Chuwarta town. The conglomeratic bed, 6 Km east of Chuwarta town, merges lithologically and stratigraphically with the conglomerate beds of the lower part of Tanjero Formation (Maastrichtian). The lithologies of both conglomerates are similar. Both of them consist of variegated chert and limestone clasts, therefore, it is thought that they have the same age and origin and belong to Tanjero Formation. This is inferred by observing lateral combination 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. This 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) إقليم كوردستان، شمال شرق العراق

كمال حاجي كريم، حبيب رشيد حبيب و سردار محمد رضا

المستخلص

تم دراسة الجزء السفلي لتكوين القولقولة الراديولاري في منطقة الفوالق الزاحفة في شمال شرق العراق، شمال شرق مدينة السليمانية. يتكون هذا الجزء من التكوين من أربعة تتابعات كلسية فتاتية (يصل سمك كل واحد منهم الى 25 م) متعاقبة مع نفس العدد من تتابعات الصوان المتطبق والطفل. تتألف التتابعات الأربعة من الحجر الكلسي المتميز بالطباقية ذات البيئة البحرية الضحلة. تتكون جميع التتابعات الأربعة من الحجر الجيري (الحبيبي والمرصوص) الدمالقي والسرئي والفتاتي مع قليل من الحجر الجيري الطيني والواكي. وتتكون المادة الحشوية فيها أساسا من السمنت الكتلي وقليل من الميكرات.

ذكر سابقاً وجود الجزء السفلي من تكوين قولقولة فوق تكويني بالامبو وكوميتان ويفصل بين هذين التكوينين وتكوين قولقولة طبقة من المدملكات ذات سمك (0.2 – 2) م. سلطت الدراسة الحالية الضوء على أصل طبقة المدملكات فوجدت بأنها تعود الى مدملكات تكوين تانجرو (الماسترختيان).

[*] Assistant Professor, Department of Geology, University of Sulaimaniyah
[**] Professor, Department of Geology, University of Baghdad
[***] Senior lecturer, Department of Geology, University of Sulaimaniyah

ولاحظت الدراسة وجود شرائح من تكوين شيرانش ضمن هذه المدملكات الواقعة تحت الجزء السفلي من تكوين قولقولة. وتم متابعة طبقة المدملكات هذه لمسافة 30 كم وذلك بدءاً من مدينة سيد صادق إلى منطقة جوارتا. فوجد بأنها، الى الشرق من مدينة جوارتة بمسافة 6 كم، تندمج طباقياً وصخارياً مع مدملكات الجزء السفلي من تكوين تانجرو. وتبين ان هذه المدملكات مشابهة صخارياً لمدملكات تكوين تانجرو، إذ إن كليهما يتكونان من القطع الصوانية متعددة الألوان وقطع كلسية مختلفة. لذالك اعتبر بأن هاتين الطبقتين لهما نفس الأصل وأنهما تعودان إلى الماسترختيان (بسبب اندماجهما جانبياً مع مدملكات تانجرو) ولتشابه الطبقتين في الصخارية، مع اختلاف بسيط هو تميز حبيبات مدملكات تكوين تانجرو بتكورها وفرزها الجيدين مقارنة بالمدملكات الموجودة أسفل تتابعات القولقولة وذلك بسبب قرب الأولى وبعد الثانية من الصخور المصدرية. ويعزى وجود شرائح من تكوين شيرانش المتلاسنة مع المدملكات تحت تكوين قولقولة الراديولاري إلى اندفاع تتابعات قولقولة فوق كلا من تتابعات شيرانش وتانجرو.

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 Bolton (1958). He mentioned that it consists of thick successions of bedded chert, shale and siliceous limestone. Moreover, the contacts of the formation are hardly determinable, due to 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 consists of thinly bedded, red, grey and green shale with intercalation of cherty radiolarian limestone and dark ferruginous shale. 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. Bolton (1958) 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 that 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 an area between Chuwarta and Said Sadiq towns only. In the involved area the lower part, of the 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 forms 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° 21' 23" and 35° 25' 48"; longitudes E 45° 10' 04" and 46° 02' 41". The studied area is located within the Zagros mountain belt in the Thrust Zone, Qulqula – Khwakurk 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 during this study; it passes through Said Sadiq town and Kaolos village (Figs.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 area, 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 south of Kaolos village, at the extreme southeastern end of the studied area, about 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 west of Dostadara village, in the middle of the studied area, about 12 Km to the northeast of Barzinja village (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 east of Chuwarta town (Fig.2B). GPS readings are latitude N 35° 38' 54.08" and longitude E 45° 41' 13.67".

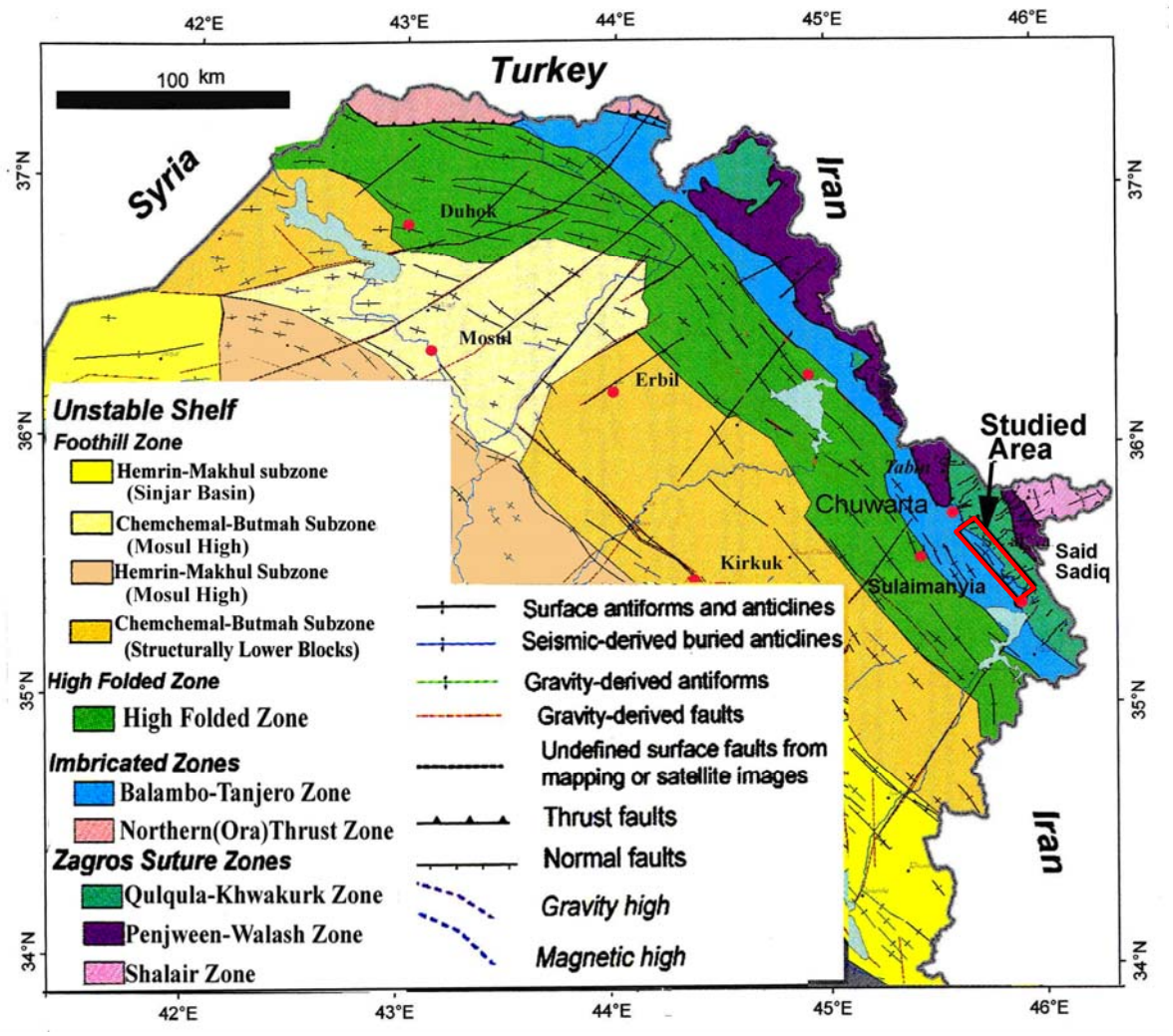

Fig.1: Tectonic Map of Iraq (after Jassim and Buday in Jassim and Goff, 2006) showing the studied area

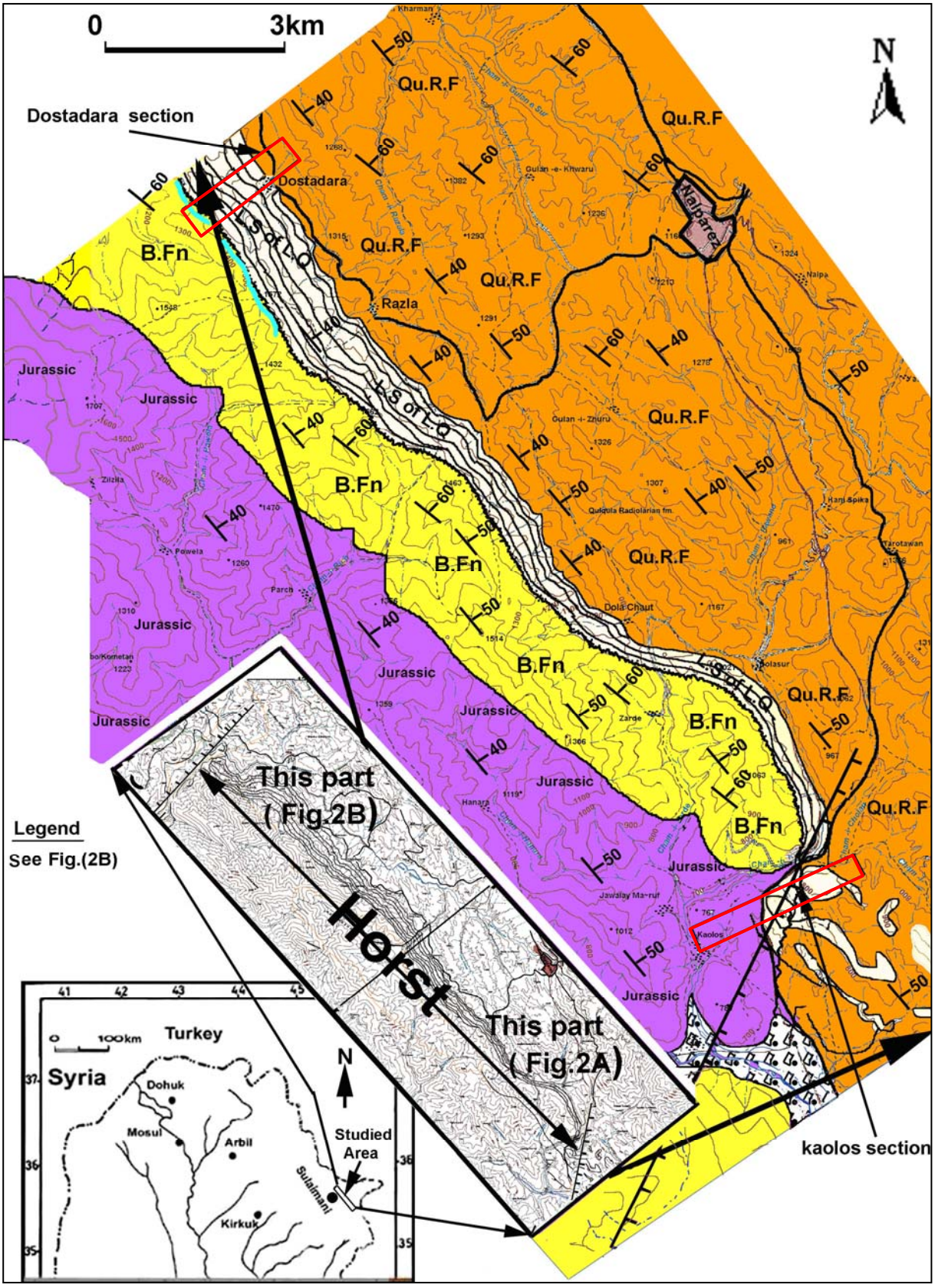

Fig.2A: Location and geological map of the studied area (the southeastern part)

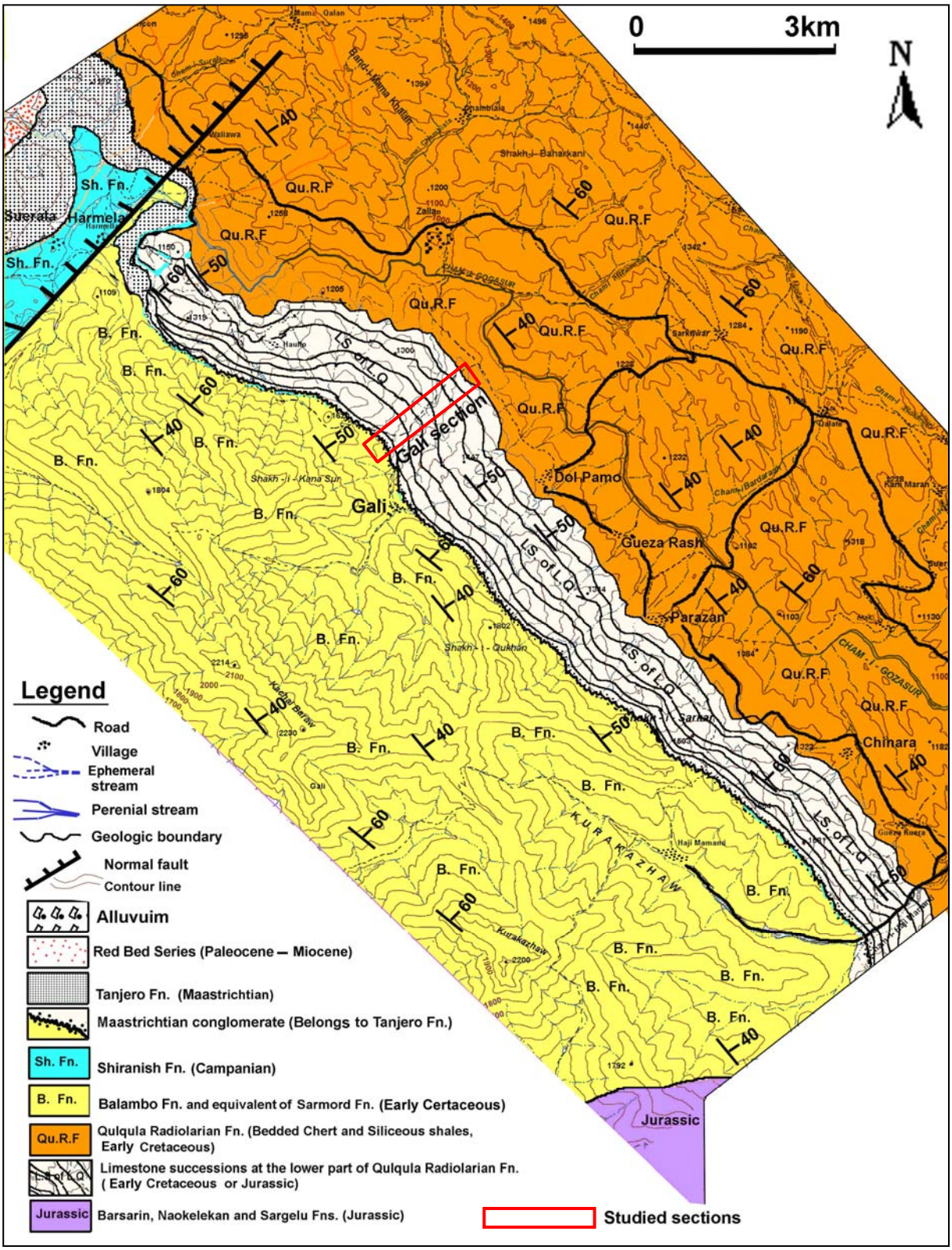

Fig.2B: Geological map of the studied area (the northwestern part)

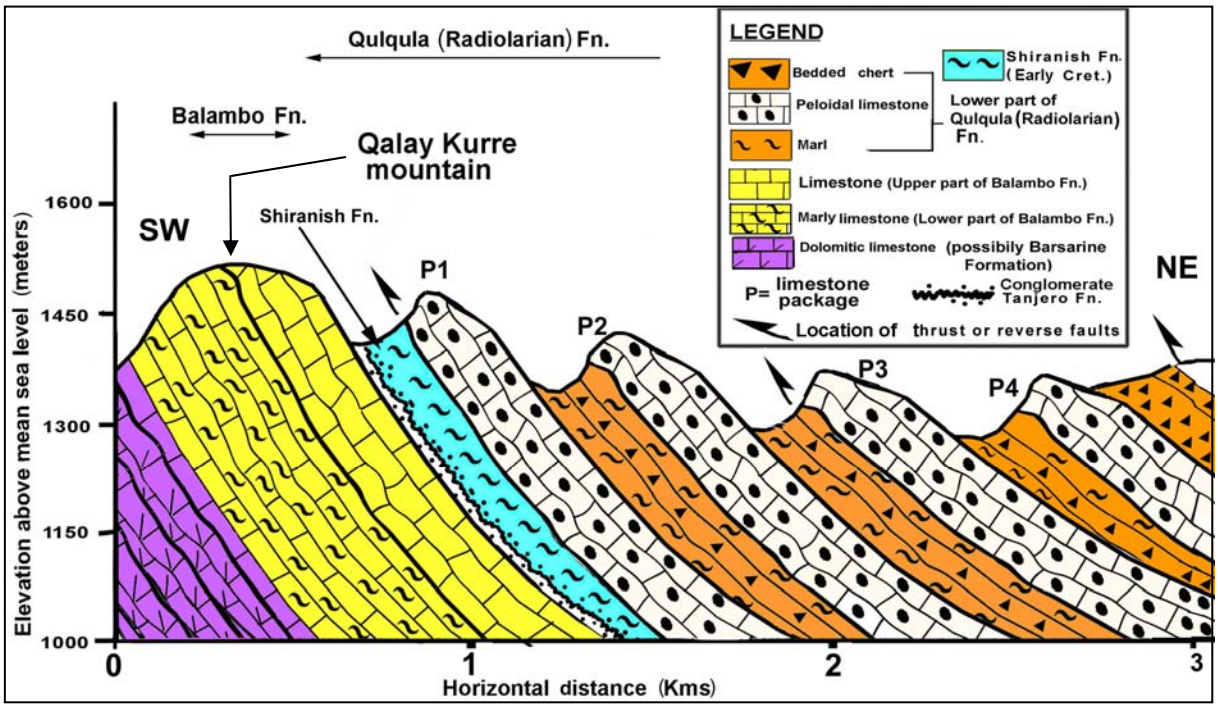

Fig.2C: Geologic cross section, passing directly west of Dostadara village section
(P1, P2, P3 and P4 represent limestone packages)

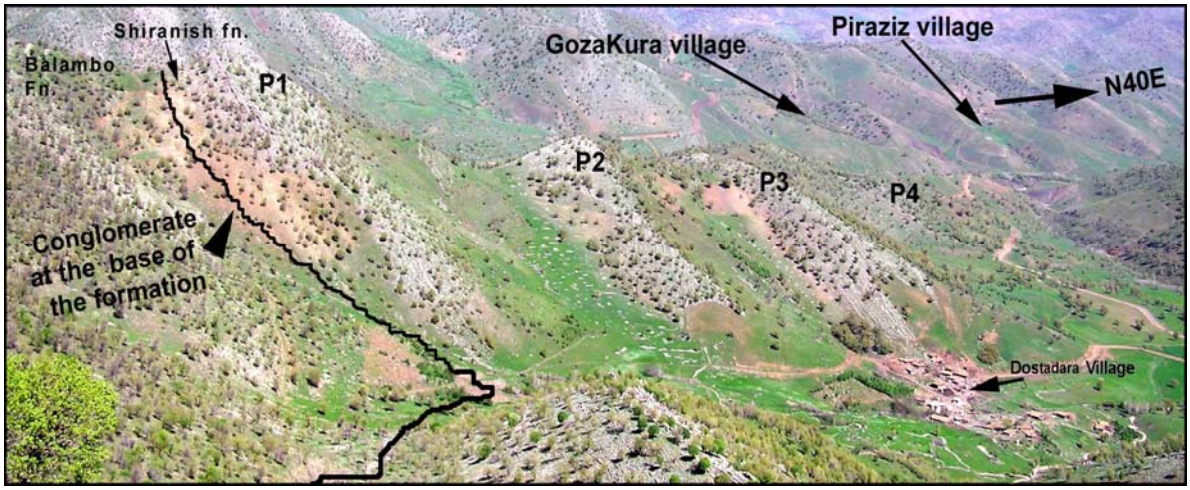

Fig.3: Limestone packages (successions) at the lower part of Qulqula Formation,
west of Dostadara village, latitude N 35° 34' 47.33" and longitude E 45° 46' 45.63"
(P1, P2, P3 and P4 represent limestone packages)
The distance between P1 and P2 is about 400 m

THE LITHOLOGY OF THE LOWER PART OF QULUQLA FORMATION

The Qulqula (Radiolarian) Formation contains two different observable lithologies in the field (Fig.4); these are: a conglomerate bed at the base of the lower part 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**

It is with thickness of (0.2 – 2) m (Karim, 2003) and consists of poorly sorted and sub-rounded gravels (with some boulders) of cherts and limestones (Figs.5 and 6), extends between Chuwarta and Said Sadiq towns. It seems that the nature of the boundaries is problematic; it is attributed to the 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 between Chuwarta and Said Sadiq (Figs.2A and B). On the basis of its deposition over the Balambo or Kometan formations, Karim (2003) claimed Late Cretaceous age. Depending on the stratigraphic position of the conglomerate, he assumed that the overlying Qulqula (Radiolarian) Formation is autochthonous.

The ideas of Karim (2003) are re-studied in detail; in the field and the following four points were proved. The **first** is that, it is true that the conglomerate is deposited during Late Cretaceous. This is confirmed by tracing the conglomerate towards northwest till it merges 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 attributed to: it laterally merges with the conglomerate of Tanjero Formation and to its lithologic similarity with that of the latter formation. The conglomerates, within Tanjero Formation are 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 thickness of more than 500 m.

The **second** is that, the age of Qulqula (Radiolarian) Formation is still controversial. According to Tahrani (2006) the age of this formation in Iran 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 the 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 para – autochthonous (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 **fourth** is that, the concerned conglomerate not only comprises of conglomerate of Tanjero Formation, but also slices (about 30 m) of friable bluish white marl occur too, located above the conglomeratic bed (Figs.7 and 8). They belong to Shiranish Formation, because they combines laterally with it, near Harmella village (Fig.2B) and it shows nearly the same lithology of Shiranish Formation, when observed by microscope and hand lens.

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

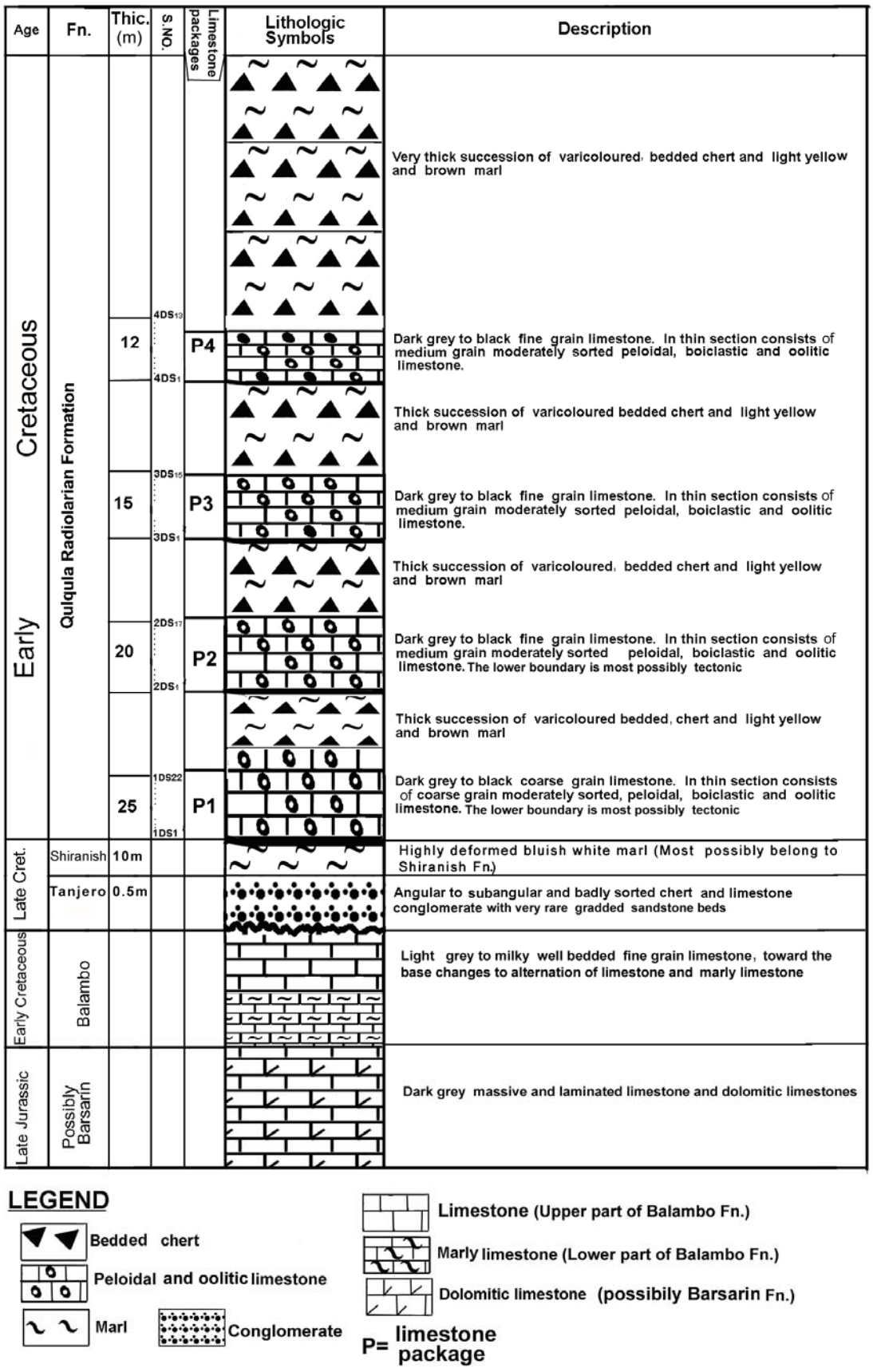

Fig.4: Stratigraphic column of Dostadara section

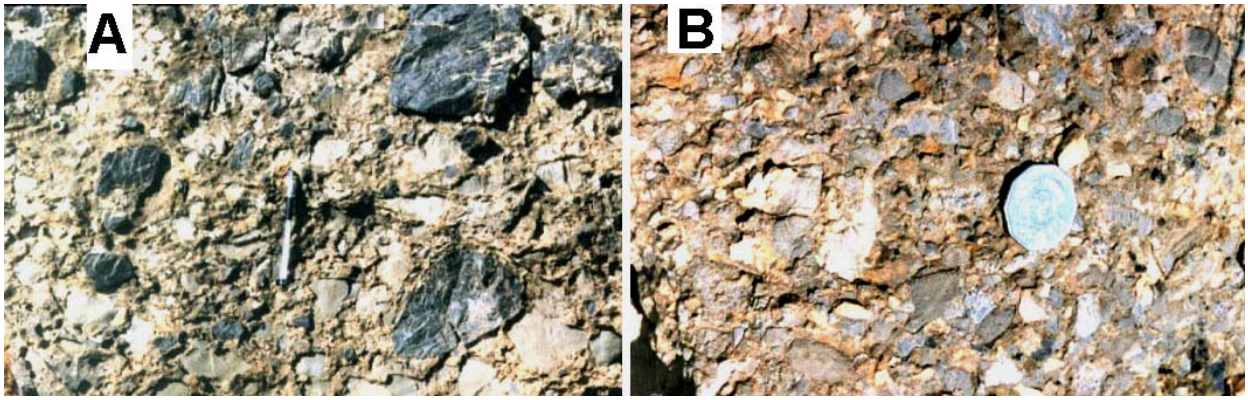

Fig.5: Texture and lithology of the conglomerate bed between Balambo and Qulqula (Radiolarian) formations. **A)** Black chert and limestone clasts near Kaolos village **B)** White chert and limestone clasts near Dostadara villages (from Karim, 2003)

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

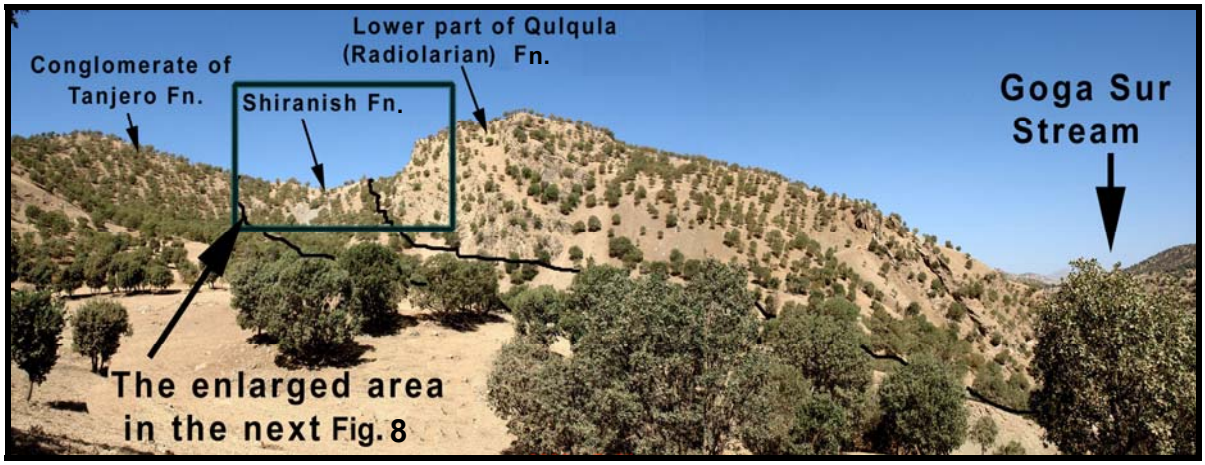

Fig.7: Qulqula (Radiolarian) Formation (Early Cretaceous) thrusted over both Shiranish and Tanjero formations (Late Cretaceous) at 1 Km west of Harmella village (8 Km west of Chuwarta town)

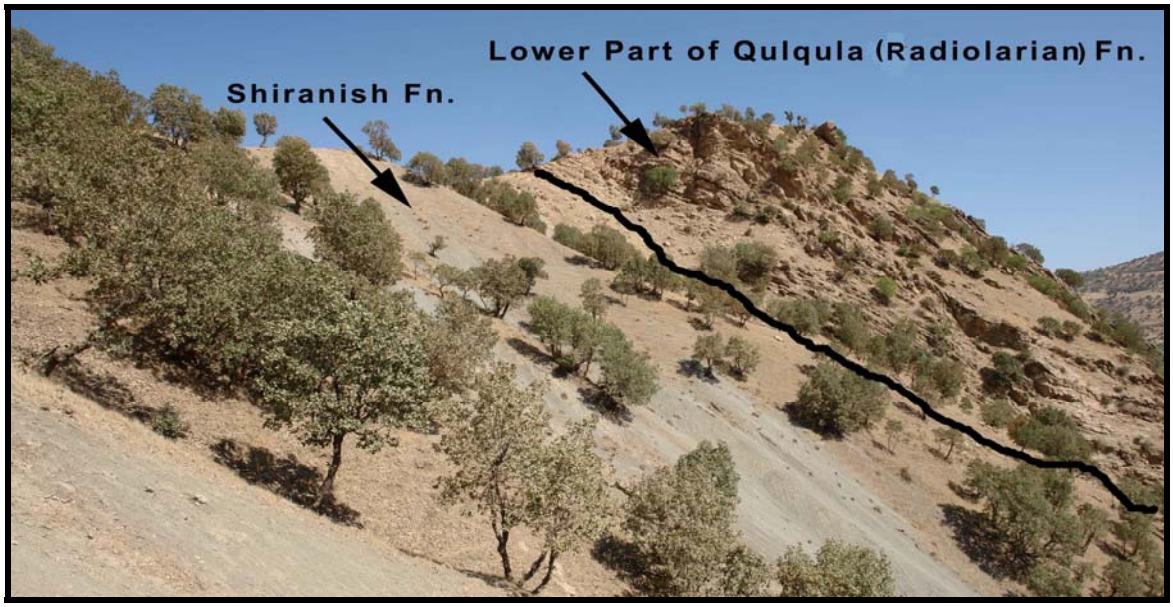

Fig.8: The enlarged area in the black parallelogram (in Fig.7), Qulqula Radiolarian Formation thrusted over Shiranish Formation
(1 Km west of Harmella village, 8 Km west of Chwarta town)

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

In the studied areas, the lower part of the Qulqula 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 package has a thickness of more than 25 m. They crop out 3 Km to the south of Harmella 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 Chwarta and Kalos village, 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).

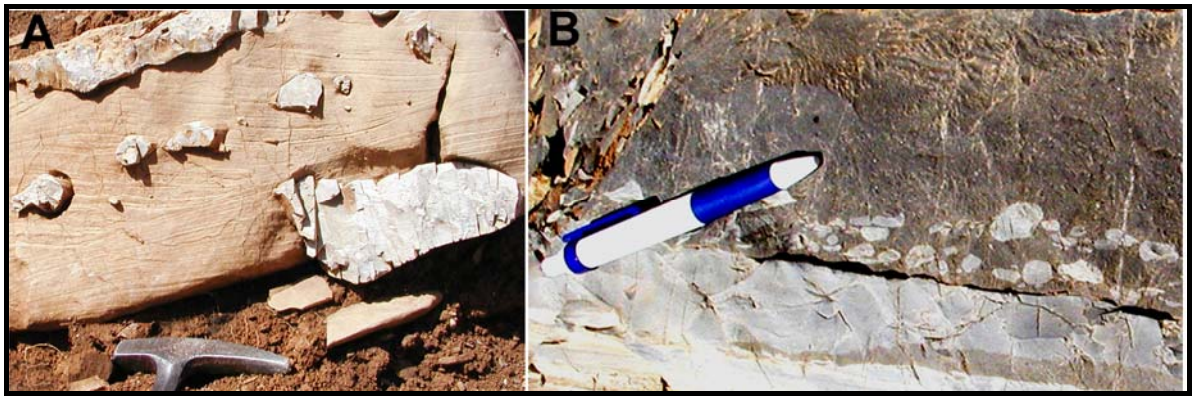

Fig.9: **A)** Cutting of the laminae (of a cross lamination) by chert nodules in the limestone succession of Qulqula Formation
B) Rip-up clasts found in the limestone member, 1 Km south of Razila village, 30 Km north of Said Sadiq town

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 INDICATING 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 sedimentary structures, the useful sedimentary structures, however, found 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 the limestone member, of darker color (Fig.9B). These clasts were used for indicating the top and bottom of the beds. As the clasts are re-deposited on the overlying bed, therefore, the bed that is shown in Fig. (9B) is in the right depositional condition and not overturned.

- **Cross lamination**

Several small scale cross laminations were observed in medium and coarse crystalline limestones (Figs.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-flow direction or sediments transport direction. The tangential laminae with flat underlying laminae indicates the top of the strata (Fig.10A).

- **Graded bedding**

In the Qulqula Formation, small scale graded bedding structures were found in two different lithologies. The first was found inside the limestone member (graded pebbly limestone) and the second was 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 either by 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 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 rest at the lowest portion of the gutter. They are found in the limestone packages (limestone members) to the north of Said Sadiq town, exactly 2 Km south

of Razila village at latitude N 35° 33' 23.23" and longitude E 45° 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 Dostadara section. In thin sections, the two different lithologies are separated by sharp boundary, the peloidal or lithoclastic grainstones are located at the top, while the wackstone rests 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.

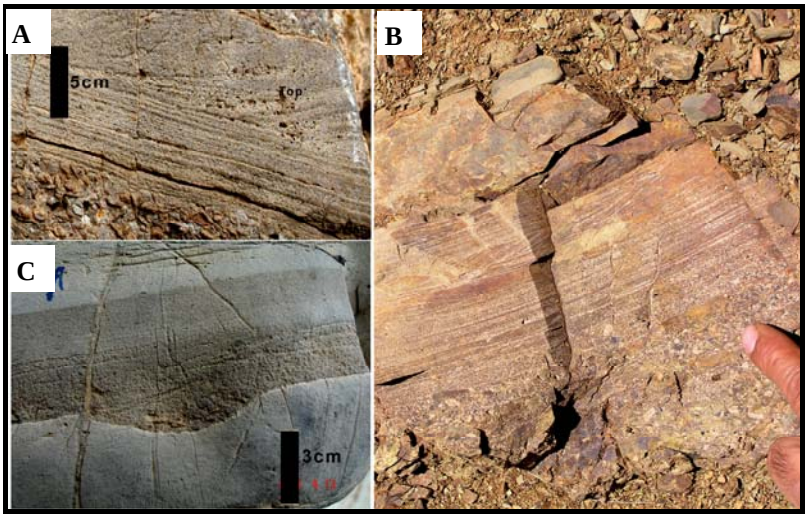

Fig.10: **A)** Cross lamination in limestone of P1, near Harmella Village, 12 Km east of Chuwarta town
B) Graded bedding and cross lamination in a conglomerate at the base of Qulqula Formation, 2 Km southwest of Dostadara village, between Kaolos village and Chuwarta
C) Gutter cast, graded bedding and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

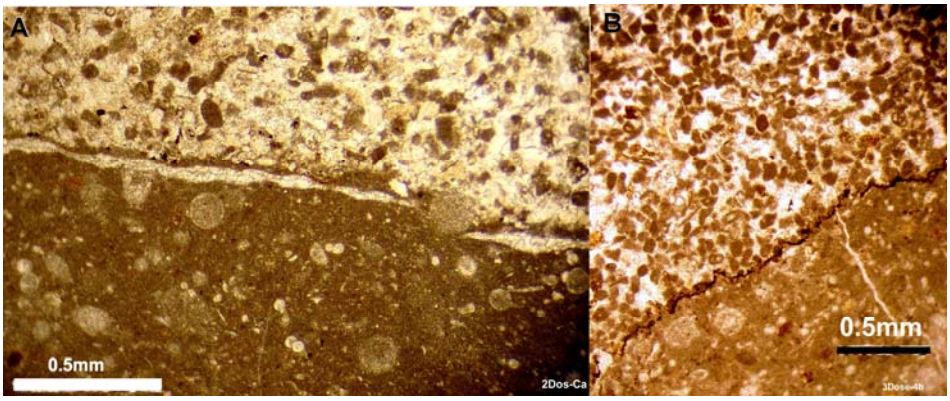

Fig.11: Thin section of sharp contact between bottom and top (wackstone and pelletal grainstone, respectively) of two limestone layers from Dostadara samples,
A) 2 Dos-1a-P2, **B)** 3Dos- 4b-P3

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 (Fig.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.

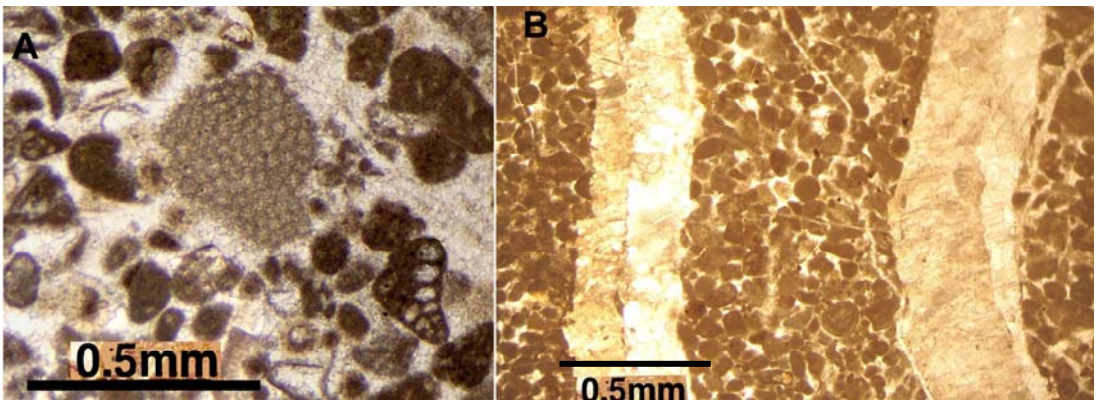

Fig.12: **A)** Clasts of scleractinian coral (center) and lithoclasts with one foram shell (lower left) in a grainstone limestone, sample: 1Dos-11a
B) Pelloid grainstone cut by two fractures that are filled with spary calcite, sample: 2Dos-9a

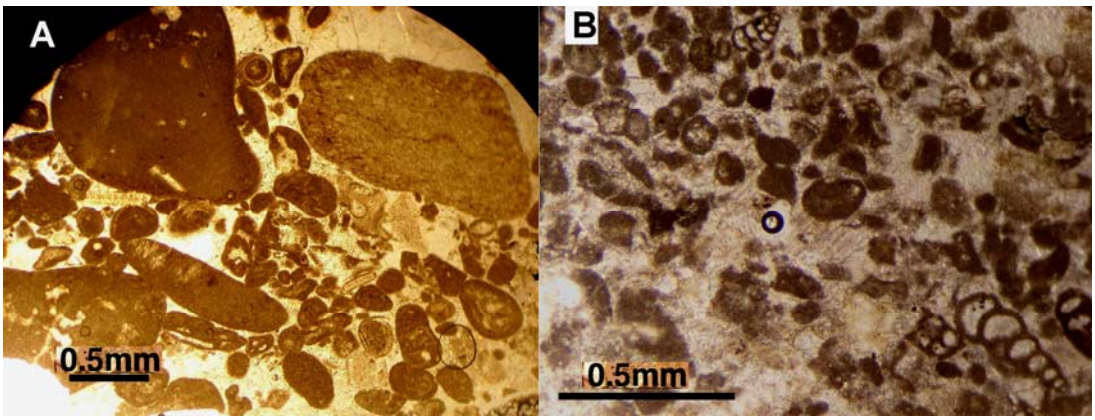

Fig.13: **A)** Badly sorted different lithoclasts, sample: 1Dos-20b, **B)** Subangular lithoclasts with foraminifera shells and pelloids in a grainstone, sample: 1Dos-20d

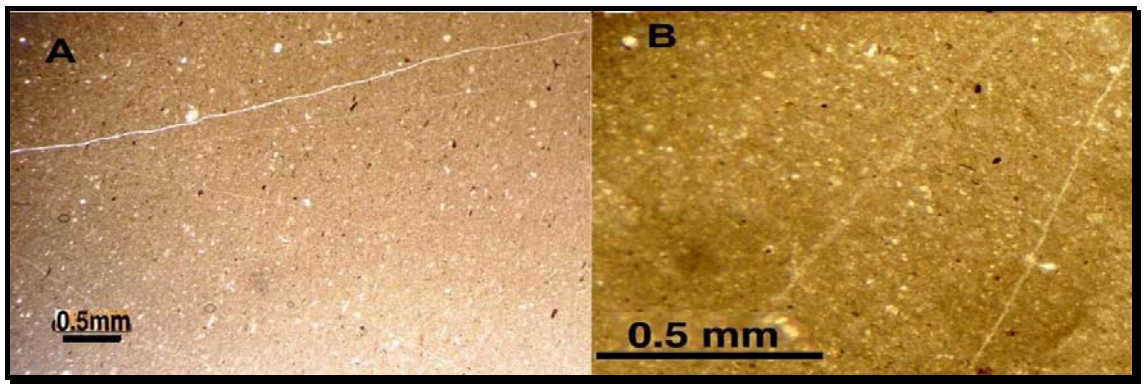

Fig.14: Mudstone lithofacies at the base of Dostadara section, samples: **A)** 2Dos-1 and **B)** 1Dos-3b

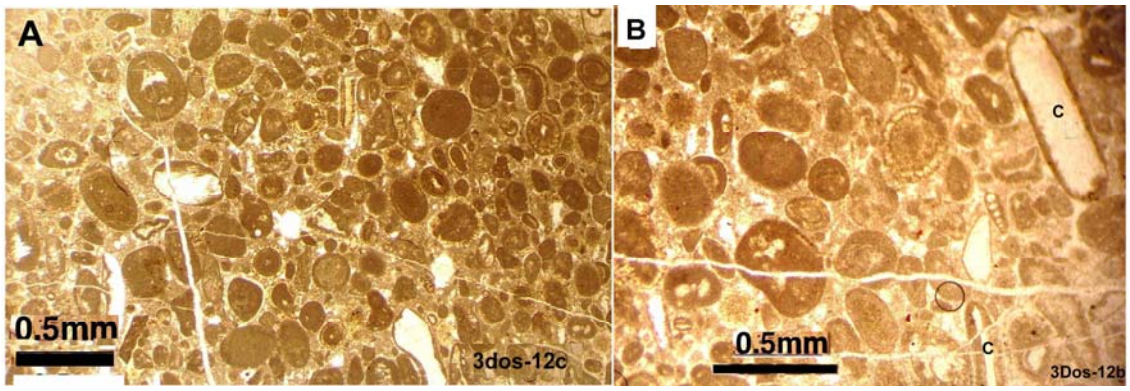

Fig.15: **A)** Ooids – peloids grainstone, which consists of spherical ooids (sample: 3Dos-12c) **B)** Superficial ooids, the oblate ooids are formed around bioclasts. Some unknown origin peloids can be seen, Dostadara section (sample: 3Dos-12b)

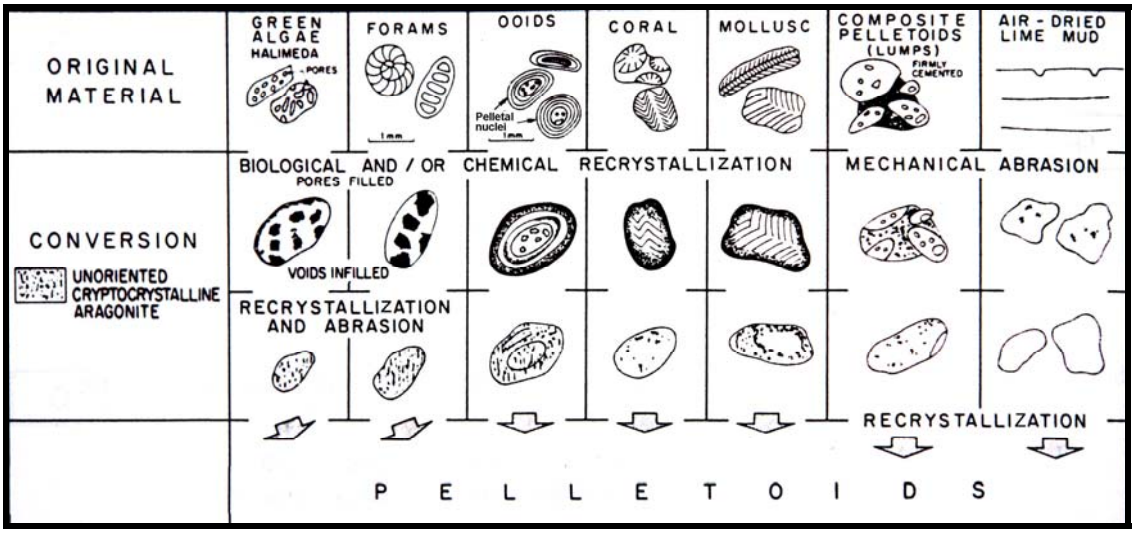

Fig.16: Different origins of peloids (Reijers and Hsu, 1985), which can be applied on the constituents of limestones of the Qulqula Formation

CONCLUSIONS

This study has the following conclusions:

- The Conglomerate bed that is located in the base of Qulqula (Radiolarian) Formation and in the top of Balambo Formation is of Late Cretaceous (Early Maastrichtian) age.
- 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 conglomerates of the lower part of Tanjero Formation.
- Slice of the Shiranish Formation occurs at the base of Qulqula (Radiolarian) Formation too, due to thrusting of the 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 the same lithologies. These lithologies constitute shallow marine detrital limestones, which are composed of peloids, ooids, lithoclasts 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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