NEW IDEAS ABOUT GULNERI FORMATION (EARLY TURONIAN) IN DOKAN AREA, KURDISTAN REGION, NE IRAQ

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ABSTRACT

Gulneri Formation (Early Turonian) consists, mainly as previously described, of shale deposited in euxinic and small relic basin. In the present study, it was found that it consists mainly of marl and marly limestone with no more than 20% of laminated shale. Thin section study showed that the shale is highly deformed, with foliation-like texture. Therefore, most probably the previously described shale is originally marl, which is changed to laminated shale-like rock, by pressure that released insoluble residue and bitumen materials from surrounding rocks. By filtering of these materials, the marl was changed to black shale-like rock. The effect of the pressure is observed by bending of the shale laminae around the spherical limestone bodies and the flattening of planktonic foraminifera to elongated shape.

The upper and lower contacts of the Gulneri Formation seem to be conformable; as conglomerates, erosional surfaces and paleosols were not found. But, short duration of possible submarine erosion or slow rate of deposition is not excluded. There are spherical limestone bodies in the formation and near the contacts, but they are not conglomerate; as assumed previously. Field and thin section studies reveled that the bodies are ball and pillow-like structures, which are formed by pressure; this is evidenced by the absence of silt and sand size grains in the ball and pillow-like structures. This formation occurs only in Dokan dam site (Northwest of Sulaimaniyah) and it does not exist in near by surrounding areas, therefore, we suggest its combination with Kometan Formation.

أفكار جديدة حول تكوين گولنيري (تورونيان المبكر) في منطقة دوكان، إقليم كردستان، شمال شرق العراق

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المستخلص

يتكون تكوين الـگولنيري (تورونيان المبكر) بشكل رئيسي، كما مذكور سابقاً، من السجيل وترسب في حوض اختزالي متبقي وصغير. استنتج في الدراسة الحالية بأنه يتكون بشكل رئيسي، من الطفل والحجر الجيري الطفلي ونسبة السجيل الصفائحي لا تتجاوز 20% من سمك التكوين. أظهرت دراسة الشرائح الرقيقة بأن السجيل مشوه جداً ونسيجه يشبه النسيج الصفائحي في الصخور المتحولة. لذلك من المحتمل ان السجيل أصله طَفَلْ وتحول الى السجيل الصفائحي بواسطة الضغط، حيث أدى الى انطلاق المحاليل الحاوية على المواد غير المذابة والمواد العضوية من الصخور المجاورة وبواسطة الترشيح تحول الطفل الى صخرة سوداء ذات مظهر السجيل. ويمكن ملاحظة آثار الضغط من تكور السجيل الصفائحي حول الأجسام الكروية للحجر الجيري وكذالك تغير شكل الفورامنفرا الى أشكال طولية.

ان الحدين العلوي والسفلي لتكوين الـگولنيري يظهران توافقياً، حيث لم تشاهد المدملكات أو التربة القديمة أو أسطح التعرية، ولكن لا نستبعد التعرية الجزئية تحت البحرية أو عدم الترسيب لفترات قصيرة. أظهرت الدراسة الحقلية تواجد تراكيب كروية ووسائدية ذات أحجام الجلاميد والحصى في التكوين، حيث تشكلت بواسطة الضغط وهي ليست مدملكات وكما ذكرت سابقاً. والدليل على هذا هو ان كل الأجسام لها نفس عمر التكوين وخالية من الحبيبات الفتاتية من حجم الرمل والغرين. يتكشف هذا التكوين في موقع سد دوكان فقط، وغير موجود في أماكن قريبة وبعيدة منها، لذلك نقترح بان يدمج هذا التكوين مع تكوين الكوميتان.

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INTRODUCTION

The Gulneri Formation was first described by Lancaster Jones (1957) in Bellen *et al*. (1959) from the Dokan Dam site, in the High Folded Zone (Figs.1 and 2), where it consists of about 2 m of black, bituminous, finely laminated, calcareous shale with some glauconite and collophane at the lower part. The age of the formation is Early Turonian (Bellen *et al*., 1959). They also cited that in some reports of Dokan Dam it is mentioned as Shiranish Shale.

The high bitumen content and dwarfed fossils indicate that the Gulneri Formation was deposited in a euxinic environment (Jassim and Buday in Jassim and Goff, 2006). The formation is separated by unconformities with both overlying and underlying Kometan and Dokan formations, respectively (Buday, 1980). According to Abawi *et al.* (2006), eight planktonic and six benthonic foraminiferal species were recorded from the type section of Gulneri Formation at the site of Dokan Dam, indicating Early Turonian age. The distribution of the formation is almost unknown. It crops out only around the type area and was struck in Kirkuk oil well (K116) in the Avanah dome. Fossils were found relatively rich.

The Late Cretaceous subsurface sections in Kirkuk oil well (K116) and Jambur oil well (13) has been studied micropaleontologically by Abawi and Hammoudi (1997). They included Gulneri Formation in the lower part of the *Marginotruncana sigali* Zone of Late Turonain age and Kometan Formation in the upper part of the *Marginotruncana sigali*, the *Dicarinella primitive*, the *Dicarinella concavata*, the *Rosita fornicata* and the *Globotruncaita elevata* Zones, which range in age from Late Turonian to Early Campanian, a local unconformity separates the two formations from each other.

The aim of this study is to reveal the characteristics of the Gulneri Formation, concerning the sedimentology and stratigraphy. Therefore, all outcrop sections were inspected around the Dokan Dam site (type area), in addition to the area around Pira Magroon, Qara Sard and Safeen anticlines (Fig.3). Both underlying and overlying contacts of the formation were given special attention and accurately examined. In the present study only three sections were found to be representative of the studied area (Fig.3). In these areas, tens of sections were inspected by necked eye and hand lens, and suitable samples were collected for laboratory studies. Thin sections were studied under polarized and fluorescent microscopes. Within all studied areas, the formation was found only in one locality, which is located directly to the south of Dokan Dam site (Fig.4).

THE NATURE OF THE CONTACTS

Bellen *et al.* (1959) mentioned that the unconformable contact of Gulneri Formation with the underlying Dokan Formation, in the dam site, is represented by the occurrence of micro-conglomerate. According to Buday (1980), a thin bituminous shale unit of Early Turonian age is bounded at the top and bottom by erosional unconformities. He mentioned that these unconformities can be found locally around Dokan area and in I.P.C. oil well (K116). This shale intervenes between the Kometan and the Cenomanian oligosteginal limestone unit. The Cenomanian oligosteginal limestone unit is defined as the Dokan Limestone and the thin Turonian shale is recognized in the nomenclature as the Gulneri Shale. He added that they were perhaps preserved from Early Turonian erosion only in slight depressions in the erosional surface, which terminates the Qamchuqa Formation.

In this study, the unconformable contact is not ascertained. This is because neither conglomerate nor karstification and paleosol were found, when the type section and surrounding areas were inspected.

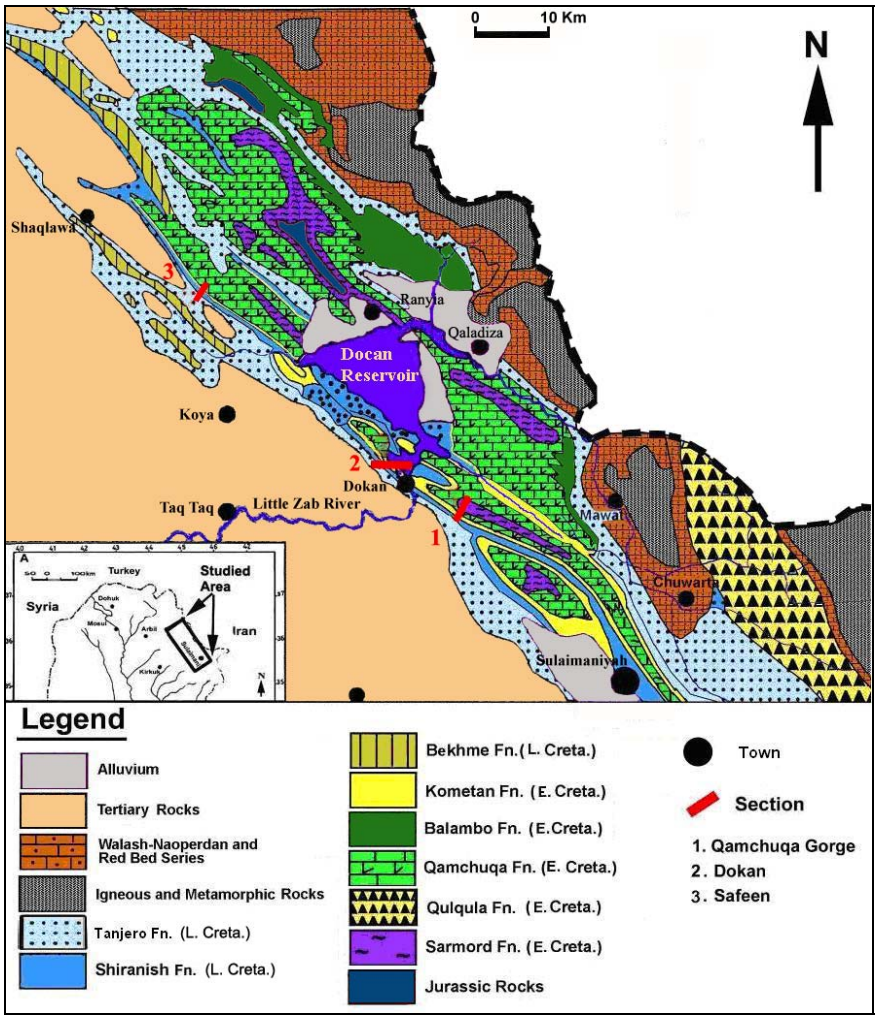

Fig.1: Geological map of the studied area and location of the studied sections (modified from Sissakian, 2000)

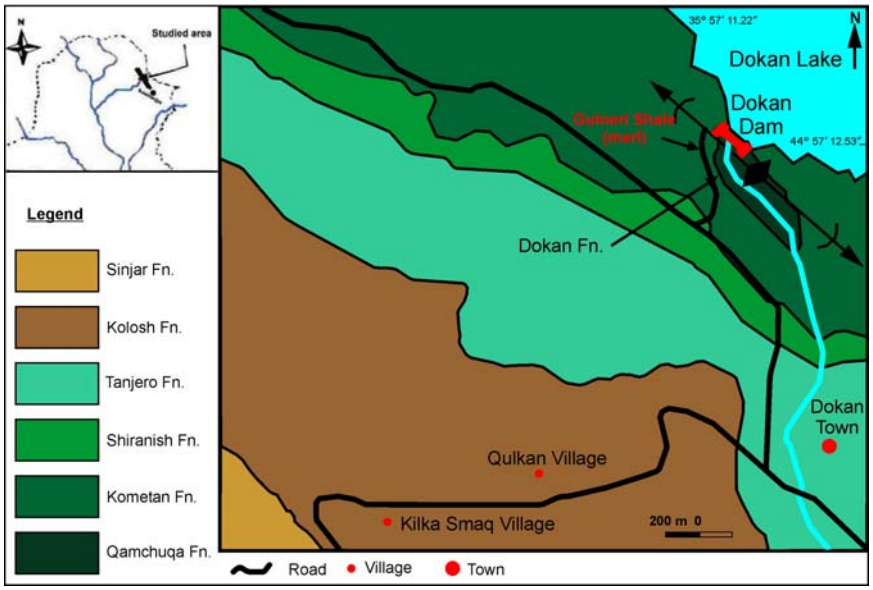

Fig.2: Simplified geological map of the type area shows Dokan Dam and Dokan Section

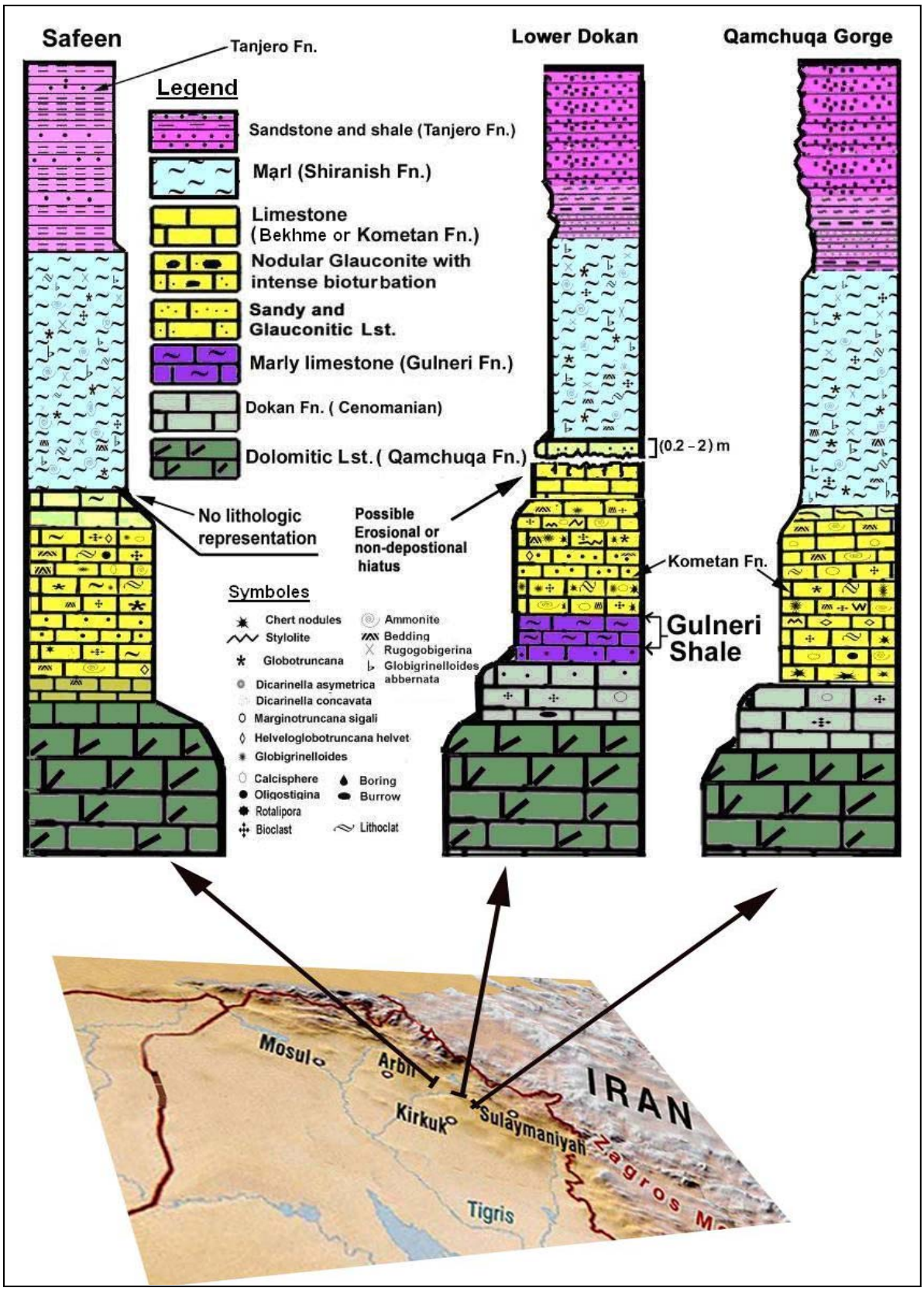

Fig.3: Stratigraphic column of the three studied outcrop sections and their location on simplified map of the northern Iraq, in which the formation appears only in the type section (Lower Dokan Section)

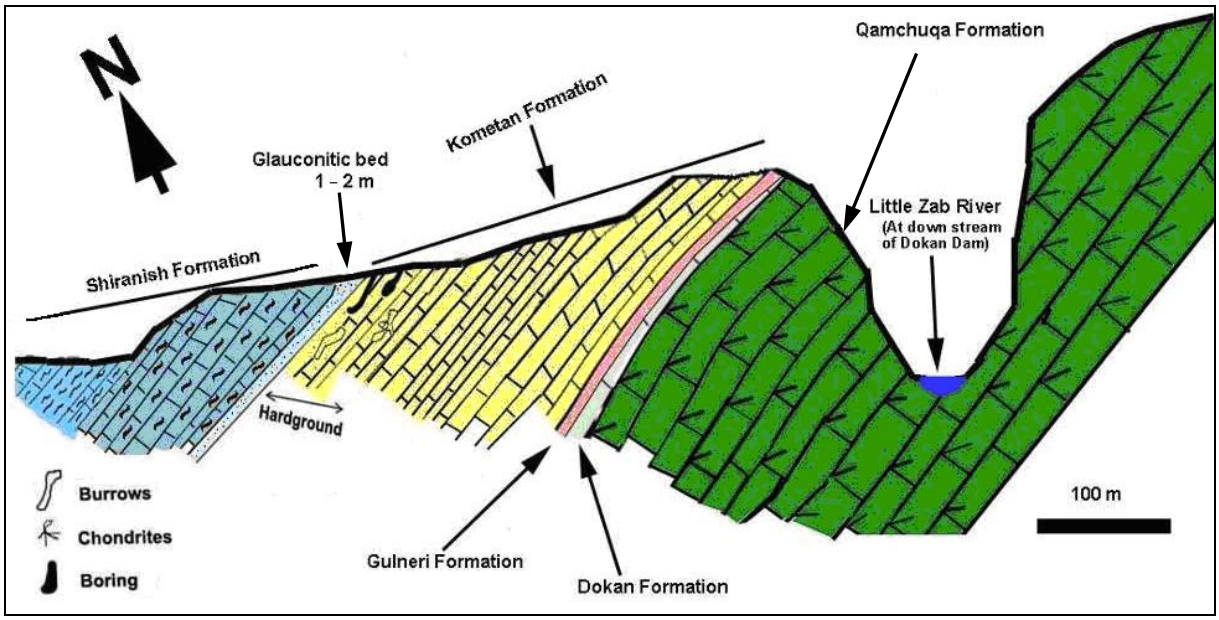

Fig.4: Schematic geologic cross section (NE – SW) in the Dokan Gorge
(directly to the south of the dam site)

This Gulneri Formation contains boulders and gravel-like limestone masses, directly to the south of the Dokan Dam site (Figs.5 and 6). These masses have hummocky smooth surface and bounded by highly deformed dark color shale-like materials, but are finely laminated or foliated (Fig.6). The masses have low spheresity and high roundness, which are not associated with terrigenous or intraformational sand-sized lithoclast or bioclasts. Therefore, these masses, which are assigned previously as conglomerate by Bellen *et al.* (1959) and Buday (1980), are most possibly, in our opinion, ball and pillow-like structures, which are formed by pressure. The origin of these structures are discussed in detail by Karim (2006), he found them in competent and incompetent beds. Reading (1985, p.15) and Einsele (2000) mentioned that the nodular shaly limestone is formed on the carbonate platform during drowning. This is applicable for Gulneri Formation, as Taha (2008) assigned it as sediments of drowning phase, which means deepening not uplifting and erosion, as interpreted by Bellen *et al.* (1959) and Buday (1980).

The aforementioned masses, ball and pillow-like structures, all have the same age of the Gulneri Formation (Early Turonian) and consist of the same lithology (fine crystalline limestone with the same foram species). These masses, if to have prerequisites as conglomerate, then must be associated with terrigenous or intraformational clastics, such as sand and bioclastic grains, but no such grains were found. The recent age determination did not refer to gaps in sedimentation, as Al-Shdidi *et al*. (1995) indicated Late Cenomanian age of Dokan Formation, while the age of Gulneri Formation is Early Turonian as recorded by Abawi *et al.* (2006). The recorded deep water planktonic foraminifera, by later authors, emphasizes the absence of unconformity. A slight sharpness of the upper and lower contacts is observed only in one locality (Fig.7), in other localities around Dokan Dam site, the contact is gradational. According to these facts, the boundary of the Gulneri Formation has not suffered from uplift and subaerial erosion. However, this study does not exclude submarine erosion, which most possibly occurred during drowning of the Qamchuqa and Dokan formations.

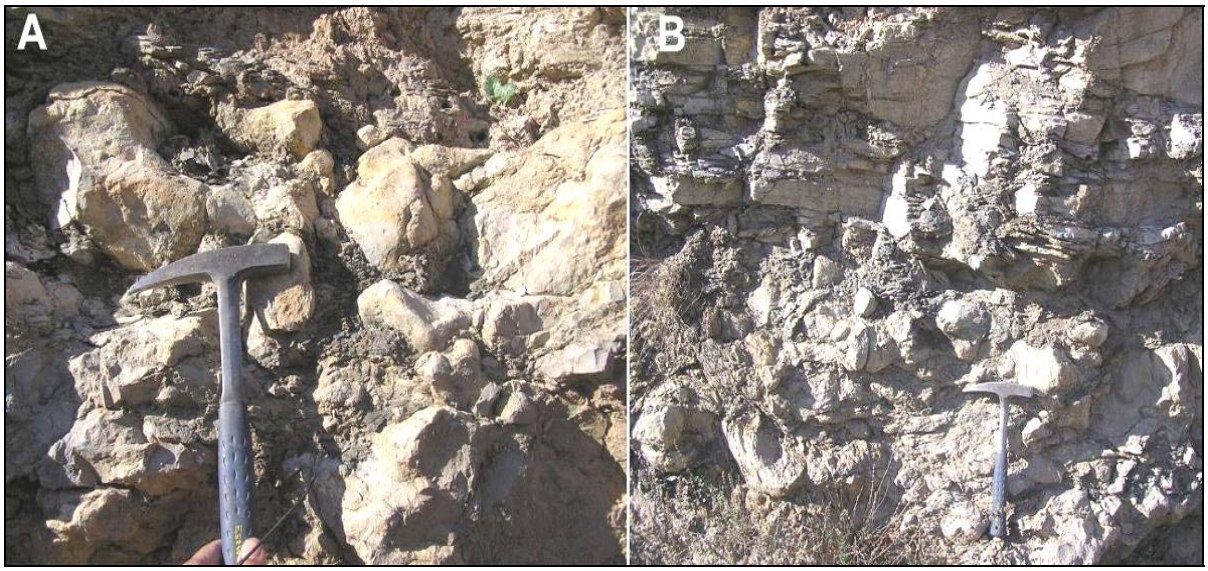

Fig.5: Close up photos of the Gulneri Formation,
note boulder and gravel-like masses of limestone.
These masses are associated with marl but does not contain sand size and bioclast grains

Fig.6: **Left**: Limestone (L), marly limestone (ML) and Black shale (BS)
some limestones are changed to pillows (PL)
Right: Effect of pressure on the limestone that is changed to pillow mass;
some of which are bended around others

The sharp contacts (almost) of Gulneri Formation with both underlying and overlying formations might be argued as unconformable by others. If this is true, then unsolvable problem will arise, because many formations contain tens of beds or packages of beds that are bounded by very clear sharp contacts, such as Injana, Fat'ha, Kolosh, Khurmala and Tanjero formations. The sharp contact could be generated by short duration of tsunami, hurricane, typhoon, storm and submarine current or environment changes.

Tucker (1991, p.129) mentioned that many gradational bed boundaries, may become sharp especially when limestone passes up into mud rocks. He added that in many limestone platforms, the bedding plane is not a primary depositional surface, but they have been produced by pressure solution during burial. This holds good for the boundary of the Gulneri Formation.

Off the Dokan dam site, the Gulneri Formation disappears and changes to thinly bedded and fine crystalline limestone, such as in Boko Zaw Gorge, 3 Km northeast of the type section and north of Lower Dokan town; 2 Km to the south of the type section (Figs.7, 8 and 9). This is true for Tabeen Gorge and both sides of Qarasard anticline, northeast and east of the dam, respectively.

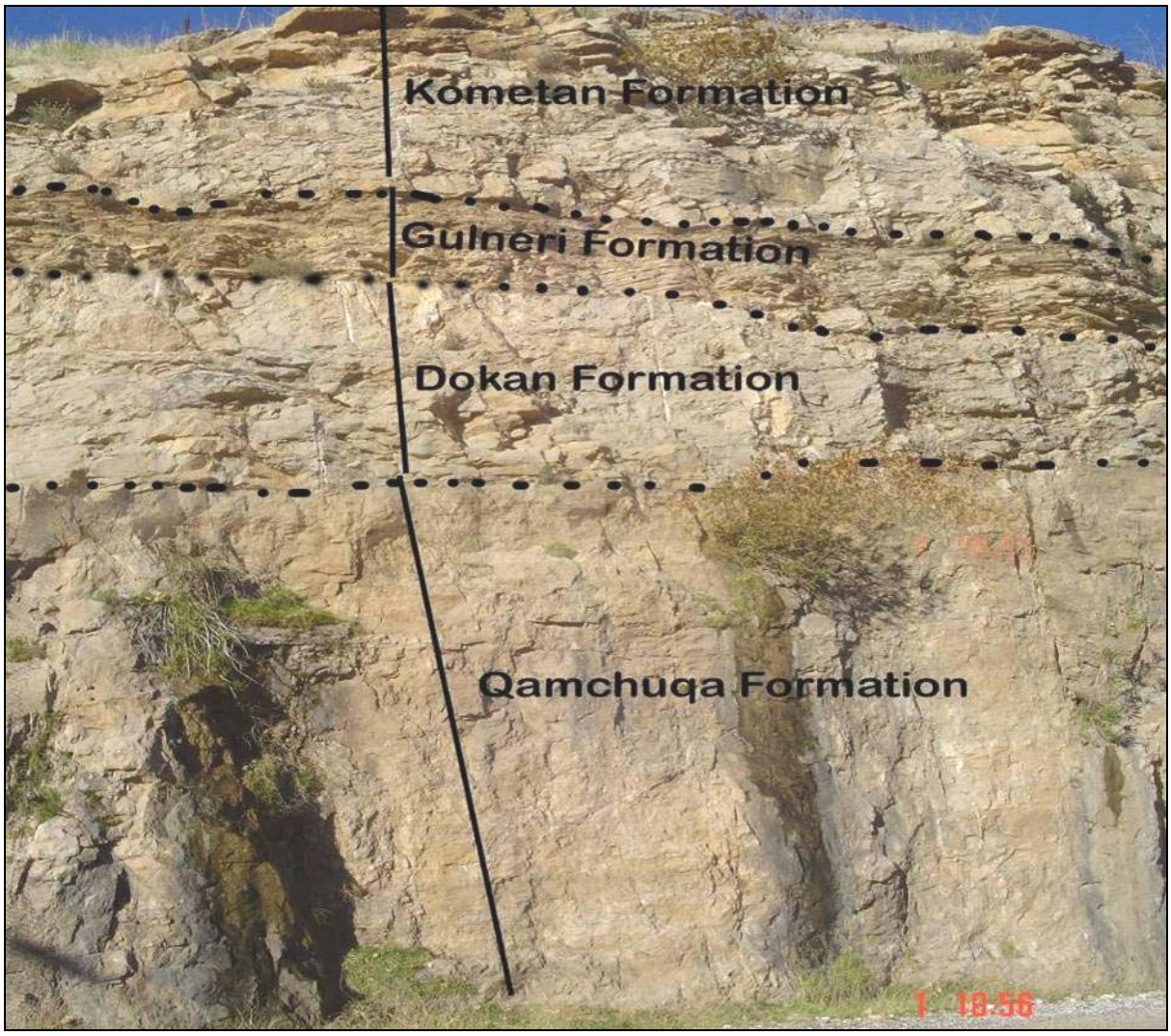

Fig.7: Road cut cliff (about 15 m high) directly to the south of Dokan Dam shows the details of the studied section

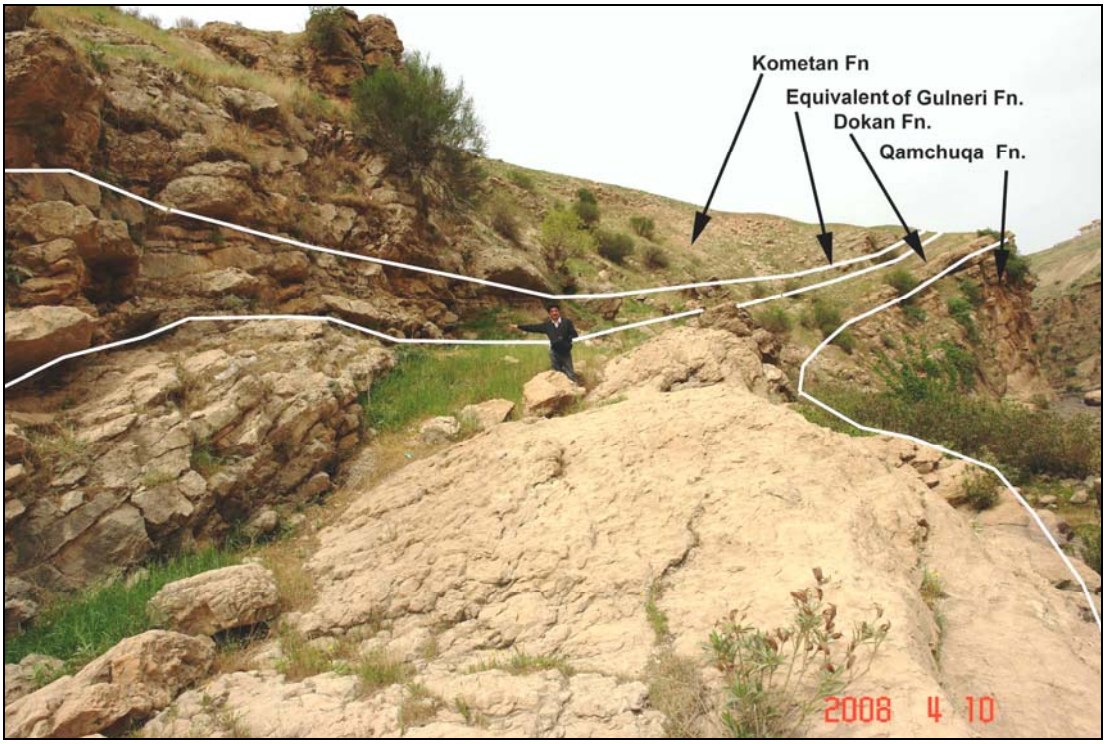

Fig.8: Equivalent of the Gulneri and Dokan formations,
down stream of the Lesser Zab River, 500 m north of Lower Dokan town

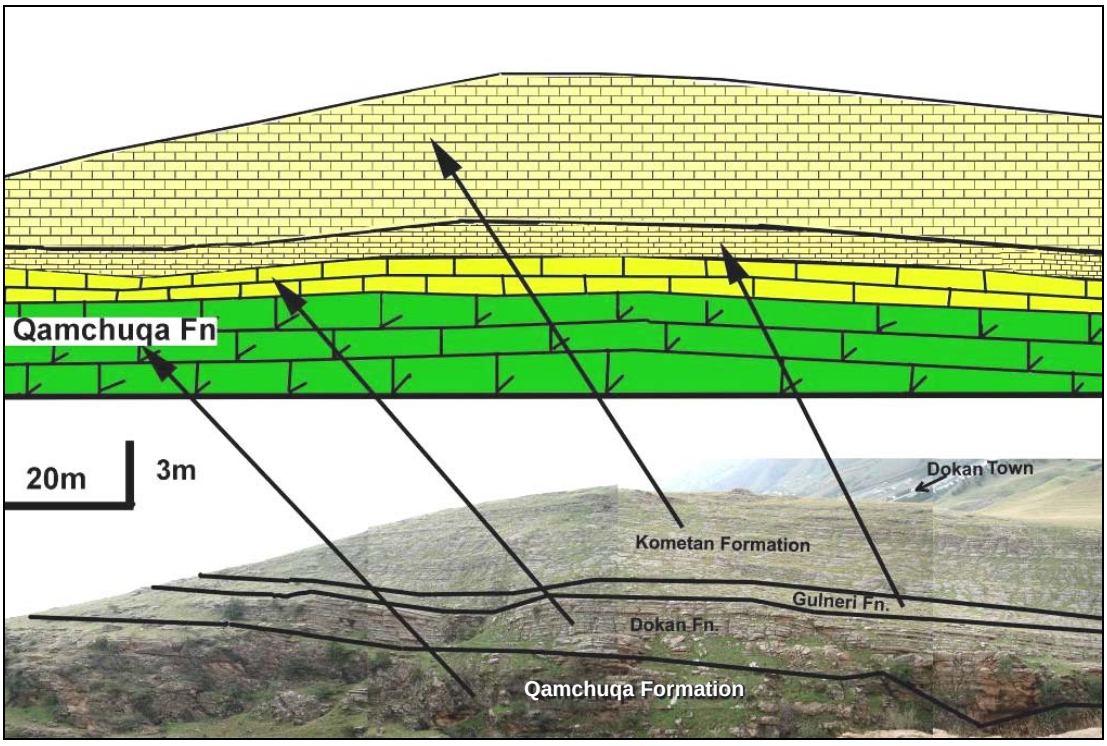

Fig.9: The Dokan and Gulneri formations;
disappear laterally in the surrounding of their type sections.
But their equivalent yet can be found in the Buko Zawa Gorge,
3 Km northwest of Dokan Dam site

PETROGRAPHY OF THE GULNERI FORMATION

The problem of the Gulneri Formation, being shale or marly limestone can be known from field and thin section studies. Bellen *et al*. (1959); Buday (1980) and Abdulla (2008) have mentioned that, in Dokan Dam site, the formation consists of about 2 m black, bituminous, thinly laminated, calcareous shale, with some glauconite and collophane at the lower part.

In the present study, the following four facts are inferred about the formation:

First, the field and thin sections study showed that the formation, in the dam site (type locality) contain only about 20% of shale-like lithology. The rest (about 80%) is composed of limestone and marly limestone with some marls and glauconite (Figs.4 and 5).

Second, the previously mentioned shale, which reaches about 20% of the total thickness of the formation, contains high content of planktonic forams (Fig.10). This high content of forams is not normal for a shale as there is no, in literature, any citation for this type of concentration of planktonic forams in shale. Potter *et al*. (1980) gave the following percentages for average shale mineral constituents: 58%, 28%, 6%, 5% and 2%, for clay minerals, quartz, feldspar, carbonate and iron oxides, respectively. These percentages are not recorded in the so called "shale" in Gulneri "Shale" Formation. Some samples are studied under normal light and fluorescent microscopes for identifying organic materials. These materials include: Alginite, Leptodetrinite, Bituminite, organo mineral complex and organic amorphous particles (Table1). According to organic petrology these organic minerals are of secondary origin and migrated into the formation (P.A. Khanaqa, personal communication, 2008).

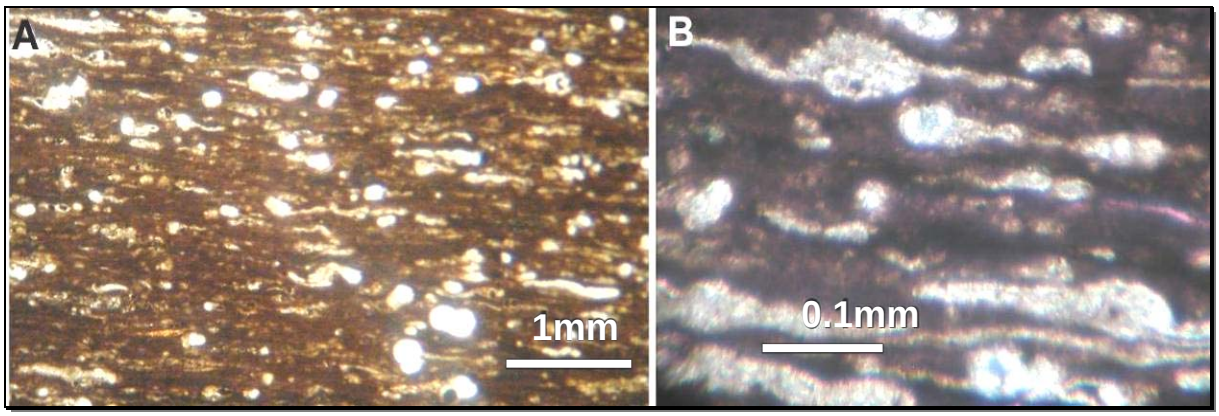

Fig.10: Two thin section photos showing intense effect of pressure on the marly limestone by which the planktonic forams are flattened and arranged parallel to the bedding plane

Table 1: Classification of the organic matter in Gulneri Formation under normal and fluorescent microscopes

Under normal light microscope	**Under fluorescent microscope**
1.Alginite (colorless if aggregate, but yellow if single)	1.Alginite (pale yellow)
2.Leptodetrinite (like as Alginite)	2.Leptodetrinite (pale yellow and brown)
3.Bituminite (colorless)	3.Bituminite (dark brown to pale brown)
4.Organo mineral complex (brown)	4.Organo mineral complex (dark brown)
5.Organic amorphous particles (dark)	5.Organic amorphous particles (dark)
6.Foraminifera (colorless)	6.Foraminifera (blue)

Third, the so called "shale" (20%) exists, in outcrops, as bended laminae, as black and hard rocks, around limestone pillow-like bodies (nodules) (Figs.5 and 6). They appear, in thin section, as black highly deformed rock. The deformation is so intense that the laminae appear under microscope as schistose rocks as they have foliation-like texture and the globular forams are deformed to elongated shape (Fig.10). These features show that these laminae are formed by pressure through dissolution of limestone and migration of bitumen. The materials (insoluble residue and bitumen) are accumulated in the marl and during compaction transformed to dark laminae that obtained shale-like rock appearance and concentrated around the limestone pillows during intense deformation. This is confirmed by occurrence of cast and mold of limestone bodies inside the formation (Figs.5 and 6). This process is discussed by Walness (1979) through which dark color solution seams are generated by pressure.

Fourth, the ratio of insoluble residue in the dark laminae is not more than 25% of the bulk of the samples. This ratio lies in the field of the limestone when the constituents are plotted on the compositional triangle of Laresen and Heald (1977) in Potter *et al.* (1980).

As nodular limestone is concerned, which is characteristic of Gulneri Shale, Nichols (1999) mentioned that the extreme pressure solution and stylolitization result in loss of most of the calcium carbonate, leaving only isolated nodules of limestone in a wavy-bedding mudstone. Nodular limestone of this type is likely to have contents of high proportion of insoluble clay, either disseminated throughout the rock, or more commonly concentrated into mud rich layer. He added that the pressure solution tends to highlight irregular distributions of clay and limestone. Therefore, in our estimate, the thin packages of laminae of shale and nodules in Gulneri shale are formed by the processes described above by Nichols (1999).

According to the mentioned facts and concerning stratigraphy and rules of formation's recognition, it is convenient to combine Gulneri Formation with the overlying Kometan Formation, because it is not mappable due to its very thin thickness and very short lateral extends.

CONCLUSIONS

This study concluded the followings:

- The Gulneri Formation contains minor shale (less than 20%) and consists mainly of marl and marly limestone, which are changed to ball and pillow-like structure by lithostatic pressure during burial.
- The shale laminae are originally marl, which are changed to shale-like rocks by pressure, solution and impregnation by bitumen.
- Geographically, the formation has short lateral extend in the studied area and can be seen only along road cut near the Dokan Dam. Outside the dam and in all directions it changes to fine crystalline limestone (Kometan Formation).
- The lithology and distribution of the Gulneri Formation show that it is better to combine the formation with the overlying Kometan Formation, in the studied area.

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