Bull. Min. Res. Exp. (2017) 154:27-39

Bulletin of the Mineral Research and Exploration

http://bulletin.mta.gov.tr

STRATİGRAPHY AND STRUCTURE OF THE SOUTHEASTERN PART OF PİRAMAGROON ANTİCLİNE, SULAİMANİ AREA, NORTHEAST IRAQ

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Research Article

Keywords:
Gulneri Formation, Dokan Formation, Kometan Formation, Nannofossil, Piramagroon Anticline, Stratigraphy of Sulaimani

Received: 29.03.2017
Accepted: 28.07.2016

ABSTRACT

The Piramagroon anticline (or Pira Magrun Mountain) elongates directly to the northwest of Sulaimani city, Northeast Iraq and its southeastern part contains two other anticlines, named Harmetool and Yakhyian anticlines in addition to their complementary synclines and many other smaller folds. The anticline has experienced intense search for oil in the last few years and a well is drilled to a depth of 3000 meters but, any evidence of oil or gas wasn't found. In the present study, the southeastern part has been studied stratigraphically and structurally and the previous studies have been critically reviewed which may help to reason about the absence of oil in the area. In this study the stratigraphy of the anticline has been determined and Kometan, Gulneri, Dokan, Balambo and Sarmord formations have been plotted on a geological map and stratigraphic column and the nannofossils have been used for the aging of intervals with undetermined ages. The thickness of the Gulneri Formation is 2-4 m and by the analysis of nannofossils its age was identified as Late Cenomanian-Early Turonian. Lithology and bedding styles of the Dokan and Upper part of the Balambo formations are very similar to Kometan Formation and they can be determined either by fossils or by using Gulneri Formation as marker bed. The outcrop of the Gulneri Formation is helpful for differentiation since it is soft and can be recognized easily in the field by its darker color. The structure of the anticline is relatively complex as it consists of asymmetrical anticlines with southwest plunge mainly in few places while it changes to overturned fold in others and is deformed by reverse fault. The anticlines are shaped by detachments on the Gulneri and Sarmord formations and by the other older soft rocks. The newly formed anticlines have the style of multi-detachment fold or multi-detachment faulted fold.

1. Introduction

The Piramagroon anticline (or Piramagrun Mountain) is one of the largest anticlines of Zagros Orogenic Belt in Northeast Iraq and has the length, width and elevation of about 45, 6 and 2.4 kms respectively. It is located between Sulaimani city, from southeast, and Surdash town, from northwest which coincides with the latitudes and longitudes of 35° 36' 57.30" N , 45° 22' 58.33" E and 35° 51' 33.11" N , 45° 05' 21.76" E respectively. Qamchuqa (or Balambo), Kometan, Shiranish and Tanjero Formations are exposed on and around the anticline while its core is occupied by Jurassic rocks (Figure 1). The present study is concerned with its southeastern part which includes the half of the surface area of the anticline. This part is located between Zewy valley at the northwest and Farouq Hotel inside Sulaimani city at the southeast which correspond to the latitude and longitude of 35° 44' 58.43" N, 45° 14' 57.88" E and 35° 34' 15.40" N , 45° 24' 25.17" E respectively. This part consists of many anticlines; the largest one is called Piramagroon anticline which plunges near Sutka village (Figure 1). The second largest one is locally famous Harmetool anticline (mountain) which is located at the east and southeast of Piramagroon anticline.

Previously, Harmetool anticline is called Sulaimani Anticline by Ma·ala (2008) and Al-Hakari (2011). Other anticlines are Sherkuzh and Yakhyiana which are located at the north and south of the Harmetool anticline with more than four smaller anticlines (Figure 1).

Very recently an oil company has drilled an oil well on the core of the anticline to the depth of 3000 meters. The well is drilled on Sarmord Formation and reached Triassic Formation without striking any trace of oil or gas. The present study is focused on the stratigraphy and structural properties of the southeastern part of Piramagroon anticline. The

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http://dx.doi.org/10.19111/bulletinofmre.305987

study is based on geologic mapping and structural analysis in addition to stratigraphic differentiation by nannofossils. Additionally, by this study it is planned to add more useful data and new geological results to the previous studies such as Aziz et al. (1999) (Figure 2), Ma, ala (2008), Al-Hakari (2011) (Figure 3) and Omar et al (2015).

1.1. Geological Setting

Tectonically, the studied area is part of the northeastern margin of the Arabian Plate, where the previous Early Cretaceous platform has transformed to a foreland basin during the Late Cretaceous (Karim, 2004). According to the tectonic subdivision of Iraq by Buday and Jassim (1987), Jassim and Goff (2006) the study area is considered to be located in the High Folded Zone while it is considered to be located in the Simply Folded Zone at the classification of whole Zagros belt by Ghasemi and Talbot (2006) (Figure 1b).

In the north of the study area (Mawat-Chwarta area) a large graben is located in which ophiolites, Tertiary, and Upper Cretaceous formations are

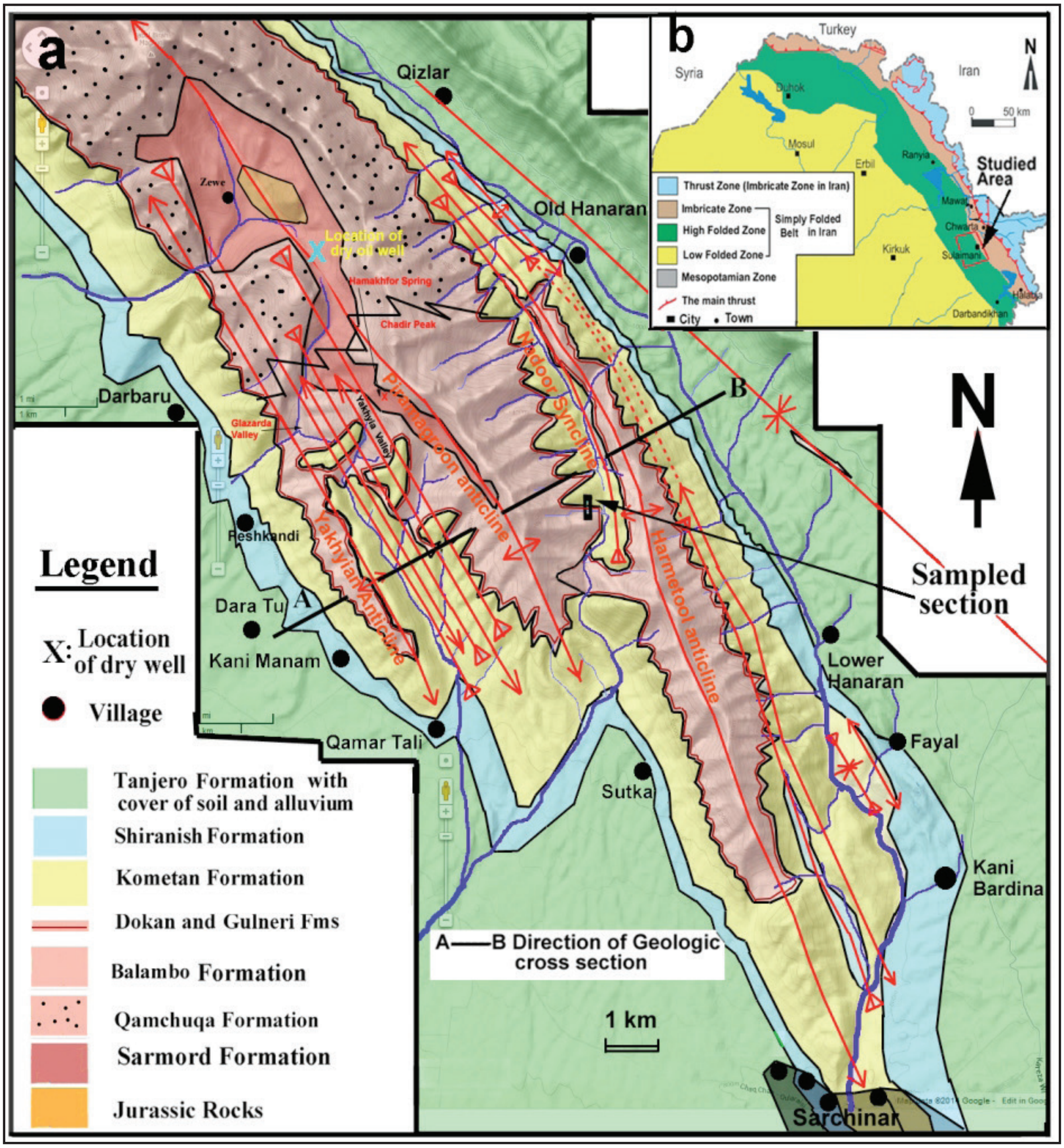

Figure 1- a) Geological and b) tectonic maps of the studied area.

outcropped. In the Graben, the Main Zagros Thrust can be observed between Qulqula Radiolarian Formation and Red Bed Series. The Upper Cretaceous Formations are Shiranish (marl), Tanjero (sandstone, marl and conglomerate) and Aqra (fossiliferous and detrital limestone) Formations (Karim, 2004; Al-Kubaysi 2008; Sadiq 2010; Özer et al. 2013; Karim and Khanaqa 2014).

Between the Graben and the study area, Azmir anticline and Chaqchaq syncline are located which are dissected by consequent valleys in which best outcrops of Cretaceous and Jurassic rocks are available for geological studies. The formations, on the anticline and in the syncline, have the same properties as those that are exposed on and around Piramagroon anticline and will be discussed in the next sections of this paper in details.

2. Result and Discussion

2.1. Stratigraphy of the Study Area

The stratigraphic study of the southeastern part of Piramagroon anticline is very important in four ways. The first one is that the study area is the zone of facies change between Qamchuqa and Balambo formations (Ameen, 2008). In this area, the thick and massive dolomitic limestone (competent beds) of the Qamchuqa Formation, from the west, changes to well bedded limestone and marly limestone (incompetent) of Balambo Formation. Therefore, the phrase "Qamchuqa/Balambo transition or QBT" is used for the equivalent of Qamchuqa Formation in the transition zone. The second is that the transitional zone, structurally, consists of alternation of competent and incompetent beds which reflect different deformational patterns that are the combination of the two end members. The third is expanding of the urbanization of the Sulaimani city towards the study area which may cover most parts during the forthcoming decade. Fourth is that the boundary between Balambo (or its reefal equivalent of Qamchuqa Formation) and Kometan Formation (Turonian-Campanian) is well exposed in the study area.

The boundary must contain either the rocks of Cenomanian- Turonian ages or events (unconformities). Many authors (Sharland et al., 2001; Al Hussaini and Matthews, 2008; Al-Qayim et al., 2012; Lawa and Gharib, 2009 and Omar et al., 2015) have cited major unconformity in this boundary. Lawa et al. (2011 in Al-Hakari, 2011) have cited that during the early Turonian, the Qulqula Radiolarian Formation and main igneous complexes were uplifted and acted as Hinterland for Foreland basin. Buday

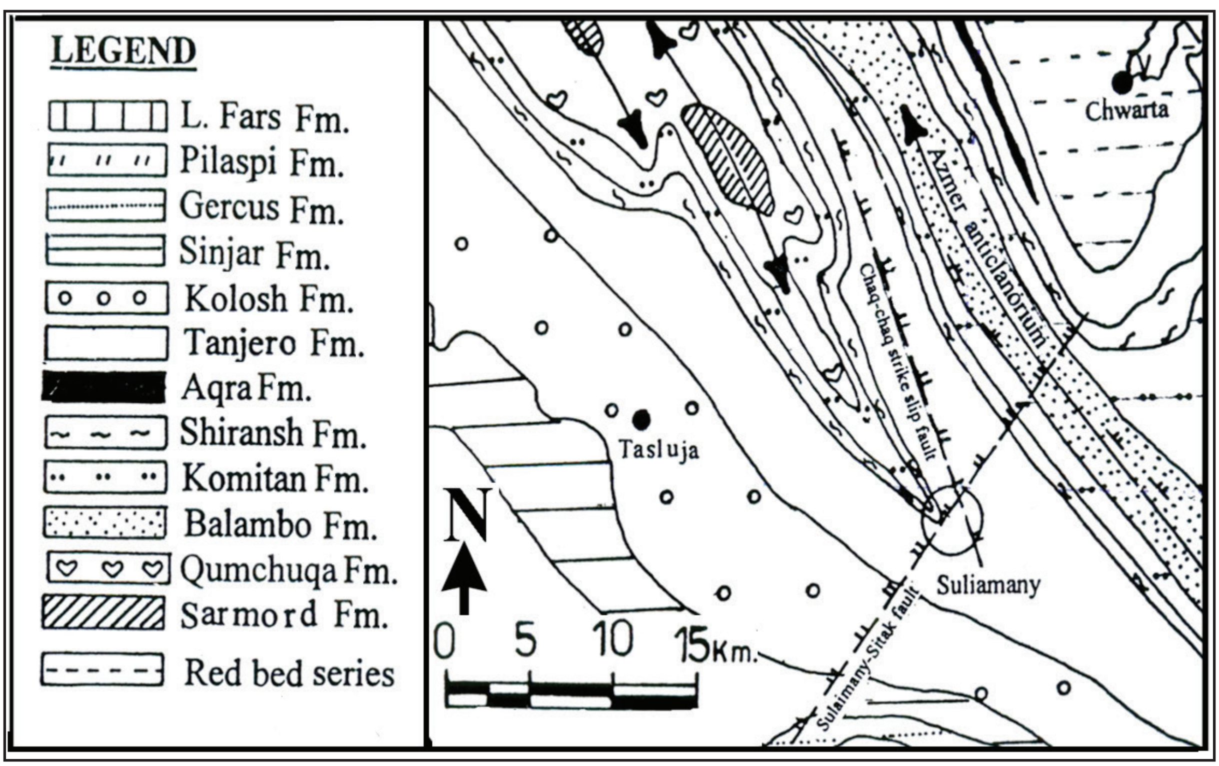

Figure 2- Geological map of the study area which shows two strike-slip faults (Aziz et al., 1999).

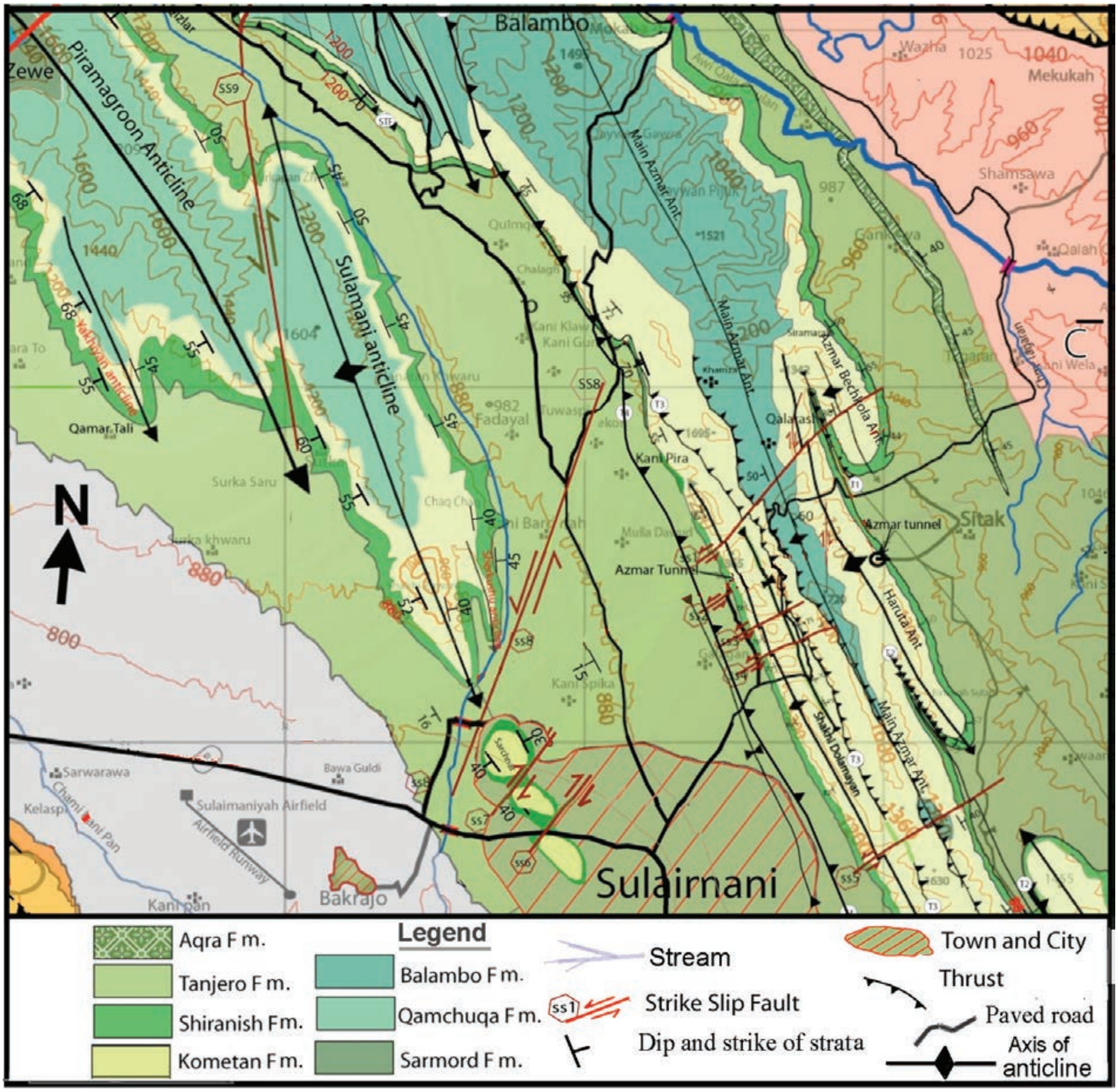

Figure 3- Geological map of the studied area (Sissakian, 2000 and Ma,ala, 2008 and modified by Al-Hakari, 2011) showing the strike slip faults that indicated by the latter authors.

(1980) and Jassim and Goff (2006) have refereed that Qulqula Conglomerate Formation had deposited at the top of the Qulqula Radiolarian Formation during the Cenomanian-Turonian age. This deposition is recently referred by Ibrahim, 2009 and Al-Qayim et al. (2012).

The present study, field inspection across many sections, has not revealed any of above signatures. Moreover, the nannofossil analysis of the boundary between Qamchuqa (or Balambo) and Kometan formations showed that the Gulneri and Dokan formations exist in the boundary and unconformities are not observed (Figure 1 and 4). This result agrees with the conclusion of the Karim and Taha (2009) who refused the unconformities that previously established at the base and at the top of the Gulneri Formation in Dokan area. The latter study concluded that the formation consist of marl and marly limestone without black shale. Karim et al. (2013) found both formations on the Azmir and Goizha anticlines and prepared a detail map of the area to the north and east of Sulaimani city which show the outcrops of the two formations.

Previously, Aziz et al. (1999), Ma·ala, (2008) and Al-Hakari, (2011) mapped the study area and

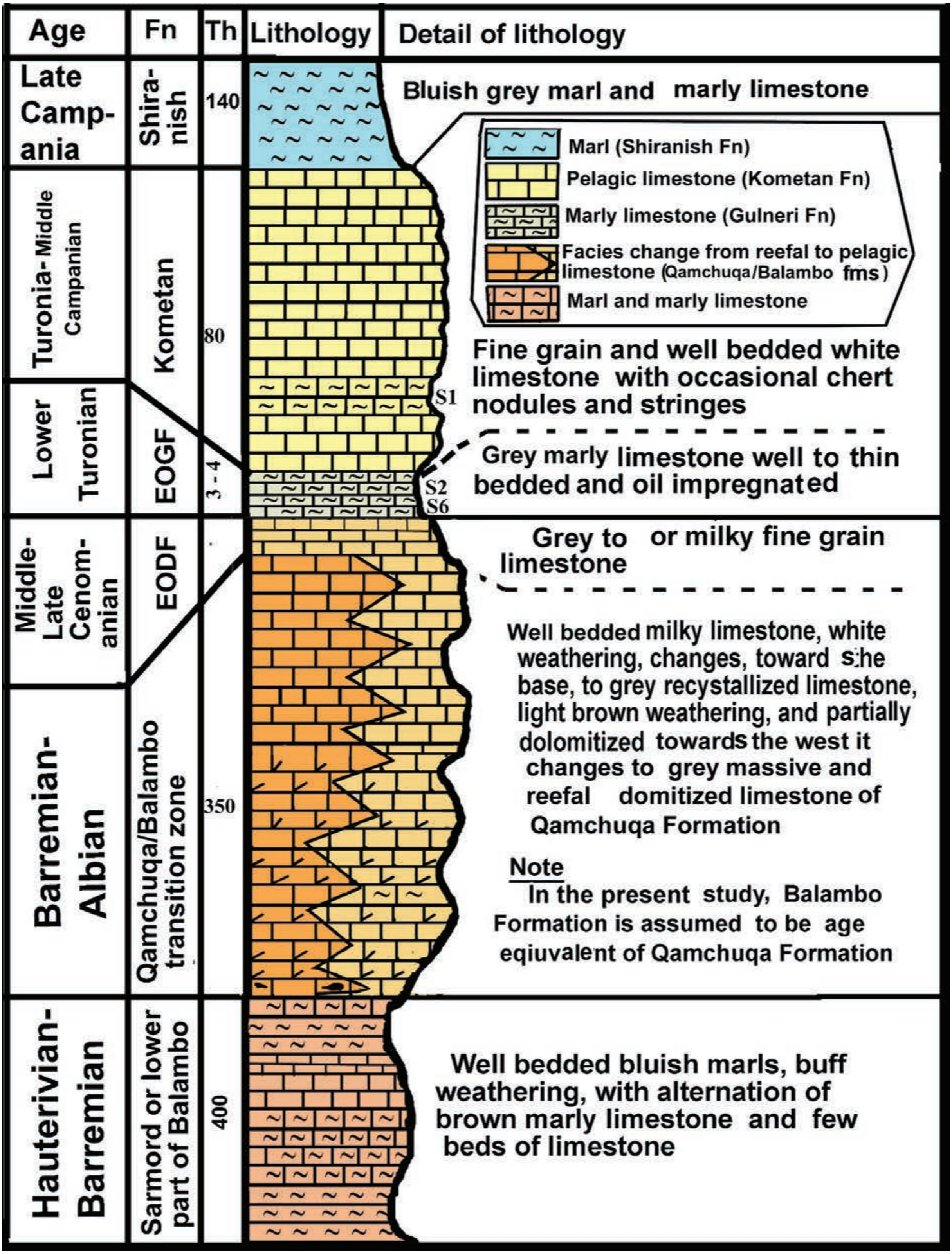

Figure 4- Stratigraphic column of the studied area drawn from the result of the present study.

indicated Qamchuqa, Kometan, Shiranish and Tanjero formations on the crest, upper and lower limbs of the anticline respectively (Figure 1 and 2). The above authors have not recorded the Gulneri and Dokan Formations. In the study area around Sulaimani City Al-Hakari (2011) and Omar et al. (2015) indicated (by stratigraphic column) that there are unconformities between Qamchuqa and Kometan formations where both Dokan and Gulneri formations are missing. About the contact between Kometan and Shiranish Formations, they showed that there is an unconformity between the two formations while the present study didn't record any unconformities and field and fossil analysis indicated conformable nature of the boundaries of the above four formations.

2.1.1. Gulneri Formation

The Gulneri Formation was first described by Lancaster Jones (1957) and Bellen et al. (1959) near the Dokan Dam site at the west of Sulaimani city, which consists of about 2 m black, bituminous, finely laminated, calcareous shale with glauconite and collophane at its lower part. The age of the formation is Early Turonian (Bellen et al., 1959).

The high bitumen content and dwarfed fossils indicate that the Gulneri Formation was deposited in an euxinic environment (Jassim and Buday, 1987; Jassim and Goff, 2006). The formation is separated by unconformities with both the overlying and the underlying Kometan and Dokan formations respectively (Buday, 1980). The present study found that it consists of well bedded marly limestone mainly and is laminated and oil impregnated occasionally. In all sections, shale has not been found and the observed lithology of marly limestone is same with the conclusion of Karim and Taha (2009) who reused the previous lithology (black shale) of Gulneri Formation at the type section near Dokan dam site. Karim and Taha (2009) has showed that the formation is deposited in the large basin in which Balambo and Kometan Formations are deposited, by model.

In the study area, the upper part of Balambo Formation, Dokan and Kometan formations are very similar in lithology and bedding patterns (Figure 5). They can be separated either by foraminifera study or by identifying Gulneri Formation which is located between the two formations. The latter formation can be observed in the field which appears as a covered dark ribbon between white limestones of Kometan and Balambo Formations. The thickness of Gulneri Formation is about 2-4 m. Between Dokan and Surdash towns, it is located between Dokan and Kometan Formation and it consists of dolomitic limestone without marl and marly limestone but it is thinly bedded and due to this property, it is highly deformed as seen in Tabeen Gorge where Karim (2014) showed a photo of the formation to prove its existence. Therefore, the result of the present study refuses the presence of the Turonian unconformity in North Eastern Iraq that was mentioned before. Lawa et al. (2013) cited an unconformity and mentioned that Dokan and Gulneri formations are not present (an unconformity with duration of 4.7 m.y) in the Tabeen Gorge 4 km to the southeast of Surdash village. Similarly, Omar et al. (2015) have recorded the unconformity and they noted the absence of Dokan and Gulneri Formations (Late Cenomanian to Early Turonian age) at the top of the Balambo and Qamchuqa Formations. They attributed this absence to the reactivations of ChaqChaq fault and tectonic uplifting of the Mawat ophiolite obduction during the Turonian. They further added that the top of the latter two formations are characterized by the disappearance of planktonic foraminiferal, nannoplanktons and palynomorphs. They assigned this gap as Pre-Aruma unconformity and attributed it to ophiolite obductions. In the present study, the sediments of the Gulneri and Dokan Formations are found and they contain in many place both nannofossils and planktonic forams.

2.1.2. Nannofossils Analysis of Gulneri Formation

Omar et al. (2015) cited that the top of Balambo Formation is unconformity and does not contain nannofossils while at the the present study many index nannofossil species which represent the age of Gulneri and Dokan formations have been found in the formation.

In the study area, the outcrops of Gulneri Formation are mostly covered and weathered; therefore, fresh sampling is difficult. For sampling, one meter deep holes have been excavated on the outcrop of the the formation. The six samples have been sent to Romania for nannofossil analysis and age determination. A

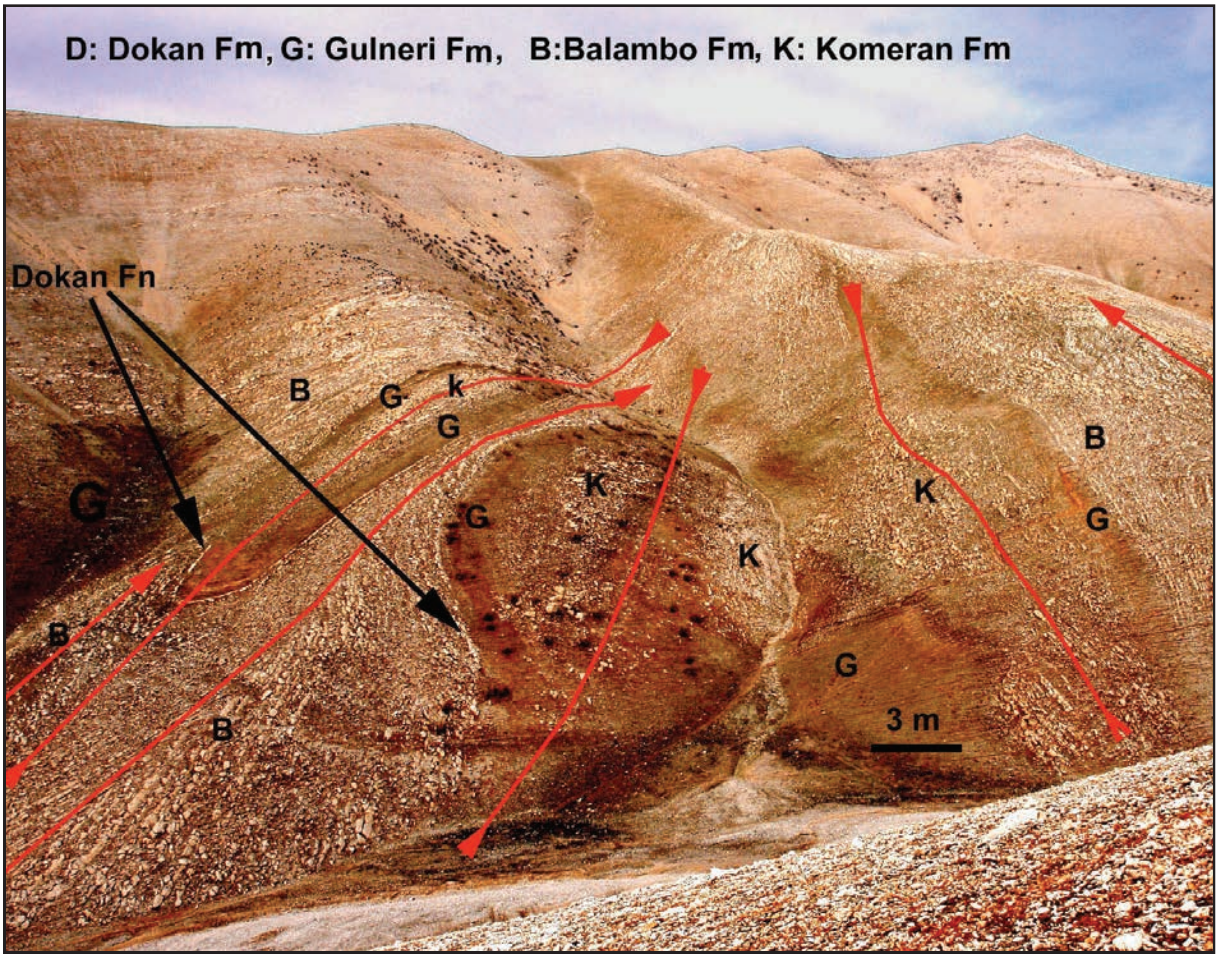

Figure 5- Southwestern side of the Nadoor valley shows the minor folding and stratigraphic differentiations.

detail report is prepared by Dr Ramona Balc (ramona. balc@ubbcluj.ro) for the nannofossils which gave the age of Late Cenomanian-Early Turonian for the sampled interval (Figure 6 and 7).

Nannofossils Species:

The age of the studied samples is given by the presence of *Corrolithion kennedyi* and *Quadrum intermedium*. The first mentioned species was identified only in one sample (sample 5). Thus, this level falls in UC3d Nannofossil Subzone (Burnett, 1998), which is Late Cenomanian in age. The top of this subzone is defined by the last occurrence (LO) of *C. kennedyi*. Next level (sample 4 and sample 3) covers the Uc3d – UC5b Nannofossil Subzones, the bioevents mark the base of the UC5b which is represented by the first occurrence (FO) of *Quadrum intermedium*. The age of the above mentioned interval is Late Cenomanian. The last level (samples 2 and 1) falls in UC5c Nannofossil

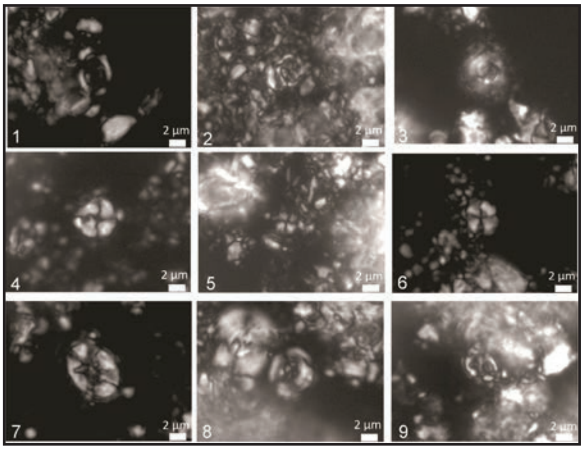

Figure 6- Species of the result of the nannofossil analysis which gives the age of Late Cenomanian-Early Turonian. Species are: **1.** *Broinsonia enormis* (Sample 1); **2.** *Corrolithion kennedyi* (Sample 5); **3.** *Cylindralithus* sp. (Sample 5); **4.** *Cylindralithus nudus* (Sample 5); **5.** *Discorhabdus ignotus* (Sample 5); **6.** *Eprolithus floralis* (Sample 2); **7.** *Eiffelithus turriseiffelii* (Sample 2); **8.** *Helenea chiastia* (Sample 5); **9.** *Helicolithus trabeculatus* (Sample 5); All photos are taken under XP light.

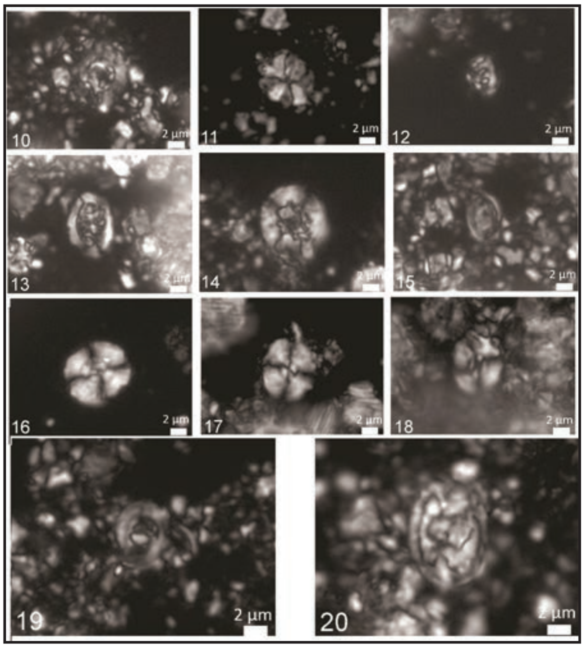

Figure 7- **10.** *Prediscosphaera cretacea* (Sample 1); **11.** *Quadrum intermedium* (Sample 3); **12.** *Rhagodiscus achlyostaurion* (Sample 5); **13.** *Rhagodiscus asper* (Sample 4); **14.** *Retecapsa crenulata* (Sample 3); **15.** *Tranolithus orionatus* (Sample 5); **16-17.** *Watznaueria barnesiae* (Sample 2); **18.** *Watznaueria ovate* (Sample 1); **19.** *Zeugrhabdotus diplogrammus* (Sample 4); **20.** *Zeugrhabdotus embergeri* (Sample 3). All photos are taken under XP light.

Subzone, the base of this subzone is defined by the FO of Q. intermedium (Figure 6). The age of this subzone is Late Cenomanian-Early Turonian.

2.2. Structure of the Study Area

When we examine the accurate analysis held in the preceding sections about the stratigraphy of the study area, the structure analysis kept in more update conditions is much more suitable than the previous studies.

2.2.1. Strike Slip and Reverse Faults

Aziz et al. (1999) have recorded two strike slip faults and called them Sulaimani-Sitak and Chaqchaq strike slip faults. They have indicated the two faults intersecting beneath western part of Sulaimani city (35° 34′ 15.40″ N and 45° 24′ 25.17″ E) (Figure 1). They added that the facies change from reefal Qamchuqa Formation to Pelagic Balambo Formation is controlled basically by deep seated Chaqchaq strike slip fault. The same idea is accepted by Ibrahim (2009), Al-Hakari (2011) and Omar et al. (2015) but they showed it diagrammatically as normal listric fault (Figure 8).

The present study doesn't agree with the citation of the above authors about the effect of the fault on the facies change from reefal limestone to deep pelagic limestone or marl during Early Cretaceous. This disagreement is due to the fact that this facies change is not restricted to the area at north and northeast of Piramagroon anticline but exists in the whole northern Iraq. On the tectonic map of Jassim and Goff (2006), this facies change is indicated as located between the Balambo-Tanjero Zone and High Folded Zones and starts from Chachaq valley and continues to the north of Rawndoz town.

The facies changes of Qamchuqa Formation (shallow reefal limestone) to Balambo Formation (deep pelagic limestone or marl) should not to be controlled by fault because this facies change is very common on the continental margin of the present day oceans where the reefal carbonate on the shelf rapidly (relatively) changes to pelagic limestone or mud on the slope or continental rise. During Early Cretaceous the Arabian platform was part of the continental margin of the New Tethys Ocean. Ameen (2008); Ameen and Karim (2009) and Karim and Taha (2009) have discussed and indicated this facies change without connecting it with faults (Figure 9).

Al-Hakari, (2011) has found two other strike slip faults in the area to the west of the Sulaimani-Sitak fault (Figure 3). The authors of the present study, as a result of the fieldwork, have not found any evidence of these four faults at the west and northwest of the Sulaimani city. The geological mapping has not detected any shifting of the axes of the folds and the topographic features in the studied area (Figure 3). Two reverse faults were observed which have had the displacement less than 20 m, one of them cut the southwestern limb of the Piramagroon Anticline and was observed inside the Yakhyian valley (Figure 10). Another reverse fault is seen on the northeastern limb of Harmetool anticline near the mouth of the Nadoor valley (Figure 11a). These two faults may be anticline break through faults due to the fact that the anticlines are detachment folds and this type of faults are observed commonly in this type of folds.

2.2.2. Type of Anticlines

There are two main anticlines in the studied area which are named Piramagroon and Sulaimani (Harmetool in the present study) anticlines by Ma'ala,

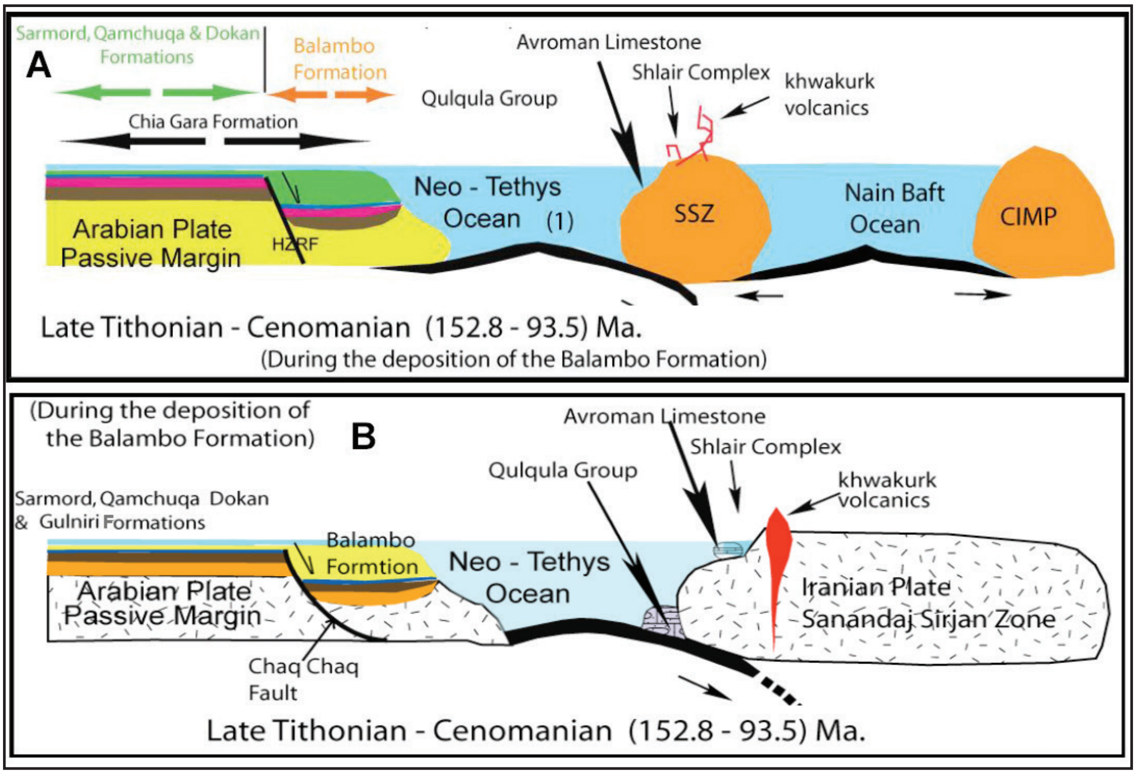

Figure 8- Paleogeography and tectonics of Late Tithonian-Cenomanian in which listric fault is indicated by: a) Ibrahim (2009), b) Al- Hakari (2009) and Omar et al. (2015).

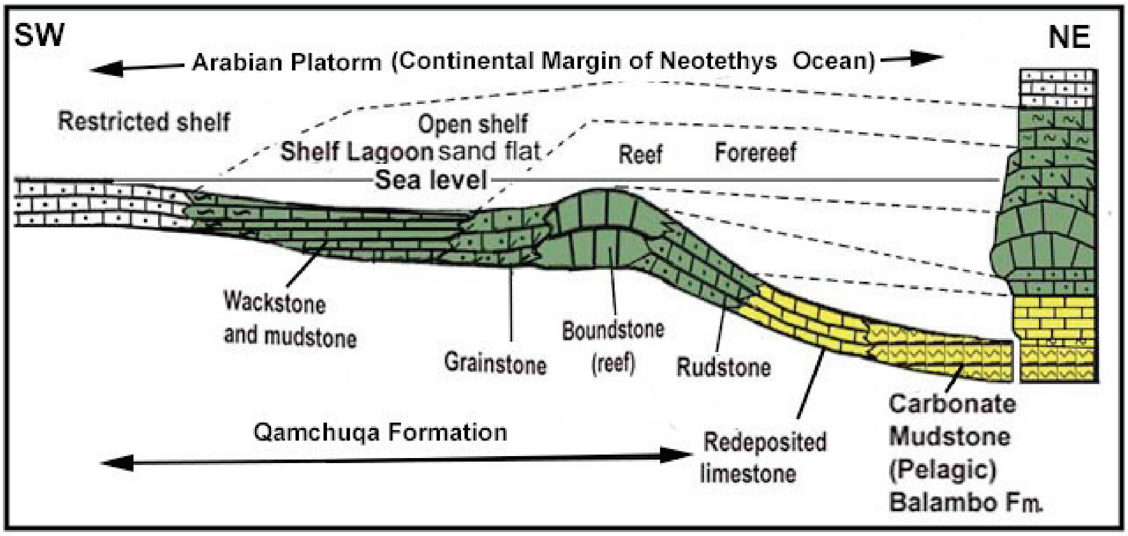

Figure 9- Paleogeography of the Arabian Platform during Early Cretaceous which shows facies changes which are not related to fault (Ameen, 2008; Karim and Ameen, 2009).

(2008) and both of them are recently mapped by Al-Hakari, (2011) who has indicated all the main anticlines as southwest vergent asymmetrical anticlines. It was observed that the above indications are true for those found inside QBT. In some cases the anticlines are reversely faulted by anticline breakthrough fault. However, the folds inside Kometan Formation behaved more or less differently. In addition to asymmetrical anticlines, Kometan Formation contains box and recumbent anticlines (Figure 11d).

Al-Hakari (2011) and Omar et al. (2015) have assigned the anticlines in the studied area as fault propagation folds (Figure 1) but the present study showed that it is detachment fold. The proof for detachment fold is discussed in detail for during the study of Azmir-Goizha anticline at the north of Sulaimani city by Karim and Ahmad (2014) . The detachments of the anticlines occurred on the Gulneri and Sarmord formations and other older soft rocks. The anticlines which were formed are in the style of multi-detachment fold or multi-detachment faulted fold. Al-Hakari (2011) mentioned that the cores of the anticlines in the study area were occupied by Qamchuqa Formation but the present study showed that Balambo and Sarmord Formations exist in the core (Figure 2, 10 and 12).

The absence of the oil in the core of the anticline is attributed, according to the result of the present study, to refolding and intense deformation of the core of the Piramagroon anticline by detachment folding which includes rotation of both limbs and squeezing of the core of the anticline. Al-Hakari (2011) and Omar et al. (2015) assigned that this refolding (parasitic folding) and squeezing, by the above processes, has destroyed any existing reservoir (Figure 5) and its seal more intensely than previous model of fault propagation folds. The latter authors explained that, as shown in the figure 13, open folds, without parasitic folds, are much more suitable for keeping accumulated oil than detachment folds aforementioned in the present study. Another reason for the absence of oil is the deep burial of the targeted rocks which are more than 10 km during Pliocene below Cretaceous and Tertiary rocks before exhumation. The burial temperature was so high that degraded the possible existed oil.

2.2.3. Sulaimani Anticline

This anticline is located inside the western part of Sulaimani city (35° 34′ 15.50″ N and 45° 24′ 25.15″ E) and geomorphologically consists of three low hills such as UN and Farouk hills (Figure 14). The plotting of its axis indicates that this anticline, most possibly, is an independent anticline. Previously this anticline is assigned as southeastern plunge of Harmetool anticline by Ma·ala (2008), Al-Hakari (2011) (Fig.13A) and Aziz et al, (1999). The elongation of the axis of Sulaimani anticline coincides with the Sherkuzh anticline (Figure 14a). Al-Hakari (2011) had indicated two strike slip faults that cut this anticline (Figure 3). In this study, only a small strike slip fault was found that strikes nearly east-west (Figure 14b)

3. Conclusion

1-The equivalents of the Dokan and Gulneri Formations are found for the first time in the study area.

2-The unconformities below and above Kometan Formation were not found.

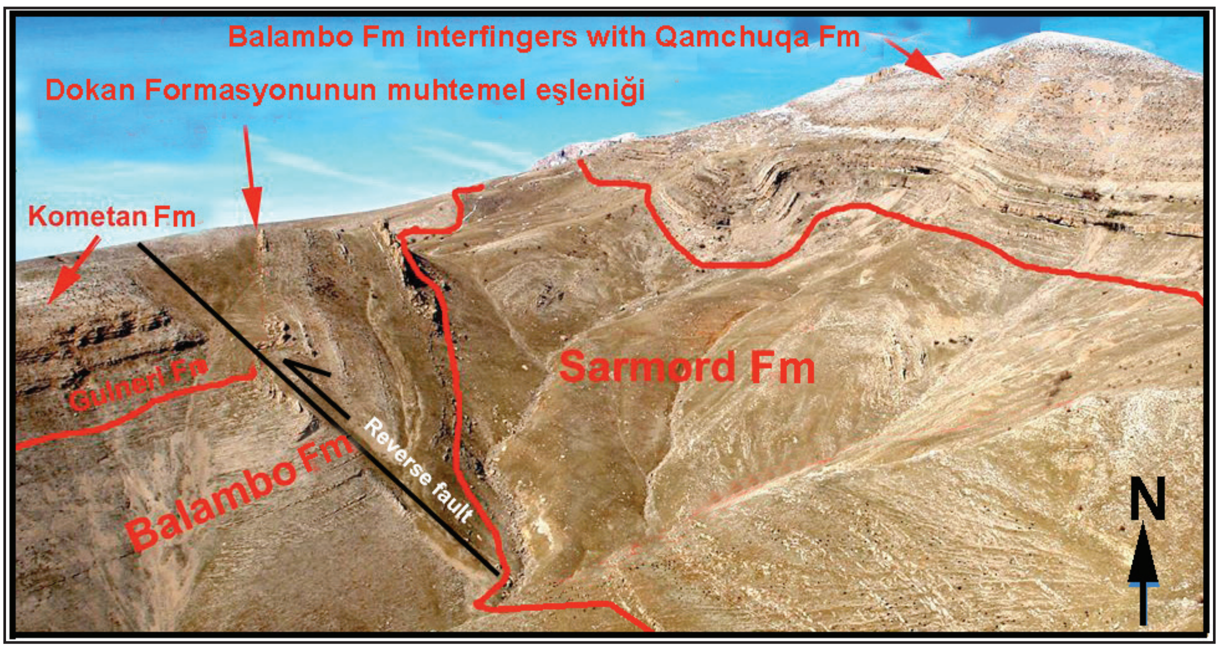

Figure 10- Folds in the south eastern limb of Piramagroon anticline, Yakhyian valley, 15 kms to the northwest of Sulaimani city, 3km to the north of Qamar Taly village.

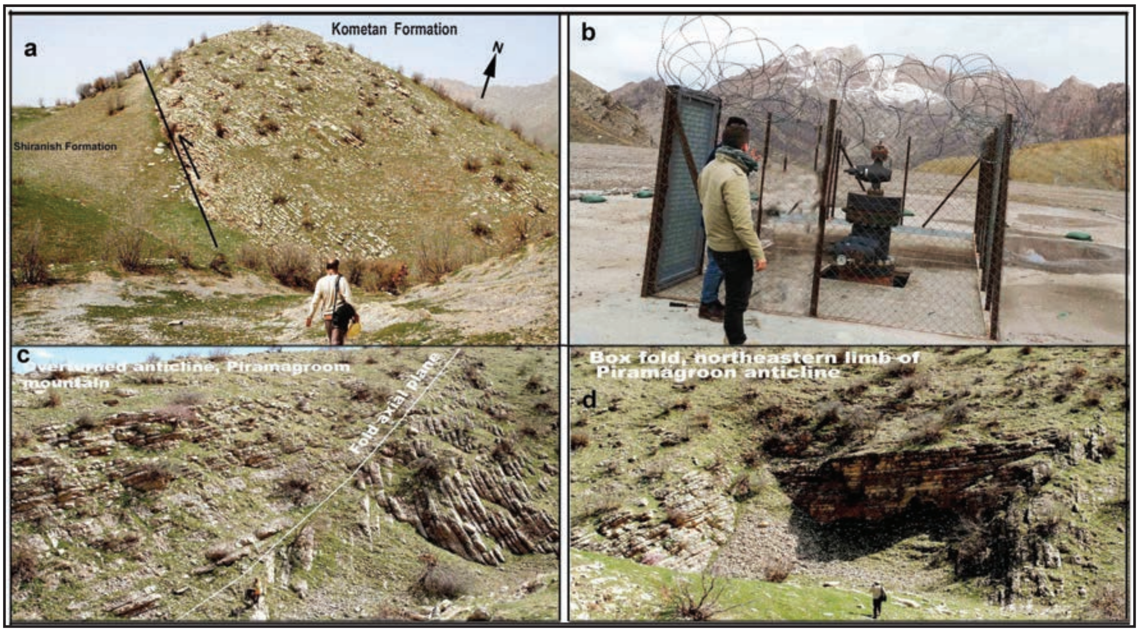

Figure 11- a) Reverse faults on the northeastern limb of Harmetool anticline near the mouth of the Nadoor valley, b) The oil well about 3000 meter deep which is dry, (c) Recumbent and box folds, (d) folds in the northeastern limb of Harmetool anticline at south west of Old Hanaran village.

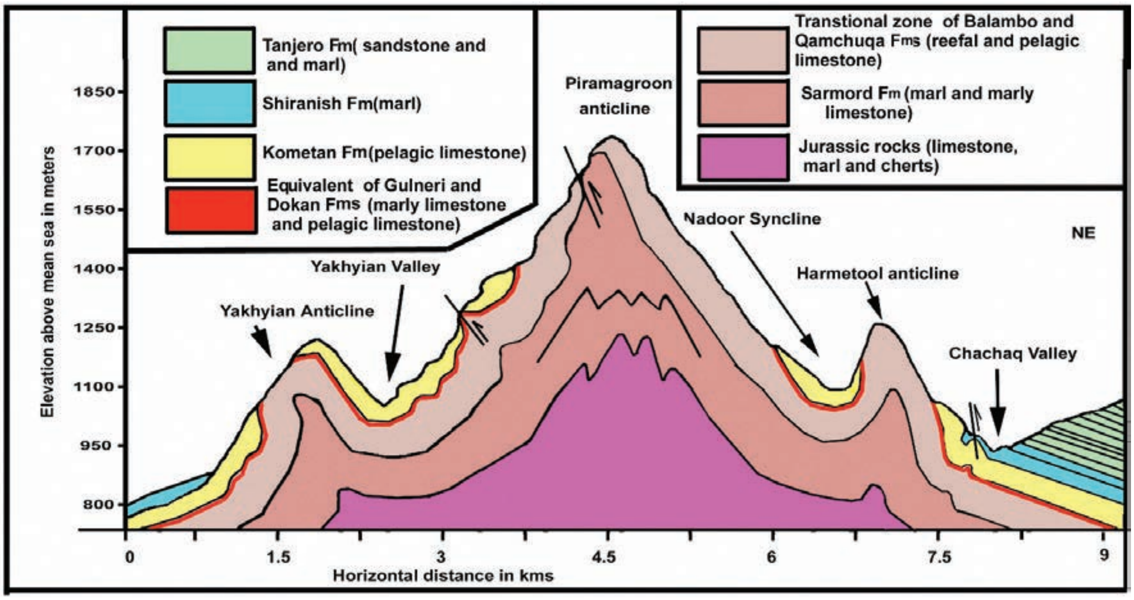

Figure 12- Geological cross section of the southeastern part of Piramagroon anticline (A----B line in the figure 1). The miner deformations are not shown.

3-The age of the Gulneri Formation is Late Cenomanian-Early Turonain

4-A new and updated geological map is drawn for the area on which all the formations are differentiated.

5-The most realistic structural analysis of the study area on which new folds and fault is recorded for the first time is revealed.

6-The folds of the area consist of detachment anticlines and synclines and detachments which occurred on marls of the Gulneri, Sarmord Formation and other older rocks.

7- The main faults are reverse faults.

8-The probable reason for the absence of oil is intense refolding and squeezing of the core of the anticline by detachment folds.

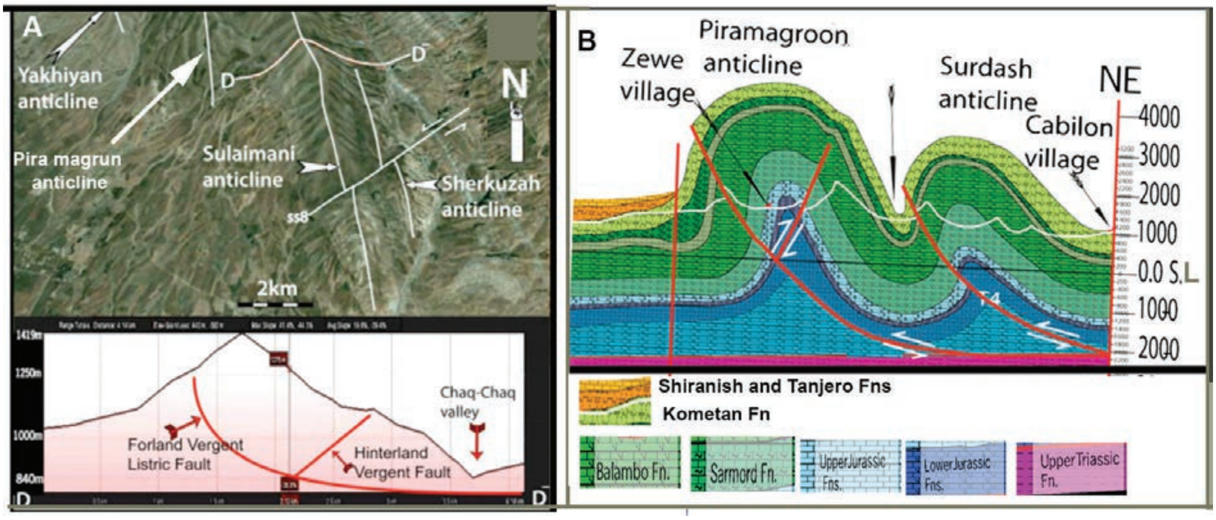

Figure 13- Two geological cross sections of A)Al-Hakari (2011) and B)Al-Hakari (2011); Omar et al.(2015) shows that they assigned the anticlines in study area as fault propagation folds which were uplifted through the reverse slipping of the hanging wall of the blind foreland vergent listric thrust fault associated with the hinterland-vergent-fault.

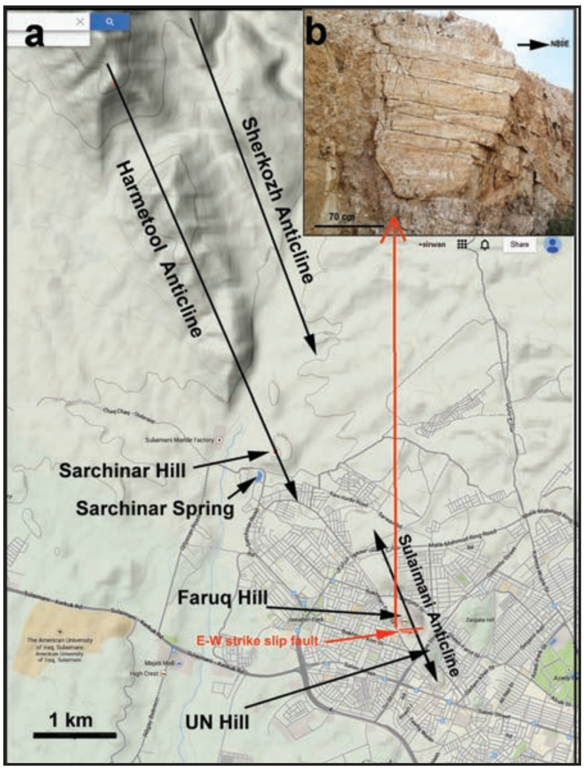

Figure 14- a) Topographic map of western part of Sulaimani city (From Google Earth) which shows the anticlines, (b) Strike slip fault between the UN and Faruq hills

Acknowledgement

The authors thank to Dr. Ramona Balc (ramona.balc@ubbcluj.ro) for her effort in the nannofossil analysis and the age determination studies.

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