THE STRATIGRAPHY OF THE EXPOSED CRETACEOUS ROCKS IN IRAQ, AS DEDUCED FROM THE RESULTS OF THE REGIONAL AND DETAILED GEOLOGICAL SURVEYS (GEOSURV 1971-1996)

Varoujan K. Sissakian *

ABSTRACT

The Cretaceous rocks, in Iraq, are characterized by their well development all over the country, on the contrary to the rocks of other geological periods. The Cretaceous rocks are exposed widely in the Iraqi Western Desert, as well as in the northeastern and northern parts of the country. They are also exposed in Sinjar and Qara Chauq mountains. The main rock types are carbonates, marl, phosphorites, shales and fine clastics. Conglomerates are also known, but only in the northeastern part of the country. Igneous complexes and metamorphic rocks are limited to the northeastern part of Iraq. The thickness of the Cretaceous rocks is highly variable, not only in different parts of Iraq, but even in one single formation. As a whole, the thickness decreases towards southwest of the country.

طباقية صخور العصر الطباشيري المتكشفة في العراق، وكما جاء نتيجة للمسوحات الجيولوجية الإقليمية والتفصيلية (جيوسيرف 1971-1996)

المستخلص

تتميز صخور العصر الطباشيري في العراق وعلى نقيض صخور بقية العصور بتواجدها في كافة أنحاء القطر. ان هذه الصخور تنكشف بشكل واسع في الصحراء الغربية العراقية ، المناطق الشمالية والشمالية الشرقية وكذلك في منطقتي سنجار وقرة جوق.إن غالبية الصخور هي كاربوناتية مع فوسفورايت و سجيل وطفل وفتاتيات ناعمة. اما المدملكات فتتواجد في المناطق الشمالية الشرقية حيث تتواجد أيضا صخور نارية ومتحولة من عمر العصر الطباشيري. يتغير سمك صخور العصر الطباشيري بشكل كبير ليس فقط في مناطق مختلفة من العراق بل حتى في التكوين الواحد. وبشكل عام فان السمك يقل باتجاه الجنوب الغربي من القطر.

INTRODUCTION

This paper deals with the exposed Cretaceous formations only. The data are mainly gained from field maps 1:20 000 and 1:25 000 on scale which are compiled as geological maps of 1:100 000 on scale which are intern compiled and published as geological maps of 1:250 000 on scale. Small parts, in the northeastern and northern parts, are compiled from interpretation of aerial photographs, 1:40 000 on scale, with extrapolation of the data from neighboring areas which are mapped in the field, by Bolton (1956, 1957 and 1958), Bolton et al. (1960), Cobbett (1957), Hall (1957), Stevenson (1957) and Sissakian and Youkhanna (1973).

The hereinafter data are compiled from the available geological reports which are mainly the results of the regional geological mapping of the country, executed during 1971–1982, beside few reports which deal with detailed geological

* Expert, State Co. of Geological Survey and Mining, P. O. Box 986, Baghdad, Iraq.
e-mail, varoujan 49@yahoo.com

mapping carried out in certain parts of the country, the geological map of Iraq, scale 1:1000 000 (first, second and third editions), Buday (1980), Buday and Hak(1980),Buday and Jassim(1987). Moreover, geological reports of the Site Investigation Company for the northern and northeastern parts of the country are used to compile the geological data about the exposed Cretaceous formations in those parts. Therefore, the data mentioned in this paper represent the present state of knowledge of the Geological Survey of Iraq.

For simplification the exposed formations are divided into two main groups, depending on the geographic location (Fig.1).The first group represents the exposed formations in the northeastern (Fig.2) and northern (Figs. 3&4) parts, whereas the second group represents the exposed formations in the Western Desert (Figs. 5&6). Moreover, the first group is subdivided into two parts representing the eugeosynclinal formations and the miogeosynclinal formations.

EUGEOSYNCLINAL UNITS

The exposed units are presented in Figs. 2 & 3, the mentioned thicknesses represent the type locality, or as mentioned.

1. Qulqula Series:-

Lithology: The lower part consists of limestone and white chert, overlain by red, green and gray chert with intercalations of radiolarian limestone, overlain by mudstone and detrital limestone. The upper part consists of conglomerate, interbedded with gray shale, detrital limestone and white chert.

Thickness: 3500m

Environment: Shaly-calcareous and radiolarian-ophiolitic preflysch stage of the geosynclinal sedimentation with clear eugeosynclinal origin (Lower part). Marine Eugeosynclinal (flysch type) (Upper part).

Age: Barremian-Aptian (Lower part), Cenomanian-Santonian? (Upper part)

2. Qandil Series:-

This series is very complex, it includes many groups, and these are:-

***Penjween, Mawat, Bulfat, Pushtashan, Qandil* and *Serginil* Groups.** The lithology is complex, with obscure relations between the different groups.

Lithology: Mainly sheared limestones, phyllites, massive metamorphosed limestones, serpentine intrusions, calc schist, basalts, metabasalts, diabase, amphibolite, norite and granodiorite.

Thickness: 3500m

Environment: Deep marine with volcanic and metamorphic activities.

Age: Lower Cretaceous

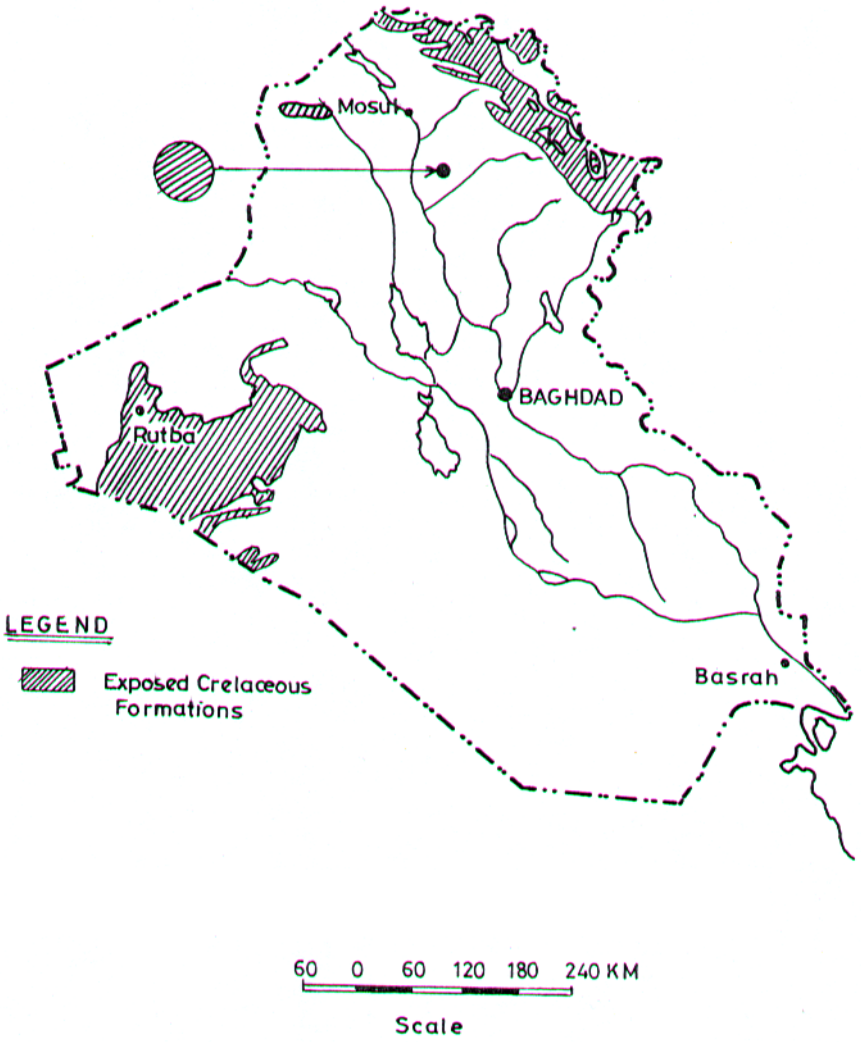

Fig. (1): The exposed Cretaceous formations in Iraq

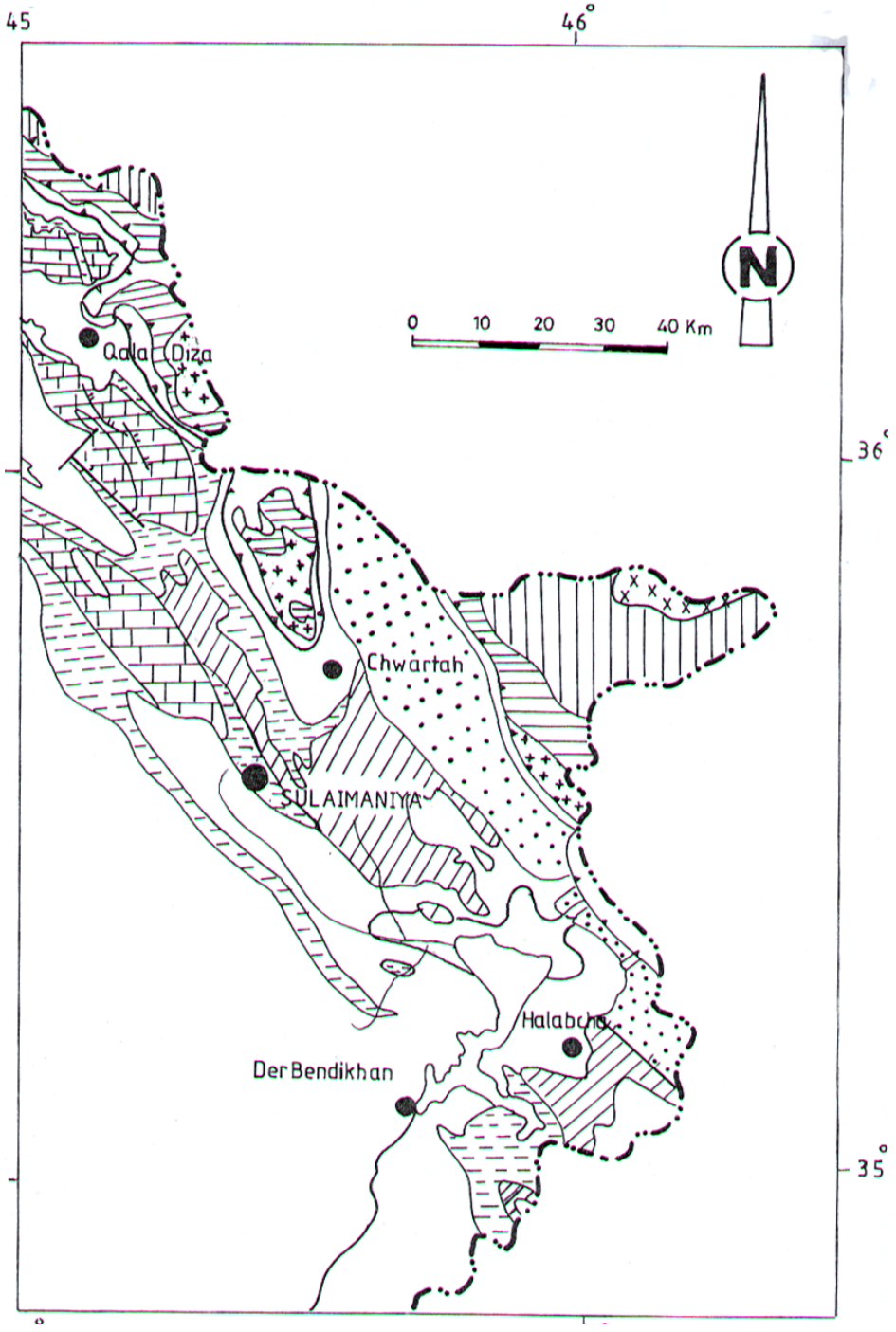

Fig. 2: The Northeastern sector (for legend refer to Fig. 7)

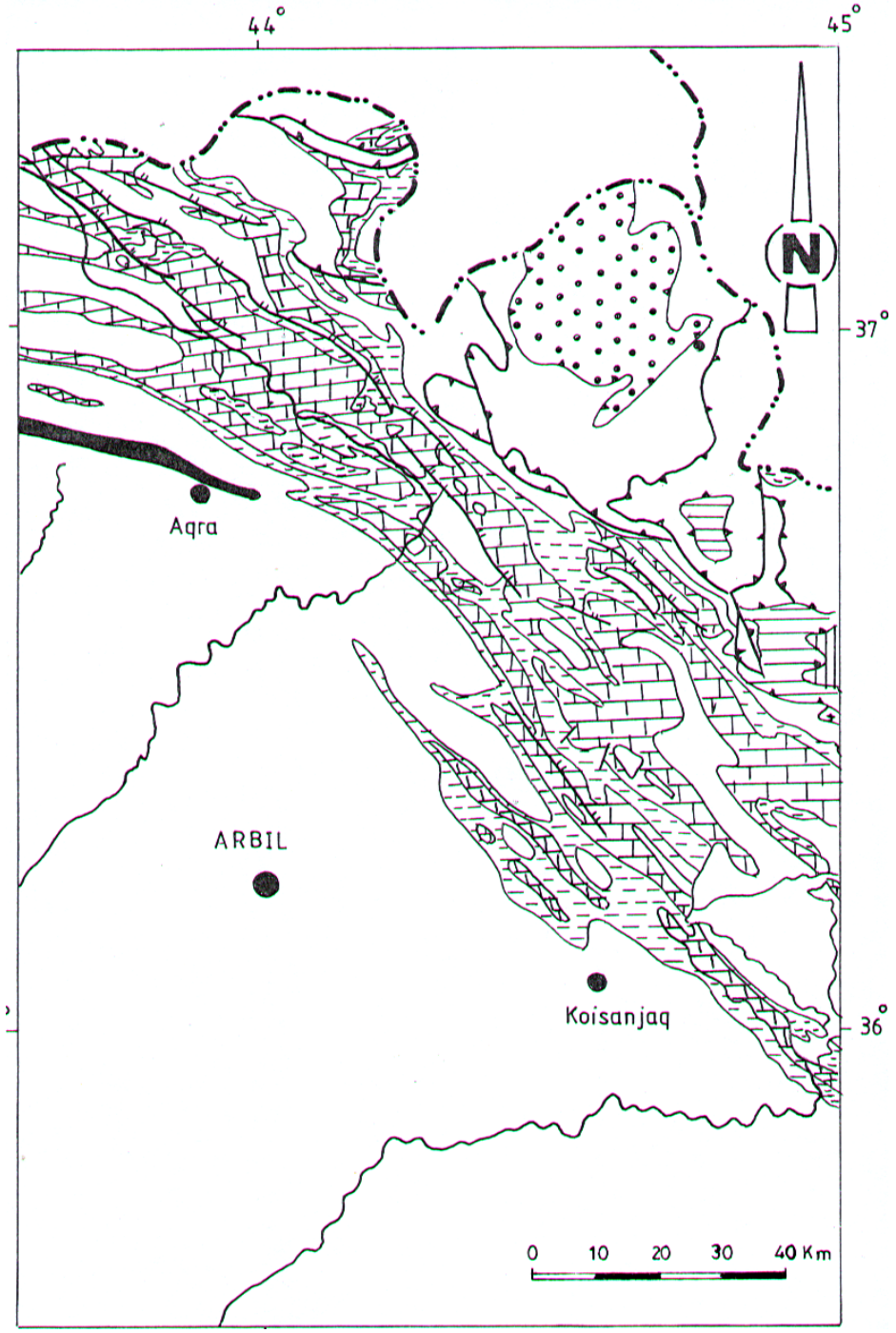

Fig. 3: The central Northern sector (for legend refer to Fig. 7)

3. Shalair Series:-

Lithology: Mainly phyllites, quartzites, greywackes, basic volcanics, sheared coralline limestone.

Thickness: 3000m

Environment: Marine stratiform form type of volcanic origin.

Age: Albian-Cenomanian

4. Kata Rash Series:-

Lithology: Acidic, intermediate and basic lavas, andesite, granite, mudstone, and limestone

Thickness: More than 3000m.

Environment: Marine, lava flows.

Age: Cenomanian-Turonian?

THE UNSTABLE SHELF AND MIOGEOSYNCLINAL UNITS

The exposed formations are presented in Figs. 2, 3&4.

1. Balambo Formation:-

It is one of the most widely spread formations of the Cretaceous Period in Iraq. It extends from the Iraqi-Iranian borders towards northwest till west of Rawandooz, with frequent interfingering with Sarmord and Qamchuqa Formations.

Lithology: Thinly bedded blue marls, dark blue shales, radiolarian limestone and thin bedded globogerinal limestone.

Thickness: 762m, ranges from 200-900m.

Environment: Open marine

Age: Lower Cretaceous (Valanganian-Turonian)

Equivalents: The formation passes laterally into Qamchuqa and Sarmord Formations. In Iran the Fahlyian and Sarwak Formations are the equivalents.

2. Garagu Formation:-

The formation is exposed only in the vicinity of the type locality in Gara Anticline.

Lithology: Mainly limestone with some marls and sandstones in the upper part.

Thickness: 92m, disappears off the type locality.

Environment: Marine, shallow water, tidal flat.

Age: Lower Cretaceous (Valanganian -Hauterivian)

Equivalents: In Iraq Yamama Formation, in Turkey Cudi Group are the equivalents. The formation passes eastwards into Qamchuqa, Sarmord and Ratawi Formations.

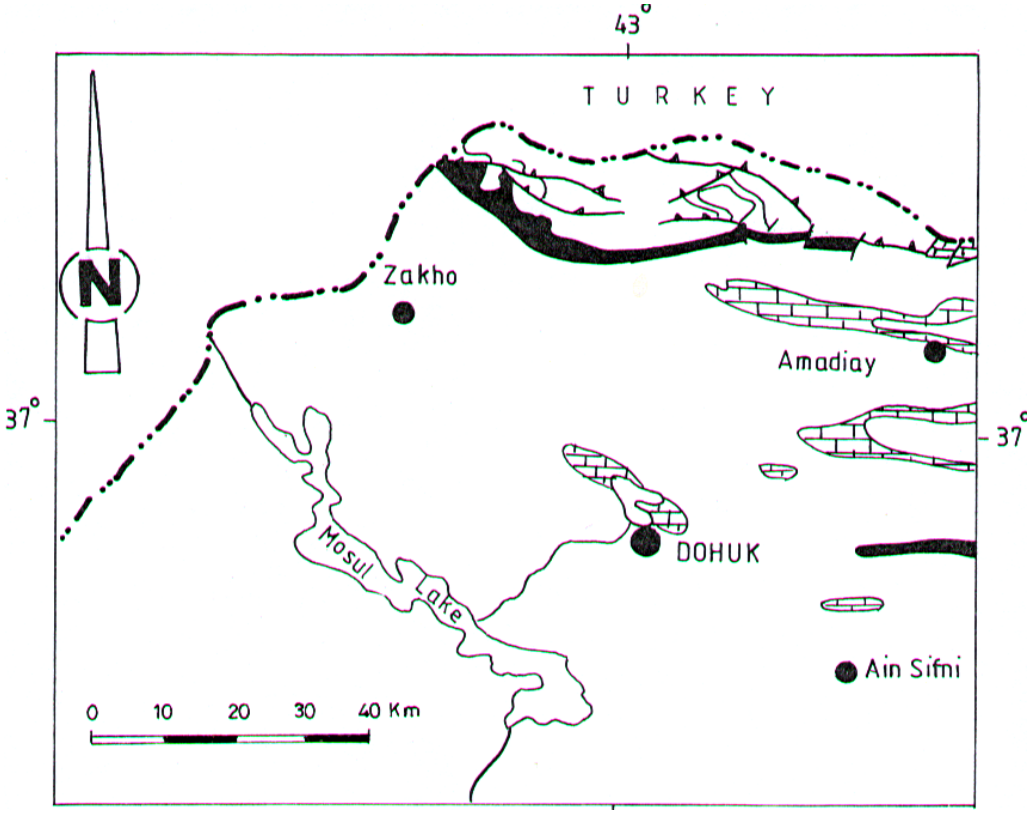

Fig. 4: The Northwestern sector (for legend refer to Fig. 7)

3. Sarmord Formation:-

It is one of the most widely spread formations of the Cretaceous Period in Iraq. It extends from the Iraqi-Iranian borders toward northwest till west of Rawandooz, with frequent interfingering with Balambo and Qamchuqa Formations:

Lithology: Mainly brown and blue marls with alternations of marly limestones.

Thickness: 455m.

Environment: Marine, inner shelf.

Age: Lower Cretaceous (Hauterivian-Barremian)

Equivalents: In Turkey Cudi Group, in Iran Gadwan Formation, in Iraq Zubair, Ratawi, Qamchuqa and Balambo are the equivalents.

4. Qamchuqa Formation:-

It is one of the most widely spread formations of the Cretaceous Period in Iraq. It forms the bulk of the main mountains in the northern and northeastern parts of Iraq, and is characterized by massive escarpments.

Lithology: Mainly massive dolomites and limestones.

Thickness: 799m

Environment: Warm tropical-subtropical, shelf-inner shelf marine conditions of normal salinity.

Age: Lower-Upper Cretaceous (Albian-Cenomanian)

Equivalents: In Turkey Cudi Group, in Kuwait and Saudi Arabia Shuaiba Formation, in Iran Dariyan and Fahlyian Formations are the best equivalents. The formation passes (eastwards) to Sarmord and Balambo Formations.

5. Dokan Formation:-

It has relatively restricted distribution, especially in surface sections, near the type locality.

Lithology: Mainly oligosteginal limestone.

Thickness: 4m, and up to 500m in Dokan vicinity.

Environment: Open Sea

Age: Upper Cretaceous (Cenomanian)

Equivalents: In Iran Sarwak Formation, in Iraq Mishrif, Rumaila, Ahmadi, Rutba and Balambo Formations are the equivalents. It is missing in Syria and Turkey.

6. Kometan Formation:-

It is one of the wide spread formations of the Cretaceous Period in the northeastern part of Iraq.

Lithology: Globigerinal-oligosteginal limestones.

Thickness: 36 m and up to 500m in the northeastern parts of Iraq.

Environment: Basinal marine of bathyal depth.

Age: Upper Cretaceous (Lower Turonian)

Equivalents : In Kuwait and Saudi Arabia, Wasia and Gudair Formations, in Iran Surgan Formation, in Syria, Soukhne Formation, in Turkey Karababa Formation, in Iraq Mashura and Sa`adi Formations are the equivalents.

7. Gulneri Formation:-

It is restricted to the type locality only, in the northeastern part of Iraq.

Lithology: Calcareous and bituminous shales.

Thickness: 1-2m

Environment: Marine, euxinic.

Age: Upper Cretaceous (Lower Turonian)

Equivalents: In Iran Surgash Formation is the equivalent. In Iraq no exact age and facies correlatives are known.

8. Merge Formation:-

It is restricted to the type locality only, in the northern part of Iraq.

Lithology: Mainly massive limestone, conglomeratic at the base.

Thickness: 46m
Environment: Marine, neritic.
Age: Upper Cretaceous (Turonian)
Equivalent: None

9. Aqra-Bekhme Formation:-

It is one of the most widely spread formations of the Cretaceous Period in the northern and northeastern parts of Iraq. It forms the bulk of the main mountains and is characterized by massive scarps. The formation was previously considered as two formations (Bellen et al., 1959). They were grouped as one formation by Jassim et al. (1984).

Lithology: Mainly limestones, reef-building, bituminous, dolomitized, globigerinal and detrital.
Thickness: 739m in Aqra, ranges from 100 to 1050m.
Environment: Marine, reef-fore reef.
Age: Upper Cretaceous (Upper Campanian-Lower Maastrichtian)
Equivalents: In Syria "massive limestone", in Turkey Kermav Formation, in Iraq Shiranish, Tanjero, Tayarat and Hartha are the equivalents.

10. Hadiena Formation:-

It is restricted to the type locality area only in the northern part of Iraq and unknown else where (in surface and subsurface sections).

Lithology: Dolomites and limestones, overlain by sandy limestone, marly limestone and conglomerate.
Thickness: 755m, dissapears off the type locality.
Environment: Marine miogeosynclinal deposit, between the ridge and trough.
Age: Upper Cretaceous (Upper Campanian-Lower Maastrichtian).
Equivalents: In Turkey Kirmav Formation, in Iraq Shiranish Formation are the equivalents.

11. Shiranish Formation:-

It is a widely spread formation of the Cretaceous Period in the northern, northeastern and locally in the northwestern parts of Iraq. It fills the trough of main synclines and grabens forming slopes and undulatory plains.

Lithology: Mainly marl (blue and white) with marly limestone, glauconitic and bituminous (locally).
Thickness: 228m, reaches up to 850m (in Anah well No.1).
Environment: Marine, deep water in subsiding basin.
Age: Upper Cretaceous (Upper Campanian-Upper Maastrichtian)
Equivalents : In Syria "Shiranish Formation", in Turkey Kermav and Gurpi Formations,in Iran Gurpi Formation, in Kuwait Bahra Formation, in Iraq Hadiena (only to the lower part of Shiranish), Tayarat , Hartha, Aqra-Bekhme,

Tanjero and Digma (only to the upper part of Shiranish) Formations are the equivalents.

12. Tanjero Formation:-

It is a widely spread formation of the Cretaceous Period in the northeastern part of Iraq. It forms slopes and undulatory plains.

Lithology: Silty marls, siltstones, sandstones, conglomerates and locally silty limestones, with main character of khaki color.

Thickness: 2018m, ranges from 500 to 2000m.

Environment: Marine, flysh sediments of sinking geosynclinal trough.

Age: Upper Cretaceous (Upper Campanian-Upper Maastrichtian)

Equivalents: In Iran Maastrichtian Flysch and chert conglomerates, in Turkey Kermav Formation and Hakari Complex in Iraq Shiranish Formation are the equivalents.

THE STABLE SHELF UNITS

The Cretaceous formations within the Stable Shelf are exposed only in the Iraqi Western Desert covering large area, which extends mainly south of latitude $33^{\circ}\ 30'$ and limited between longitudes $39^{o}\ 30'$ and $42^{o}\ 00'$ (Figs. 5&6).

The exposed formations of the Cretaceous Period are reviewed hereinafter (from oldest to youngest) with more details than other parts of Iraq due to many new findings.

1. Nahr Umr Formation:-

The formation was recognized by Al-Mubarak and Amin (1983) for the first time in the Western Desert. It extends as narrow strip along Wadi Horan, southeast of H_1 then comes out of Wadi Horan as a narrow strip in north-south direction, for about 60km till the Express Way No.1, there it changes its direction to east-west and extends for about 65km,till 15km east of Rutba town. There, it is covered by Mauddud Formation (Fig. 4).

Lithology: Mainly quartzitic varicolored sandstones, with siltstones and claystones. Characterized by fining upward sequences. In karst areas, orthoquartzite is common. Petrified free trunks and leaves, could be locally found in the upper parts with a horizon of green sandy marl.

Thickness: Highly variable, from 3m in the extreme northeastern parts to 16m (exposed) in the central parts, then decreases towards west. In Tlaiha well the drilled thickness (from the surface) is 51m (not penetrated totally).

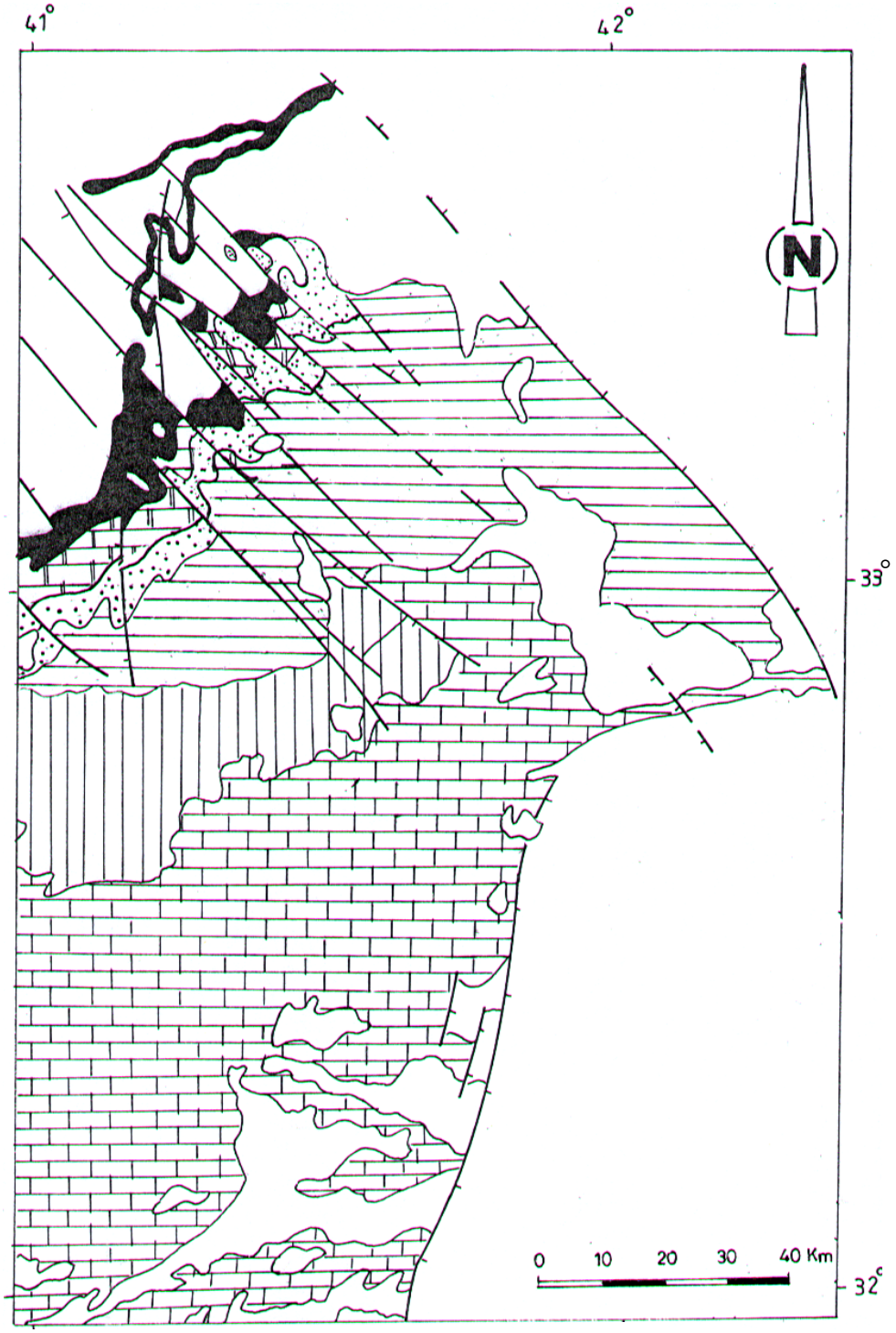

Fig. 5: The eastern sector of the Western Desert (for legend refer to Fig. 7)

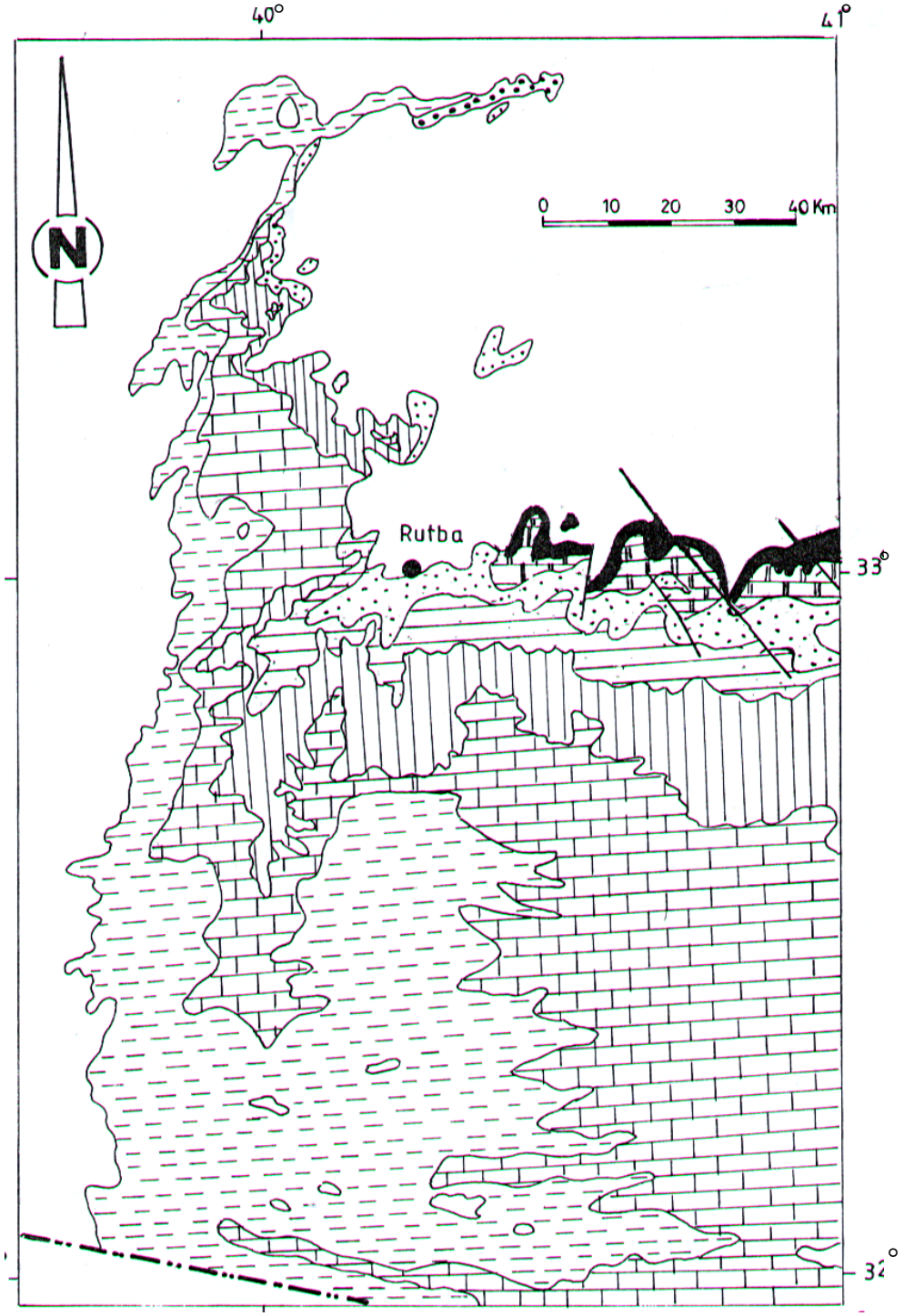

Fig. 6: The western sector of the Western Desert (for legend refer to Fig. 7)

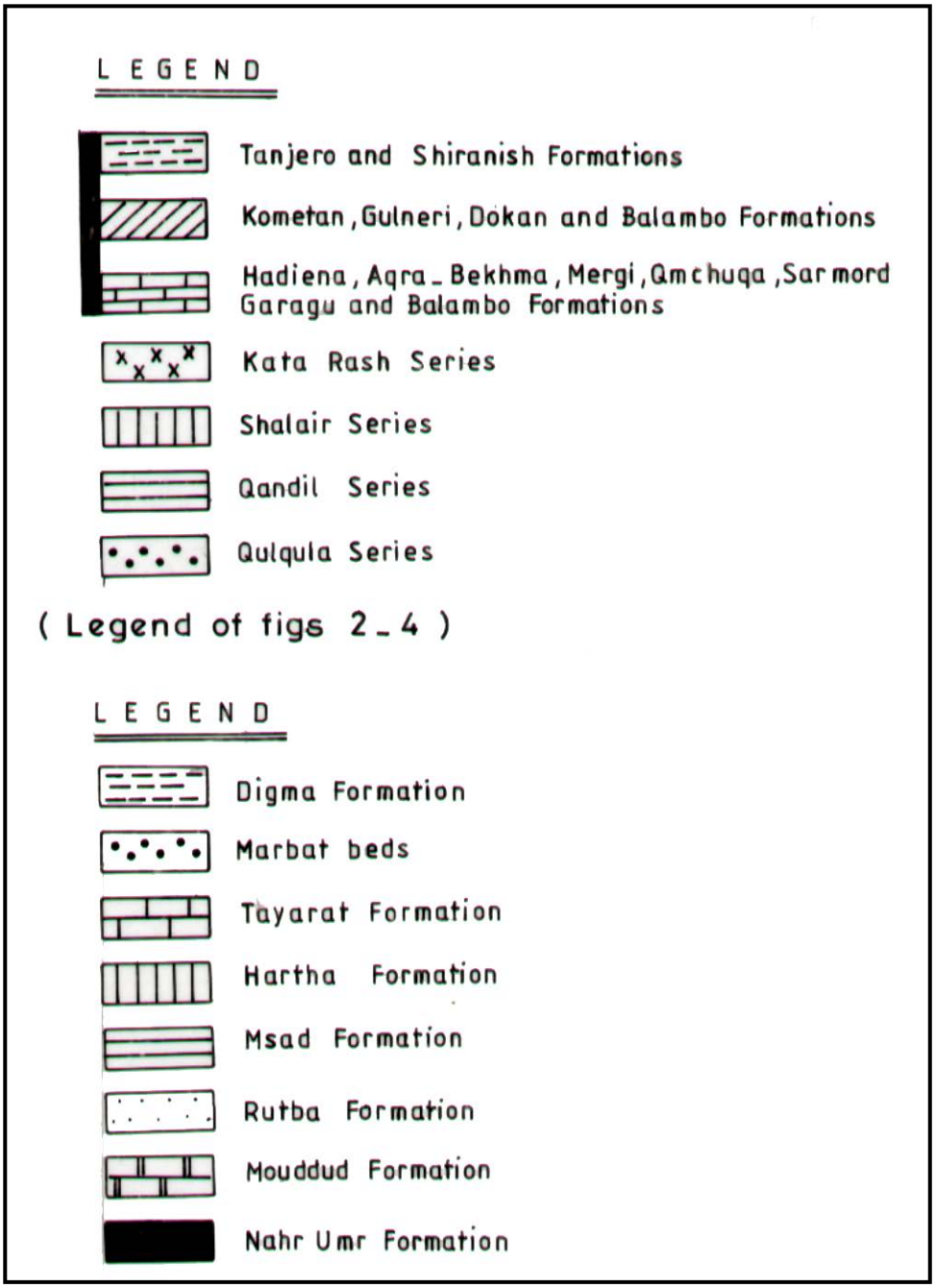

Fig. 7: Legend of figs 2 – 6

Environment: Marine, shallow coastal.

Age: Lower Cretaceous (early Albian-Cenomanian)

Lower Contact: Unconformable, overlying Zor Hauran, Ubaid, Hussainiyat, Amij; Muhawir and Najmah Formations, with sharp and clear contact mainly due to lithological difference.

Upper Contact: Mainly overlain conformably and gradationally by the Mauddud Formation, the contact is based on the first carbonate horizon. Locally overlain unconformably by the Ratga, Euphrates and Ghar Formations.

Equivalents and synonym: In Kuwait Nahr Umr Formation, in Turkey Areban Unit, in Syria Albian basal clastics and Aptian-Albian clastics, in Iraq Jawan, Rim, Qamchuqa and Sarmord Formations are the equivalents.

2. Mauddud Formation:

The formation was recognized by Al-Mubarak and Amin (1983) for the first time in the Western Desert. Jassim et al. (1984) grouped the formation with the Nahr Umr Formation. But in this paper the proposal of Al-Mubarak and Amin (1983) is adopted, because it was ascertained by Al-Azzawi and Dawood (1996). It extends as a narrow strip, starting from north of Wadi Amij in northeast - southwest direction for about 50km till south of the Express Way No.1. There, it changes its direction towards east -west and extends for about 70km till 10km east of Rutba town. There, it is covered by Rutba -Msad Formation (Figs. 5&6).

Lithology: Mainly dolostones and limestones, silty or marly, yellow and red in color. The lower part is rich in oysters.

Thickness: 9m, ranges from 5 to 52m (increasing westwards).

Environment: Marine, central -inner shelf.

Age: Lower-Upper Cretaceous (Albian-Cenomanian)

Lower Contact: Underlain conformably and gradationally by the Nahr Umr Formation.

Upper Contact: Usually overlain unconformably by the Rutbah Formation. The contact is clear and sharp, based on the first appearance of the clastics above the carbonates.

3. Rutba Formation:-

The formation is grouped with Msad Formation by some authors like Jassim et al. (1984). But, the formation (in this study) is presented separately according to its original definition by Foran and Keller (1937). The formation is exposed north of Wadi Amij and extends as a narrow strip toward southwest till the Express Way No.1. There, it changes its direction to east-west and extends for about 130 km, till 10km west of Rutba town. There, it changes again its direction towards north and extends till the western rim of Al-Ga'ara depression, north of Wadi Mullusi (Figs.5&6).

Lithology: Mainly sandstones, white and yellow in color, locally changes to orthoquartzite which is colored by dark brown desert varnish usually friable, cross bedded, fine to coarse grained.

Thickness: 9m in the northeastern part, increases to 35m in the southwestern part (of the exposure areas).

Environment: Marine, shallow water (beach).Although some fluvial or fluvio-lacustrine indications exist too.

Age: Cretaceous (Cenomanian)

Lower Contact: Underlain unconformably by many formations (in different-parts), Mulussa, Zor Horan, Najmah and Mauddud Formations. The contact is sharp and clear due to lithological differences.

Upper Contact: Overlain unconformably? by the Msad Formation. The contact is based on the first appearance of dolomite or sandy dolomite or silty marl. Locally iron oxides or red claystone is developed at the contact. In the northern rim of Al-Ga`ara depression it is overlain by the Digma Formation.

Equivalents: In Saudi Arabia Sakakah Formation, in Syria Nubian Formation, in Iraq Mahilban, Rumaila, Dokan and Balambo Formations are the equivalents.

4. Msad Formation:

The formation is exposed in the same areas where the Rutbah Formation is exposed. But in the eastern part of the exposed area, it is widely spread, covering vast area (Figs. 5&6). There it was considered by Al-Mubarak and Amin (1983) as the Mahaliban Formation, but latter on they changed it to Msad Formation. It wedges out west of Rutba town. Jassim et al.(1984) grouped the formation with Rutba Formation. But in this paper the original definition was followed that was ascertained by Al-Azzawi and Dawood (1996).

Lithology: Mainly dolomites, pink, grey, yellow and red in color, sandy, silty and marly, locally fossiliferous, with rare marls and sandstones of yellow grey and brown colors.

Thickness: 16m in the eastern part, increases to 49m in the western part, then decreases and disappears northwest of Rutba town.

Environment: Marine, transgressive sea, with influx of ferruginous clastics.

Age: Cretaceous (Cenomanian -Turonian)

Lower Contact: Unconformable?, underlain by the Rutba Formation.

Upper Contact: Unconformable, overlain by the Tayarat or Hartha Formation based on the first appearance of yellow marl, which occasionally contains iron oxides, overlain by dolomite of fenestral porosity.

Equivalents: In Kuwait Mishrif and Magwar Formations, in Iran Sarvak Formation, in Syria Lower Judea Formation, in Turkey Mardin Formation, in Iraq Mishrif, Dokan, Rumaila, Mergi and Gir Bir Formations are the equivalents.

5. Hartha Formation:

The formation is grouped by some authors with the Tayarat Formation, as the Hartha -Tayarat Group (Jassim et al., 1984.). But, they were considered here separately, according to their original definitions.

The formation is exposed west of Kilo 160 area along Wadi Al-Hzimi, and extends east - west for about 150km, till 10km west of Rutba town. There it wedges out (Figs. 5&6).

Lithology: It consists of two parts. The lower part is composed of sandstones with local conglomerates, the sandstones change laterally to sandy limestone. The upper part is composed of yellow and green fossiliferous sandy marls alternated with fossiliferous limestones, occasionally contain reef- building corals.

Thickness: 45m near Rutba town, increases southeastwards to 160m, but decreases again eastwards and disappears, (truncated by fault).

Environment: Marine, warm tropical to sub -tropical of shelf depth.

Age: Cretaceous (Upper Campanian – Lower Maastrichtian)

Lower Contact: Unconformable, underlain by Msad Formation.

Upper Contact: Conformable, overlain by the Tayarat Formation. Locally basal conglomerate is developed (Jabal Tayarat vicinity).The contact is based mainly on the first appearance of massive carbonates of the Tayarat Formation and on the top of green marl of the Hartha Formation.

Equivalents: In Saudi Arabia Aruma Formation, in Kuwait Bahrah Formation, in Syria Soukhne Formation, in Turkey Karabogas Limestone, in Iraq Shiranish, Tanjero, Aqra-Bekhme and Digma Formations are the equivalents.

6. Tayarat Formation:

The formation is exposed widely, south of Kilo 160 area and extends westwards for about 160km.There, south of Jabal Tayarat (the type locality), the exposure area narrows drastically and extends as narrow strips along wadi Horan, then northwards along the western rim of Al-Ga`ara depression and part of its northern rim (near Marbat Al-Hussan) where it wedges out (Figs. 5&6). It is worth to mention that in Jabal Tayarat vicinity, the formation may interfingers with Digma Formation and probably the upper part of Hartha Formation (oral communication with Dr. Khaldoun Al-Bassam, 1999). In the Ga'ara-Rutba area the name "Na'aja Beds" was informally used by Al-Bassam et al. (1990) for the Tayarat Formation, but it was latter defined by Hassan (1998) as the Tayarat Formation.

Lithology: Mainly yellow and green marls, dolomites and limestones. Locally sandstones and very rarely conglomerates occur too. Quartz geods and chert concretions are common.

Thickness: 35m in Jabal Tayarat, increases rapidly to about 200m, towards southeast, between wadi Ghadaf and wadi Tabbal.

Environment: Marine, inner shelf, shallow warm conditions and subtidal for

the upper part.

Age: Upper Cretaceous (Upper Campanian-Maastrichtian)

Lower Contact: Conformable, underlain by the Hartha Formation.

Upper Contact: The overlying formation is the Digma Formation, in the southwestern and western parts. The contact is conformable based either on the top of the last shelly limestone or the base of the first yellowish green marl of the Digma Formation. In the southeastern and eastern parts the formation is overlain unconformably by the Umm Er Radhuma Formation, based on a horizon of pink and papery shale, overlying shelly chert-bearing limestone.

Equivalents: As in Hartha Formation.

7. Digma Formation:-

The Digma Formation in this paper was introduced after detailed stratigraphic study of the Cretaceous rocks in the Western Desert (Hassan, 1998) and adopted by GEOSURV. It has no relation to the so-called " Digma Formation " of Buday and Hak (1980), which was renamed as " Semhat Formation " in Jassim et al. (1984). However, the upper part of the so-called " Jeed Formation " introduced by Jassim et al. (1984) is identified as the Digma Formation, in this paper. It was identified by Al-Bassam et al.(1990) as the " Safra Beds ". However, detailed work has clearly defined the Digma Formation in the Western part of the Western Desert as a succession of a yellow marl and shale topped by shelly limestone. Digma Formation and upper part of the Tayarat Formation are interfingering.

The Digma Formation is exposed along the northern and western rims of Al-Ga`ara depression, as narrow strip, then extends southwards till the Iraqi - Saudi Arabian borders. There, it extends for 50 -60km eastwards (Fig. 6).

Lithology: Papery marl, ochre in color, claystone, porcelenite, phosphorite and shelly limestone. Oysters (lofa), pelecypods and gastropods are common.

Thickness: 15m in Rdhuma Al-Safra,increases west and southwards to 30-40m.

Environment: Marine, inner shelf.

Age: Upper Cretaceous (Upper Maastrichtian)

Lower Contact: Conformable, with the underlying Tayarat Formation and locally interfingers with its upper part (personal communication with Dr. Khaldoun Al-Bassam, 1999). In the central parts of the northern rim of the Ga'ara depression it is underlain by "Marbat Beds". However, in the extreme northeastern part of the northern rim of Al-Ga'ara depression it is underlain unconformably by the Gaara Formation.

Upper Contact: Conformable, with the overlying Akashat Formation, based on the last bed of shelly limestone, which is usually silicifide. However, in the northern rim of Ga'ara it is truncated by erosion.

Equivalents: In Syria Soukhne Formation, in Jordan Belqa Formation, in Turkey Karababa Formation, in Iraq Hartha, Tayarat and Shiranish Formations are the equivalents.

8. Marbat Beds:

The Marbat Beds were recognized by Al-Bassam et al. (1990) for the first time along the northern rim of Al-Ga`ara depression, from Qasir Al-Halgoom westwards to Marbat Al-Hisan Hill (Fig. 6).

Lithology: Mainly pebbly brown sandstone and yellow, rippled sandy dolostone. South westwards of Marbat Al-Hisan (type locality) the facies changes to coarser clastics, as fining upwards cycles with conglomerates, at base passing upwards to pebbly and fine sandstones, silty claystone, claystone, sandy dolostone and rarely fossiliferous detrital limestone. Several cycles of this type were recognized. Petrographic studies revealed that this unit is composed of 46% dolostones, 15% limestones, 27% sandstone and 12% claystone.

Thickness: 20 – 50 m (increasing from south to northeast).

Environment: Fluvial and fluviomarine.

Age: Upper Cretaceous (Campanian – Maastrichtian)

Lower Contact: Unconformable, overlying the Ga'ara Formation, the contact is based on the first appearance of pebbly calcareous sandstone or conglomerate.

Upper Contact: Conformable, transitional either with Tayarat or Digma Formations. In the former case, the contact is based on the first appearance of thick creamy dolomicrite, whereas in the latter case, the contact is based on the first appearance of thick yellow dolomicrite. Both contacts revealed interfingering of marine with delta sediments.

Equivalents: Hartha Formation, Tayarat and / or Digma Formations.

DISCUSSION

Because no recent data are added to the stratigraphy of the exposed Cretaceous in the northern and northeastern parts of Iraq, the discussion will be emphasized only on the exposed Cretaceous rocks in the Iraqi Western Desert.

The type locality of the **Nahr Umr Formation** is in Nahr Umr oil filed. According to Buday (1980), it is well distributed over the northeastern margins of the Stable Shelf in subsurface sections. Al-Mubarak and Amin (1983) recognized the formation in the Western Desert along wadi Horan during the regional geological mapping. This was ascertained by Al-Azzawi and Dawood (1996). However, according to the most recent study carried out by Hassan (1998), the formation is not encountered in the exposed stratigraphic sequence. He claimed that the whole sequence of the Cretaceous rocks till the Msad Formation belongs to the Rutbah Formation, which means the sequence including Nahr Umr, Mauddud and Rutbah Formations in this paper. He also claimed Aptian - Cenomanian age for this sequence.

It is believed by GEOSURV that the Cretaceous sequence up to Msad Formation includes surely Rutba Formation which is underlain by Mauddud and Nahr Umr Formations, respectively and as they are presented on the geological maps 1:25 000 on scale and smaller (1:1000 000) (Sissakian, 2000).

The same holds good for the **Mauddud Formation,** which is also claimed by Hassan (1998) to be the equivalent of the **Msad Formation**. The two formations have different ages, as they are defined from their type localities.

The **Hartha Formation** which was proved to be exposed in the Western Desert by Al-Mubarak and Amin (1983), Buday and Hak (1980) and Al-Azzawi and Dawood (1996), is denied by Hassan (1998). He included the sequence of the Hartha Formation with that of the Tayarat Formation. Buday and Hak (1980) described a basal conglomerate horizon between Hartha and Tayarat Formations, south of Jabal Tayarat. Al-Mubarak and Amin (1983) described a fenestral porosity horizon in the contact between them. Both criteria are indications of a break in sedimentation; therefore the two formations can be separated accordingly. They were mapped as two formations in the detailed geological survey of Akashat-Ga'ara-Rutba-H_3 area (Al-Bassam et al., 1998). Moreover, the lithology of the combined Hartha and Tayarat sequence does not resemble the lithology of either Hartha or Tayarat Formation separately, which means the exposed sequence is also a good indication for the presence of the two formations.

The **Digma Formation**, which is the youngest Cretaceous rocks in the Western Desert, was first recognized and mapped by Buday and Hak (1980), although Sattran and Mansour (1975) referred to the presence of the formation in the Ga`ara area. But, the sequence claimed by Buday and Hak (1980) as the Digma Formation represents the sequence of Hartha Formation and the lower part of the Tayarat Formation. Therefore, Hassan (1998) is the first who recognized the true Digma Formation (Maastrichtian) in the Western Desert, which is the same sequence, called as "Safra Beds" by Al-Bassam et al. (1990). It is worth to mention that Jassim et al. (1984) claimed the name **Jeed Formation** for the involved sequence with part of the Tayarat Formation. Therefore, the name "Jeed Formation" is abandoned and the name Digma Formation is used instead.

The following studies are recommended:-

- The study of precise age (using isotopes), environment and areal distribution of the eugeosynclinal units are highly recommended.
- The detailed stratigrphic study of the sequence involving Nahr Umr, Mauddud, Rutbah, Msad Hartha and Digma Formations is highly recommended to establish their identity.
- Detailed stratigraphic study of Merge and Hadiena Formations since they are known only from their type locality areas, without any farther extensions.
- The state of Aqra-Bekhme Formation, whether they are one formation or otherwise.

REFERENCES

Al-Azzawi,A.M. and Dawood,R.M.,1996. Detailed geological survey of bauxite investigation in northwestern part of Kilo 160 area (Western Desert). GEOSURV Lib. No.2431.

Al-Bassam,K.S.,Karim,S.A.,Mahmoud,K.,Yakta,S.A.,Saeed,L.K.and Salman,M.,1990. Geological survey of the Upper Cretaceous -Lower Tertiary phosphorite- bearing sequence, Western Desert, Iraq. GEOSURV Lib. No. 2008.

Al-Mubarak,M.A. andAmin,R.M.,1983.Regional geological mapping of the eastern part of the Western Desert and the western part of the Southern Desert . GEOSURV Lib.No.1380.

Bellen, R.C., Van, H.V. Dunington, Wetzel, R. and Morton, D., 1959. Lexique Stratigraphique International. Asie, Fasc10a Iraq, Paris.

Bolton,C.M.G.,1956. The Geology of the Rawanduz-Gala Dizeh area. Site Investigation Co., GEOSURV Lib.No.268.

Bolton,C.M.G.,1957. Report for summer season 1957. The Geology of Rania area. Site Investigation Co., GEOSURV Lib.No.271.

Bolton, C. M. G., Hall, P. K., McCarthy, M. J., Cobbett, G. P. R. and de Villiers ,P. R., 1960. The Geological Map of Iraq. Site Investigation Co. England.

Buday,T. and Hak,J.,1980. Report on the geological survey of the western part of the Western Desert .GEOSURV Lib.No.1000.

Buday, T.,1980. The Regional Geology of Iraq, Vol.1, Stratigraphy and Paleontology. GEOSURV,Baghdad , 445P.

Buday,T. and Jassim ,S.Z.,1987. The Regional Geology of Iraq , Vol.2, Tectonism, Magmatism and Metamorphism. GEOSURV, Baghdad 358 P.

Cobbett,G.P.R.,1957. Geology of the Kani Rash area .Site Investigation Co., GEOSURV Lib.No.270.

Foran and Keller,1937 in Bellen, R. C. Van, Dunnington, H. V., Wetzel, R. and Morton,D.,1959. Lexique Stratigraphique International. Asie, Fasc 10a, Iraq , Paris.

Hall,P.K.,1956.Geology of the Baibu area, east of Amadiya.Site Investigation Co. GEOSURV Lib.No.269.

Hassan,K.M.,1998.Palaeoecology and Stratigraphic Distribution of Cretaceous Molluscs, Western Desert, Iraq. Unpublished Ph.D. Thesis. Baghdad University, Baghdad, Iraq.

Jassim,S.Z.,Hagopian,D.H. and Al-Hashimi,H.A.,1986. Geological Map of Iraq, scale 1:1000 000, 1st ed. GEOSURV, Baghdad.

Jassim,S.Z.,Hagopian,D.H. and Al-Hashimi,H.A.,1990. Geological Map of Iraq, scale 1:1000 000, 2nd ed. GEOSURV, Baghdad.

Sattran V., and Mansour, J., 1975 in Buday, 1980. The Regional Geology of Iraq, Vol.1 Stratigraphy and Paleogeography. GEOSURV, Dar Al-Kitab Publishing House, University of Mousl, Iraq.

Sissakian,V.K.and Youkanna, R.Y.,1979. The Geology of Erbil -Shaqlawa -Koisanjaq -Raidar area. GEOSURV Lib. No. 975.

Sissakian V. K., 2000. Geological Map of Iraq, 3rd ed. Scale 1:1 000 000. GEOSURV , Baghdad, Iraq.

Stevenson, P. C. and Cobbett, P. G. R., 1958. Geological map, Kurdistan Series, scale 1:100 000, Sheet K_3, Merga Sur. Site Investigation Co., GEOSURV Lib. No. 275.