Microfacies of the Upper Cretaceous-Lower Tertiary Rocks of Um Rijam Area, South Jordan

by

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ABSTRACT

This paper deals, for the first time, with the microfacies of the Upper Cretaceous - Lower Tertiary rocks of south Jordan. Twenty three microfacies associations are recognized, described, discussed and illustrated.

This study gives a record of the stratigraphic sequences of the various microfacies, their paleoecologic significance and names of the rocks, taking into consideration the result of quantitative analysis of their insoluble residues.

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Introduction

The aim of this petrographic investigation of the Upper Cretaceous - Lower Tertiary rock samples collected from two sections measured at the Um Rijam area, south Jordan (Figs. 1, 2 & 3), is to achieve a quantitative nomenclature of these rocks on the basis of the relative amounts of the main contents of their insoluble residues (I.R.). This study also gives an insight into the paleoenvironmental conditions which prevailed during the deposition of these rocks. A third aim of these investigations, which are carried out for the first time on rocks from Jordan, is to present a record of the stratigraphic sequences of various microfacies that may be used as a tool for correlating rock succession of the same age and facies, at other localities, with these well dated rocks outcropping in the Um Rijam area.

Lithostratigraphy

The Upper Cretaceous - Lower Tertiary lithostratigraphic units recognized in the area under consideration have been recently studied by the present co-workers Youssef et al. (1982 a, b, in press), and by Abdel Malik (1982).

The following lithologic description of these units is based on field observations and laboratory studies namely, the quantitative analysis of the insoluble residue and microfacies of these rocks. The names of the three lithostratigraphic units recognized in this area are here amended to conform with the Code of Stratigraphic Nomenclature, (1970) as follows, from top to base :

Top 3 — Sar'a Formation.
2 — Taqiye Formation.
1 — Ghareb Formation.

Sar'a Formation : The Sar'a Formation is described in detail by Daniel (1963) who gave this name to Sar'a chalk and flint rock succession, defined on the slopes below the villages of Rafat and Sar'a (Surah) in the shaphela, Palestine and attributed this rock unit to the Lower and Middle Eocene.

The lower part (about 56 m) of the Sar's Formation in the Um Rijam area is represented by white to yellow massive limestone (fossiliferous foraminiferal biomicrite/sparce foraminiferal biomicrite/packed foraminiferal biomicrite; 93.87 - 99.86% carbonate, I.R. composed of : 0007 - 9.8 % clay and 0.00 - 2.77 % silt) and

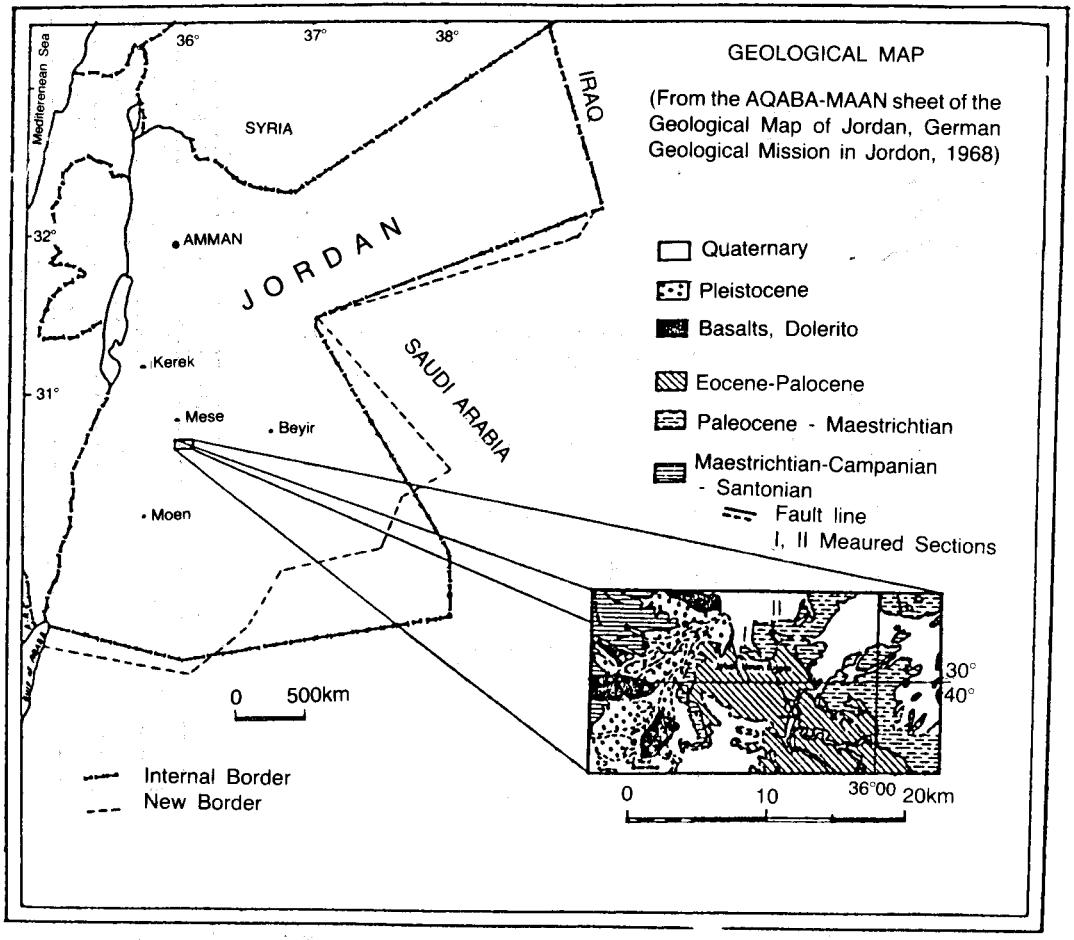


Fig. 1. Location Map

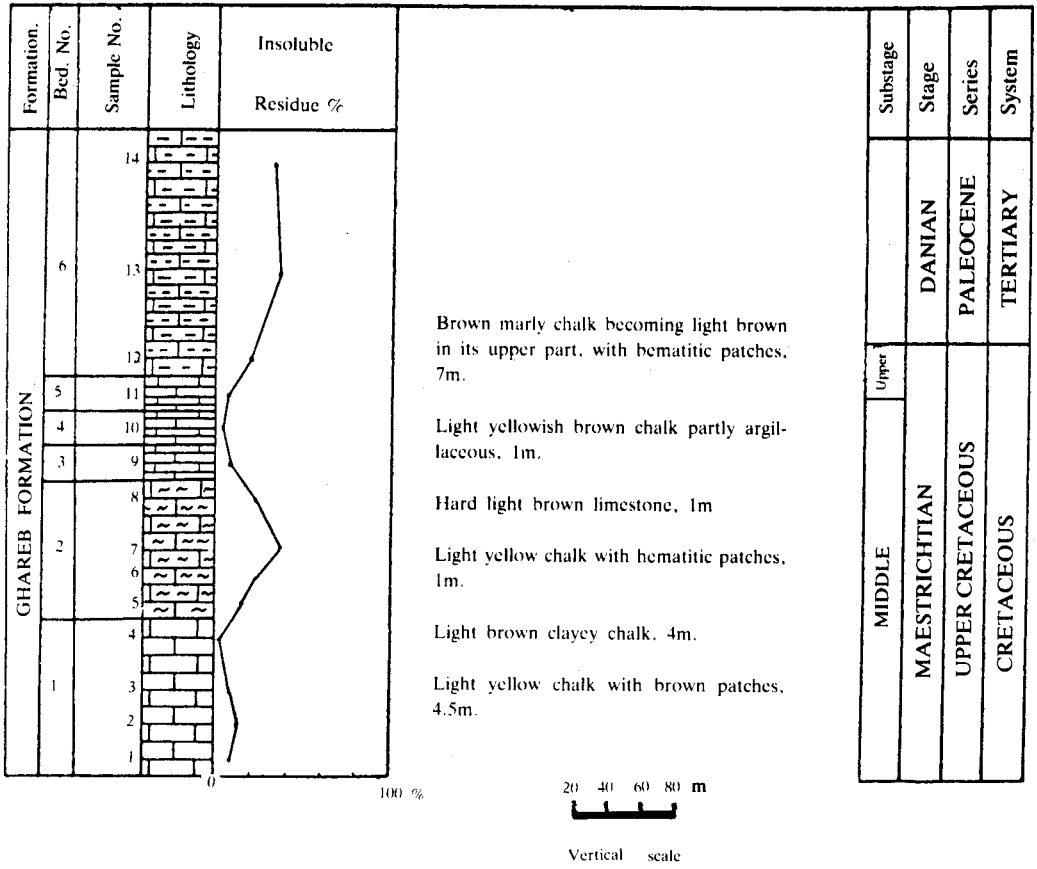
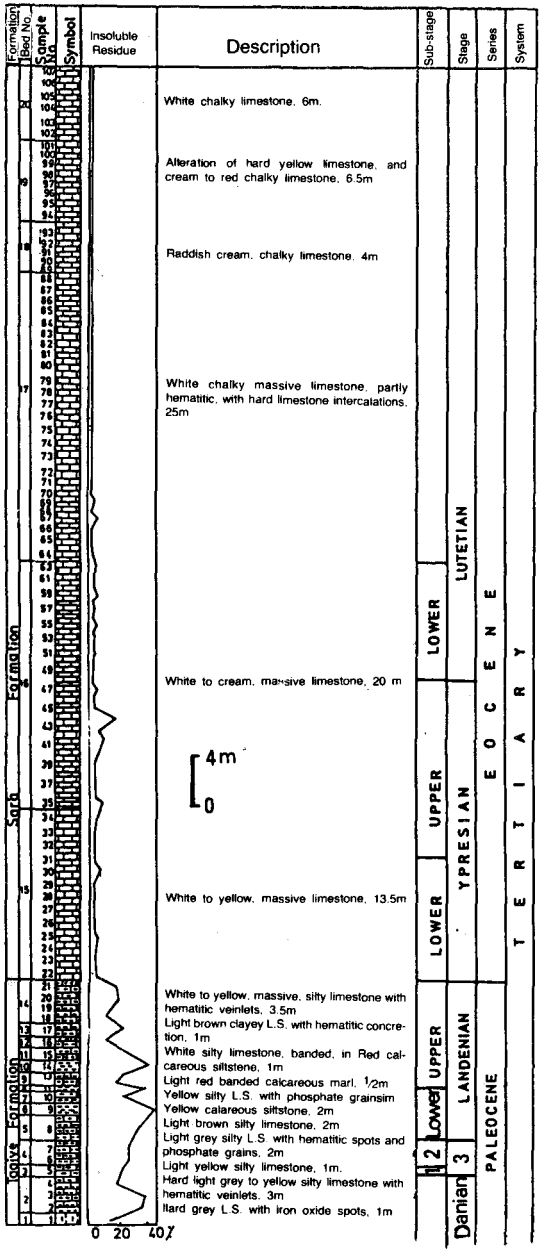


Fig. 2. Columnar Section of the Upper Cretaceous -Lower Tertiary rocks of Um Rijam II



1 Lower 2 Upper
3 Heersian

Fig. 3. Columnar Section of the Upper Cretaceous - Lower Tertiary rocks of Um Rijam I

white to cream massive limestone (fossiliferous foraminiferal biomicrite/sparce foraminiferal biomicrite/packed foraminiferal biomicrite, 93.19 - 99.92 % carbonate, I.R. : 0.08 - 6.33 % clay and 0.00 - 2.56 % silt), sometimes becoming chalky. The upper part (about 17 m) of this formation consists of alternations of hard yellow limestone and soft cream, sometimes light brown, chalky limestone (fossiliferous foraminiferal biomicrosparite/fossiliferous foraminiferal intramicrosparite/sparce foraminiferal biomicrosparite/packed poorly washed foraminiferal biosparite/packed sorted foraminiferal biosparite/fossiliferous rounded foraminiferal biosparite/gypsiferous intrasparite; 95.78 - 100.0 % carbonate, I.R. : 0.00 - 2.21 % clay and 0.00 - 2.0 % silt).

The thickness of the Sar'a formation in Um Rijam I is 73m. It is assigned to the Lower and the Middle Eocene., (Daniel, 1963; Youssef et al., a & b, in press and Abdelmalik 1982, in press).

Taqiye Formation : Daniel (1963) redefined and described in detail this rock unit which he restricted to the "Taqiye Marl" succession in Jordan and attributed it to the Paleocene. The same author also mentioned that some authorities correlated the Taqiye marl succession of Jordan with the Esna Shale formation of Egypt.

The Taqiye Formation in the Um Rijam area consists mainly of alternating beds of light grey chalk (packed poorly washed foraminiferal biosparite; 86.91 % carbonate, I.R. : 2.14 % clay and 7.79 % silt), and light green to light yellow silt and chalk (fossiliferous foraminiferal biomicrite/intramicrite./fossiliferous foraminiferal biomicrosparite; 59.61 - 81.25 % carbonate, I.R. : 5.78 - 12.30 % clay and 12.97 - 29.01 % silt). These become sometimes phosphatic, (fossiliferous foraminiferal biomicrosparite, 77.33 % carbonate, I.R. : 3.5 % clay and 19.16 % silts), or yellowish to reddish calcareous siltstone (38.02 % carbonate, 3.47 % clay and 58.51 % silt). White colouration dominates the lower part of this formation, while the upper part is, generally, light green to light brown.

The name Taqiye Formation is used here provisionally because the type section of this formation in east Jordan (Edh Dhira syncline), is said to be composed of clayey marls and marls (Daniel, 1963; p. 378). In the Um Rijam area, however, the sequence is made up of chalks and silty chalks of the same general colour as the rocks of the type section. The present co-workers believe that difference in lithology calls for a more accurate determination, i.e. quantitative nomenclature of rock types in the type section of the formation. If this expected quantitative nomenclature requires, as it is thought, a renomination of the rock types of the type

section of this formation, the necessary amendment of those rock types in that section should be then published. Otherwise, the provisional use of the name "Taqiye Formation" for that particular chalk succession at the Um Rijam area should be revised. It belongs to the Paleocene (Daniel, 1963; Youssef et al. 1982 and Abdelmalik 1982).

Ghareb Formation : The term Ghareb Chalk Formation is reviewed in detail by Daniel (1963). This formation, at the Um Rijam area, consists mainly of light yellow and light brownish yellow chalk, (fossiliferous foraminiferal biomicrite; 85.11 - 90.43 % carbonate, I.R. : 6.59 - 9.88 % clay and 1.95 - 5.01 % silt), few rather argillaceous chalk bands (sparce foraminiferal biomicrite; 63.33 - 83.32 % carbonate, I.R. : 12.36 - 20.44 % clay and 1.62 - 6.5 % silt) and a light brown limestone band (sparce foraminiferal biomicrosparite, 95.63 % carbonate; I.R. : 3.05 % clay and 1.32 % silt). Occasionally, iron oxide patches and stains intercalate the sequence.

The exposed thickness of the Ghareb formation at Gebel Um Rijam (Section II) is 18.5 m.

Its lower part (about 16.2m) is attributed to the Middle and Upper Maestrichtian whereas its upper part (7.4m) is assigned to the Lower Paleocene (Danian).

Microfacies

The petrographic terminology and nomenclature used here are those introduced by Folk (1959, 1962). Hoewer, the elaborate, rather quantitative "carbonate textural spectrum" of the Folk (1962) amendment is used here.

In addition to the "energy" interpretations of the various rock types given by Folk, an attempt to determine the "energy index" (E.I.) of Plumley et al (1962) is made here. The paleoenvironmental conditions are thus interpreted on the basis of Folk's classification and the E.I., wherever possible.

The present study is based on the examination of 150 thin sections which represent 121 rock samples of the Um Rijam succession.

The microfacies represented in the Um Rijam succession are grouped into the assemblages given below. Although the lumping of these assemblages is a convenient method of presenting the results, it raised some difficulties. The most relevant of these is that the differences in the paleontologic and the petrographic

characteristics of the rock types are so slight that they were not given their due importance, especially in determining the E.I. classes and subclasses which depend mainly on detailed differences of the rock components.

In the following description of microfacies, the sample numbers U.R.II, 1-14 are those of the Um Rijam section II, beginning by the oldest. The samples of section I are numbered 1-107, 1 being the lowermost.

1 — Micrite

Pl. I, Fig. 1

Matrix is microcrystalline. The rock is a marly chalk (I.R. : clay = 4.97%, silt = 19.31 %) and shows faint lamination.

Fragments of foraminiferal tests are abundant. Whole tests form less than 1 % of the rock. Intraclasts are not abundant and they range in size from fine to very fine (size grade). Some test fragments are phosphatized; an observation which is not very common. In most of the phosphatized rocks in the sequence, the process affects patches of the matrix, some of the allochems and far less frequently the fillings of tests and shell fragments.

The only representative of this type of rock is sample 10. E.I. III_3. According to Folk, this micrite indicates calm water conditions. The E.I., however, points to a "slightly agitated" environment.

2 — Intradismicrite

Pl. I, Fig. 2

The recrystallized sparry parts form disconnected portions of laminae and are mostly phosphatized. The rock is impregnated by iron oxides and is a limy marl (I.R. : clay = 20.1 % , silt = 37.35 %).

Intraclasts are not infrequent and are rounded and range in size from fine to very fine (size grade). Few intraclasts are phosphatized.

This rock type is only represented by sample 14. EI = II_3. Folks interpretation of such a rock type is rather noncomittal (Folk, 1959, p. 22). The E.I., on the other hand, indicates an "intermittently agitated" environment.

3 — Intramicrite

P1, I, Fig. 3

Intraclasts are abundant in all the samples examined. They are mostly rounded. The majority of them are coarse (size) but some are very coarse (size) and a few are fine. One sample (9) contains abundant fine sand-size quartz grains which are angular to subangular.

Foraminiferal tests (**Globorotalia** sp.) are rare. Fossil fragments are found in some samples. Intraclasts are mostly phosphatized and in one sample (8) lath-like phosphatic "intraclasts" are common.

This rock type is represented by sample U.R. II-3 and samples U.R.I-8, 9, 13 & 17.

I.R. analysis indicates that the rocks belonging to this assemblage are mostly marly and usually contain abundant silly material (up to 58.51 % , in sample 9). A few are highly calcareous (carbonate = 89.22 % , in sample U.R. II-3).

The E.I. ranges between IV, and IV_2. This indicates a "Moderately agitated" environment.

4 — Fossiliferous foraminiferal biomicrite

P1. I, Figs. 4-6

The foraminiferal tests, embedded in the micrite matrix, range from 1 to 2 % in some samples and reach about 10 % in others. Test fragments are common.

Thin sections of most samples of this biomicrite range in colour in the thin section from amber to light brownish yellow. In most cases specks of iron oxides (probably after pyrite) are common in the matrix. Patches of the matrix are also stained by iron oxides.

Intraclasts are rounded and fine size to medium size grained. Some of them, as well as patches of the matrix are phosphatized.

This microfacies is represented by samples U.R. II-1, 2 & 13, and samples U.R. I-2, 3, 6, 7, 12, 42, 43, 70, 73, 74, 75, 78, U.R.I. Calm water conditions are indicated (Folk, 1959, 1962). The E.I., ranging between I_2-II_3, points to environmental conditions ranging from "quiet" to "intermittently agitated" (Plumley et al, 1962).

5 — Sparce foraminiferal biomicrite

Pl. II. Figs. 7-12, Pl. III, Figs. 13-14

Foraminiferal tests usually form more than 20 % of the sample. Intraclasts are few and subangular tc rounded. In some samples they range in size from fine to medium, in others from coarse to very coarse. The intraclasts are phosphatized. The matrix, in most cases, is light brownish yellow and is partly phosphatized. In a few cases (e.g. sample 30) test fragments are also phosphatized. This rock type is represented by samples U.R. II-4, 5, 7, 11 & 12, and samples U.R. I-18, 21, 30, 35, 46-48, 52, 53, 57, 59, 61, 62, 63, 64, 66, 68, 69 of U.R.I. Folk's classification suggests a low energy environment. The E.I. which ranges from I_2 to II_3, indicates "quiet" to "intermittently agitated" conditions of deposition.

The rocks belonging to this assemblage range in composition from pure limestone or chalk to marly and silty limestone or chalk.

6 — Fossiliferous foraminiferal pelmicrite

Pl. III, Fig. 15

Foraminiferal tests make up about 2-3 % of the rock, but fine-medium sized pellets abound. Parts of the micrite matrix are recrystallized into sparry calcite. Thin sections show the faint laminiation of the rock.

This microfacies is represented by one sample (15) which is a marly chalk (I.R. : clay = 10.5 %, silt 23.09 %). According to Folk this microfacies reflets low energy conditions. The E.I. ($=II_3$), however, indicates an "intermittently agitated" environment.

7 — Fossiliferous foraminiferal biodismicrite

Pl. III, Fig. 16

Most of the original foraminiferal biomicrite is recrystallized, leaving small branching patches of the original micrite. This is yellowish brown in colour, while the sparry calcite is clear, colourless and devoid of fossils. The only representative of this microfacies is sample U.R. II-14 which is a marly chalk (I.R.: clay=23.58% and silt 8.93 %).

The original rock, before recrystallization, represents a biomicrite that has been deposited under calm water conditions. The E.I. of the original rock is propably II_1, i.e. reflecting "intermittently agitated" conditions.

8 — Sparce foraminiferal biodismicrite

P1. III, Fig. 17

This microfacies is similar to the above described rock type. The main difference is that here the foraminiferal tests form more than 10 % of the remaining micrite patches and that these patches of the micrite are phosphatized and include some intraclsts which are rounded to subrounded and coarse to very coarse.

The only sample belonging to this microfacies is that of U.R. II-11, which is a chalk (I.R. : clay = 5.16 %, silt = 2.10 %).

The microfacies, in its original form, represents a calm water environment that had been disturbed by agitation from time to time (intraclasts). The E.I. indicates (II_2) an "intermittently agitated" environment.

9 — Packed foraminiferal biomicrite

P1. III, Fig. 18, P1. IV, Figs. 19-24; P1. V, Figs. 25-27

Foraminiferal tests make up, in most cases, the bulk of the rock. Almost all the samples contain intraclasts which are usually subangular to rounded and fine, medium or coarse-sized. Some of them are phosphatized and in a number of samples, patches of the micrite matrix and, rarely, foraminiferal tests are also phosphatized.

Insoluble residue analysis shows that the rocks range from almost pure types of limestone and chalk to marly limestone and chalk (up to 99 % carbonate).

This microfacies is represented by sample U.R. II-8 and by the following samples of U.R. I-16, 25, 26, 27, 28, 29, 31, 32, 33, 34, 36, 37, 38, 39, 40, 41, 45, 49, 50, 51, 54, 58, 62, 65, 71 & 72.

Folk's interpretation of similar types of rock is that it was deposited in calm water. The E.I. of the examined samples varies between I_2 and II_3 which indicates, according to Plumley et al. (1962), that these rocks were deposited in a "quiet" to "intermittently agitated" environment.

10 — Fossiliferous foraminiferal biomicrosparite

P1. V, Fig. 28

The foraminiferal tests in this microfacies make up 2-3 % of the studied rock

samples. Intraclasts are few, subangular to rounded and range in size from fine to medium grained. Some intraclasts, tests and shell fragments are phosphatized. Lath-like phosphate grains are found in some samples.

Insoluble residue analysis shows that three of the studied rock sample (55, 56, 98) belonging to this microfacies are pure limestones (up to 99.97 % carbonate). The remaining two samples (4 and 5) are marly chalk that contain an appreciable silty fraction (19.16 % in sample 5).

This rock type is represented by samples U.R. I-55, 56, and 98; and U.R. II-4 and 5.

The environment of this microfacies, according to Folk, is slightly agitated. The E.I. (II_2-III_3) reflects "intermittently agitated" to "slightly agitated" environments.

11 — Fossiliferous foraminiferal intramicrosparite
Pl. V, Fig. 29

Intraclasts form the major part of the samples examined. They are generally rounded but in one sample (No. 11, Pl. V, Fig. 29), they are angular to subrounded. Although large patches of the fine sparry matrix as well as some intraclasts are phosphatized, yet the foraminiferal tests have not been phosphatized. Few pellets seem to be detrital phosphate grains as observed in sample II.

Sample II is a limey marl (I.R. : clay = 9.8 %, silt = 35.71 %). The other studied samples contain only a fraction of a percent of insoluble residue, since the phosphate content, being soluble in acid, is accordingly added to the carbonate content of the rock.

This microfacies is represented by samples U.R. I-11, 99, 101 and 102.

The energy level, according to Folk's classification, is rather high. The E.I. (IV for all the samples) reflects a "moderately agitated" environment.

12 — Sparce foraminiferal biomicrosparite
Pl. V, Fig. 30, Pl. VI, Fig. 31

Foraminiferal tests reach to about 20 % of the rock. Few fine to very fine intraclasts are found in the fine grained sparry matrix. Some of the intraclasts are

phosphatic. All the samples are almost pure carbonate (I.R. : ranges between a fraction of a percent and about 3 %).

This microfacies is represented by sample U.R. II-10 and samples U.R. 1-22 & 24 and represents according to E.I., a rather agitated environment. Values of E.I. range between III_1 and III_3, thus indicating "slightly agitated" conditions of deposition (Plumley et. al. 1962).

13 — Sparite

Pl. VI, Fig. 32

The rock has evidently been recrystallized. Irregular patches of the original foraminiferal, yellowish brown, biomicrite are strewn by the clear, fine to medium grained sparry matrix.

The rock is represented by one sample (U.R. II-9) which is a slightly clayey chalk.

The original rock seems to have been deposited in a calm environment. The E.I. of the relics of the foraminiferal biomicrite is II_1, i.e. "intermittently agitated."

14 — Poorly washed intrasparite

Pl. VI, Fig. 33

The matrix is composed of fine to medium grained sparry calcite with a few foraminiferal tests. Intraclasts are subangular to rounded, medium to coarse. One of the studied two samples (U.R. II-6) is characterized by the presence of phosphatized patches of matrix and some intraclasts, numerous specks and small patches if iron oxides and by the occurrence of gypsum patches.

Sample U.R. II-6 is a marly chalk (I. R. : clay = 16.29 % , silt = 4.31 %), while sample 77 is a pure limestone (I.R. about 0.02 %).

Folk (1962) considers such poorly washed intrasparites as equivalent to clayey or immature sandstones. That means that the present samples were deposited in a slightly agitated environment in which they propably were rapidly buried. The E.I. varies between "moderately agitated" (IV for sample U.R. II-6) and "slightly agitated" (III_2 for sample 77).

15 — Fossiliferous poorly washed foraminiferal biosparite
Pl. VI, Fig. 34

The matrix is composed of fine to medium grained sparry calcite. Foraminiferal tests form about 6-10 %. Numerous specks and small iron oxide patches are strewn in the matrix. Intraclasts are medium to coarse and rounded; some of them are phosphatized (sample U.R. I-79).

Recrystallized tests of **Globorotalia** spp. and **Globigerina** spp. are embedded in these rocks.

The two samples (U.R. I-76 & 79) belonging to this microfacies are composed of pure limestone which contains only a small fraction of a percent of insoluble residue.

According to Folk, this microfacies could have been formed in an environment similar to that of the fore-mentioned recorded type (microfacies 14), i.e. under, slightly agitated, with probable rapid burial conditions of deposition. The E.I. varies within a narrow range, being III_2 for sample 76 and III_3 for 79. The conditions of deposition were, therefore, "slightly agitated."

16 — Packed poorly washed foraminiferal biosparite
Pl. VI, Fig. 35

Matrix formed of fine to coarse sparry calcite. Foraminiferal tests and fragments form the bulk of the rocks belonging to this microfacies. Intraclasts are medium to coarse, subangular to rounded. In most cases, patches of the matrix, numerous intraclasts and filling of some tests are phosphatized. In one case (sample 1), tests are filled by gypsum.

The rocks are all pure limestones (I.R. : ranging from 0.07 - 0.00 %) except sample 1 which is a slightly silty chalk (I.R. : clay = 2.14 %, silt = 7.79 %).

This microfacies is represented by samples U.R. I-1, 81, 96, 104 and 105.

According to Folk's interpretation, the environment of such a microfacies was fairly agitation. The E.I. (=III_3 for all samples) indicates a "slightly agitated" environment.

17 — Fossiliferous unsorted foraminiferal biosparite

Pl. VI, Fig. 36

The matrix is either fine to medium or medium to coarse grained. In addition to whole foraminiferal tests, fragments of tests are common. Intraclasts are relatively abundant, rounded and medium sized. Some intraclasts, shell fragments, other than foraminiferal, and patches of the matrix are phosphatized. The phosphatized patches in samples 87 and, to a certain extent, in sample 91 are quite large. Recrystallization of parts of the matrix into coarser sparry is occasionally observed as in sample 91.

The rocks are all pure limestones (somewhat phosphatic) with only a small fraction of a percent of insoluble residue.

This microfacies is represented by samples U.R. I-86, 87 & 91.

The energy level, according to Folk (1959 & 1962) is rather high. The E.I. (III_3-IV_2), however, indicates that the environment ranged from "slightly agitated" to "moderately agitated."

18 — Sparce unsorted foraminiferal biosparite

Pl. VII, Fig. 37, 38 & 39

The matrix is formed of their fine to medium or medium to coarse sparry calcite. Recrystallization of the matrix is evident in some samples. The foraminiferal tests are poorly sorted, and more scattered than those reported in the above microfacies association. Intraclasts are rounded and are medium to coarse grained. Many intraclasts and patches of the matrix (especially in samples 85, 89 and 90) are phosphatized.

The rocks are all pure limestones (phosphatic) with only a small fraction of a percent of insoluble residue.

This microfacies is represented by samples U.R. I-80, 82, 83, 84, 85, 88, 90 and 92.

The energy level, according to Folk (1962) is quite high.

The E.I. (IV_1-IV_2), however, indicates a "moderately agitated" environment.

19 — Packed sorted foraminiferal biosparite
Pl. VII, Fig. 40

The matrix is composed mainly of coarse sparite. Intraclasts are frequent, rounded and medium to coarse sized. Patches of the matrix and a few foraminiferal tests are phosphatized. Recrystallized foraminiferal forms (**Globorotalia** spp.), are embedded in these rocks.

The rocks are pure limestones (slightly phosphatic). The I.R. is 0.03 % in sample 93 and 0.00 % in sample 94.

This type of microfacies is supposed to have been subject to winnowing by strong and persistent current. Such rocks may, however, "also form in lower energy areas where for some reason no lime mud is produced or available" (Folk, 1962, p. 67). This could have been the case during the formation of the microfacies under consideration because considerable recrystallization evidently took place. The E.I. (IV_3) indicates a "moderately agitated" environment.

20 — Fossiliferous rounded foraminiferal biosparite
Pl. VII, Fig. 41

The matrix is composed of fine to coarse sparite. Fossils, including foraminiferal tests are highly recrystallized and rounded. In most cases these fossils are hardly recognizable because of recrystallization and probable abrasion. Intraclasts are rounded and medium to coarse. Patches of the matrix and parts of test fillings are sometimes phosphatized (sample 95).

The rocks are either completely dissolved in acid (105) or contain only a very minute fraction of a percent of insoluble matter, (sample 106). They are thus all pure limestones.

The description shows that the environment of deposition was highly agitated. The E.I. (IV_2 for all samples), however, indicates 'moderately agitated' conditions.

21 — Gypsiferous intrasparite
Pl. VII, Fig. 42

The matrix is composed of fine to medium sparite which is largely replaced by very coarse crystalline gypsum. Rare foraminiferal tests are observed and others are recrystallized. Intraclasts are rounded and medium to coarse. Some intraclasts are phosphatized.

The only representative sample of this microfacies (100) is almost completely dissolved in acid.

The original rock could have been deposited in a high energy environment. The E.I. is probably IV_1 and indicates "moderately agitated" conditions.

Conclusion

From the microfacies study of the Upper Cretaceous - Lower Tertiary rocks at the Um Rijam area, south Jordan it is possible to conclude the environment of deposition of the studied three rock units. The Ghareb Formation was deposited under calm, quite to intermittently agitated environment; the Taqiya Formation was deposited under quiet to intermittently agitated at its base, to moderately agitated in its middle part, to quiet to intermittently agitated environment in its upper part and the Sar'a Formation was deposited under a moderately agitated environment in its lower part to quiet to intermittently agitated in its upper part.

PLATE I EXPLANATION OF PLATES

"For all figures, the magnification is 55".

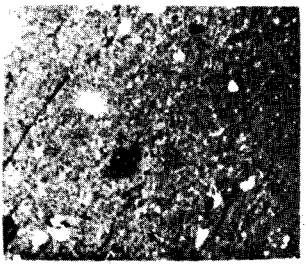


Fig. 1

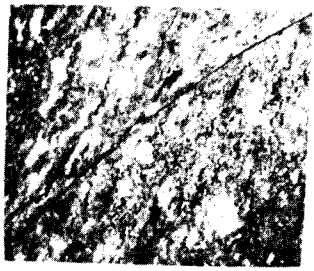


Fig. 2

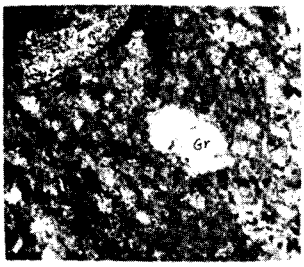


Fig. 3

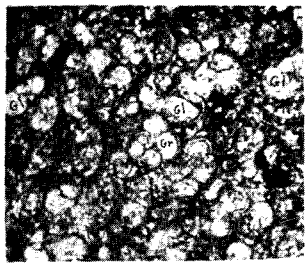


Fig. 4

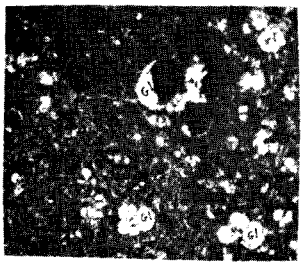


Fig. 5

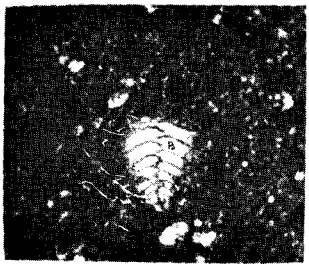


Fig. 6

Figure 1: Micrite, foraminiferal fragments together with few intraclasts embedded in a micrite matrix, sample 10.

Figure 2: Intradismicrite, recrystallized, disconnected sparry crystals embedded in a micrite matrix, sample 14.

Figure 3: Intramicrite, coarse calcite crystals together with phosphatized grains and few of **Globorotalia** sp. (Gr.) embedded in a micrite matrix, sample 17.

Figure 4: Fossiliferous foraminiferal biomicrite, **Globorotalia** spp. (gr.) and **Globigerina** spp. (Gl) embedded in a micrite matrix, sample U.R. II-13.

Figure 5: Fossiliferous foraminiferal biomicrite, partly replaced Globigerina spp. (Gl) embedded in a micrite matrix, sample 3.

Figure 6: Fossiliferous foraminiferal biomicrite, **Bolivinopsis** sp. (B) together with foraminiferal fragments embedded in a micrite matrix, sample 3.

PLATE II

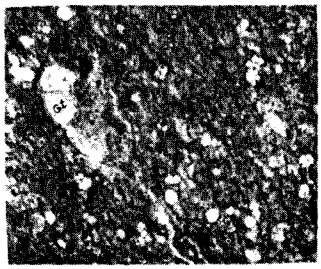


Fig. 7

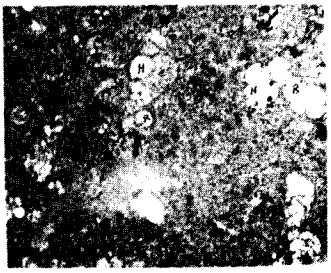


Fig. 8

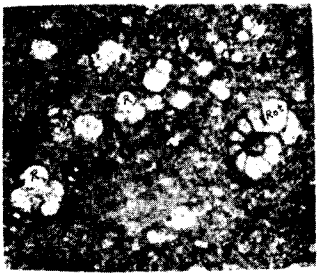


Fig. 9

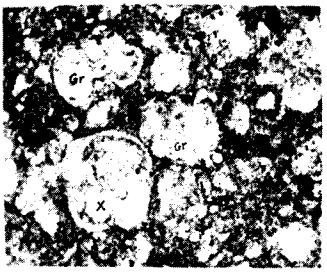


Fig. 10

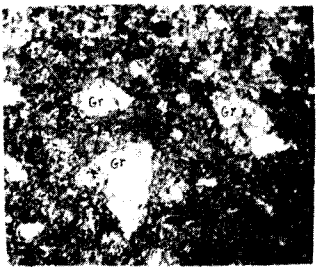


Fig. 11

Fig. 12

Figure 7: Sparce foraminiferal biomicrite, **Globotruncana** sp. (Gt) together with few intraclasts embedded in a micrite matrix, sample U.R. II.4.
Figure 8: Sparce foraminiferal biomicrite, **Rugoglobigerina** spp. (R) together with **Heterohelix** spp. (H) embedded in a micrite matrix, sample U.R. II-5.
Figure 9: Sparce foraminiferal biomicrite, **Rugoglobigerina** spp. (R) together with Rotalii-forms (Rot.) embedded in a micrite matrix, sample U.R. II-7.
Figure 10: Sparce foraminiferal biomicrite **Globorotalia aequa** (×) together with **Globorotalia** spp. (Gr.) embedded in a micrite matrix, sample 18.
Figure 11: Sparce foraminiferal biomicrite, **Globorotalia** spp. (Gr.) embedded in a partly phosphatized micrite matrix, sample 21.
Figure 12: Sparce foraminiferal biomicrite, **Bulimina** sp. (Bm) together with small allochems embedded in a micrite matrix, sample 47.

PLATE III

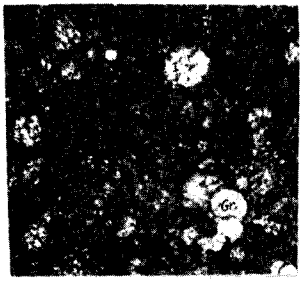


Fig. 13

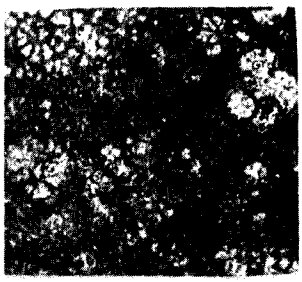
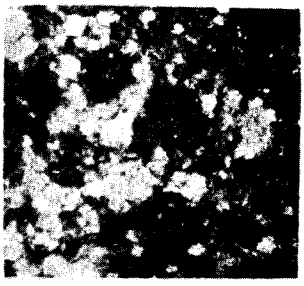


Fig. 14

Fig. 15



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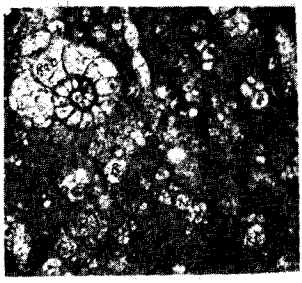

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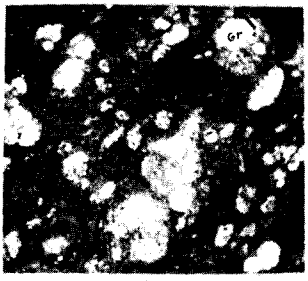

Fig. 18

Figure 13: Sparce foramini feral biomicrite, **Globorotalia** sp. (Gr.) together with rounded intraclasts (I) embedded in a micrite matrix, sample 48.
Figure 14: Sparce foraminiferal biomicrite, **Globorotalia** spp. (Gr.) together with Rotalii-form (Rot) embedded in a micrite matrix, sample 53.
Figure 15: Fossiliferous foraminiferal (f) pelmicrite, fine pellets together with recrystallized sparry crystals embedded in a micrite matrix, the rock shows faint lamination, sample 15.
Figure 16: Fossiliferous foraminiferal biodismicrite, the dark colour shows the original biomicrite while the recrystallized sparite is colourless and devoid of fossils, sample U.R. II-14.
Figure 17: Sparce foraminiferal biodismicrite, **Rugoglobigerina** spp. (R) together with Rotalii-form (Rot) embedded in a partly phosphatized micrite, sample U.R. II-11.
Figure 18: Packed foraminiferal biomicrite, **Globorotalia** spp. (Gr.) together with subangular to rounded intraclasts embedded in a micrite matrix, sample 16.

PLATE IV

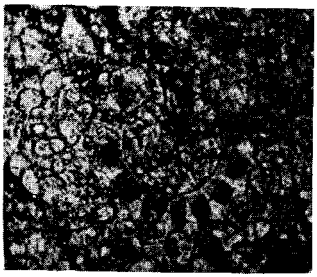

Fig.19

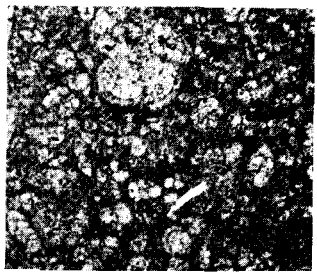

Fig.20

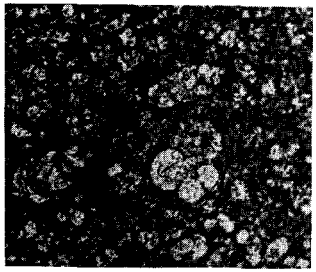

Fig.21

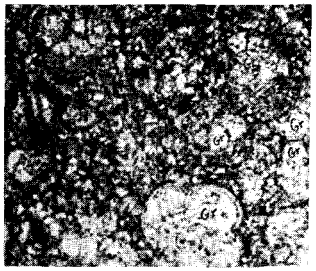

Fig.22

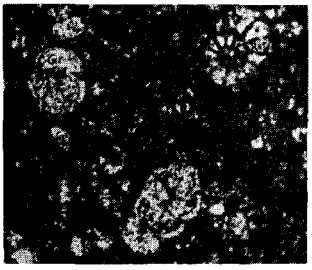

Fig.23

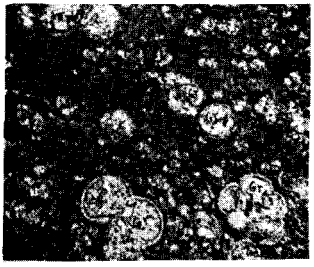

Fig.24

Figure 19: Packed foraminiferal biomicrite, echinoid (E) stem (?) together with rounded intraclasts embedded in a micrite matrix, sample 25.
Figure 20: Packed foraminiferal biomicrite, **Globorotalia** sp. (Gr.) **Bulimina** sp. together with rounded intraclasts embedded in a micrite matrix, sample 33.
Figure 21: Packed foraminiferal biomicrite, **Globorotalia** sp. (Gr.) **Bulimina** sp. (Bm) together with rounded intraclasts embedded in a micrite matrix, sample 36.
Figure 22: Packed foraminiferal biomicrite, **Globorotalia** spp. (Gr.) together with small subangular intraclasts embedded in a micrite matrix, sample 45.
Figure 23: Packed foraminiferal biomicrite, **Globorotalia** spp. (Gr.) and Rotalii-forms (Rot) together with small subangular intraclasts embedded in a micrite matrix, sample 49.
Figure 24: Packed foraminiferal biomicrite, **Globorotalia** spp. (Gr.) together with small subangular intraclasts embedded in a micrite matrix, sample 51.

PLATE V

Fig. 25

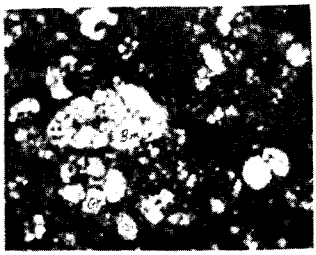

Fig. 26

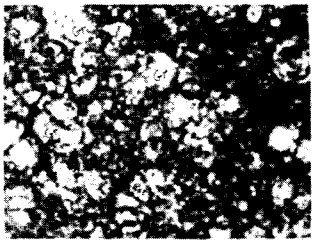

Fig. 27

Fig. 28

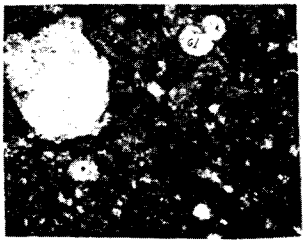

Fig. 29

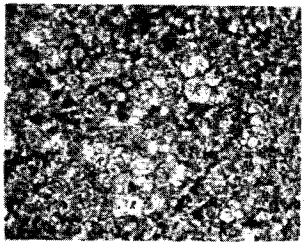

Fig. 30

Figure 25: Packed foraminiferal biomicrite, **Globorotalia** sp. (Gr.) together with subangular intraclasts embedded in a micrite matrix, sample 62.
Figure 26: Packed foraminiferal biomicrite, **Globorotalia** sp. (Gr.), **Bulimina** sp. (Bm) together with foraminiferal fragments embedded in a micrite matrix, sample 71.
Figure 27: Packed foraminiferal biomicrite, **Globorotalia** sp. (Gr.), Rotalii-form (Rot) together with small subangular intraclasts embedded in partly phosphatized micrite matrix, sample 72.
Figure 28: Fossiliferous foraminiferal biomicrosparite, phosphatized grain together with small subangular intraclasts embedded in a microsparite matrix, sample 5.
Figure 29: Fossiliferous foraminiferal intramicrosparite, **Globigerina** sp. (Gl.) (?) together with large patches of phosphatized fine sparry grains embedded in a microsparite matrix, sample 11.
Figure 30: Sparry foraminiferal biomicrosparite, **Rugoglobigerina** sp. (R), representatives of family Heterohelicidae, **Heterohelix,** (H) together with very fine intraclasts embedded in a sparry matrix, sample U.R. II-10.

PLATE VI

Fig. 31

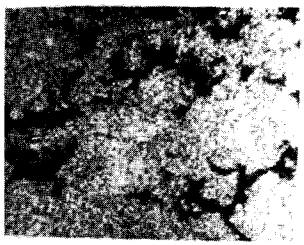

Fig. 32

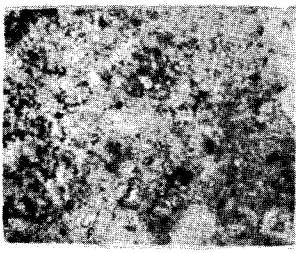

Fig. 33

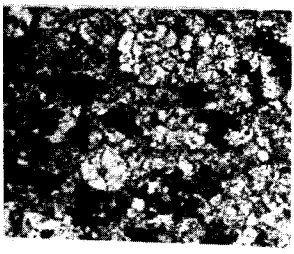

Fig. 34

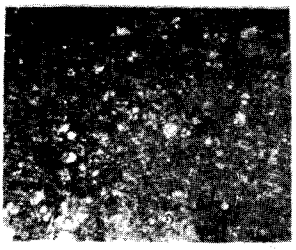

Fig. 35

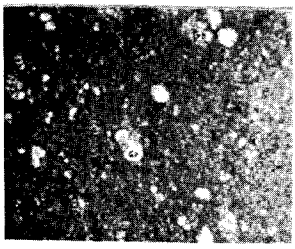

Fig. 36

Figure 31: Sparce foraminiferal biomicrosparite, **Globorotalia** spp. (Gr.) together with fine subangular intraclasts embedded in a micrite matrix, sample 22.
Figure 32: Sparite, recrystallized medium grained sparry matrix together with irregular patches of the original biomicrite, Sample U.R. II-9.
Figure 33: Poorly washed intrasparite, few foraminiferal test (F) together with rounded intraclasts embedded in a sparite matrix, sample U.R. II-6.
Figure 34: Fossiliferous poorly washed foraminiferal biosparite, recrystallized **Globorotalia** spp. (Gr.) together with small patches of iron oxides embedded in sparite matrix, Sample 79.
Figure 35: Packed poorly washed foraminiferal biosparite, foraminiferal tests (F) and fragments together with fine intraclasts embedded in a sparite matrix, sample 81.
Figure 36: Fossiliferous unsorted foraminiferal biosparite, recrystallized **Globorotalia** spp. (Gr.) together with rounded intraclasts embedded in a fine grain sparry matrix, sample 87.

PLATE VII

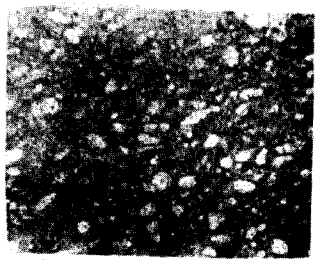

Fig. 37

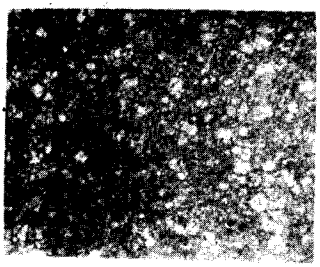

Fig.38

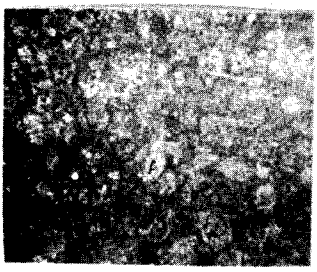

Fig.39

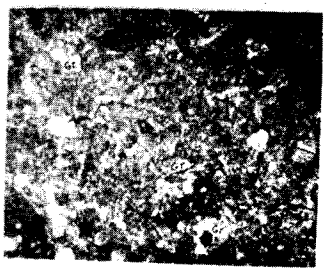

Fig.40

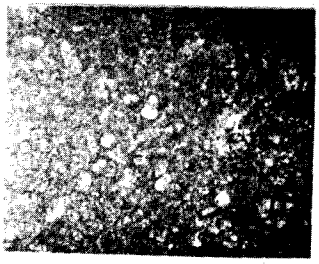

Fig.41

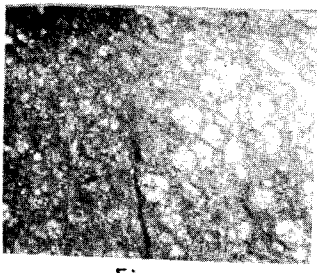

Fig 42

Figure 37: Sparce unsorted foraminiferal biosparite, **Globorotalia** spp. together with medium, rounded intraclasts embedded in a fine sparry matrix, sample 83.
Figure 38: Packed unsorted foraminiferal biosparite recrystallized foraminiferal tests together with rounded intraclasts embedded in medium grain sparry matrix, sample 88.
Figure 39: Sparce sorted foraminiferal biosparite, recrystallized foraminiferal tests (F) together with few rounded intraclasts embedded in a fine to medium sparry matrix, sample 80.
Figure 40: Packed sorted foraminiferal biosparite, abundant recrysatallized **Globorotalia** spp. together with rounded intraclasts embedded in a sparry matrix, Sample 94.
Figure 41: Fossiliferous rounded foraminiferal biosparite, recrystallized rounded foraminiferal tests together with rounded intraclasts embedded in a fine sparry matrix, sample 95.
Figure 42: Gypsiferous intrasparite, rounded intraclasts embedded in a fine sparry matrix partly replaced by coarsely crystalline gypsum, sample 100.

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سحنات دقيقة لصخور الطباشيري العلوي ـ الثلاثي السفلي في منطقة أم رجام ، جنوب الأردن

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ملخـــــــــــص

هذا البحث يعالج ولأول مره السحنات الدقيقة لصخور الطباشيري العلوي ـ الثلاثي السفلي من جنوب الأردن . فقدتم تمييز والتعرف على ثلاثة وعشرون سحنة دقيقة ، وصفت ونوقشت ووضحت في سبع لوحات .

وقد أمكن التعرف على بيئة الترسيب لهذه التجمعات السحنية الدقيقة لمختلف التكاوين الصخرية ووجد أن تكوين غارب قد تم ترسيبه تحت بيئة هادئة إلى بيئة متقطعة الرجرجه ، ووجد ان بيئه تكوين طاقيه هادئة إلى متقطعة الرجرجه عند الجزء السفلي من التكوين إلى متوسطة الرجرجه في الجزء الأوسط ثم هادئة إلى متقعة الرجرجه عند الجزء العلوي منه . اما بيئه تكوين ساره فهي متوسطة الرجرجه في النصف السفلي من التكوين إلى هادئه إلى متقطعة الرجرجه عند النصف العلوي منه .