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Microfacies of the Thebes Formation at Gabal Um El Ghanayem and Gabal Ghanima, Kharga Oasis, Egypt

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(with 2. figs., 1 table and 9 plates)

Abstract: This paper deals with the description of the microfacies of the Early Eocene limestone (Thebes Formation), exposed at Gabal Um El Ghanayem and Gabal Ghanima, Kharga Oasis. The stratigraphic and ecologic significance of these microfacies has been discussed. Nineteen microfacies associations can be found. These different type reflect deposition in an environment ranging between littoral zone and infralittoral subzone.

Introduction

The Thebes Formation of SAID (1960) covers an extensive area. It extends westward from the Nile Valley untill Kharga Oasis, where it caps the scarp which bounds the depression from the east. This scarp extends unbroken between Qasr Gyb at the north and Dush at the southern part of the depression. Two columnar sections were measured and sampled in some detail. One in Gabal Ghanima and the other at Gabal Um El Ghanayem. The indurated rock succession is more or less homogeneous in character and is typically Lower Eocene. Detailed study of about 100 thin sections shows that they are fairly rich in various organisms, and accordingly several microfacies assocciations are encountered.

In the present work FOLK's petrographic classification for limestones is used (FOLK; 1959, 1962). Publications of CUVILLIER (1951), GHORAB and ISMAIL (1957), HANZAWA (1961), SWETT (1964), ROWN (1964), SAM BOGGS (1966), SADLER (1966), ISMAIL and SELIM (1969), OMARA et al. (1969), YOUSSEF et al. (1969) and BARAKAT and ARAFA (1972) are also taken into consideration.

Stratigraphy

The stratigraphy of the Kharga scarp succession has been treated by ZITTEL (1883), BALL (1900), BEADNELL (1909), HASSAN (1953, 1959), NAKKADY (1959), ABDU (1960), ABDU et al. (1969), SAID (1961, 1962), SHINNAWI (1964), AWAD and GHOBRIAL (1965) and more recently by KENAWY (1974).

The Thebes Formation in the studied two columnar sections is entirely calcareous, and is composed of limestones which vary from chalky to cavernous ones and they are either nummulitic, operculiniid, assiliniid or alveoliniid.

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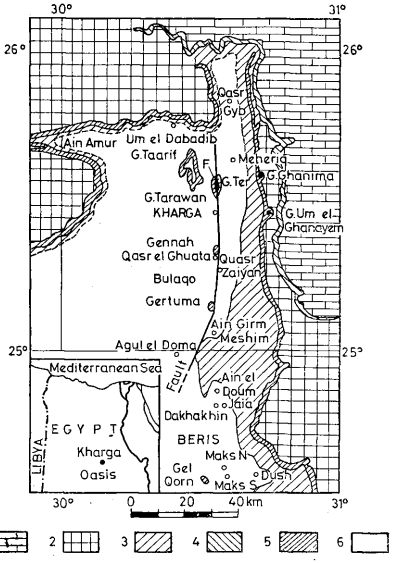

Fig. 1. Geological map of Kharga oasis showing the location of Gabal Um El Ghanayem and Ghanima. Legend: 1. Thebes formation, 2. Chalk, 3. Varigated shales, 4. Esna shale, 5. Dakhla shale (and basal phosphatic beds), 6. Nubia sandstone

Lithologic and faunistic distinctions in the Thebes limestones allow dividing them informally into three rock units of member status. These informal members, from bottom to top, are:

c) *Alveolina* cavernous limestone.
b) *Assilina-Operculina* laminated white chalky limestones.
a) Nummulitic greyish limestone.

KENAWY (1974) subdivided the topmost part of the Esna Shale and the Thebes Formation in the studied Um El Ghanayem section, from base upwards into following biostratigraphic zones:

1. Nummulites exilis-nitidus zone

This zone coincides with the upper 14 meters of the Esna Shale. It also contains *Nummulites buxtorfi*, SCHAUB, *N. subramondi* DE LA HARPE and *N. planulatus planissimus*. These primitive species of *Nummulites* suggest Late Landenian (Ilerdian, HOTTINGER and SCHAUB, 1960) age for this zone.

2. Nummulites deserti zone

This zone coincides with the lower 20 meters of the Thebes Formation. It also contains *Nummulites subramondi* DE LA HARPE and *N. planulatus* (LAMARCK). Early Ypresian age is assigned to this zone.

3. Assilina granulosa—Operculina canalifera zone

This zone comprises 66 meters of the Thebes Formation, and is characterized by the following larger foraminiferal assemblage in an ascending order of abundance:

Assilina granulosa (D'ARCHIAC), *Operculina canalifera* D'ARCHIAC et HAIME, *Assilina laminosa* GILL and *Assilina nili* DE LA HARPE. Early Ypresian age is also assigned to this zone.

4. Alveolina decipiens-pastisilata zone

It is confined to the uppermost cavernous limestone of Gabal Um El Ghanayem only, it contains also *Alveolina oblonga* D'ORBIGNY, *A. ovicula* NUTTAL, *A. rotundata* HOTTINGER, *A. cucumiformis* HOTTINGER, *A. ellipsoidalis* SCHWAGER; *Orbitolites complanata* LAMARCK, *Orbitolites* sp. and *Fabularia* sp.

This zone is assigned to the Late Ypresian.

Biostratigraphic correlation between the two columnar sections show that, the first three zones are typically represented in Gabal Um El Ghanayem and Gabal Ghanima, where the upper most zone is only represented in Gabal Um El Ghanayem. This is attributed to the north and northeast general dipping, characterising the Upper Cretaceous—Early Eocene succession in both Karga and Dakhla Oasis (GHOBRIAL, 1967; HERMINA, 1967; and HAFEZ, 1973) and the subsequent erosion in Gabal Ghanima.

Microfacies

The following is a detailed description of the different microfacies association, besides its significance as an indication to the paleoecologic characters and the conditions that prevailed during sedimentation.

A. Biogenic limestone

1. Nummulites biomicrite

The rock is mainly composed of *Nummulites* sp. (30—40), represented by *Nummulites deserti*, *N. burdigalensis* and small primitive nummulites, as well as few percentage of smaller benthonic and planktonic foraminifera, rare *Operculina canalifera*, and molluscan, algal and bryozoan fragments, all are cemented by pure micrite cement. Where the cement is recrystallized to microsparite, the rock is termed *nummulitic biomicrosparite*.

This microfacies association is represented at the base of Thebes Formation at the both measured sections.

2. Algal biomicrite

This microfacies association is essentially built up of abundant calcareous green algae (50—60%), with few percentages of benthonic foraminifera mostly

Textularia sp., and other planispiral forms, rare *Alveolina ellipsoidalis*, *Alveolina* sp., *Orbitolites* sp., bryozoa, pelecypods and gastropod fragments, intraclasts, and echinoid spines. In other variety, the rock is completely stained by iron oxides. Most of the above fossil allochems are recrystallized to microspary or spary calcite. Where the cement is recrystallized to microsparite, the rock is termed *Algal microsparite*.

This rock type is represented in different beds at different horizons of Gabal Ghanima and Um El Ghanayem.

3. Assilina biomicrite

The bulk of the rock mainly consists of *Assilina* (30—50%), represented by *Assilina laminosa*, *A. placentula*, *A. praespira* and *A. nili* and few percentages (less than 10%) of algal, bryozoan, operculines, nummulites and smoutina fragments. In other varieties rare benthonic foraminifera and primitive small nummulites are also recorded. All these constituents are cemented by micrite cement. In other variety, the cement is mostly dolomitized, so that the rock is termed *dolomitic assilina biomicrosparite*.

This microfacies association is mainly represented within the *Assilina—Operculina* zone, in both Ghanima and Um El Ghanayem section.

4. Miscellanea biomicrite

In thin sections, this rock type is mainly composed of *Miscellanea* sp. (20—30%), and few primitive small nummulites, bryozoa, pelecypod and algal fragments, and rare benthonic small foraminifera. In other variety and where the cement is microsparite, the rock is termed *Miscellanea biomicrosparite*.

It is represented at the uppermost part of *Assilina—Operculina* zone in Gabal Um El Ghanayem.

5. Alveolina biomicrosparite

This type is mainly composed of *Alveolina* sp. (20—30%), represented by *Alveolina oblonga*, *A. decipiens*, *A. ellipsoidalis*, *A. cucumiformis*, *A. ovicula* and *A. pasticillata*. Few percentages of other fossil fragments, probably algae, bryozoa and molluscan fragments, and rounded to subrounded intraclasts are also encountered in some varieties. All are cemented by microsparite calcite.

This type forms the main part of the *Alveolinae* biozones in Gabal Um El Ghanayem.

6. Smoutina biomicrite

It is mainly composed from abundant *Smoutina* sp. (20—30%) and few percentage of *Operculina canalifera*, benthonic and planktonic foraminifera and rare bryozoa and algal fragments, embedded in micrite cement.

It is only represented in Gabal Ghanima within *Nummulites deserti* zone.

7. Foraminiferal biomicrosparite

It consists of smaller foraminifera mainly miliolids and few percentages of algal and molluscan fragments, embedded in microsparite, partially sparite cement. It is only represented as a band within the *Alveolina* zona, in Gabal Um El Ghanayem.

Where the miliolid percentage becomes most abundant, the rock is termed *miliolid biomicrosparite.*

8. Bryozoa biomicrudite

It contains abundant bryozoa fragments (up to 40%), and other fossil fragments, propably algal and molluscan fragments of an average diameter >2 mm, embedded in micrite.

It is represented in more than one horizon within the *alveolines* biozone of Gabal Um El Ghanayem.

9. Annelid biomicrite

The rock is mainly composed of abundant unidentified annelid fragments with few percentages of algal fragments (<10%), cemented by micrite cement.

This microfacies rock type forms a th in bandwithin the operculiniid—assiliniid biozone in Gabal Um El Ghanayem.

10. Nummulites—Operculina biomicrite

In thin sections, the rock is formed of an accumulation of *Nummulites burdigalensis, Nummulites deserti,* other small primitive nummulites, and *Operculina canalifera,* and *O. libyca,* as well as small percentage of bryozoa, orbitolites, algae and molluscan fragments, embedded in micrite cement. In other variety, the cement is completely stained by iron oxides, and the rock is termed *ferrugineous Nummulites—Operculina biomicrite.*

This microfacies association forms the gradational part between biozone 2 and 3, in both Um El Ghanayem and Gabal Ghanima.

11. Operculina—Smoutina biomicrosparite

It is essentially composed of *Operculina canalifera, O. libyca* (30—40%), and *Smoutina* sp. (10—15%) and few percentages of algal, nummulites, bryozoan, echinoid spines, rare intraclasts and benthonic foraminifera. Mostly the above allochems are partially replaced by chalcedony or stained by iron oxides. Partially where the groundmass is dolomitized, the rock is partially termed *dolomitic Operculines—Smoutina biomicrosparite.*

It is represented in the lower part of operculiniid—assiliniid biozone of Gabal Ghanima.

12. Alveolinas—Fabularia biosparite

It is mainly formed of *Alveolina* sp. (20—25%) and *Fabularia* sp. (>10%), and small percentage of miliolids, especially quinqueloculins and other benthonic foraminifera, and rare algal and bryozoan fragments, embedded in sparite cement.

This type is represented in the upper part of alveoliniid biozone of Gabal Um El Ghanayem.

13. Nummulites—Smoutina biomicrite

This association is mainly composed of *Nummulites deserti, N. burdigalensis,* small primitive nummulites, *Smoutina* sp. and other small percentage of *Operculina canalifera, O. ammonea,* pelecypods, algae and bryozoan fragments and benthonic and planktonic foraminifera, embedded in micrite cement.

It is represented at the upper part of *Nummulites deserti* biozone of Gabal Ghanima.

14. Assilina—Operculina biomicrite

It is mainly composed of a mixture of assilines and operculines (20—30%), represented by *Assilina laminosa, A. placentula, A. praespira, A. nili, Operculina libyca, O. ammonea, O. canalifera,* and small percentage of algae, bryozoan and molluscan fragments. Badly preserved benthonic and plantonic foraminiferal sp. are also recorded in other variety. All the constituents are embedded in biomicrite cement.

This microfacies association forms the assiliniid—operculiniid biostratigraphic zone, in both Gabal Um El Ghanayem and Gabal Ghanima.

15. Nummulites—Algal biomicrite

In thin sections, the rock is mainly composed of *Nummulites deserti, N. atacicus, N. globulus,* small primitive nummulites, and of abundant algal fragments, with few percentages of other fossil fragments, benthonic small foraminifera and echinoid spines, in micrite cement. The latter is disturbed by recrystallized sparite patches. On the other hand the fossil allochem is mostly recrystallized either to microsparite or sparite.

It forms one bed within the *Nummulites deserti* zone in both Gabal Ghanima and Gabal Um El Ghanayem.

16. Algal—Ostracoda biomicrosparite

This microfacies association is mainly composed of abundant algal fragments and Ostracods, and few percentages of miliolids, mostly quinqueloculines and other unidentified fossil fragments cemented by microsparite cement. It forms one bed within the alveoliniid biozone of Gabal Um El Ghanayem.

B. Microcrystalline limestones

17. Nummulites bearing micrite

This association consists mainly of fossil fragments which do not exeed 10% of the *Nummulites* sp., embedded in micrite cement.

It is recorded within *Nummulites deserti* zone of both Gabal Ghanima and Gabal Um El Ghanayem.

18. Micrite

It is mainly composed of cryptocrystalline to microcrystalline calcite. Some unidentified fossil fragments constitute less than 2% of this association.

19. Microsparite

Composed of pure microspary calcite (0,035 mm in diameter).

The latter two lithofacies form thin bands within the succession of the Thebes Formation.

Diagenesis

Post lithification diagenetic processes are well recorded in the Ghanima—Um El Ghanayem Lower Eocene limestone succession, and include:

1. *Recrystallization:* Most of the fossil allochem is mostly recrystallized into either microsparite or sparite. This phenomenon is also observed in the groundmass, where the original micrite is now microsparite or sparite.

2. *Dolomitization:* It is a less extensive diagenetic phenomenon and it is well represented by one bed at the lower part of the assilines—operculines zone. In thin sections parts of the fossil allochem and most of the cement calcite are partially replaced by dolomite rhombs.
3. *Silicification:* It is represented by replacement of patches of the calcite groundmass and the other allochems by a chalcedony and microcrystalline quartz.
4. *Ferrugination:* Ferrugination diagenetic phenomenon is observed, where isolated grains of iron oxides are scattered within the cement, or where parts of the fossil allochem, or most of the cement is replaced by iron oxide.

Paleoenvironment and conditions of sedimentation

The following, is an attempt to throw more light on the conditions of sedimentation, and the environment of deposition of the Early Eocene succession of Gabal Ghanima and Um El Ghanayem, based on the above detailed microfacial analysis.

Microscopically, the different microfacies types are fairly rich in various organisms. However, they have little significance as regard to bathymetric considerations.

In the present work, calcareous green algae, bryozoa, *Orbitolites* and the larger foraminifera are considered to be deposited in an environment, ranging from reefal to outer neritic zone (Brown, 1964, Omara et al., 1969, Mourad et al., 1969, and Tillman, 1971). The presence of scattered benthonic and planktonic foraminifera, echinoid spines molluscan fragments with bryozoa, algae, orbitolites and nummulites indicate an open shallow marine facies, and within the zone of light penetration (Tillman, 1971). The presence of *Ostracoda* sp. with algae are also considered here to indicate shallow (reefal) environment. The absence of any terrigenous material means that the site of deposition was far enough from the shore, and the current was not strong enough for transporting these materials. The presence of few rounded to subrounded intraclasts reflects local uplifting of the bathymetric surface, gentle agitation, water turbidity, and the currents were strongly enough to remove the intraclasts to a distance not far from the site of deposition. The allochemical constituents of the biogenetic types are mostly fragmented and abraded. However the evidence of only minor abrasion and lack of evidence of breakage of other faunal structures may also indicate that these allochems were originated close to the site of deposition. Micrite and microsparite microfacies indicate deposition in relatively deeper part (inner neritic) and short lived currents (Folk, 1959).

The above discussion shows that the medium of deposition was of oscillatory type and no general trend for deepening or shallowing of the sea can be easily traced. It is probable that after the deposition of the underlying Esna Shale, which is considered to have been deposited in the deep neritic environment (Moore, 1963, and Hafez, 1973) the sea became relatively shallow, and the Thebes Formation was deposited in an environment ranging between reefal to the shallow neritic environment (open shelf), lying on the eastern side of El Kharga uplift (Hafez, 1973).

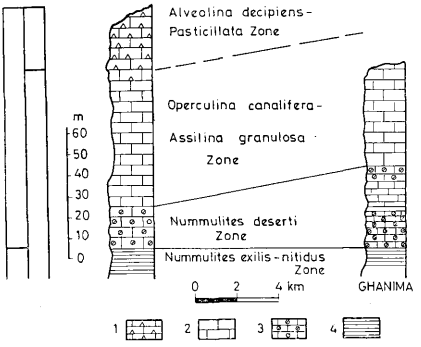

Fig. 2. Biostratigraphic correlation of Um El Ghanayem and Ghanima sections, Kharga oasis, Egypt. Legend: 1. Alveolinid limestone, 2. Chalky limestone, 3. Nummulitic limestone, 4. Esna shale

Summary and conclusions

Study of about 100 thin sections, representing the indurated hard limestone of the Thebes Formation in two columnar sections exposed in Gabal Um El Ghanayem and Gabal Ghanima, shows that microfacial properties of these limestones lead to a better understanding of the environment of deposition of these rocks.

It was found that the succession in the studied two sections is entirely calcareous, and is composed of limestones which vary to chalky limestone and it is nummulitic, operculiniid, assiliniid or alveoliniid.

Lithologic and faunistic distinctions in the succession allow dividing it into different and distinct nineteen microfacies associations. Some of these microfacies form distinct and characteristic biostratigraphic zones. Correlation by microfacies between the two sections is attempted (Fig. 2). It was found that microfacies associations containing *Alveolina* sp. *(Alveolina* zone) are only represented in Gabal Um El Ghanayem. This is attributed to the general north-northeast dipping and the subsequent erosion in Gabal Ghanima.

We can conclude that, the microscopical and megascopical characters of the different limestone types indicate the deposition in an open shelf, ranging from reefal to inner neritic zone, and is lying on the eastern side of El Kharga uplift (Hafez, 1973).

Explanation of Plates

Plate I.

1. Foraminiferal biomicrosparite.
   Alveolina decipiens-pasticillate zone, Um El Ghanayem section. ×20
2. Algal biomicrite.
   Alveolina decipiens-pasticillata zone, Um El Ghanayem section. ×20

Plate II.

1. *Alveolina — Fabularia* biosparite.
   Alveolina decipiens-pasticillata zone, Um El Ghanayem section. ×10
2. Miliolid biosparite.
   Alveolina decipiens-pasticillata zone, Um El Ghanayem section. ×20

Plate III.

1. *Alveolina* biomicrite.
   Alveolina decipiens-pasticillata zone, Um El Ghanayem section. ×10
2. Bryozoa biomicrudite.
   Alveolina decipiens-pasticillata zone, Um El Ghanayem, section. ×20

Plate IV.

1. *Nummulites* biomicrite.
   Nummulites deserti zone, Ghanima section. ×20
2. *Nummulites* biomicrite.
   Nummulites deserti zone, Um El Ghanayem section. ×10

Plate V.

1. *Smoutina* biomicrite.
   Nummulites deserti zone, Ghanima section. ×20
2. *Nummulites-Smoutina* biomicrite.
   Nummulites deserti zone, Ghanima section. ×20

Plate VI.

1. *Assilina-Operculina* biomicrite.
   Assilina granulosa-Operculina canalifera zone, Ghanima section. ×20
2. Algal-Ostracoda biomicrosparite
   Alveolina decipiens- pasticillata zone, Um El Ghanayem section. ×20

Plate VII.

1. Annelid biomicrite.
   Assilina granulosa-Operculina canalifera zone, Um El Ghanayem section. ×20
2. *Nummulites-Operculina* biomicrite.
   Nummulites deserti zone, Ghanima section. ×20

Plate VIII.

1. *Assilina-Operculina* biomicrite.
   Assilina granulosa-Operculina canalifera zone, Ghanima section. ×20
2. *Miscellanea* biomicrite.
   Assilina granulosa-Operculina canalifera zone. Um El Ghanayem zone. ×20

Plate IX.

1. *Assilina* biomicrite.
   Assilina granulosa-Operculina canalifera zone, Um El Ghanayem section. ×10
2. Algal biomicrite.
   Alveolina decipiens-pasticillata zone, Um El Ghanayem section. ×20

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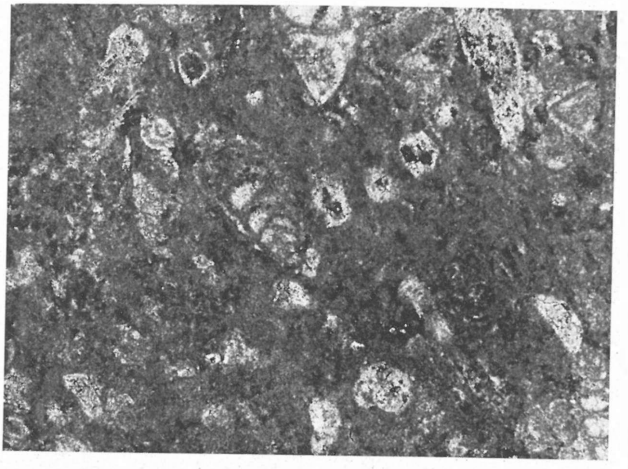
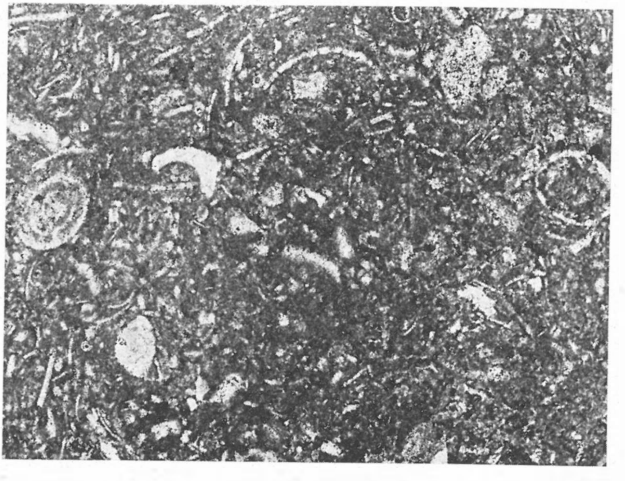
The recorded microfacies association within the biostratigraphic zones in both Gabal Ghanima and Um El G hanayem

+ = present — = absent *Table 1.*

Biostratigraphic zone	Microfacies association	Gabal Um El Ghanayem	Gabal Ghanima
	Alveolina-Fabularia biosparite	+	—
Alveolina decipiens	Microsparite	+	—
	Foraminiferal biomicrosparite	+	—
—	Bryozoa biomicrudite	+	—
	Alveolina biomicrite	+	—
pasticillata	Micrite	+	—
	Algal biomicrite	+	—
zone	Algal-Ostracoda biomicrite	+	—
	Miscellanea biomicrite	+	—
Assilina granulosa	Annelid biomicrite	+	—
	Assilina-Operculina biomicrite	+	+
—	Microsparite	+	+
Operculina canalifera	*Assilina* biomicrite	+	+
	Algal biomicrite	+	+
	Operculina-Smoutina biomicrosparite	—	+
zone	*Nummulites-Operculina* biomicrite	+	+
	Nummulites-Operculiba biomicrite	+	+
Nummulites	*Smoutina* biomicrite	—	+
	Nummulites-Smoutina biomicrite	—	+
deserti	Algal biomicrite	+	+
	Nummulites-Algal biomicrite	+	+
	Microsparite	+	+
zone	Micrite	+	+
	Nummulites bearing micrite	+	+
	Nummulitic biomicrite	+	+

Plate I.





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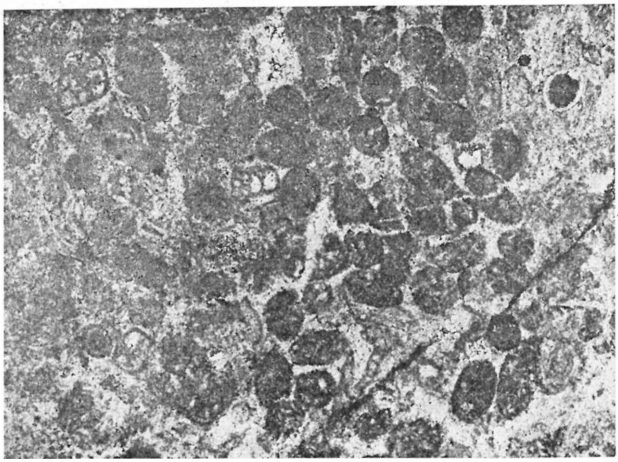

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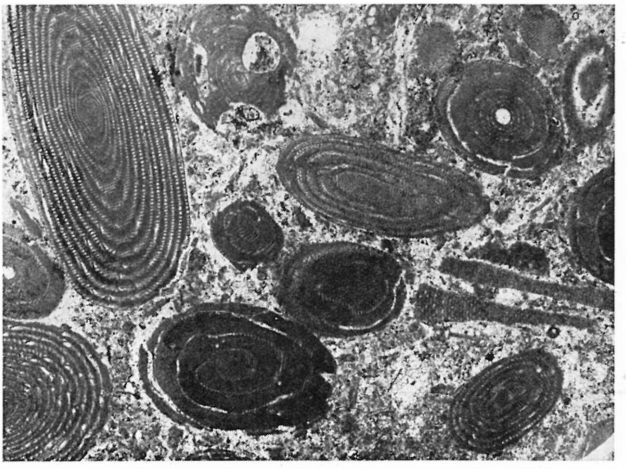

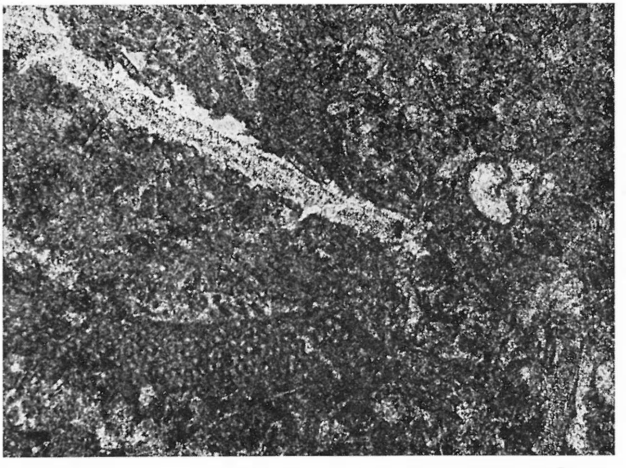

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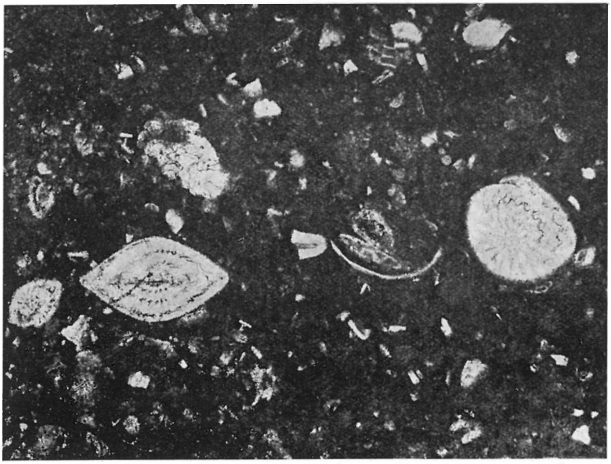

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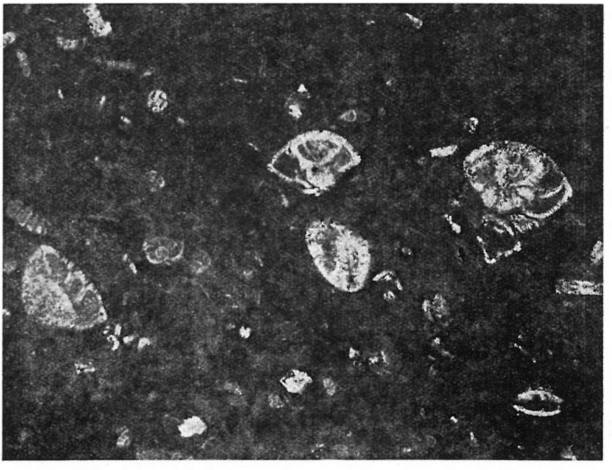

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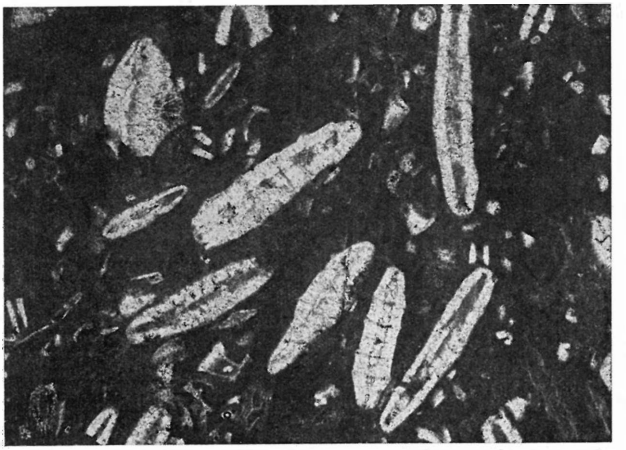
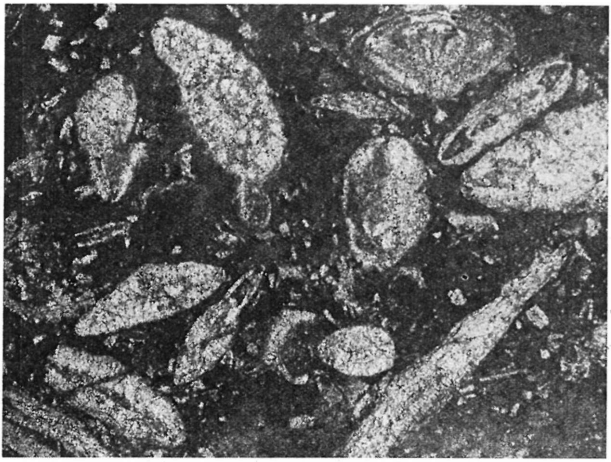


Plate VII.

Plate VIII.



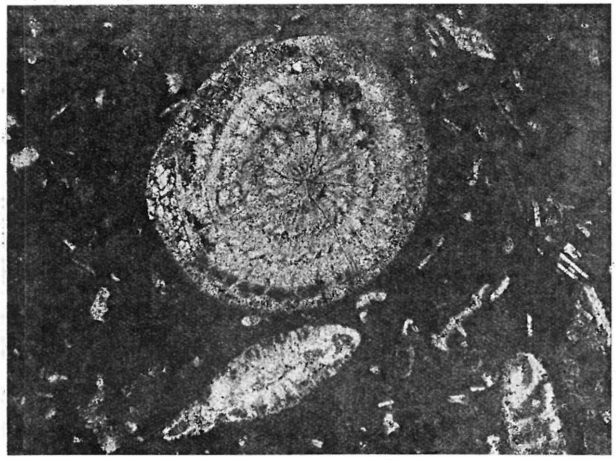


Plate IX.