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Some Microfacies Characteristics of Tuwaiq Mountain Limestone (Upper Jurassic) in Central Tuwaiq Mountains

Saleh Mohamed Okla

Geology Department, College of Science, King Saud University, Riyadh, Saudi Arabia

ABSTRACT. A complete section of the Tuwaiq Mountain Limestone (upper Jurassic) was measured along a new road cut through the Tuwaiq Mountain escarpment between Riyadh and Al Mizahmia to the west. The section is 193 meters thick. The lower 103.3 meters of the section are designated as the Lower Tuwaiq Mountain Limestone, and the upper 89.7 meters are designated as the Upper Tuwaiq Mountain Limestone. Incomplete sections in the Upper Tuwaiq Mountain Limestone were also measured at the Old Darb Al Hijaz to the north of the main complete section and at Wadi Nisah to the south. These are 49.3 m and 27 m thick, respectively.

The Lower Tuwaiq Mountain Limestone is characterized by alternating light yellow, spicular biomicrites and light gray, pelletiferous biomicrites. The Upper Tuwaiq Mountain Limestone comprises light gray, hard, ledge forming biomicrites with abundant corals, stromatoporoids and algae. The microfacies of the Tuwaiq Mountain Limestone are the product of carbonate deposition in two major carbonate environments that prevailed successively over the flooded Arabian Platform. The first represented a calm and sheltered sea floor that was subject to periodic agitation, whereas the second had more open marine conditions. The final phase of deposition was particularly characterized by abundant blue green and dasycladacean algae.

The present study is the third in a series of investigations dealing with microfacies of Jurassic carbonates (Okla 1983 and Okla 1984). The first two dealt with Hanifa and Jubaila Formation, respectively, while the present study describes the Tuwaiq Mountain Limestone. These units crop out in a graben region known as the Tuwaiq Mountains, which form one of the major topographic features of the central Arabian Peninsula, running north-south subparallel to the eastern edge of the Arabian Shield. The central Tuwaiq Mountains include the area west, north-west and south-west of the city of Riyadh (Fig. 1). This area is intensively dissected by several Wadi systems and tectonic grabens.

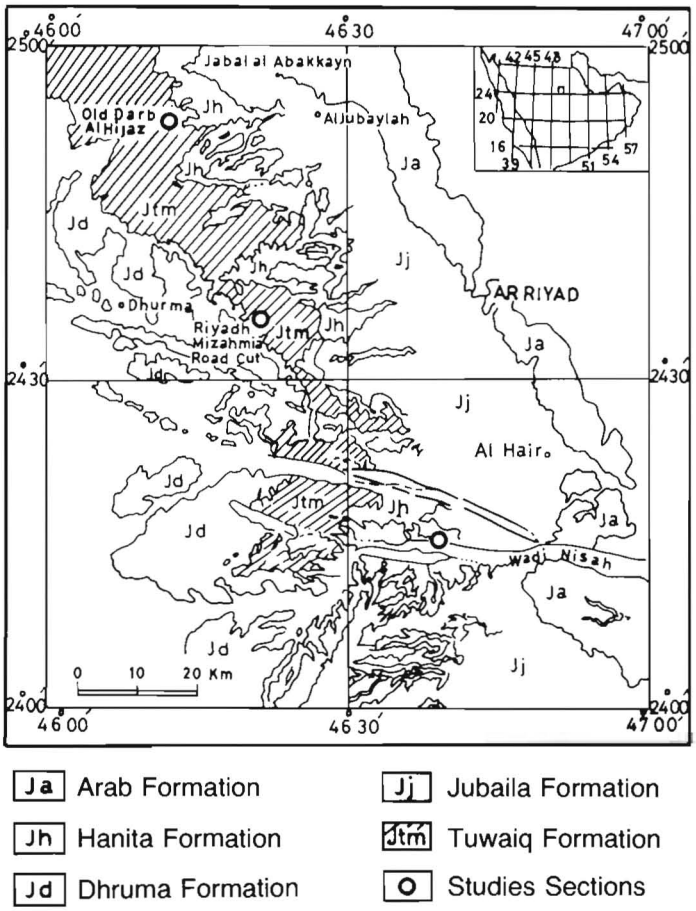

Fig. 1. Geologic map of Jurassic outcrops in central Tuwaiq Mountains. (Redrawn from Bramkamp and Ramirez 1958)

A complete section through the Tuwaiq Mountain Limestone was measured in a new cutting on the road running west from Riyadh to Al Mizahmia (lat 24° 38′N, long 46° 43′E, Fig. 1). This new cutting has made possible the measurement of a complete section of the formation for the first time. Elsewhere, the steep escarpment made by the formation has made measurement of complete sections impossible.

Incomplete sections through the Upper Tuwaiq Mountain Limestone were measured at the Old Darb Al Hijaz 60 km north-west of Riyadh, and at Wadi Nisah 60 km south of the city of Riyadh.

The Tuwaiq Mountain Limestone is an oil producing formation at Abu Hadriya, Fadhili and Qatif oil field in eastern Saudi Arabia (Powers *et al.* 1966) and a source rock to the east (Ayres *et al.* 1982).

Stratigraphy

The Tuwaiq Mountain Limestone is named after Jabal Tuwaiq, a spectacular, nearly parallel sequence of west facing scarps developed in the Jurassic rocks of Central Arabia. Max Steineke, in 1937, described and defined the Tuwaiq Mountain Limestone as a member of Tuwaiq Formation (Powers *et al.* 1966, Powers 1968). In 1945, Bramkamp raised the Tuwaiq formation to a group and elevated the Mountain Limestone to a formation. The term, Tuwaiq group, was then discarded and the Jurassic stratigraphic nomenclature assumed its present form (Fig. 2).

The type section occurs along the Old Darb Al Hijaz road, between lat 24° 51′ 56″N, long 46° 07′ 10″E and lat 24° 56′ 56″N, long 46° 13′ 32″E. In the type area, the base of the Tuwaiq Mountain Limestone is at the contact between soft

Stage	Formation	Rock-Types
TITIONINAN	HITH	Anhydrite 90 m thick
	ARAB	Calcarenite, calcarenitic and aphanitic limestone 124 m thick
KIMMERIDGIAN	JUBAILA	Aphanitic limestone and dolomite, some calcarenite, calcarenitic limestone and sandstone 118 m thick
	HANIFA	Aphanitic limestone, calcarenitic limestone and calcarenite. 113 m thick
OXFORDIAN AND CALLOVIAN	TUWAIQ MOUNTAIN	Aphanitic limestone, calcarenitic limestone, calcarenite, and abundant coral and stromatoporoids in upper part. 203 m thick
CALLOVIAN BATHONIAN AND BAJOCIAN	DHRUMA	Aphanitic limestone and shales some calcarenite, dominantly sandstone south of 22°N and north of 26°N. 375 m thick.
TOARCIAN	MARRAT	Shale and aphanitic limestone subordinate sandstone. 103 m thick

Fig. 2. The Jurassic succession in central Saudi Arabia (After Powers *et al.* 1966).

calcarenitic limestone and underlying olive-green shale of the Dhruma. The upper limit is the contact of massive coral-bearing limestone with overlying marl and soft limestone of the Hanifa Formation (Powers *et al.* 1966, Okla 1983). The Tuwaiq Mountain Limestone conformably overlain by the Hanifa Formation above.

Microfacies

Microfacies of the measured sections of the Tuwaiq Mountain Limestone distinctively indicate a lower and upper sub-divisions of the formation (Fig. 3). The Lower Tuwaiq Mountain Limestone as measured along the new Al-Riyadh-Mizahmia Road is 103.3 meters thick, where its contact with the underlying Dhruma Shale is seen.

This part of the formation is composed of number of microfacies characterized by alternating spiculate and pelletiferous beds (Table 1). The lowest recognizable unit is 17.5 meters thick. It is generally light yellow, hard biomicrite. It is characterized by having varying amounts of calcareous spicules and pellets (Pl. I, Fig. 1). A second recognizable unit in the measured section is 13.5 meters thick. It is light

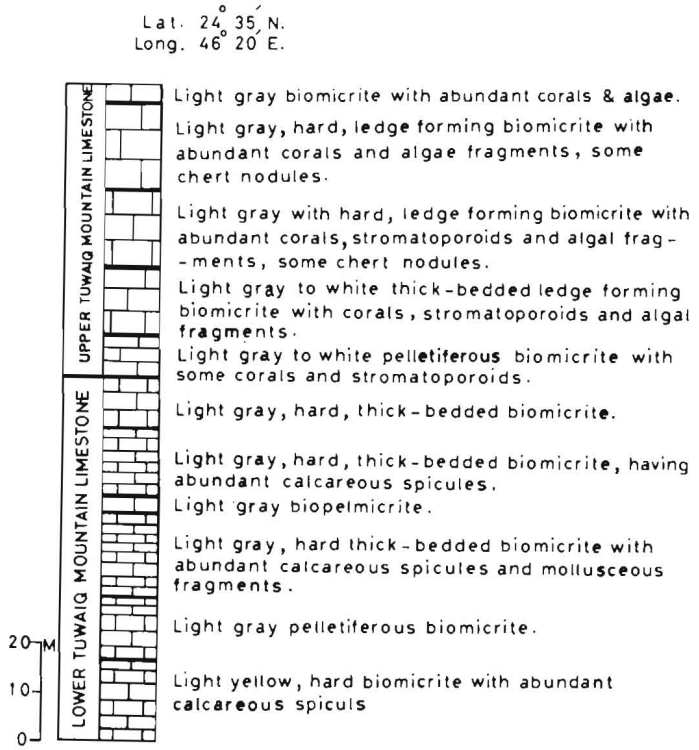

Fig. 3. Measured section of Tuwaiq Mountain Limestone along Riyadh-Mizahmia road cut.

gray, hard biomicrites, becoming biopelmicrite in its upper third. A third unit is 29.4 meters of light gray spicular biomicrite (Pl. I, Fig. 2). The unit is relatively thick bedded and partly dolomitized. A fourth unit is 5.3 meters of light gray, hard, biopelmicrite having 20% pellets (Pl. I, Fig. 3). It is characterized by medium-sized pellets, foraminifera and some coral fragments. A fifth unit is 21 meters of light gray spicular biomicrite. A sixth unit is 16.6 meters of light gray, hard, biopelmic-

Table 1. Lower Tuwaiq mountain limestone along Al-Riyadh–Mizahmia road.

Unit	Thick-ness (m)	Description
6	3.2	biopelmicrite : light gray, hard, having 20% pellets and foraminifera.
	8.0	biomicrite : light gray, hard pelletiferous.
	5.4	biopelmicrite : light gray, hard, having 20% pellets and molluscan fragments.
5	3.4	biomicrite : light gray, hard spicular.
	7.0	biomicrite : light gray, hard, thick-bedded and spicular.
	5.3	biomicrite : light gray, hard, having 20% calcareous spicules and formaminifera.
	5.3	biomicrite : light gray, hard, spicular.
4	5.3	biopelmicrite : light gray, hard with 20% pellets.
3	8.0	biomicrite : light gray hard, spicular, having some foraminiferal molluscan fragments.
	12.1	biomicrite : light gray, hard spicular, thick-bedded and partly dolomitized.
	5.5	biomicrite : light gray, hard, spicular.
	3.8	biomicrite : light gray, hard, thick-bedded.
2	3.3	biopelmicrite : light gray, hard, having 20% pellets.
	5.6	biomicrite : light gray, hard, having 20% pellets and molluscan fragments.
	4.6	biomicrite : light gray, hard pelletiferous.
1	3.3	biomicrite : light yellow, hard, having 20% intraclast, spicules and pellets.
	3.5	biomicrite : light yellow, hard, spicules bearing.
	2.0	biomicrite : light yellow, hard, having 25% calcareous spicules thick-bedded.
	5.5	biomicrite : light yellow, hard, spicular and pelletiferous.
	3.2	biomicrite : light yellow, hard, spicular and pelletiferous.

Plate I

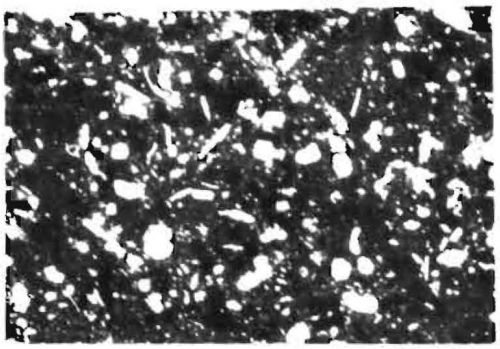

Fig. 1

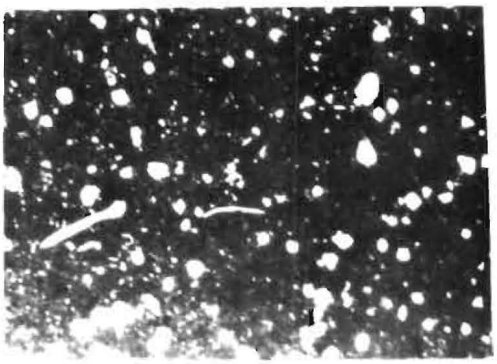

Fig. 2

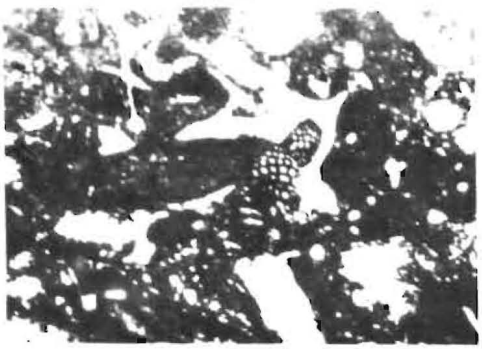

Fig. 3

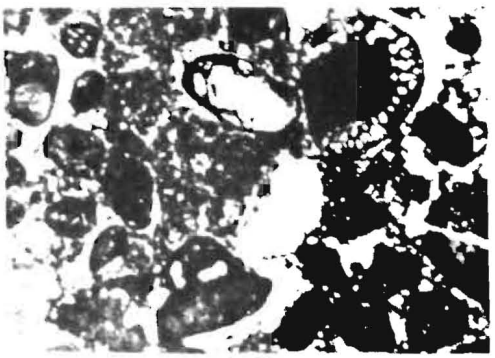

Fig. 4

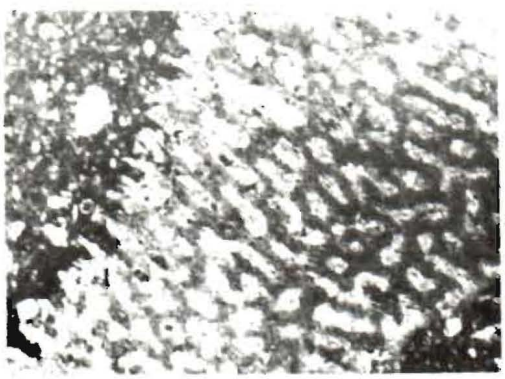

Fig. 5

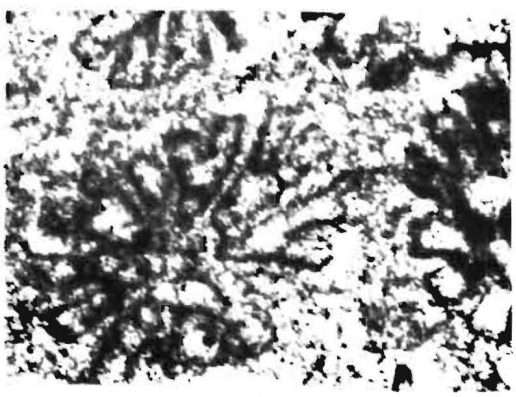

Fig. 6

rite (Pl. I, Fig. 4). This unit forms a persistent bed at the top of the Lower Tuwaiq Mountain Limestone.

The Upper Tuwaiq Mountain Limestone as measured along the new road cut is 89.7 meters and consists of light gray, well-bedded biomicrites characterized by having abundant corals, stromatoporoids and algae, (Table 2). The Lowest recognizable unit is 14.1 meters of light gray biomicrite, having abundant fragments of solitary and colonial corals (Pl. I, Fig. 5). A second unit is 21.4 meters of light gray biomicrite and biopelmicrite. The biomicrite is characterized by having oncolites, corals and stomatoporoids, and algal fragments (Pl. I, Fig. 6). A third unit is 24.1 meters of light gray and white biomicrite, having spicular, molluscan and coral fragments (Pl. II, Fig. 1). The uppermost unit of Upper Tuwaiq Mountain Limestone is 3.8 meters of thin-bedded light gray, pelsparite and biomicrite. The pelsparite is 1.6 meters thick. The biomicrite is 2.2 meters of light gray having abundant coral, stromatoporoidal and algal fragments.

The incomplete sections that were measured in the Upper Tuwaiq Mountain Limestone are 49.3 meters at the Old Darb Al Hijaz road and 27 meters at Wadi Nisah. These are particularly important for their fossil algal constituents. Both sections correspond to unit 10 and 11 of Upper Tuwaiq Mountain Limestone along the Riyadh-Mizahmia road. At the Old Darb Al Hijaz Road, the lowest measured unit is 13.6 meters of light gray, hard biomicrite having abundant corals and algal fragments. Above that is 6.2 meters of light gray biomicrite with coral and algal

Plate I

Fig. 1. Photomicrograph of spicular and pelletiferous biomicrite showing calcareous spicules and pellets in micrite matrix (×20).
Lower Tuwaiq Mountain Limestone, Riyadh-Mizahmia Road.

Fig. 2. Photomicrograph of spicular biomicrite showing calcareous spicules (×20).
LowerTuwaiq Mountain Limestone, Riyadh-Mizahmia Road.

Fig. 3. Photomicrograph of biopelmicrite showing medium-sized pellets, foraminiferal and molluscan fragments. (×20).
Lower Tuwaiq Mountain Limestone, Riyadh-Mizahmia Road.

Fig. 4. Photomicrograph of biopelmicrite showing pellets and a fragment of the foraminiferal test of *Kurnubia* sp. (×20).
Lower Tuwaiq Mountain Limestone, Riyadh-Mizahmia Road.

Fig. 5. Photomicrograph of coral bearing biomicrite showing cross section of colonial coral (×20).
Upper Tuwaiq Mountain Limestone, Riyadh-Mizahmia Road.

Fig. 6. Photomicrograph of biomicrite showing cross section of coral fragments (×20).
Upper Tuwaiq Mountain Limestone, Riyadh-Mizahmia Road.

Plate II

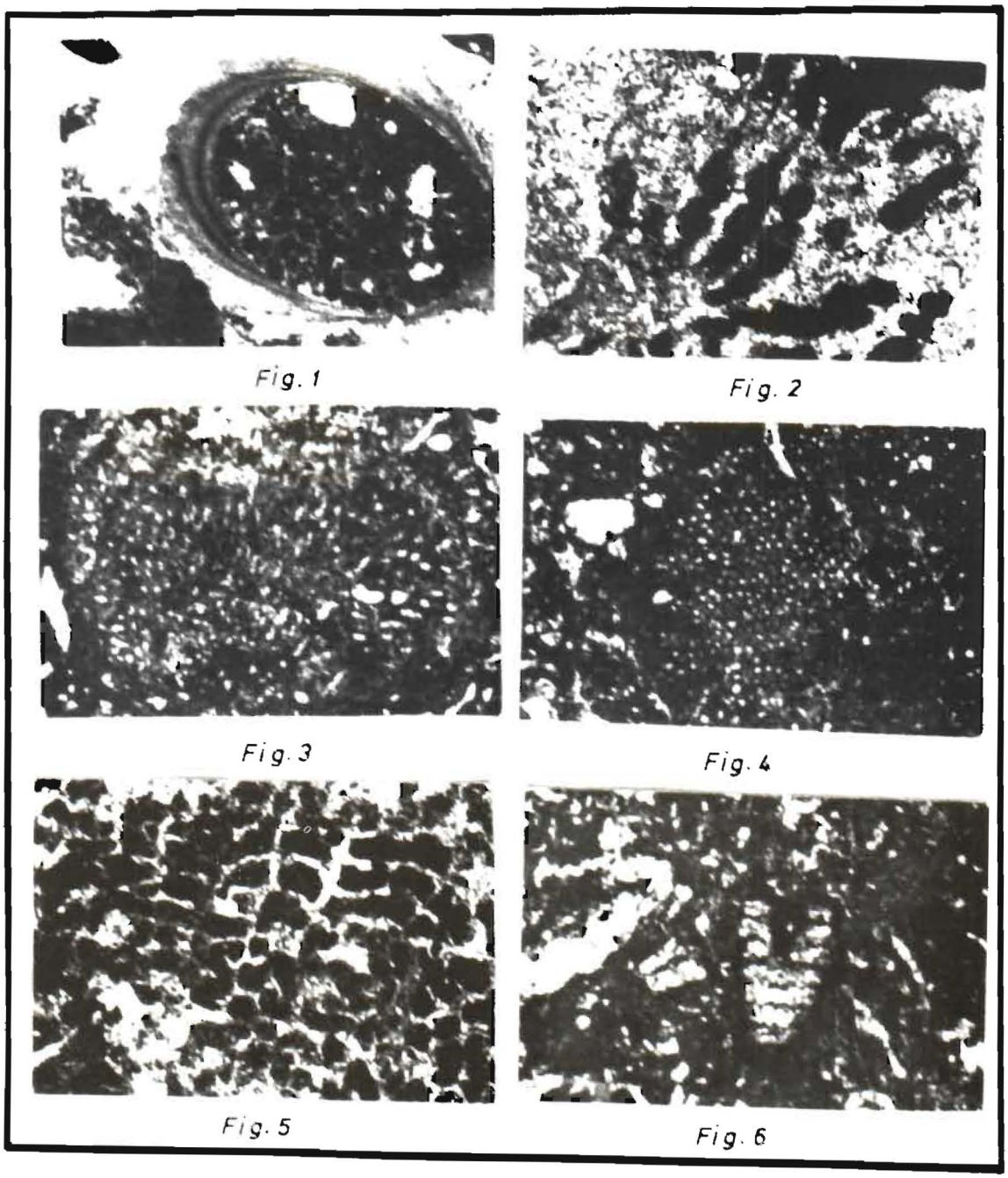

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Table 2. Upper Tuwaiq mountain limestone along Al-Riyadh–Mizahmia road.

Unit	Thick-ness (m)	Description
11	0.7	biomicrite : light gray, hard having coral, stromatoporoidal and algal fragments.
	1.5	biomicrite : light gray, hard having coral, stromatoporoidal and algal fragments.
	1.6	pelsparite : light gray, hard, with 35% pellets.
10	4.8	biomicrite : light gray, hard with coral and molluscan fragments.
	6.4	biomicrite : light gray, hard, spicular and with coral fragments.
	6.4	biomicrite : light gray, hard having molluscan fragments.
	8.7	biomicrite : light gray, pelletiferous and having coral fragments.
9	4.8	biomicrite : light gray, hard, spicular and having molluscan fragments.
	19.3	biomicrite : light gray to white having coral, stromatoporoidal and algal fragments.
8	3.8	biopelmicrite : light gray, hard.
	17.6	biomicrite : light gray to white having oncolites, coral, stromato-poroidal and algal fragments.
7	5.4	biomicrite : light gray to white, hard, pelletiferous.
	5.5	biomicrite : light gray to white, hard, having pellets and spicules.
	3.2	biomicrite : light gray to white, hard, having corals stromato-poroidal and algal fragments.

Plate II

Fig. 1. Photomicrograph of biomicrite showing faceal pellets within section of molluscan shell (×20). Upper Tuwaiq Mountain Limestone, Riyadh-Mizahmia Road.

Fig. 2. Photomicrograph of biomicrite showing cross section of coral fragment (×20). Upper Tuwaiq Mountain Limestone, Old Darb Al Hijaz Road.

Fig. 3. Photomicrograph of biomicrite showing a section of algae *Cayeuxia* (×20). Upper Tuwaiq Mountain Limestone, Old Darb Al Hijaz Road.

Fig. 4. Photomicrograph of biomicrite showing a possible algal fragment (× 20) Upper Tuwaiq Mountain Limestone, Old Darb Al Hijaz Road.

Fig. 5. Photomicrograph of biomicrite showing a section through a coral fragment (× 20). Upper Tuwaiq Mountain Limestone, Old Darb Al Hijaz Road.

Fig. 6. Photomicrograph of biomicrite showing a part of a dasycladacean algae (× 20). Upper Tuwaiq Mountain Limestone, Wadi Nisah.

fragments (Pl. II, Fig. 2). The overlying 13.7 meters are light gray biomicrite having abundant algal and coral fragments (Pl. II, Fig. 3). The upper 5 meters of the same interval becomes more peloidal beside having coral and algal fragments. The uppermost unit of the measured section is 15.8 meters of light gray, hard biomicrite that corresponds to the upper part of unit 10 and 11 in the measured section along the Riyadh-Mizahmia road. It is characterized by coral and algal constituents, particularly in the uppermost 3 meters (Pl. II, Fig. 4-5). The most well represented algae in the measured section is the *Cayeuxia* sp. (Flugel 1982). At Wadi Nisah, a 27 meter section was measured in the uppermost part of Upper Tuwaiq Mountain Limestone. It corresponds to the upper part of unit 10 and 11 in the Riyadh-Mizahmia road cut and represents biomicrite with abundant algal and coral fragments (Pl. II, Fig. 6), (Bassoullet *et al.* 1978).

Environmental Interpretation

Microfacies of the Tuwaiq Mountain Limestone in central Tuwaiq Mountains revealed two major episodes of carbonate deposition. One is represented by the Lower Tuwaiq Mountain Limestone and characterized by alternating spicular biomicrites and pelletiferous biomicrites with molluscan and foraminiferal constituents. The second is represented by the Upper Tuwaiq Mountain Limestone and characterized by biomicrites having corals, stromatoporoids and algal constituents. The algae are particularly common in the uppermost beds of the formation. It is apparent that the Tuwaiq Mountain Limestone microfacies are the product of carbonate deposition over the flooded Arabian Platform west of the Luristan basin (Murris 1980, Ayres *et al.* 1982). The Lower Tuwaiq Mountain Limestone was deposited in conditions of generally low energy with occasional episodes of higher energy producing spicular biomicrites alternating with pelletiferous biomicrites. During the deposition of the upper part of the formation, however, open marine conditions were prevailing as corals, stromatoporoids and algae were the most abundant constituents of the sediments (Scholle 1978). Near the end of deposition of the formation, the environment promoted algal growth particularly the blue green alga *Cayeuxia* sp. and dasycladacean algae. This indicates shoaling of the water as the deposition of the formation was completed.

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بعض خصائص السحنات الدقيقة لمتكون جبل طويق (الجراسى العلوى) فى وسط جبال طويق

صالح محمد العقلا

قسم الجيولوجيا - كلية العلوم - جامعة الملك سعود - الرياض - المملكة العربية السعودية

لقد تم قياس قطاع كامل لمتكون جبل طويق (الجر اسى العلوى) على طريق الرياض المزاحمية الجديد. وقد أظهر القياس أن سماكة المتكون ١٩٣ متراً، كما أمكن تقسيم هذا القطاع إلى جزء سفلى بلغت سماكته ١٠٣,٣ متراً وجزء علوى بلغت سماكته ٨٩,٧ متراً. هذا وقد تم قياس جزءين آخرين أحدهما على درب الحجاز القديم شمال الرياض وبلغت سماكته ٤٩,٣ متراً والآخر فى وادى نساح جنوب الرياض وبلغت سماكته ٢٧ متراً.

وقد وجد أن الجزء السفلى لمتكون جبل طويق يتكون من سحنات دقيقة تتميز باحتو ائها على بقايا الإسفنجيات وبعض العقد الصغيرة، فى حين أن الجزء العلوى لمتكون جبل طويق يتكون من سحنات دقيقة تتميز باحتوائها على بقايا المرجانيات والطحالب الدقيقة (الأشنات)، ويظهر أن السحنات الدقيقة لمتكون جبل طويق قد ترسبت فى بيئتين، الأولى تميزت بهدوء نسبى فى حركة المياه، والثانية كانت بيئة بحرية عادية حيث تكونت فيها المرجانيات. كما أن المرحلة الأخيرة من ترسيب المتكون تميزت بوجود الطحالب الدقيقة.