Arab Gulf J. scient. Res. **4** (1), pp. 177-189 (1986)

Microfacies and Environment of Upper Tuwaiq Mountain Limestone (Upper Jurassic) in Central Saudi Arabia

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ABSTRACT. The Tuwaiq Mountain Limestone is one of five prominent rock units in the Upper Jurassic of central Saudi Arabia. It is 193 meters thick near the city of Riyadh. The Upper 90 meters of the formation is designated as the Upper Tuwaiq Mountain Limestone. It consists of light gray, hard, ledge forming biomicrite with abundant algae, corals and stromatoporoids. The most common fossil algae are the oncoidal forms of the blue-green alga genus *Cayeuxia*. The coral genera *Amphiastraea* and *Microsolena* are among the commonest remains of the frame-builders of possibly small reef-like structures. The Upper Tuwaiq Mountain Limestone was deposited in open marine environment of moderate depth. Surges of high turbulent water produced allochthonous facies particularly at the close of deposition.

As early as 1937, when Max Steineke described and defined the Tuwaiq Mountain Limestone, it was noted that the upper part of the formation is coral-bearing, dense and pure limestone (Powers *et al.* 1966). The Tuwaiq Mountain Limestone was named after Jabel Tuwaiq, a spectacular, nearly parallel sequence of west facing scarp developed in the Jurassic rocks of central Arabia. During the investigation of the microfacies of Jurassic rock units in central Tuwaiq Mountains (Okla 1983, 1984a & b), the Tuwaiq Mountain Limestone was measured along a new road cut, 30 Km west of Riyadh (Fig. 1). The measured section is 193 meters thick of which the upper 90 meters are designated as the Upper Tuwaiq Mountain Limestone. Incomplete sections through the Upper Tuwaiq Mountain Limestone were sampled in the vicinity of the measured section.

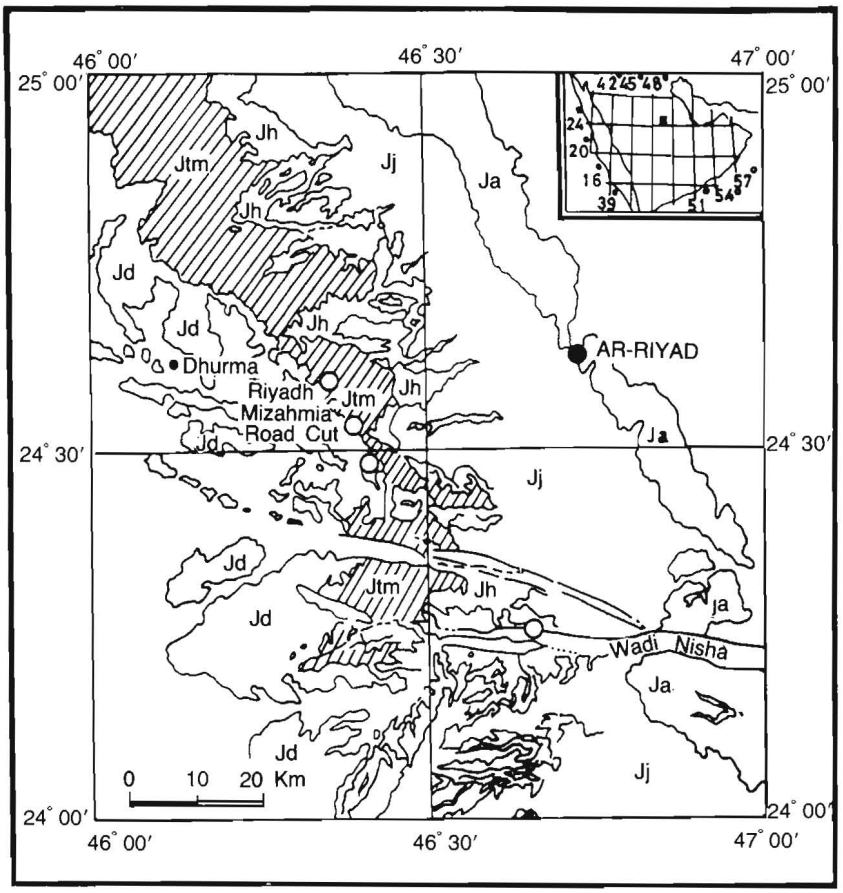

Fig. 1. Geologic Map of Jurassic Outcrops in Central Tuwaiq Mountains

Ja	Arab Formation	Jj	Jubaila Formation
Jh	Hanifa Formation	Jtm	Tuwaiq Mountain Ls.
Jd	Dhruma Formation	○	Studied Sections

(After Bramkamp and Ramirez 1958)

The Tuwaiq Mountain Limestone is one of the major Jurassic carbonate rock units of Saudi Arabia (Fig. 2). It is also an oil producing formation at Abu Hadriya, Fadhile and Qatif Oil fields of eastern Saudi Arabia (Powers *et al.* 1966).

STAGE	FORMATION	ROCK - TYPES
TITHONIAN	HITH	Anyhydrite 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 stromatoproids 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 Power *et al.* 1966)

Microfacies and Environment of Deposition

The Tuwaiq Mountain Limestone is distinctively subdivided into lower and upper divisions. The Lower Tuwaiq Mountain Limestone is 103 meters of alternating light yellow, spiculate biomicrite, and light gray, pelletiferous biomicrite (Fig. 3). The Upper Tuwaiq Mountain Limestone is 90 meters of light gray well-bedded biomicrites characterized by having abundant fossil algae, corals and

stromatoporoids. A few thin pelsparites are found in the uppermost part of the formation. The best represented fossil alga in the Upper Tuwaiq Mountain Limestone is the genus *Cayeuxia* (Pl. I, Fig. 1, 2, 3, 4 and 5). These blue-green algae were particularly abundant in the Upper Jurassic of Europe. They were recorded, in Southern Germany, from allochthonous carbonate sediments that were deposited adjacent to coral reefs (Flügel 1982). The European allochthonous sediments had between 10 and 65% of their constituents as remains of the genus *Cayeuxia*. They were interpreted as having being deposited in a basin with maximum depth of about 80 meters. In the Upper Tuwaiq Mountain limestone, these blue-green algae are found in biomicrite with relatively large remains of corals, mostly in the form of oncoidal grains. Large pieces of the thalli of these blue-green algae are found but many samples showed small broken pieces. Other associated fossil algae are possibly solenoporacean (Pl. I, Fig. 6) and the dasycladacean algae (Pl. II, Fig. 1 and 2). These algal forms are particularly common in the open marine platforms (Flügel 1982).

The Upper Tuwaiq Mountain Limestone is also characterized by having abundant foraminiferal remains belonging to the genus *Kurnubia* (Okla 1984b). Another form of the foraminifera is remains of the genus *Anchispirocyclina*. These foraminifera and the aforementioned dasycladacean algae are particularly important in the zonation of shallow water facies of the Upper Jurassic. They are most commonly found in the pelletiferous biomicrite facies.

The biomicrites of the Upper Tuwaiq Mountain Limestone are especially noted for having abundant remains of corals (Pl. II, Fig. 5 and 6 and Pl. III, Fig. 1, 2, 3, 4 and 5). Some coral heads as large as 40 cm in diameter havd been found at different localities in the studied area. Steineke *et al.* (1958) reported the presence of small reefs up to 15 meters high and about 50 meters in diameter, just west of Riyadh. These, however, have not been observed in the sampled sections, although their presence is very likely. The possible remains of *Amphiastraea* and *Microsolena* are positive indicators of frame-builders. These forms have been reported from the Upper Jurassic reef complex in north-western Yugoslavia (Turnsek *et al.* 1981).

Other organic remains are those of stromatoporoids (Pl. III, Fig. 6). Massive and laminar forms are closely associated with corals. They were commonest in the Upper Jurassic shallow water environments, particularly in association with reefs (Turnsek *et al.* 1981, Flügel 1982).

From the aforementioned findings, it can be concluded that the Upper Tuwaiq Mountain Limestone was deposited in a shallow sea of moderate depth, where frame-building organisms grew in the form of small reef and bioherms. Turbulent waters prevailed, particularly at the close of deposition, as allochthonous and oncoid-bearing sediments were deposited.

In the studied area, the Tuwaiq Mountain Limestone, as a whole, represents

Plate I

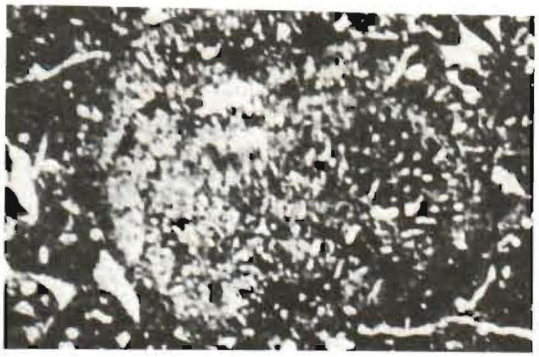

Fig. 1. Photomicrograph showing the filamentous blue-green alga *Cayeuxia* sp. (X 20).

Fig. 2. Photomicrograph showing another form of the blue-green alga *Cayeuxia* sp. (X 10).

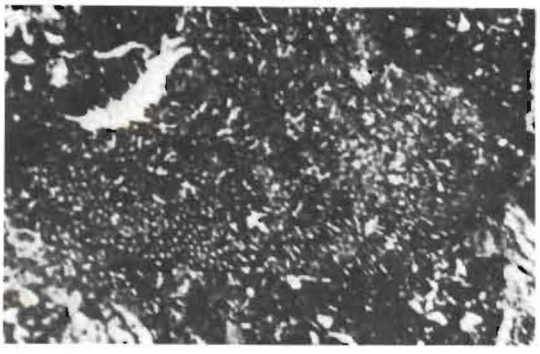

Fig. 3. Photomicrograph showing groups of thalli of the same blue-green alga as above (X 10).

Plate I. Continued

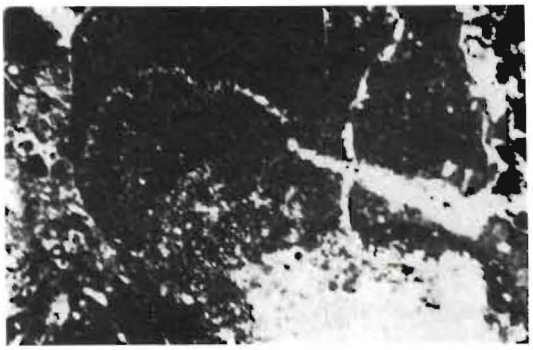

Fig. 4. Photomicrograph showing another form of the blue-green algae of the same type as above (X 15).

Fig. 5. Photomicrograph showing a part of possibly a thallus blue-green algae (X 15).

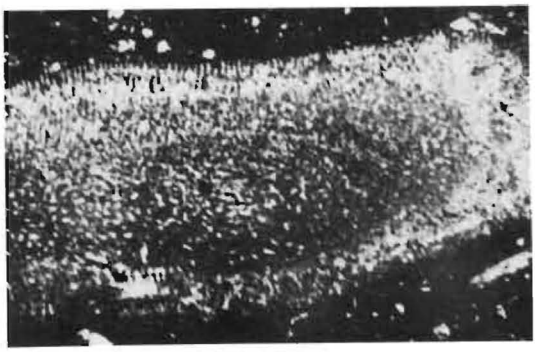

Fig. 6. Photomicrograph showing possibly a solenoporacean red alga (X 5).

Plate II

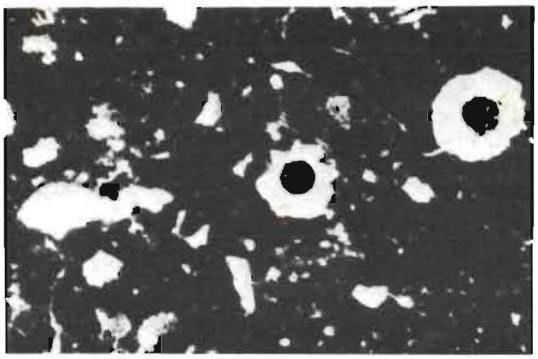

Fig. 1. Photomicrograph showing remains of dasycladacean green alga (X 30).

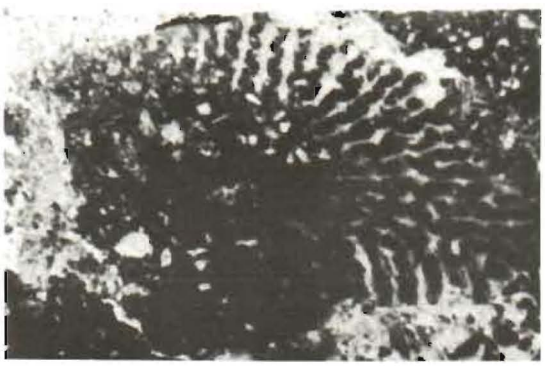

Fig. 2. Photomicrograph showing possibly a dasycladacean green alga (X 15).

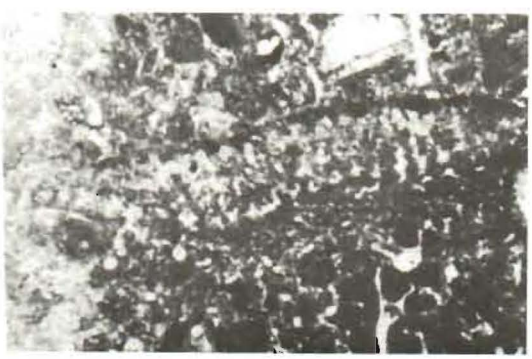

Fig. 3. Photomicrograph showing a large foraminiferid *Anchispirocyclina* sp. (X 20).

Plate II. Continued

Fig. 4. Photomicrograph showing another form of foraminiferid (X 40).

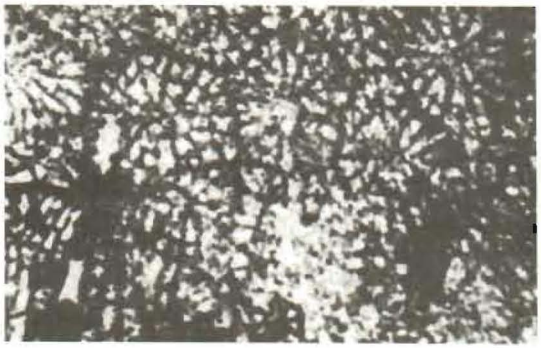

Fig. 5. Photomicrograph showing a form of possibly frame-building colonial coral (X 5).

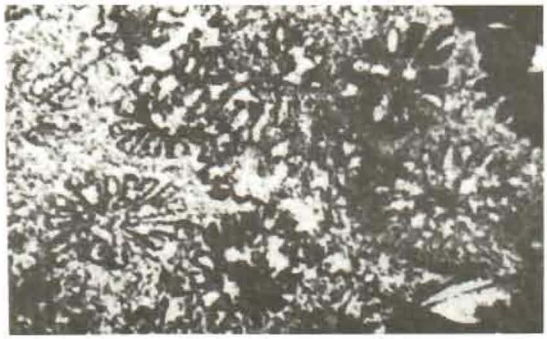

Fig. 6. Photomicrograph showing a form of possibly the coral *Goniocora* sp. (X 10).

Plate III

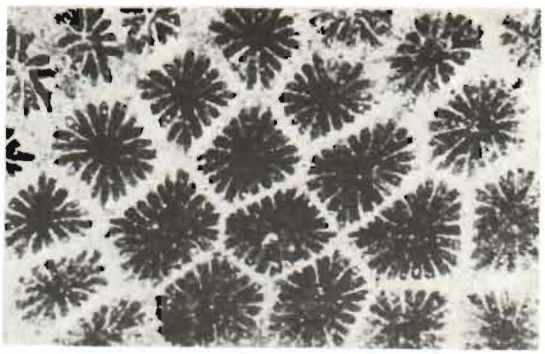

Fig. 1. Photomicrograph showing a section of the colonial coral *Amphiastraea* sp. (X 5).

Fig. 2. Photomicrograph showing another form of a possibly frame-building colonial coral. (X 5).

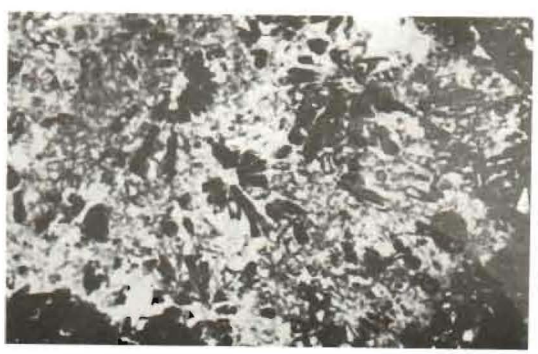

Fig. 3. Photomicrograph showing a section of another colonial coral (X 5).

Plate III. Continued

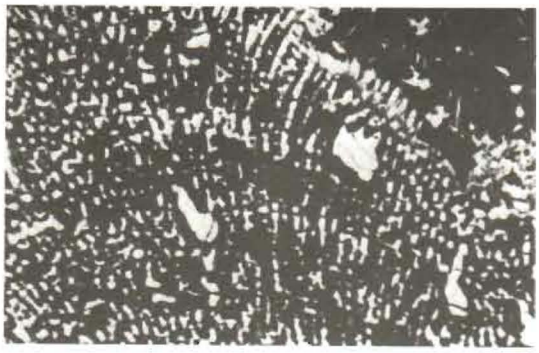

Fig. 4. Photomicrograph showing a transverse section of *Microsolena* sp. (X 5).

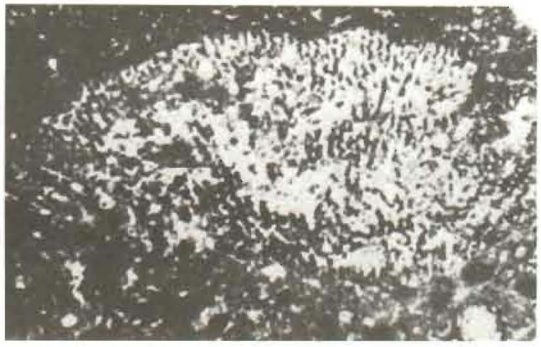

Fig. 5. Photomicrograph showing a longitudinal section of *Microsolena* sp. (X 10).

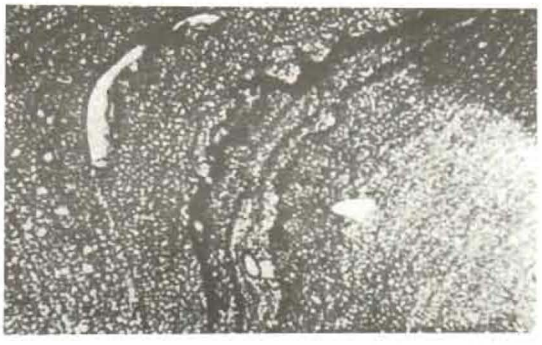

Fig. 6. Photomicrograph showing possibly a section of stromatoporoid. (X 5).

the thickest known section of the formation in Central Saudi Arabia (Powers *et al.* 1966). The formation thins out to the north and south as the lithology of the formation changes from pure limestone in the studied area to sandy limestone and

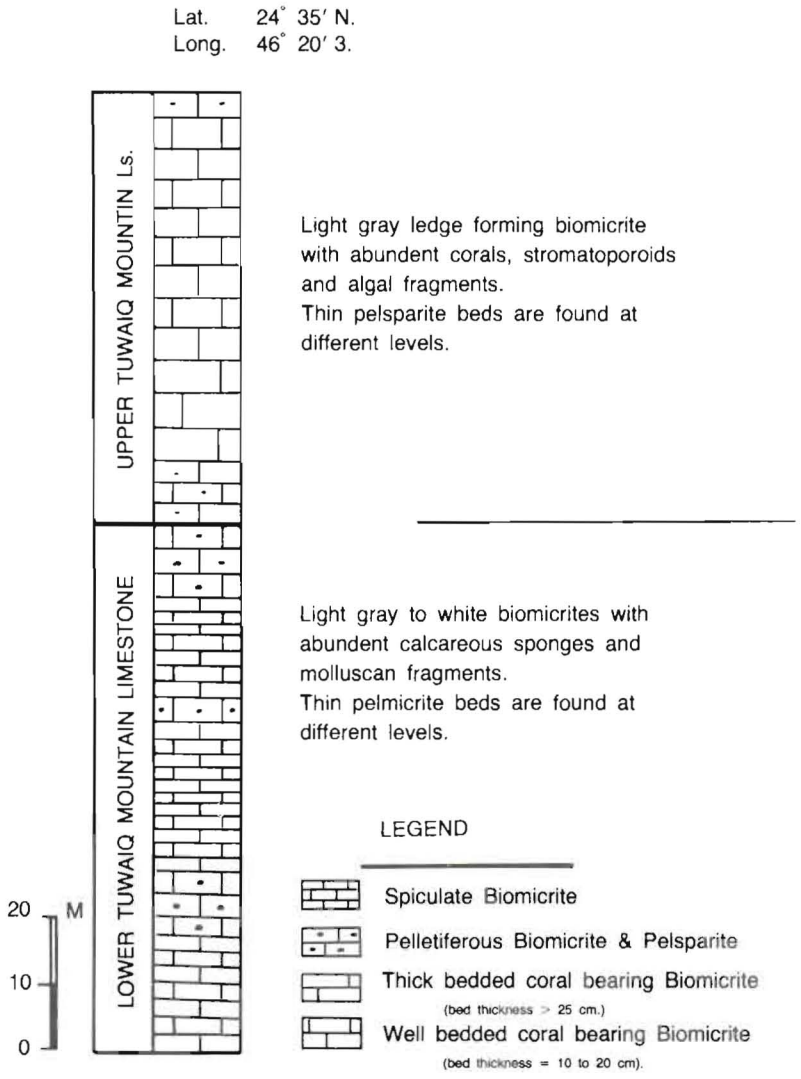

Fig. 3. Measured Section of Tuwaiq Mountain Limestone along Riyadh - Mizahmia Road Cut.
(Redrawn from Okla 1984b)

sandstone. These sandstones possibly mark ancient shorelines adjacent to the Arabian Shield to the west. The central Tuwaiq Mountains, therefore, represent the central area of the Arabian carbonate shelf and possibly the most active area of carbonate sedimentation during Callovian and Oxfordian times. This Arabian carbonate shelf was bordered to the west by the Arabian Shield and probably covered the whole area between the Rub El Khali basin to the southeast and the Basrah basin to the north-east.

Acknowledgement

I am very thankful to Mr. Mukhles Wali from the geology department, for his assistance during the sampling of the sections and to Mr. Mohamed Eftikhar from the botany department, for his assistance in taking the photomicrographs.

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(Received 28/07/1984;
in revised form 28/11/1984)

السحنات الدقيقة وبيئة مُتكوِّن جبل طـويق العلوي (الجراس العلوي) في وسط المملكة العـربية السعودية

صالح محمد العقلا

قسم الجيـولوجيـا ـ كلية العلوم جـامعة الملك سعـود ـ الريـاض ـ المملكة العربية السعودية

يُكـوِّن مُتكـوِّن جبـل طـويق واحـداً من خمسـة متكـونـات في الجـراسي العلوي في وسط المملكة العـربيـة السعـوديـة ويبلغ سمكه ١٩٣ متراً قرب مدينة الرياض. ويَتميَّز الجـزء العلوي من هذا المتكون، الـذي يبلغ سمكه ٩٠ متـراً لكونـه رمادي اللون وصلب ويُكوِّن الجزء البـارز من سلسلة جبال طـويق، كما يحتوي على العديد من بقايا الطحالب الدقيقة والمرجانيات المتحجرة.

وقد دَلَّت دراسة السحنات الدقيقـة للجزء العلوي من متكـون جبل طـويق عـلى وجـود بقـايـا متحجـرة للطحـالب الزرقاء ـ الخضراء والخضراء والحمراء، وكذلك بقايا متحجرة للمـرجانيـات التي تدل عـلى أن هذا الجـزء من متكون جبـل طويق ترسب في بيئة بحرية متوسطة العمق وأنه كان يحدث في تلك البيئـة حركـة للمياه نتـج عنها تـرسب أنـواع السحنـات المنقولة.