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MICROFACIES ANALYSIS AND DEPOSITIONAL ENVIRONMENTS OF THE SHUQRA FORMATION AT JABAL ALMAHDAD, MASWAR DISTRICT, YEMEN REPUBLIC

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ABSTRACT

The Shuqra Formation is one of four prominent formations of the Amran Group (Middle Jurassic–Lowermost Cretaceous) of the Yemen Republic. This formation overlies the stratified sandstone beds of the Kuhlan Formation. The study section (Jabal Al-Mahdad) is located at the Maswar District, 40 Km. west of Amran town. The stratigraphic sequence in Jabal Al-Mahdad is characterized by basement complex comprising Akbra Shale, Kuhlan Formation, Amran Group and Tawilah Group.

Fifty-four samples were collected and examined in detail to determine the microfacies and then to interpret the depositional environment of the Shuqra Formation in the study area. Four major microfacies are distinguished from those samples. These microfacies include: mudstone, wackestone, packstone and grainstone. Wackestone is the dominant one and is pelletical and fossiliferous (foraminiferal, ostracodal and algal) subfacies while packstone is pelletical, oolitic and fossiliferous (crinoidial) subfacies. The grainstone microfacies is distinguished to fossiliferous and pellitical.

The identified microfacies indicated that the Shuqra Formation in this area was deposited in a shallow marine environment within restricted platform, open platform and winnowed platform. The water energy level has changed from agitated (during oolitic subfacies time) to moderate (during the wackestone time) and quite (during mudstone time).

INTRODUCTION

A series of studies have been undertaken to investigate the microfacies characteristics of the Amran Group (Middle Jurassic–Earlymost Cretaceous) in Yemen (El Anbaawy, 1984 & 1985; El Anbaawy and Al Thour; 1989; Al Thour, 1988, 1992 & 1997; and Al Wosabi, 2001). In the present paper the microfacies of the lower part of the Amran Group (Shuqra Formation) will be discussed because it represents one of the famous sources and reservoir unit in Marib–Al Jawf Basin, as well as it form one of the major topographic features of the northern parts of the country which is called the Yemen High Plateau. This formation outcrops in a vast area to the east, north, northwest of Sana'a basin, Hodiedah, Taiz, Abyan and Hadhramawt Governorates (Fig.1).

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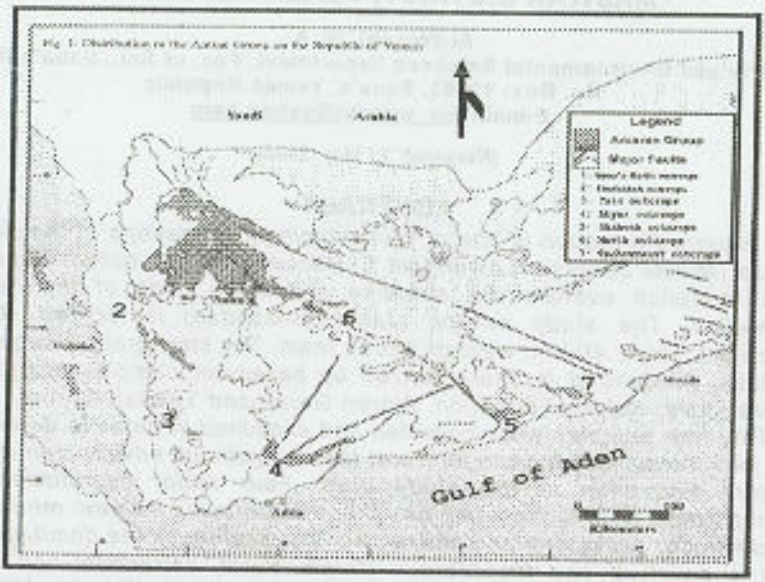

To realize the target of this paper, section of the Shuqra Formation was measured in the study area (Maswar district) west of the Amran town. This section (Jabal Al Mahdad) (Fig. 2) used to determine the microfacies characteristics of the mentioned formation in the west region of the country according to the appearance of the lower and upper boundaries of the studied rock unit there.

Lamare (1923) introduced the name Amran series to describe the Jurassic carbonate rocks in Yemen. This name was emended by Beydoun (1964) to Amran Group. Many authors studied and discussed the stratigraphic position of this rock unit such as Beydoun 1964; Geukens 1966; El-Anbaawy 1984 & 1985; Al-Thour 1988 and 1992; Smewing & Walley 1988; El-Nakhal 1990; Al-Wosabi 1993 & 2001; Michael *et al.*, (1998) and Beydoun et al., 1998. Several subdivisions were supposed by these authors but in the present study subdivision of Beydoun *et al.*, (1998) will be used (Table 1). It was established and documented by the international Lexicon of Stratigraphy.

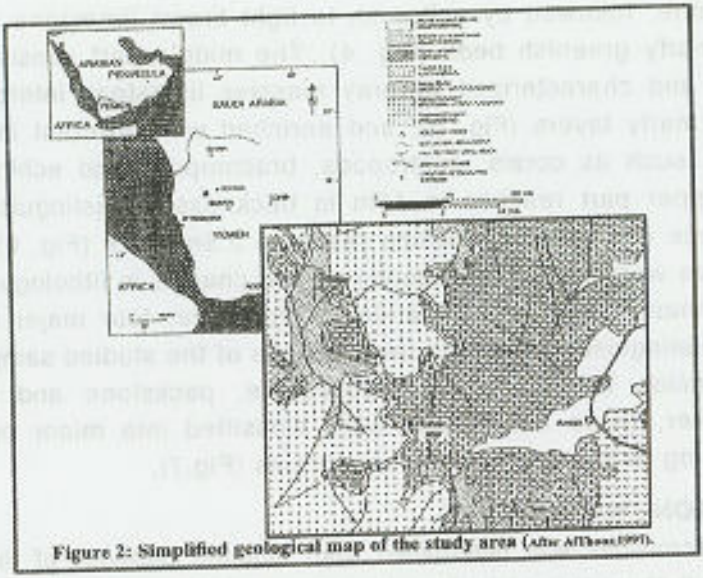

Figure 2: Simplified geological map of the study area (After Alfhous(1997)).

Shuqra Formation represents the lowest rock unit belongs to the Amran Group. This name "Shuqra Formation" was introduced by Hybroek (in Wetzel and Morton, 1950 and Hudson, 1954) as Shuqra Limestone and then used by Beydoun (1964) as Shuqra Formation. The thickness of this formation in its type section reaches to 98m, but it may reaches to 149m in some areas such as Dathina area (Beydoun *et. al.*, 1998). In the study section, thickness of the Shuqra Formation reaches to 88m.

Many authors determined the age of Shuqra Formation (e.g., Smewing & Walley 1988; Michael *et al.*, 1998 and Al- Wosabi 2001and 2003) based on algae, ammonites and foraminifera respectively as Bathonian-Kimmeridgian. Moreover, Simmons and Al Thour 1994 gave Callovian-Kimmeridgian age to this formation at the west Sana'a region by using algal and foraminiferal contents. In the study area, the formation overlies the sandstone beds of the Kuhlan Formation and underlies the Madbi Formation of the Amran Group with gradational conformable contacts.

MICROFACIES ANALYSIS

The Shuqra Formation was measured in a new cutting on the road running southwest from the highway of Amran-Hajjah to Bait Othaqah village (the Center of Maswar District). The study section attains about 88m thick. It can be subdivide informally to three parts (Fig. 3). The lowest one is 19m., and represented by gray cherty fossiliferous

limestone, followed by yellowish to light brown limestone intercalated with marly greenish beds (Fig. 4). The middle part consists of about 53m., and characterized by gray massive limestone intercalated with many marly layers (Fig. 5), and enriched with different invertebrates fossils such as corals, gastropods, brachiopods and echinodermates. The upper part reaches to 16m in thickness. It distinguished by the presence of marly beds which reach to 2.5m thick (Fig. 6). Fifty four samples were collected depends on the change in lithology. According to Dunham (1962) classification of limestone, four major microfacies were distinguished from the thin sections of the studied samples. These microfacies are mudstone, wackestone, packstone and grainstone. Moreover, these microfacies were classified into minor or subfacies according to the type of carbonate grains (Fig.7).

MUDSTONE MICROFACIES

This microfacies was determined from different positions of the sequence (Fig.7). It characterized by its light creamy colored with a rare appearance of different types of fossils such as foraminifera and ostracoda. Mudstone microfacies were affected by stylolitization in many horizons (plate I, A, B and C).

WACKESTONE MICROFACIES

The wackestone microfacies has a mud-supported depositional texture with more than 10% grains. This microfacies was dominant through the study sequence of the Shuqra Formation (Fig. 7). The grains of this microfacies are fragments of diverse organisms. The dominant components are different invertebrates, included bivalves fragments, spicules, ostracoda, gastropod fragments, echinoderm plates, algal debris and fragments. The intraclasts Wackestone microfacies was classified into many sub or minor microfacies which are: ostracodal wackestone (Plate I D&E), algal wackestone (Plate I F-H), fossiliferous wackestone (Plate II A-D), pellitical wackestone (Plate II E) and foraminiferal wackestone (Plate II f-h & Plate III A-F). The sediments of this facies characterized by its light colures (yellow to whitish), angular nature of the bioclasts formed of molluscs. Many diagenitic features were detected such as stylolites and recrystallization.

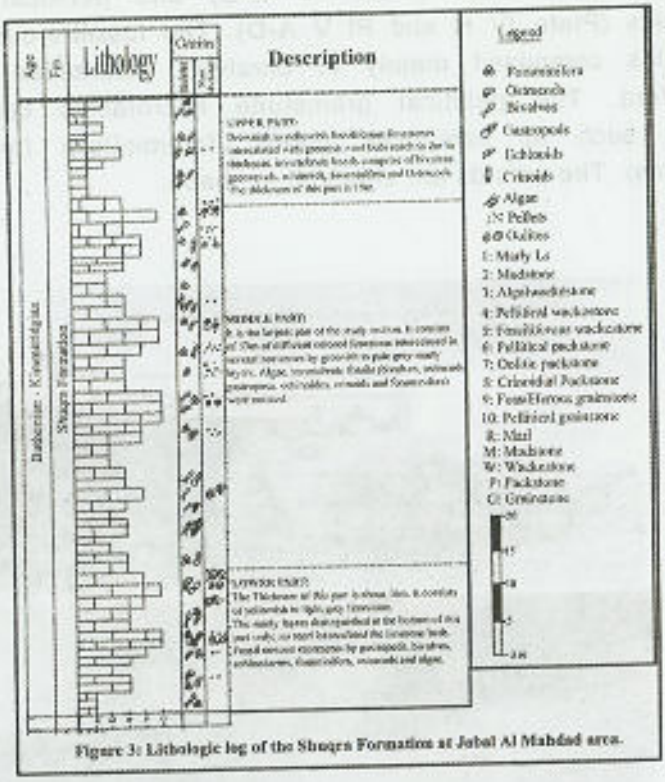

Figure 3: Lithologic log of the Shuqra Formation at Jabal Al Mahdad area.

PACKSTONE MICROFACIES

Packstone was reflected by oolitic packstone (Plate III G, H), pellitic packstone (Plate IV A&B) and crinoidial packstone (Plate IV C&D). It was detected in many horizons of the study section (Fig. 7). This microfacies consists mainly of pellets, oolites and fossils or skeletal derbies. There are many bioclasts refer to invertebrates such as foraminifera (textulariins and miliolids), bivalves, gastropods, crinoids, echinoid plates and spines, Ostracods, algae and other recrystallized shell fragments). Algal fragments and derbies were common. The ooids are spherical to pellitical in shape with nuclei mainly of bioclasts and micrite carbonate grains.

GRAINSTONE MICROFACIES

Grainstone microfacies was detected from the lower and middle part of the study section (Fig. 7). This microfacies is characterized mainly by grains reach to 90% or more supported each others within a spray calcite matrix. The grains consist mainly of fossils and pellets as well as some oolite grains. The grainstone microfacies was distinguished to

fossiliferous grainstone (Plate IV E-G) and pellitical grainstone microfacies (Plate IV H and Pl V A-D). The fossiliferous grainstone microfacies composed mainly of bivalves, echinoidea, algae and foraminifera. The pellitical grainstone microfacies contain many bioclasts such as echinoidal plates, foraminifera (miliolids and textulariins). The peloids are elliptical in shape.

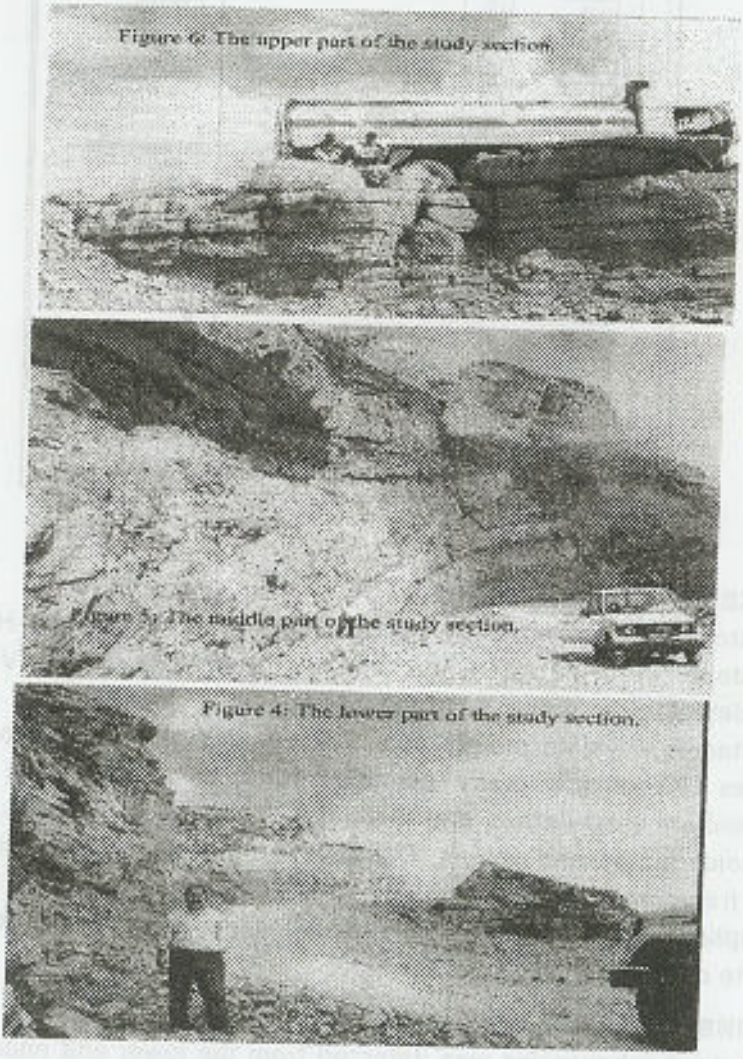

Figure 6: The upper part of the study section.

Figure 5: The middle part of the study section.

Figure 4: The lower part of the study section.

DEPOSITION ENVIRONMENTS:

The identified microfacies of the Shuqra Formation at Jabal al-Mahdad reflect different shallow marine environments. According to Wilson, 1975 and Flugel, 1982, the determined microfacies were distributed within a restricted platform, open platform and winnowed platform (Fig.7). The mudstone and fossiliferous mudstone may represent calm conditions such as on mud flat and could also represent quit basins more than 50m deep (Christensen,1968).

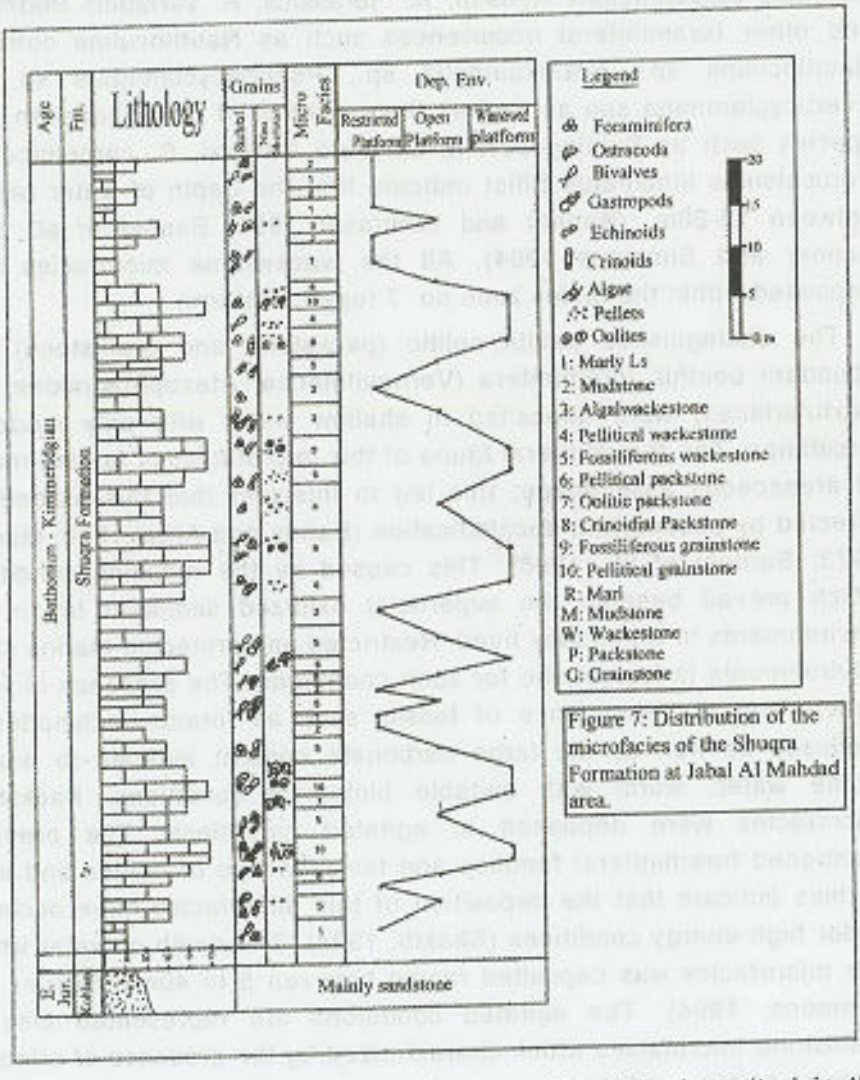

Figure 7: Distribution of the microfacies of the Shuqra Formation at Jabal Al Mahdad area.

This microfacies is similar to facies no. 19 which deposited in the facies zone no. 8 of Flugel (1982) within the restricted platform. The different wackestone facies were deposited in shallow niritic water of

open circulation at or just below wave base (Wilson, 1975; Flugel, 1982) The water energy was in a moderate level during the deposition of different wackestone microfacies except that of algal facies which deposited in relatively calm conditions within the vigorous and oxygenated facies.

The presence of some foraminiferal species within the wackestone microfacies gives an idea about the depth of water. In example Kurnubia palastiniensis Henson, K. jurassics, K. variabilis Redmond, and other foraminiferal occurrences such as Nautiloculina oolithica, Nautiloculina sp., Bramkampella sp., Pseudocyclammina sp. and Everticyclammina spp as well as the presence of dasycladacean algal species such as Salpingoporella annulata Carozzi, S. carpethica and Perocalculus inopinatus Elliot indicate that the depth of water ranging between 10-20m. (Banner and Whittaker 1991; Banner *et al.*, 1991 Banner and Simmons 1994). All the wackestone microfacies were deposited within the facies zone no. 7 (open platform).

The distinguished pellitic-oolitic (packstone and grainstone) with abundant benthic foraminifera (Verneuilinacea, Ataxophragmidae, and Textulariacea) were deposited in shallow water with only moderate circulation. The foraminiferal fauna of this microfacies is formed mainly of arenaceous assemblage; this led to interpret that this association affected by postmortem decalcification (Bandy and Arnal 1960; Murray, 1973; Samuel *et al.*, 1996). This caused by the reducing conditions which prevail beneath the superficial oxidized sediment lay in the environments in which they lived. Restricted and protected marine shoal environments is typical site for such conditions. The presence of fecal pellets and the abundance of fossils such as forams, echinoderms, molluscs as well as the large carbonate content indicate to normal saline water, worm with suitable biological conditions. Packstone microfacies were deposited in agitated conditions. The previous mentioned foraminiferal families and the presence of oolites and algal derbies indicate that the deposition of this microfacies have occurred under high energy conditions (Shakib, 1994). The depth of water where this microfacies was deposited raging between 5 to 40m. (Banner and Simmons, 1994). The agitated conditions are represented also by grainstone microfacies which characterized by the presence of crinoids, skeletal derbies, oolites.

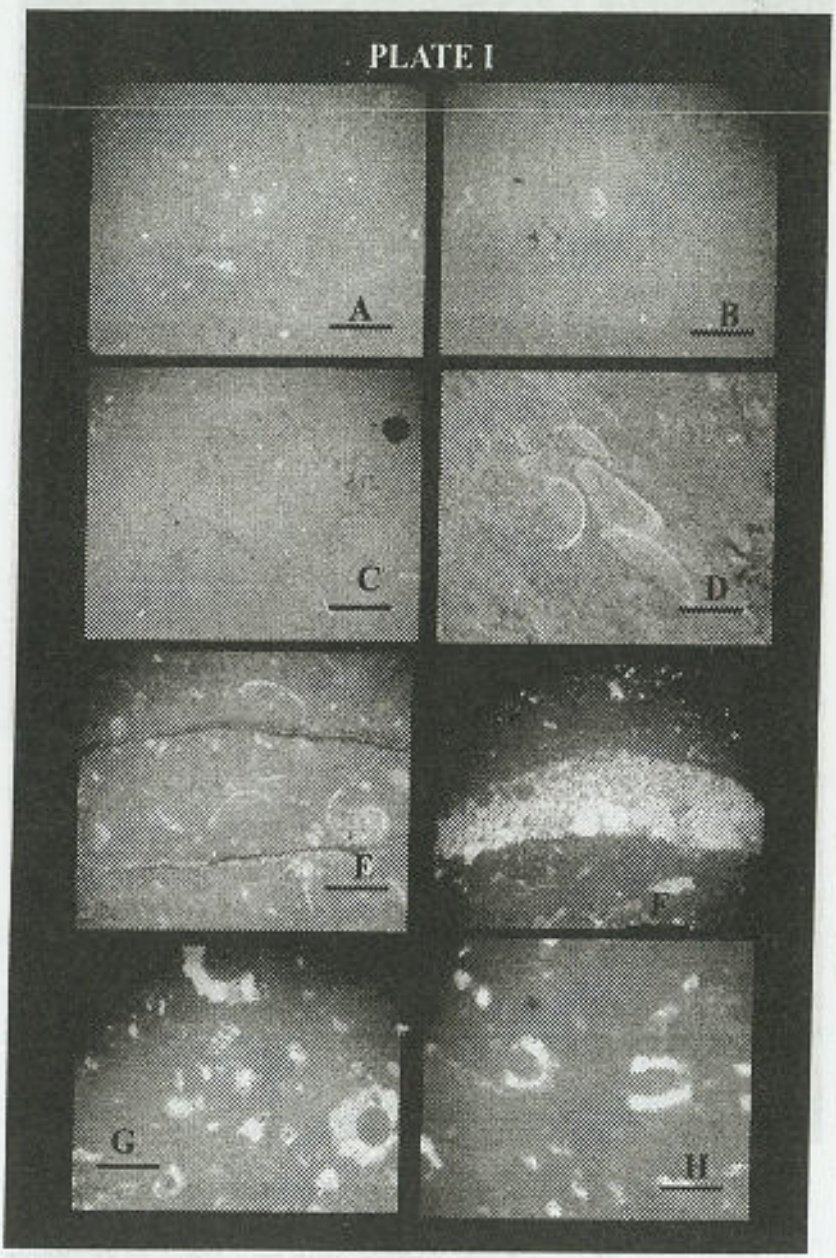

PLATE: I (Scale bar = 125μm).

A and B) Different foraminiferal tests in a mudstone microfacies. C) Stylolitization characterized the mudstone microfacies. D) Ostracod valves within the ostracodal wackestone microfacies. E) Ostracod valves and different foraminiferal tests characterized the ostracodal wackestone microfacies. F) *Permocalculus inopinatus* within the algal wackestone microfacies. G) *Salpingoporella annulata*, algal debris and biserial foraminiferal tests within the algal wackestone microfacies. H) *Salpingoporella annulata* within the algal wackestone microfacies.

PLATE II

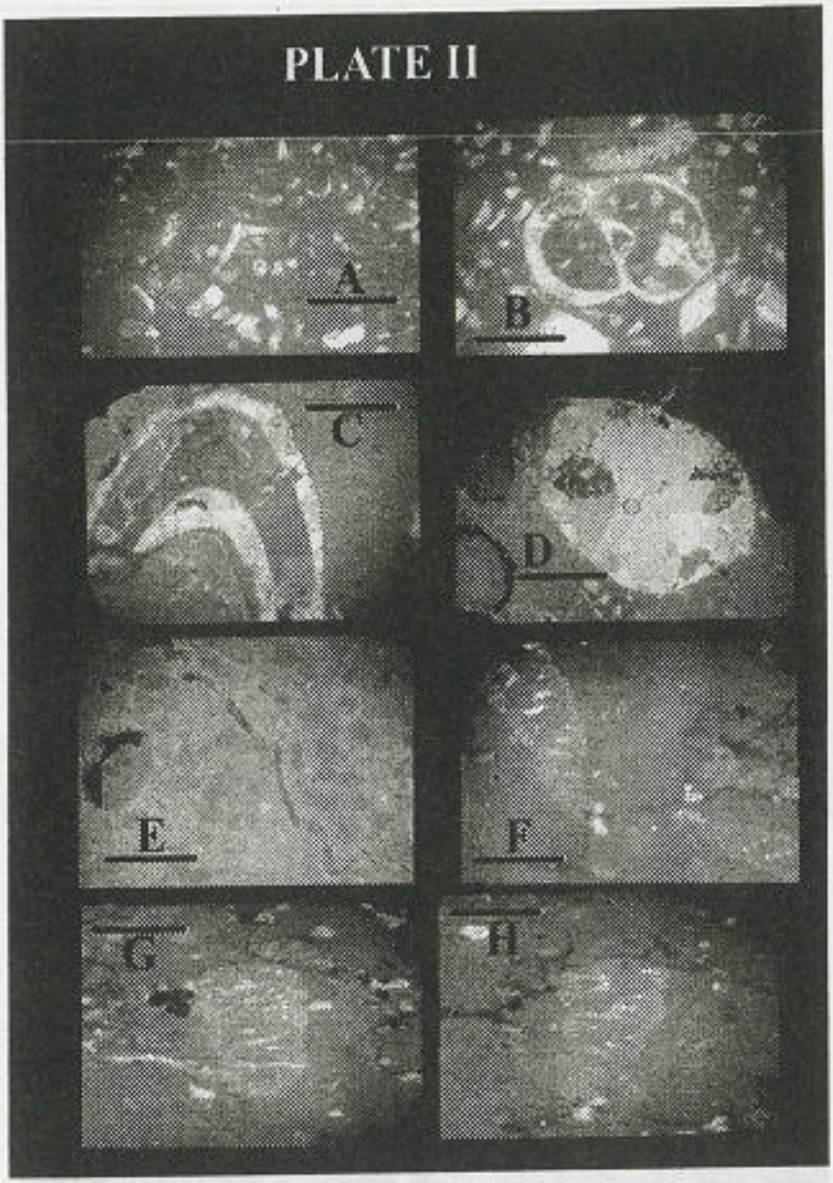

PLATE II (Scale bar = 125μm except the mentioed states).
A) Sponge spicules, skeletal debries, foraminiferal tests and ostracod valves in the fossiliferous wackestone microfacies. B) Cross section in gastropod shell, echinoidial spinoes at the top and skeletal debries within the fossiliferous wackestone microfacies. (Scale bar = 250μm). C) Bivalve fragnent in the fossiliferous wackestone microfacies. (Scale bar = 270μm). D) Recrystallized Brachiopod valve affected by rwithin the fossiliferous wackestone microfacies. (Scale bar = 250μm). E) Elliptical pellets and skeletal debries within the pellitical wackestone microfacies. F) Longitudinal sections in the *Kurnubia jurassica* at the lef top and *K. variabilis* at the right bottom of the slide characterized the foraminiferal wackestone microfacies. G) *Kurnubia palastinensis*, and different skeletal debries within the foraminiferal wackestone microfacies. H) *Kurnubia jurassica* within the foraminiferal wackestone microfacies.

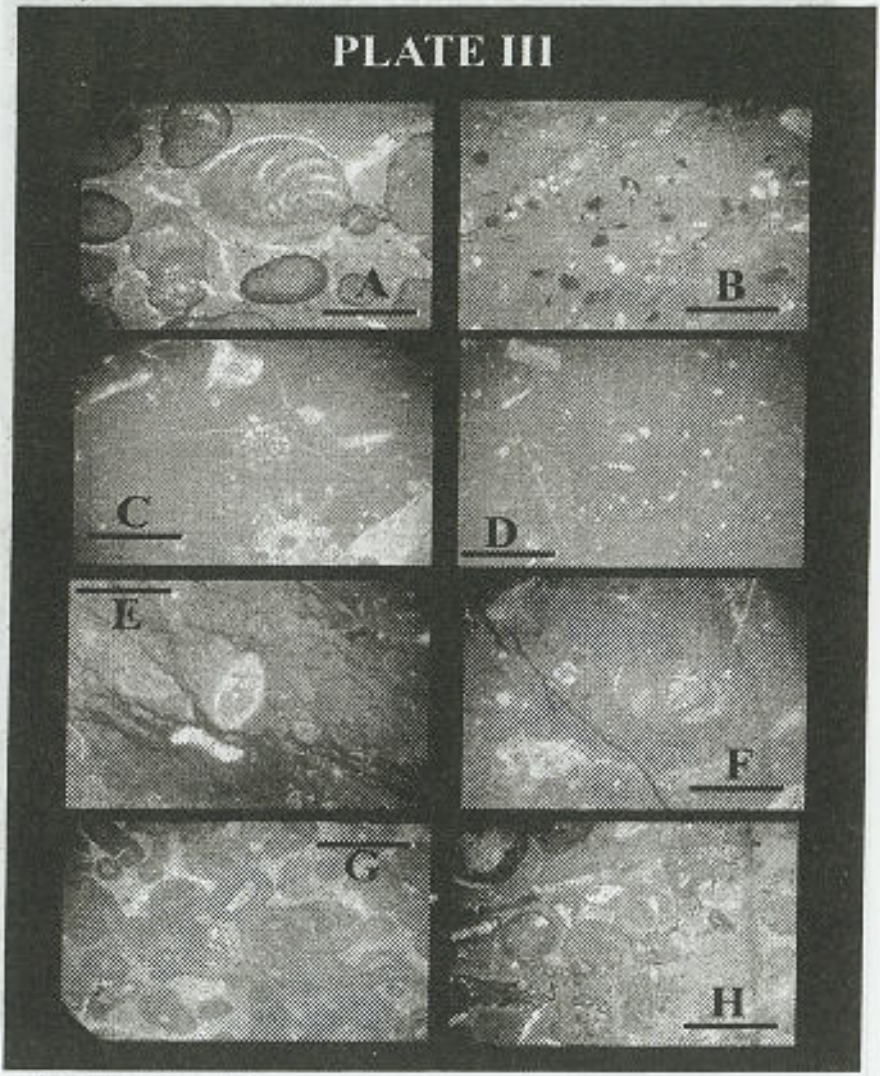

PLATE III (Scale bar = 125μm).
A) *Bramkampella sp.* and *Pseudocyclammina sp.* and some pellets within the foraminiferal wackestone microfacies. B) *Everticyclammina sp.* within the foraminiferal wackestone microfacies.
C) *Nautiloculina oolithica* within the foraminiferal wackestone microfacies. D) Longitudinal sections in *Nodosaria sp.* and sponge spicules within the foraminiferal wackestone microfacies. E) *Lenticulina sp.* Ostracod valves and skeletal debries within the foraminiferal wackestone microfacies.
F) *Ataxophragmidae* tests characterized the foraminiferal wackestone microfacies. G) Elliptical and spherical ooids and some pellits within the oolitic packstone microfacies. H) Ooids affected by compresion and stylolitization within the Oolitic wackestone microfacies.

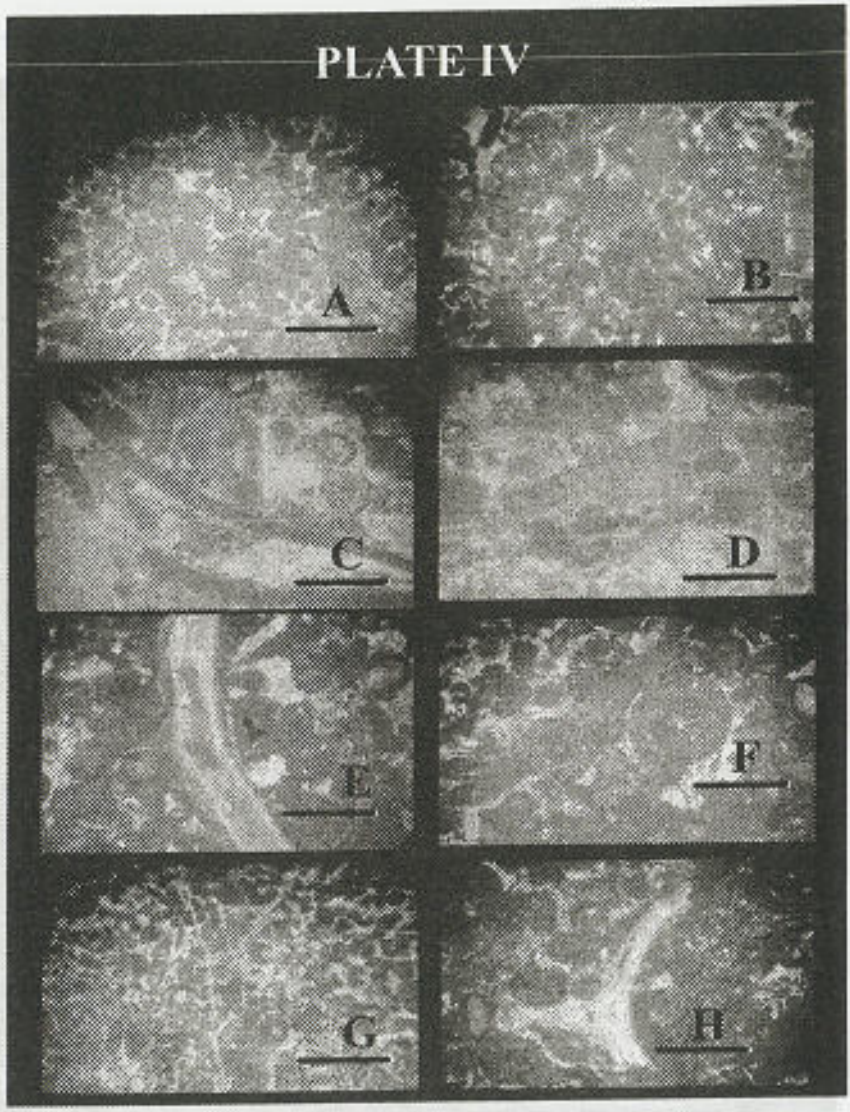

PLATE IV (Scale bar = 125μm).
A) pellets, foraminiferal tests and ooides within the pellitic packstone microfacies. B) Elliptical pellets and skeletal debries within the pellitic packstone microfacies. C) Crinoidial stems, pellets and skeletal debries within the crinoidial packstone microfacies. D) Part of crinoidial stems, pellets, and skeletal debries within the crinoidial packstone microfacies. E) Bivalves fragment skeletal debris and pellets within the fossiliferous grainstone microfacies. F) Echinoid spinoes, skeletal debries and some pellets within the fossiliferous grainstone microfacies. G) Many foraminiferal tests and pellets characterized the fossiliferous grainstone microfacies. H) Pellets, fossil fragments characterized the pelletic grainstone microfacies.

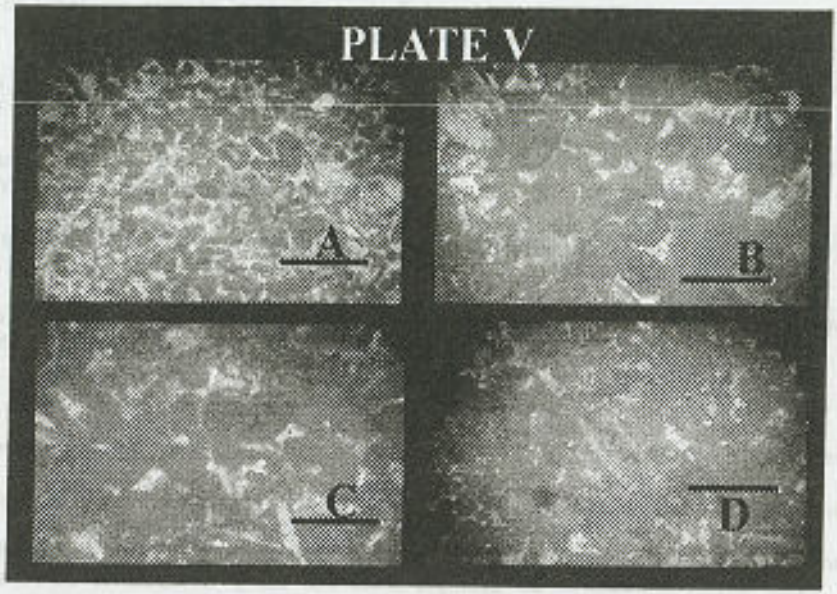

PLATE V (Scale bar = 125μm).
A) Elliptical pellets and many foraminiferal test within the pellitic grainstone microfacies. B) Pellets and some ooids within the pellitic grainstone microfacies within the pellitic grainstone microfacies.C) Compacted pellets and some ooids within the pellitic grainstone microfacies within the pellitic grainstone microfacies. D) Compacted section of pellitic grainstone microfacies shown pellets, fossil fragments and ooids.

CONCLUSIONS

Microfacies analysis of the Shuqra Formation (Middle-Upper Jurassic) at Jabal Al Mahdad, about 40 km west of the Amran town in the Yemen Republic, has revealed the presence of a number of microfacies. The sequence was subdivided into three distinguished informal parts. The lower part consists of 19 m of cherty gray limestone. The middle part composed of 53 m of gray massive limestone intercalated with many marly layers, whereas the upper part is about 16 m thickness and characterized by thick marly beds.

The microfacies that distinguished from the studied sequence represented by Mudstone, wackestone, packstone, grainstone and boundstone. By the correlation of these microfacies with that of Flugel (1982) were deposited in a shallow marine environment (restricted platform, open platform, winnowed platform and platform margin). The low energy water conditions are indicated by fossiliferous mudstone while the high energy shallow water conditions are indicated by the pellitic and oolitic packstone and grainstone facies.

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تحليل السحنات الدقيقة وبيئات الترسيب لتكوين الشوكرا في جبل المهداد ومنطقة المسوار بالجمهورية اليمنية

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تكوين شوكرا يعتبر أحد التكوينات البارزة والهامة لمجموعة عمران باليمن ، حيث تنتمي الى الجوراسي الأوسط والكريتاسي السفلي. هذا التكوين ممثل في قطاع جبل المهداد في منطقة مسوار ، ٤٠ كم غرب مدينة عمران . لقد تمت الدراسة على ٤٤ عينة سطحية جمعت من تكوين شوكرا حيث فحصت ودرست بالتفصيل لتحديد أنواع السحنات الدقيقة والتي استخدمت في تفسير بيئة الترسيب لهذا التكوين . ولقد تم تمييز أربع أنواع رئيسية من السحنات وهي :

grainstone,packstone, wackestone,mudstone

السحنات الدقيقة المعرفة توضح أن ترسيب تكوين الشوكرا في منطقة مسوار حدث في بيئة بحرية ضحلة داخل منطقة الرصيف البحرى المغلقة والمفتوحة ، وأن مستوى الطاقة المائي قد تغير من شديد أثناء (oolitic subfacies) ، الى متوسط أثناء(wackestone) ثم مستوى هادئ أثناء تكوين السحنة الطينية (mudstone) .