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Geologic Mapping and Stratigraphy of the Sedimentary Sequence in Haddat Ash Sham Area Northeast of Jeddah, Saudi Arabia

A. Bahafzalla, A.N. Basahel, H.H. Mansour and S. Omara

Faculty of Earth Sciences, King Abdulaziz University, Jeddah, Saudi Arabia

ABSTRACT. Clastics of unknown nomination cropping out in Haddat Ash Sham area have been geologically mapped and defined. The Haddat Ash Sham Formation with its three members, namely the Kheslef, the El-Hegre, and the Borma members have, therefore, been introduced. An unexpected extension of the Maestrichtian to Paleocene Usfan Formation with apparent conformity overlies the Haddat Ash Sham Formation.

This crucial occurrence together with the fact that the Haddat Ash Sham Formation rests with marked unconformity on the Pre-Cambrian basement complex point out that its age might be Cretaceous or even older. The local structural features exhibited by these clastics have also been briefly discussed.

Remnants of mostly clastic sediments of Upper Cretaceous to Tertiary age are widely distributed in the neighbourhood of Jeddah. Two localities are well-known since some time, and are, as well, of particular interest. Three kilometers to the north of the small village of Usfan, 55 km to the north of Jeddah, Maestrichtian to Paleocene clastics and carbonates have been observed and documented by Karpoff (1955, 1957a, b). The Usfan Formation, which according to Karpoff (1955, 1957a, b) amounts to 95.5 m in thickness, consists mainly of sandstones, shales, marls, and a conspicuous carbonate ledge which yielded abundant molluscs, shark teeth definitely indicating shallow marine depositional environment. The Usfan Formation is conformably overlain by the Shumaysi Formation, the main outcrops of which are in Wadi Fatima, 40 km to the east of Jeddah. The Shumaysi Formation is mainly composed of sandstones, siltstones bracketing an oolitic ironstone bands, which attain thickness ranging between 20 and 200 m (Al-Shanti 1966). On the basis of poorly preserved megafossils, the Shumaysi Formation has been dated as

Eocene or Oligocene (Al-Shanti 1966). Recently, polynomorphs have been detected in a shale bed sandwitched between the oolitic ironstone beds and just above them (Moltzer and Binda 1981). The pollen spectrum dates the middle horizons of the Shumaysi Formation as Early Eocene or Cuisian. The Shumaysi Formation is believed to be deposited on continental, esturine and marginally marine depositional environments (Moltzer and Binda 1981). The Usfan Formation is, therefore, thought of as a short marine incursion in the complex Shumaysi cycle of deposition (Basahel *et al.* 1982).

The outcropping belt of clastics which extend between the two above mentioned localities did not receive much attention. However, Brown and Jackson (1960) and Brown *et al.* (1962) designate some exposures in between, encompassing those cropping out in Haddat Ash Sham area, which are the subject matter of the present investigation. Geologic mapping of Haddat Ash Sham exposures reveals, however, that the Usfan Formation which crops out there, is underlain by a thick clastic sequence (250 m) which is of Cretaceous or even older in age.

Stratigraphy

A. Lithostratigraphy

Generally speaking, the sedimentary sequence exposed in Haddat Ash Sham area is formed of a thick clastic section with few carbonates, and is easily divisible into two formations, in ascending order, are the Haddat Ash Formation and the Usfan Formation.

1. *The Haddat Ash Sham Formation*

As mentioned before, Brown *et al.* (1962) mapped the Haddat Ash Sham exposures as Shumaysi Formation. Field relations, the comparative stratigraphic situation, and lithologic composition reveal that the succession under consideration differs from those described as Shumaysi Formation, and moreover is older than it at least by the duration of the Paleocene period provided that the Shumaysi Formation is Eocene in age. This succession is considered here to represent a rock unit of a formational status never recognised before in the stratigraphic column of Saudi Arabia. Accordingly, the Haddat Ash Sham Formation has been coined, after Haddat Ash Sham village (Fig. 1) where the type section of the formation occurs.

Geographically, the formation extends from the latitude of El-Gommoum village at the south to the latitude of Usfan Village at the north. The vertical and lateral lithologic variation of Haddat Ash Sham Formation allows its subdivision into three members, from base upwards; the Kheslef Member at the north and its counterpart El-Hegre Member at the south, and the Borma Member.

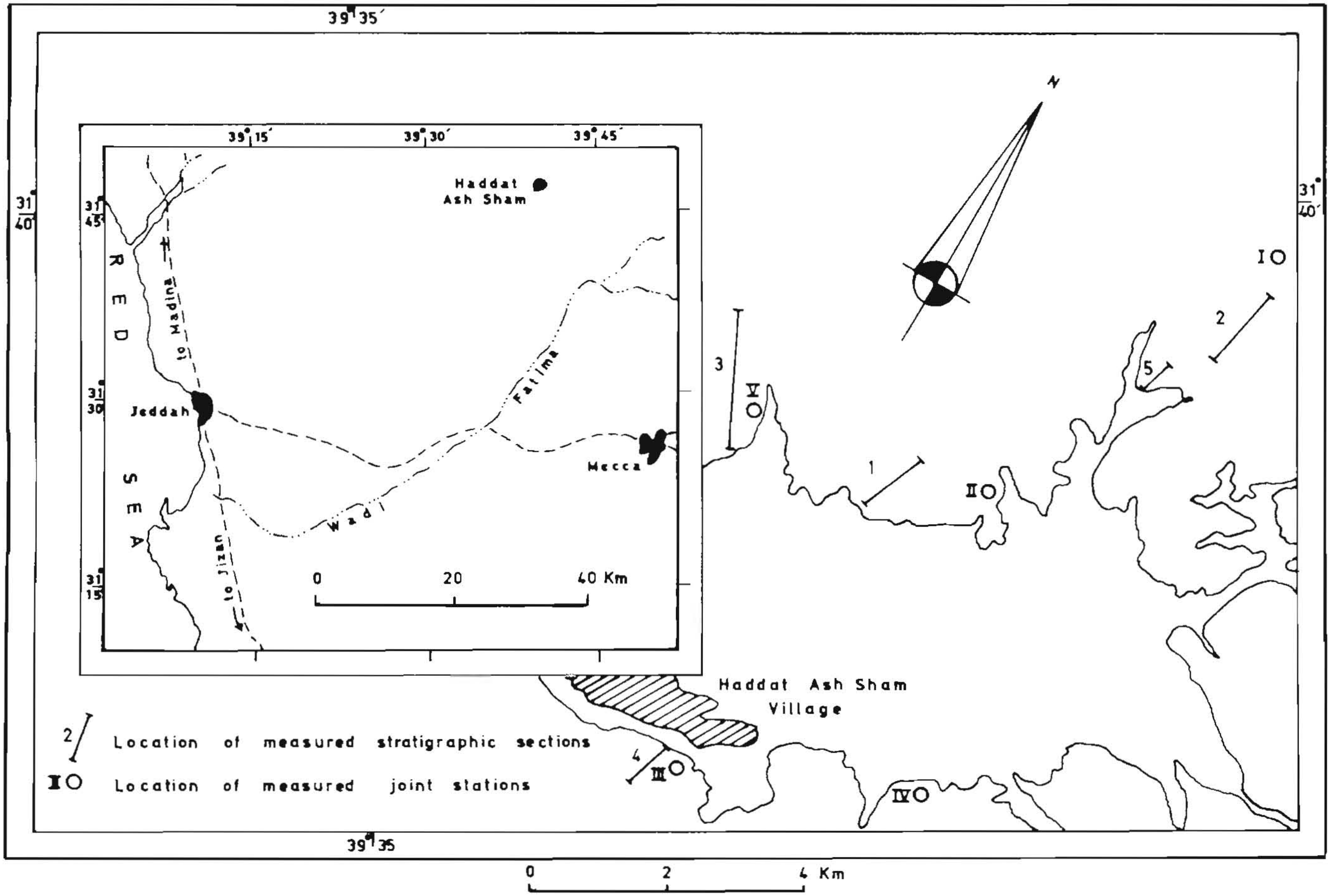


Fig. 1. Location map of the mapped Haddat Ash Sham area.

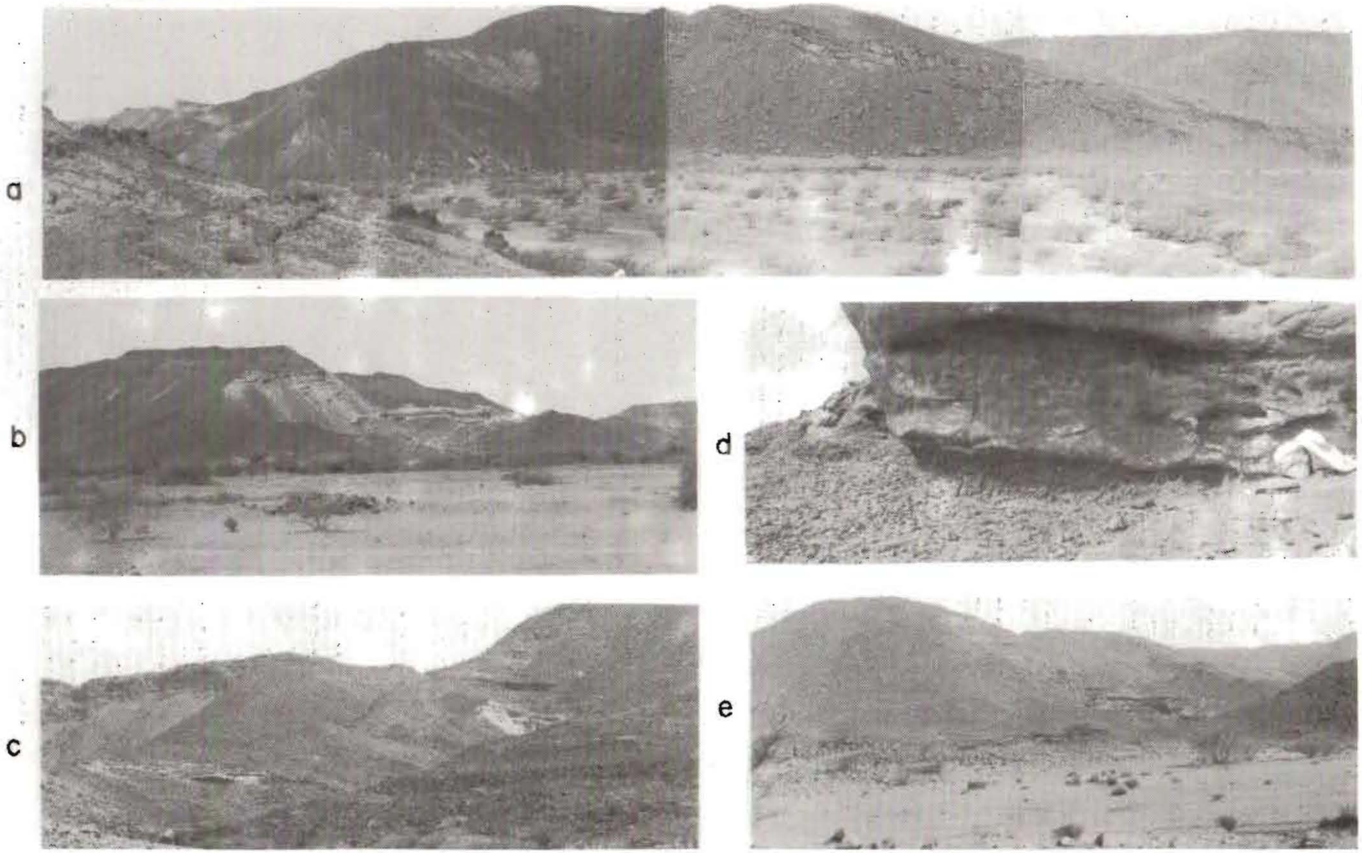
Plate I

a

b

a. Panoramic view showing the general stratigraphic sequence of the Borma Member which thrown down against the El-Hegre Member, at the southern scarp of the area. Note the vertical lithologic variation of the El-Hegre Member.
b. General panoramic view of the Usfan Formation, where it unconformably overlies the basement complex. Note the step faults affecting the succession. The limestone ledge (middle member) separates the lower and the upper members of the formation. The Usfan Formation is thrown down against the Borma Member.

Plate 2



a. Panoramic view showing detailed succession of the upper member of the Usfan Formation. The calcareous bed (middle member) form the base of the succession. The coarse clastic sedimentary rocks form the top of the member.
b. General view of the Kheslef Member. Note the basaltic sheets capping the succession.
c. Contact between the Kheslef Member and the Borma Member.
d. Bed of coarse conglomerate, intervening the Kheslef Member, and underlying highly bioturbated claystone.
e. General view of the Borma Member, capped by basaltic sheets.

a. *The Kheslef Member*. The name 'Kheslef Member' is introduced after Wadi Kheslef which drains the northwestern part of the mapped area, where the type locality of the member could be found. Figure 2 shows the extension of the member in the mapped area.

The member unconformably overlies the rigid surface of the peneplained Pre-Cambrian basement complex and conformably underlies the Borma Member. In its type locality, the member measures about 117 m and is composed of interbedded, pebbly, coarse to fine cross-bedded sandstones; rippled, bioturbated and cross-laminated claystones and siltstones (Pl. 2a, c). Thin bands of conglomerates indicate more than one diastem at the lower half of the member (Pl. 2d). At the

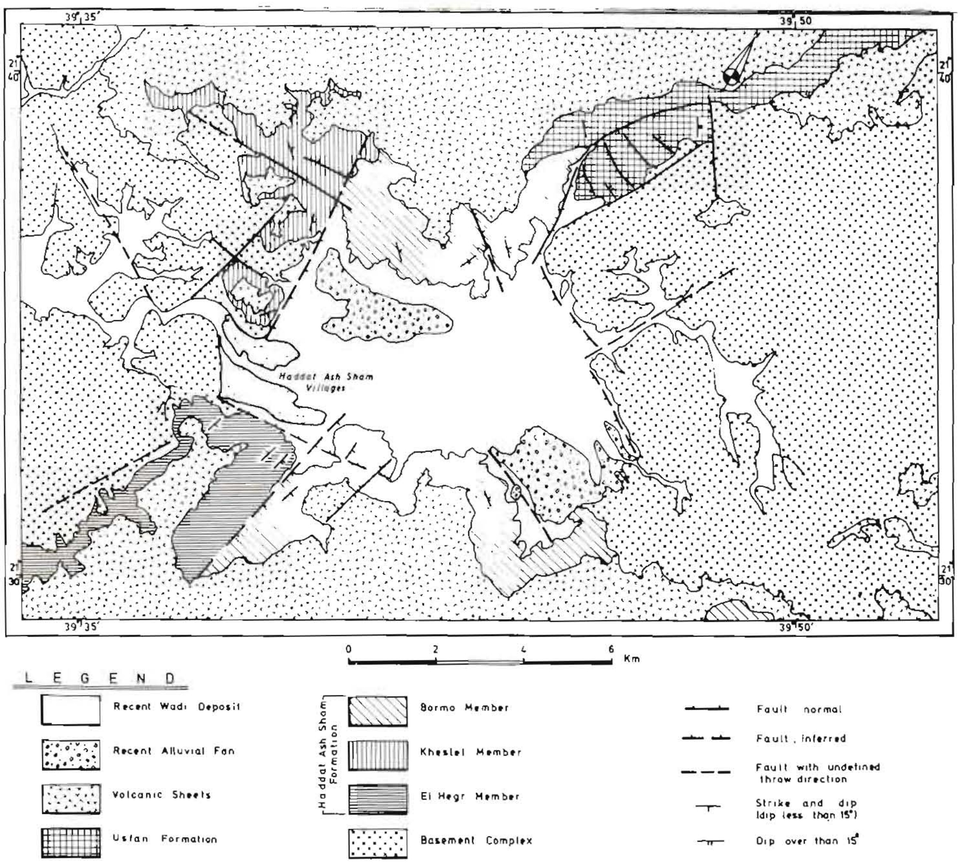


Fig. 2. Photo-geological map of Haddat Ash Sham area.

top part of the member diagenetic, ferruginous sandstone and claystone beds are encountered (Pl. 2a).

The following is a brief lithologic description of the stratigraphic succession of the Kheslef Member representing its type section of the member.

Lithology	Thickness (m)
■ Basement complex (base).	
■ Sandstone, coarse-grained, calcareous, friable, poorly sorted, partially conglomeratic, moderately bioturbated, with lower and upper erosional surfaces	1.5
■ Sandstone, medium-grained, highly cross-bedded, intercalated by two thin bands (2-5 cm) of conglomerates	2.0
■ Conglomerate, calcareous, cross-bedded, ripple-marked, grading upwards to finer texture	1.0
■ Sandstone, conglomeratic	2.0
■ Sandstone, coarse-grained, friable, cross-bedded	3.3
■ Sandstone, fine-grained, rippled, cross-laminated	3.0
■ Claystone, calcareous, bioturbated	3.8
■ Sandstone, coarse-grained, conglomeratic, cross-bedded	2.0
■ Sandstone, medium-grained, friable, ill-sorted, fining upwards in grain size	1.2
■ Sandstone, coarse-grained, cross-bedded	1.5
■ Sandstone, fine-grained, cross-laminated, highly bioturbated	6.0
■ Claystone, gently bioturbated	0.6
■ Claystone, sandy, poorly bioturbated	1.2
■ Sandstone, coarse-grained, friable	3.5
■ Sandstone, ferruginous, conglomeratic, highly bioturbated	2.0
■ Claystone, sandy, poorly bioturbated	1.0
■ Claystone, sandy, highly bioturbated	2.0
■ Sandstone, conglomeratic, friable, cross-bedded	1.3
■ Sandstone, calcareous, moderately bioturbated	1.0
■ Conglomerate, friable, fining in grain size upwards	0.8
■ Sandstone, conglomeratic, calcareous	1.0
■ Claystone, calcareous, massive	13.0
■ Sandstone, friable, massive, coarse-grained	1.0
■ Claystone, partially bioturbated	3.5
■ Claystone, sandy, gypsiferous, intercalated by two conglomeratic bands (each up to 20 cm thick)	5.0
■ Sandstone, coarse-grained, argillaceous, friable	1.0
■ Claystone, sandy, intercalated by conglomeratic band (10 cm thick)	2.0

■	Sandstone, conglomeratic	0.6
■	Sandstone, argillaceous, highly bioturbated at its upper part	0.6
■	Sandstone, coarse-grained, cross-bedded	3.5
■	Sandstone, fine-grained, calcareous, friable	2.0
■	Claystone, bioturbated	4.0
■	Sandstone, coarse-grained, argillaceous, cross-bedded	1.5
■	Claystone, sandy	1.0
■	Sandstone, argillaceous	3.0
■	Claystone, ferruginous, highly bioturbated	0.6
■	Sandstone, argillaceous, coarse-grained	4.0
■	Siltstone, sandy	1.6
■	Claystone, calcareous	0.8
■	Sandstone, medium-grained, cross-bedded	7.6
■	Sandstone, coarse-grained, friable	4.6
■	Sandstone, fine-grained, ferruginous	2.0
■	Claystone, ferruginous	4.0
■	Sandstone, coarse-grained, ferruginous, conglomeratic	3.0
■	Basaltic sheets (top)	
	Total:	117.0

b. *The El-Hegre Member.* The term 'El-Hegre Member' is introduced here as the southern counterpart of the Kheslef Member, overlying the Pre-Cambrian basement complex and conformably underlying the Borma Member. The uneroded part of the section measures about 80 m thick, and is well-developed to the south of the El-Hegre Village, where its type locality has been chosen (Fig. 3).

The stratigraphic succession of the El-Hegre Member is composed at its base of well-bedded coarse to fine-grained sandstone, locally conglomeratic and cross-bedded. At its middle part, it is composed of interbedded shales and siltstone and their derivatives, and is intercalated by few horizons of sandstones (Pl. 3). The top part of the succession is mainly sandstones (Pl. 1a, 3). It is worth mentioning that the El-Hegre Member is conspicuously rich in siliceous stromatolites of different types and configurations and in the meantime is moderately to highly bioturbated (Pl. 3c).

The type section of the El-Hegre Member is measured near El-Hegre Village (Fig. 1, 3), and its description is as follows:

	Lithology	Thickness (m)
■	Mudstone, rich in siliceous stromatolites (base)	5.0
■	Siltstone, massive	1.0

▪ Sandstone, fine-grained, massive	2.0
▪ Mudstone, calcareous, massive	0.3
▪ Siltstone, massive, poorly bioturbated	0.3
▪ Siltstone, massive	0.4
▪ Ironstone, oolitic, argillaceous	0.3
▪ Siltstone, massive	0.5
▪ Claystone, rich in siliceous stromatolites	5.0
▪ Siltstone, burrowed	2.5
▪ Mudstone, with siliceous stromatolites	10.0
▪ Siltstone, cross-laminated, bioturbated	5.5
▪ Shale, partially cross-laminated, with small-scale cross-bedding in certain horizons	12.0
▪ Sandstone, medium-grained, moderately bioturbated	1.0
▪ Shale	1.2
▪ Sandstone, fine-grained, ferruginous, cross-laminated	2.0
▪ Siltstone, ferruginous, gypsiferous, with siliceous stromatolites	0.2
▪ Sandstone, fine-grained, massive, partially cross-laminated as its top	1.5
▪ Shale	14.0
▪ Sandstone, fine-grained, gypsiferous, bioturbated as its top (top of El-Hegre Member)	15.0
Total:	80.0

c. *The Borma Member*. The term 'Borma Member' is introduced here to describe the stratigraphic succession, directly overlying the Kheslef Member and the El-Hegre Member in the northern and the southern parts of the mapped area, respectively. On the other hand, it conformably underlies the Usfan Formation.

The term is coined after Wadi Borma that drains the middle part of the northern plateau, where the type locality of the member has been considered.

The Borma Member (at its type locality, section no. 1, Fig. 3) measures about 42 m in thickness, furnishing the main parts of the scarps in the middle part of the mapped area. The regional geographic distribution of the member needs further detailed field investigations.

Generally speaking, the Borma Member is composed of cross-bedded, mostly conglomeratic sandstone of different size grades, mostly unsorted and cross-bedded, conglomerates and breccias of different size grades, with rare bioturbated claystone and siltstone thin bands near the base of the member.

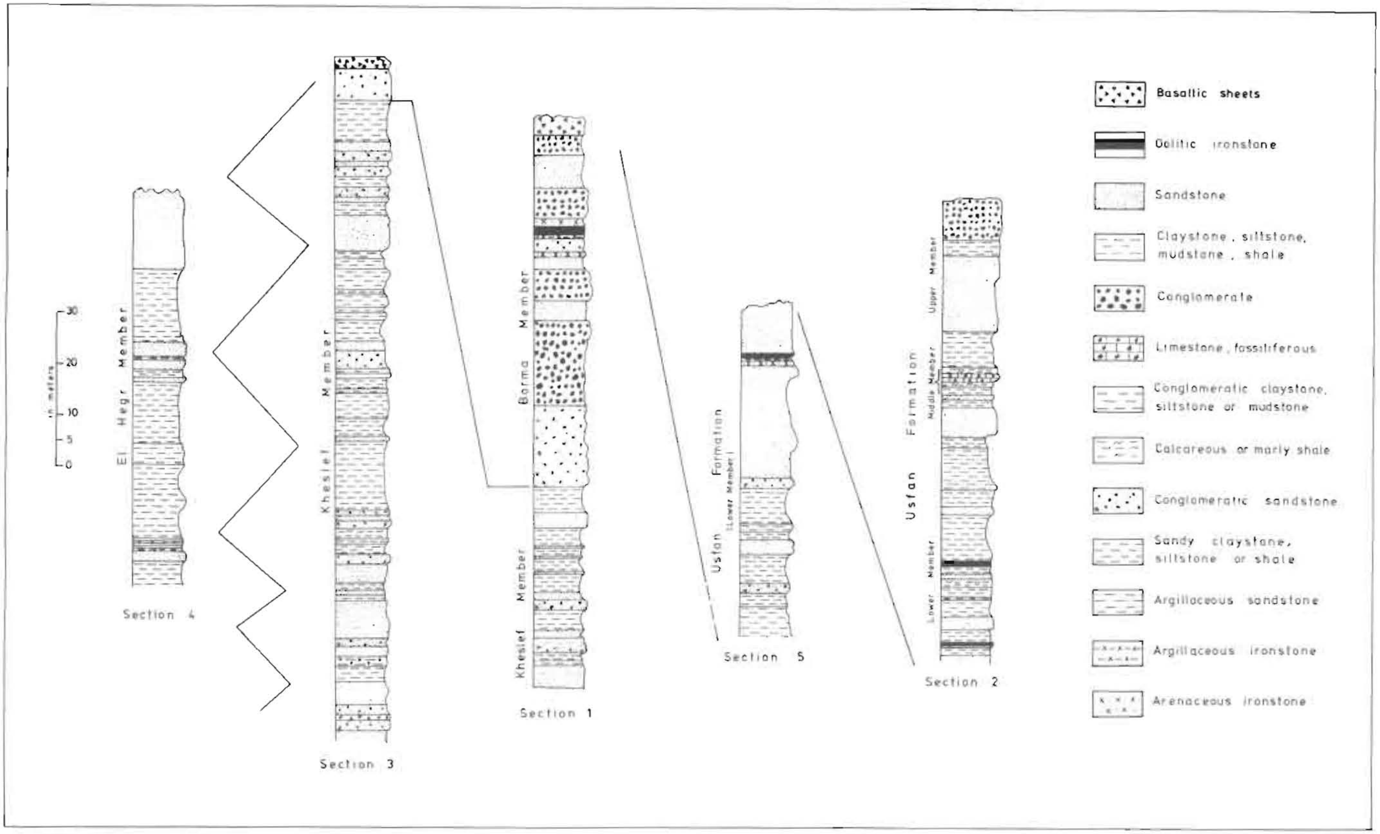
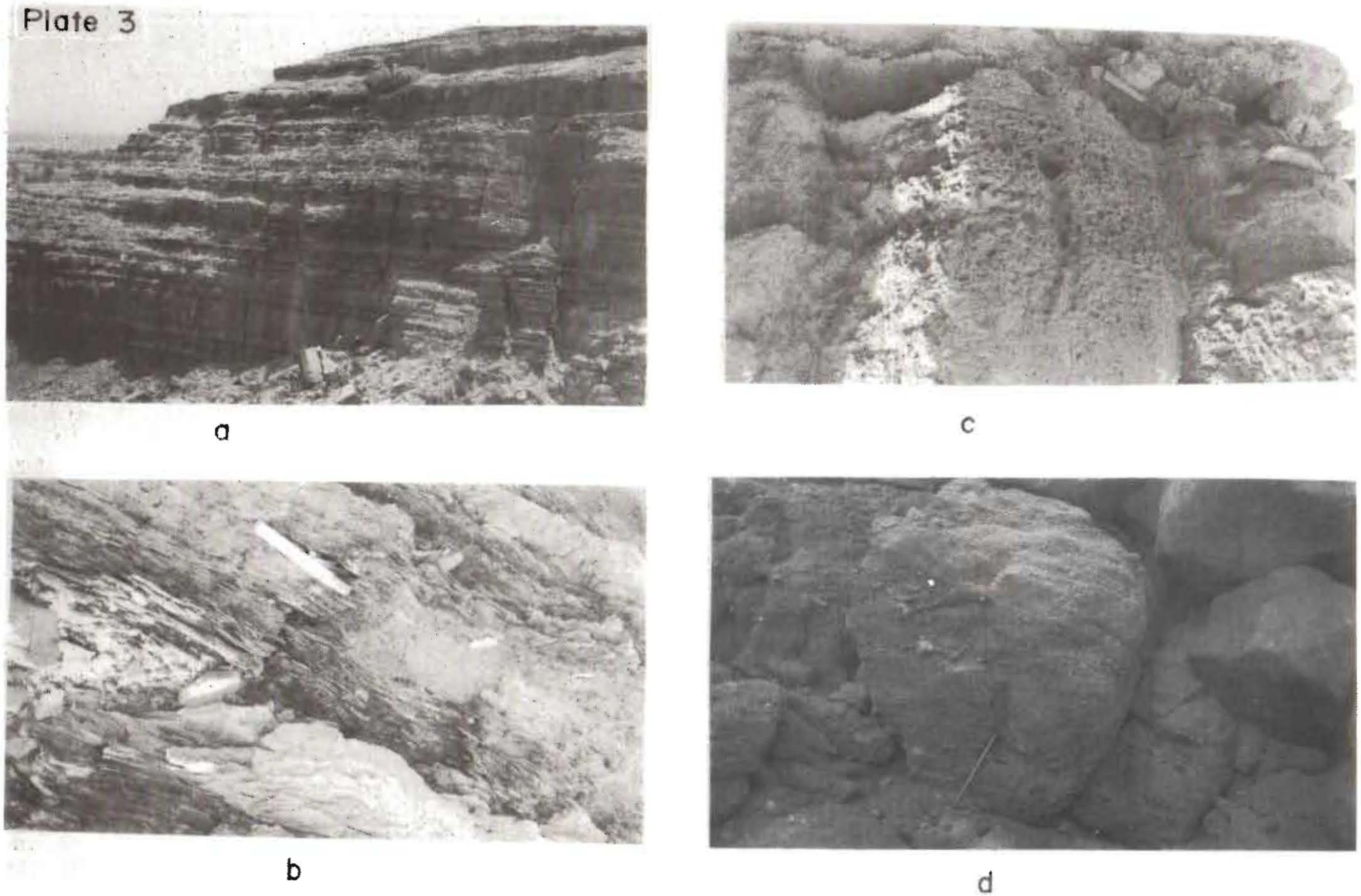


Fig. 3. Lithostratigraphic correlation between the measured columnar sections in Haddat Ash Sham area.



a. General view showing the well-bedded succession of the El-Hegre Member.
b. Papery shale facies of the El-Hegre Member.
c. Highly bioturbated, stromatolitic facies of the El-Hegre Member.
d. Cross-bedded badly sorted conglomeratic facies of the Borma Member.

The Borma Member runs as follows from base to top (section No. 1, Fig. 3), overlying the Kheslef Member:

Lithology	Thickness (m)
▪ Sandstone, coarse-grained, conglomeratic, poorly bioturbated	8.0
▪ Conglomerate, cross-bedded, and with graded bedding	9.5
▪ Sandstone, coarse-grained, friable, with small scale cross-bedding	1.0
▪ Sandstone, fine-grained, cross-laminated, rarely bioturbated	3.0
▪ Conglomerate, grading upwards into coarse-grained sandstone	6.0
▪ Sandstone, coarse-grained, highly ferruginous, cross-bedded, intercalated by thin bands (10-15 cm) of ferruginous sandy conglomerate	2.5
▪ Ironstone, sandy	0.7
▪ Sandstone, coarse-grained, ferruginous, cross-bedded	2.5
▪ Ironstone, argillaceous	1.2
▪ Ironstone, oolitic, sandy, cross-bedded	1.5
▪ Conglomerate, friable, ferruginous, generally fining in grain size upwards with cross-bedding of different scales	6.0
▪ Basaltic sheets (top)	2.0
Total:	42.0

2. *The Usfan Formation*

As mentioned before, the Usfan Formation was previously designated by Karpoff (1955, 1957a, b) to describe the sedimentary sequence exposed 3 km to the north of small village of Usfan, 55 km north of Jeddah, and is composed mainly of sandstone, claystones with their derivatives, intercalated by a fossiliferous limestone ledge. According to him, the latter is rich with plenty of venicardids and mostly sharply sculptured turritellids.

Unexpectedly in Haddat Ash Sham area, the Usfan Formation (about 92 m thick) with its key fossiliferous limestone bed overlies the Borma Member (Pl. 1b). Locally the formation directly overlies the basement rocks (Pl. 4b). Field observations show that the succession has a wide distribution extending between Usfan and El Gommoum villages.

The vertical lithologic variation of the Usfan Formation in the Haddat Ash Sham area as well as in its type locality permits its classification into three informal members of local interest, *viz*, lower, middle and upper members (Pl. 1a, 2).

The lower member is composed of cross-bedded sandstones mostly conglomeratic and shales intercalated by three bands of oolitic iron ore. The middle member is composed of highly fossiliferous limestone which is underlain and overlain by fossiliferous marl beds. The upper member is composed of shale succession overlain by cross-bedded gypsiferous sandstone and sandy shale. Cross-bedded, ill-sorted conglomeratic sandstones and conglomerates cap the upper member.

The succession of the Usfan Formation exposed in the Haddat Ash Sham area from base upwards is as follows, as measured in sections No. 2, 5, Fig. 3.

Lithology	Thickness (m)
■ Sandstone, coarse-grained, cross-bedded, bioturbated	2.0
■ Sandstone, fine-grained, ferruginous with lenticular bedding, and cross-lamination	3.0
■ Sandstone, coarse-grained, ferruginous, cross-liminated	4.0
■ Sandstone, medium-grained, cross-laminated, poorly bioturbated and mud-cracked at its top	3.5
■ Sandstone, ferruginous, medium-grained	0.8
■ Claystone, ferruginous	0.15
■ Ironstone, oolitic	0.6
■ Sandstone, medium-grained, bioturbated, with siliceous stromatolites at its top	1.5
■ Sandstone, fine-grained, cross-bedded	0.8
■ Sandstone, coarse-grained	0.2
■ Sandstone, medium-grained, cross-laminated, highly bioturbated near its top	0.3
■ Ironstone, oolitic	0.5
■ Sandstone, medium-grained, oolitic, ferruginous	0.15
■ Shale, laminated	1.0
■ Siltstone, ferruginous, gypsiferous	0.2
■ Shale, gypsiferous	1.5
■ Sandstone, cross-bedded	2.5
■ Shale, gypsiferous near the top	3.5
■ Siltstone, cross-laminated	0.7
■ Sandstone, fine-grained, cross-laminated	2.0
■ Shale, stromatolitic at the middle part	2.3
■ Sandstone, fine-grained, cross-laminated, rippled	1.5
■ Siltstone, cross-laminated, rippled	3.5
■ Siltstone, sandy, gypsiferous	1.0
■ Siltstone, marly, poorly fossiliferous with pelecypods, ferruginous	0.1
■ Siltstone, sandy, cross-laminated, rippled	7.0

■ Shale, gypsiferous, rippled, with flaser and lenticular beddings	2.5
■ Sandstone, fine-grained with flaser and lenticular beddings, and ripple marks and cross-lamination	6.0
■ Siltstone, cross-laminated	1.5
■ Sandstone, fine-grained, ferruginous, with lenticular bedding	0.6
■ Siltstone, ferruginous	1.3
■ Mudstone, calcareous, cross-laminated, ripple marked, with lenticular and flaser-beddings	1.0
■ Limestone, marly, fossiliferous, conglomeratic, mud-cracked, with rain drop imprints	2.5
■ Siltstone, cross-laminated, locally bioturbated	7.5
■ Sandstone, fine-grained, moderately bioturbated, cross-laminated	10.0
■ Sandstone, medium-grained, cross-bedded	5.0
■ Conglomerate to conglomeratic sandstone, cross-bedded at different horizons, shows graded bedding, establishing the surface of the plateau	10.0
Total:	92.2

B. *Age Assignment*

As mentioned before, in Haddat Ash Sham area there is conspicuous exposure of the Usfan Formation. The middle carbonate member of the formation is virtually a pelecypod lumachelle full of venericards. From the same horizon in the type section of the formation, Karpoff (1957a, b) documented *Venericardia ameliae* (Peron), *V. ameliae* var. *arfellensis* (Rosi-Ranchetti), *Corbula striatuloids* Forbes, *Lucina desioi* Ch. Risp which point out to the Maestrichtian. However, strongly sculptured turritellids, are identical to those recorded from the Paleocene of Egypt (Abbas 1971). Overlying the carbonate ledge of the middle member of the Usfan Formation in Haddat Ash Sham area is a hard greyish marl which has yielded a foraminiferal faunule of mostly agglutinated forms. Few Globorotalloids, which are rather badly preserved and compressed have also been encountered. Cretaceous elements such as Globotruncanas, Bolivinoides, Neofabellina, etc. are missing. Such negative evidence may still favour a Paleocene age.

It could be thus concluded that the carbonate bed of the middle Usfan member has been deposited at the close of the Cretaceous and the advent of the Paleocene. The clastic section (lower member of the Usfan Formation) together with the Haddat Ash Sham Formation could tentatively be assigned to the Cretaceous or even older. This section remains one with clastics of Nubia facies which in Egypt ranges in age from Carboniferous to Cretaceous (Said 1962). It is, therefore, highly recommended to undergo a study of the polynomorphs (if they are present) of this clastic section to determine its exact age.

On the other hand, the clastic section overlying the middle carbonate member could be dated as Paleocene or even younger. The Usfan Formation is conformably overlain by the Shumaysi Formation which is on the basis of few rather badly preserved mega fossils (pelecypods and gastropods) has been dated as Eocene or even Oligocene (Al Shanti 1966). Recently, a pollen assemblage indicate a lower Eocene (Cuisian) age for the middle member of the Shumaysi Formation (Moltzer and Binda 1981). This might be a further evidence for the conformity between the Shumaysi and the Usfan Formation.

Local Structural Features

The mapped area is structurally rather simple. It is mainly formed of nearly horizontal or very gently dipping beds with angles ranging from 2° to 5° east or northeast. However, in the vicinity of faults local drags with dips up to 20° have been observed. The prominent structural feature in Haddat Ash Sham area is faulting and jointing. Folding has not been observed except in the vicinity of faults where beds are sometimes dragged and even flexured.

1. *Faulting*

Generally, the faults mapped (Fig. 2) show limited extension ranging between less than one kilometer up to 10 km. Most of the faults are high angle normal faults with generally small throw. However, some faults have been recorded to have a displacement that reaches more than 70 m, particularly in the southern part of the area where the Borma Member is thrown down against the El-Hegre Member (Pl. 1a). In the northeastern part of the mapped area as well, a complete section of the Usfan Formation is thrown down against the Borma Member. Generally, the NE-

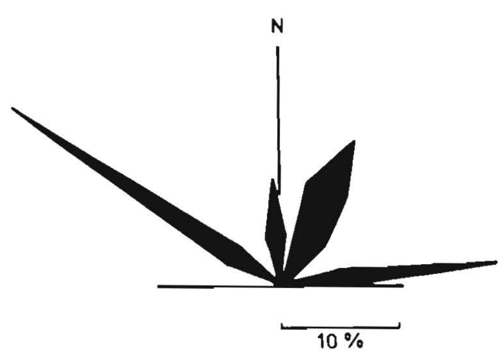


Fig. 4. Rose frequency diagram of the major faults encountered in the Haddat Ash Sham area.

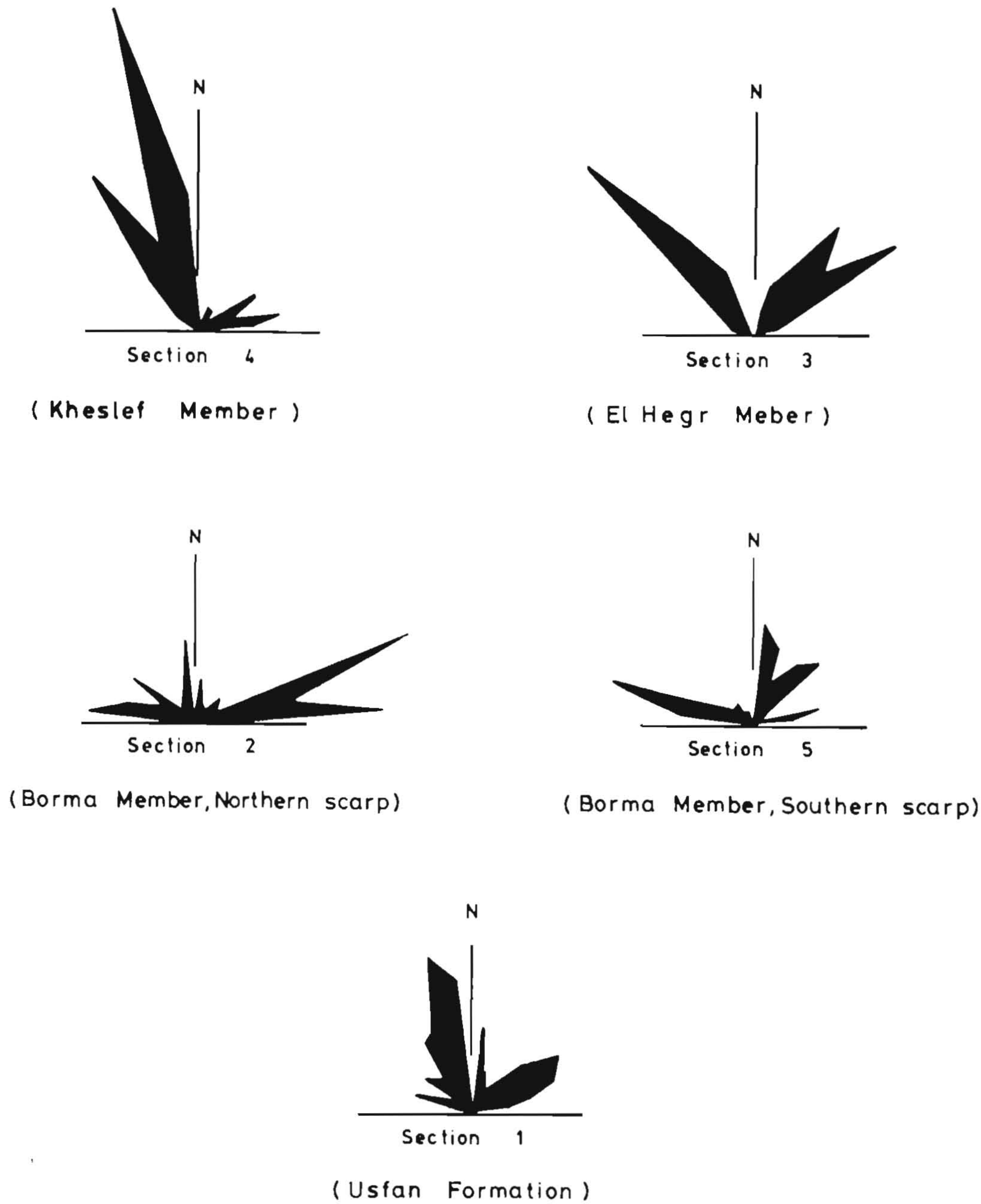
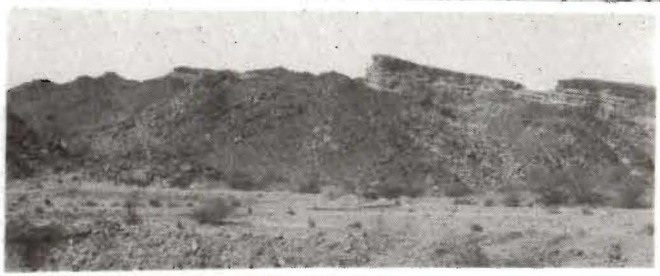


Fig. 5. Rose frequency diagrams of the minor joints measured in different stations covering the different mappable units.

Plate 4

a

b



c

d

a. Kheslef Member thrown down against the basement complex.
b. Base of the Usfan Formation unconformably overlying the basement complex.
c. Two minor, normal faults forming a horst cuts throw the El-Hegre Member.
d. Highly dipping, cross-bedded, sandstone facies of the Upper Member of the Usfan Formation.

SW faults form elongate grabens in the southwestern and northeastern parts of the investigated area. Most of the scarps and valleys dissecting the area are fault controlled.

Figure 4 shows that the recorded faults could be classified, according to their trends, into N50°-60°W, N80°-90°E, N20°-30°E and N0°-10°W sets arranged in a decreasing order of abundance. Minor faults (Pl. 4) forming small grabens and horsts are abundant and, in general, they are reflections and, thus, parallel to their associated faults.

2. *Jointing*

The sedimentary succession of the map area is highly dissected by joints of different trends. Joints have been measured at five stations which have been chosen in the studied area to cover its different rock units (Fig. 1). Azimuth frequency diagram has been constructed for each joint station (100 joints were measured in each station).

The primary maxima of the joint trends lie at N10°-20°W, N60°-70°E, N40°-50°W, N20°-30°W and N-N10°W, whereas the second maxima lie at N-N 10°W, N10°-90°E, N50°-60°E, N30°-40°W, and N-N10°E. This clearly shows that the joints mostly trend parallel or slightly oblique to their associated faults.

Usually, joints are perpendicular to the bedding planes, and as the beds are nearly horizontal so they are mostly vertical. However, relative competency of the concerned beds play an important role in joint behaviour. For example, in the Kheslef and El-Hegre Members where beds are usually comparatively competent, joints are regularly disposed, as could be observed from the rose diagrams (Fig. 5), whereas in the Borma Member where beds are rather coarse-grained, and friable, joints deviate markedly from their supposed courses.

Finally, in present state of knowledge nothing could be said about the relation between the trends of the faults and joints in the map area and the surround basement trends except that they are mostly parallel and hence might be interpreted as reflections of the basement trends or they might be inherited or rejuvinated from ancient lines of weakness dissecting the basement complex.

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وضــع لخرائــط الجيــولــوجيــة ودراســة استراتيجرافية للتتابع الرسوبي لمنطقة هدى الشام شمال شرق جدة بالمملكة العربية السعودية

أحمد با حفظ الله ، أحمد با سهل ، حسن حافظ منصور و سيد عمارة
كلية علوم الأرض ـ جامعة الملك عبد العزيز ـ جـدة ـ المملكة العربية السعودية

وضعت خرائـط جيولوجية لصخور فتاتية مجهولة الاسم ظاهرة في منطقة هدى الشام وتم تعريفها ، ومن ثم ، أمكن تعريف متكـون هدى الشـام بأعضـائـه الثـلاثـة ؛ الخسلف والهجـر والـبرمـا . ويغطى متكـون هدى الشام امتداد غير متوقع من المستريخى إلى متكون العسفان الباليوسينى بتوافق واضح .

هذا الوجود الحاسم إضافة إلى أن متكون هدى الشام يرقـد بلا توافق واضـح فوق صخـور قاعيـة ترجع إلى ما قبل الكمبر ى يشير ان إلى أن عمره يرجع إلى الطباشير ى أو ربما أقـدم من ذلـك . وينـاقش البحث باختصار السمات البنيوية التى تظهرها هذه الصخور الفتاتية .