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Petrography and Synsedimentary Processes of Carbonate beds of Fat'ha Formation. In selected sections at Al-Qayyara area, south of Mosul, Northern Iraq.

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Abstract

Fatha was studied in two sections at Alqayyara area southern of Mosul. Petrographically, Sands Fatha indicated composed of quartz monocrystalline and polycrystalline type, while the feldspar forming mostly of plagioclace feldspar and K-feldspar. The rock fragments mostly come of igneous, metamorphic and sedimentary origins. Fat'ha Formation is affected by diagenetic process such as Cementation, Compaction, Neomorphism and Dissolution. limestone beds contain sedimentary structures the effect of environmental factors on shallow environments. The current study showing that the Fatha Formation contains fossils, trace fossils, high percent benthonic foraminifera (Rotallida and Miliolida) and low other fossil such as mollusca.

Key words: Petrography, Fat'ha, Al-Qayyara

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دراسة صخارية وتأثير العمليات الرسوبية المصاحبة لترسيب الطبقات الجيرية لتكوين الفتحة في مقاطع مختارة قرب منطقة القيارة جنوب مدينة الموصل – العراق

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الملخص: -

درست صخور تكوين الفتحة في منطقة القيارة جنوب الموصل. بتروغرافياً، تظهر رمال تكوين فتحة بأنها مؤلفة من النوع الكوارتز الاحادي والمتعدد التبلور، بينما يشكل الفلدسبار في الغالب البلاجيوكليز والفلدسبار البوتاسي. أن الصخور والقطع الصخرية في الغالب هي ذات اصل ناري ومتحول ورسوبي. تأثرت تكوين فتحة بالعمليات التحويرية كالسمنتة والانضغاط والتشكل الجديد والاذابة. تحتوي طبقات الصخور الجيرية على تراكيب رسوبية ثانوية، وتظهر هذه التراكيب تأثرها بعوامل البيئات الضحلة. أظهرت الدراسة بأن تكوين الفتحة يحتوي على المتحجرات والاحافير الاثارية، ونسباً عالية من الفورامنفيرا القاعية الروتاليد والمليوليد مع احتواءه على القليل من المتحجرات الاخرى مثل محاريات راسية القدم.

الكلمات المفتاحية: بتروغرافية، فتحة، قيارة

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Introduction:

This paper is to study the effect of sedimentary processes on limestone beds that contain fossils and trace fossils which were observed in the field (1 - 1.5 m). We notice that limestone beds contain sedimentary structures and signs of living organisms that are formed by the effect of environmental factors on shallow environments. This causes the formation of sedimentary structures and signs of its effect before the time of sediment consolidation.

The region of the study lies within the Low Folded Zone according to the Geological map of [1]. Also it lies within the Foothill zone of the unstable shelf of the Arabian plate according to the tectonic map of Iraq [2] Figure (1).

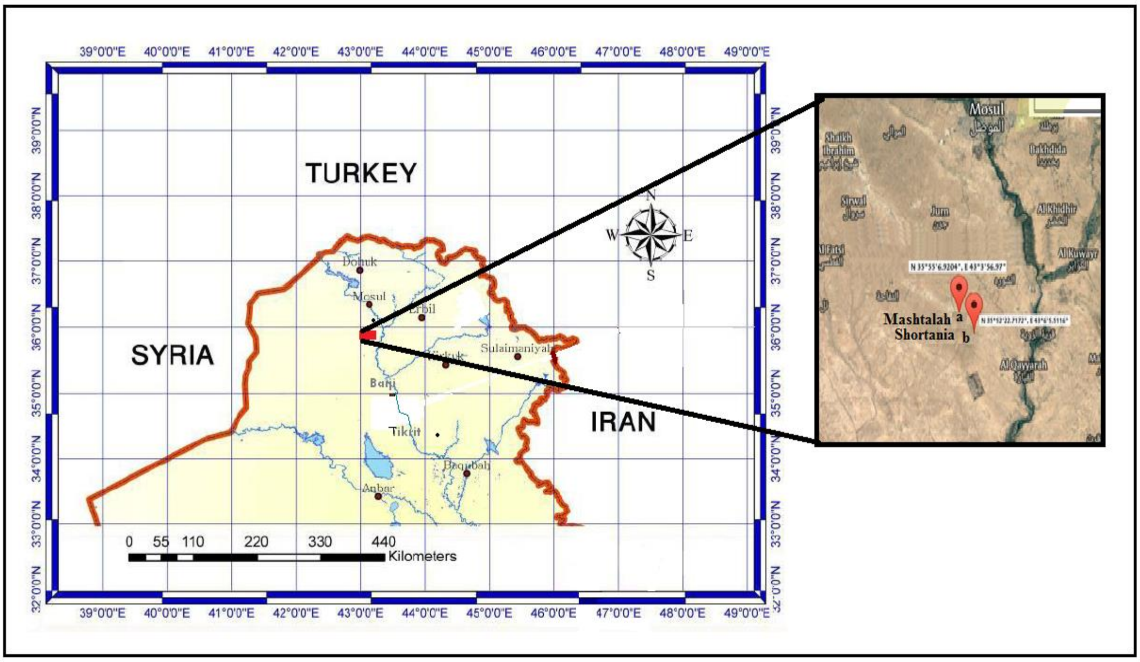


Figure (1):- The location of study. a - (Al- Mashtalah section) showing its coordinates.
b - (Al- Shortania section) showing its coordinates.

Structurally, the region contains many low structures with direction of (NW–S E) like the folds of Mishraq, Hammamul Alil, and Al-qaiyarah. These structures separated by low synclines , where many sinkholes with different diameters have been found. These sinkholes result from the effect of water on evaporates rocks causing their dissolution. Stratigraphically , many sequences are outcroped in the region and range in its ages from Miocene to Recent Fatha Formation wich consist from alteration of clastic and non-clastic beds Injana Formation, which consist from clastic beds of claystone, sandstone and Quatrnery Formation consist from clastic beds of conglomerate, sandstone and claystone [3]. Fatha Formation in subsurface structure have four Litho-Unite ranging age Middle Miocene. Each cycle is distinguished by achain of the following sediments (green - red shale, limestone, gypsum, anhydrites and salt rocks). The nomenclature of the formation has been edited into Fatha formation in Iraq [4]. The ideal section for the formation was chosen on the Western limb of Makhool fold.

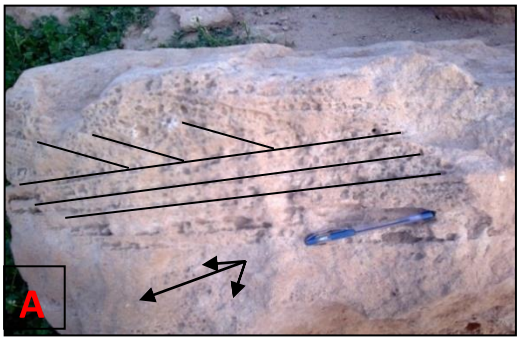
The fold consists of irregular sedimentary sequences of greenish gray Marl, reddish brown Marl, limestone, and anhydrites. Fat'ha formation is considered as one of the important formations in the Middle East region because of its wide extensions and economical importance. It covers the margins of the stable shelf and all unstable shelf [5]. The depositional basin Fat'ha Formation takes the direction of North West – South East and it extends from North East of Syria across Iraq to South West of Iran [6]. It constitutes one of the essential formations for the group of anticline folds that have been discussed earlier by [7]. The thickness of the formation different from one place to another according to the proximity from the centre of the basin and to the effect of the construction movements during the modelling of the formation, [6] has shown that the sedimentary basin of Fat'ha Fm. is controlled mainly by the construction movements that resulted in sudden intermittent drop of the bottom of the sedimentary basin which was reflected in the formation and development of rhythmic cycles. The sequence of formation sediments (that start with limestone rocks, Marl rocks, Evaporites rocks, and lastly, the salty rocks) shows that it is collectively a sign of alternation of the sedimentary cycles consequence of this formation because of the change in quality of water which is affected by being connected or disconnected to the open sea. The importance of the formation comes from the fact that it contains large amount of sulphur sediments especially in Almishraq area [8]. It also contains some salty sediment that has economical value in addition to the industrial uses of limestone and evaporites. The formation rocks are considered so important that they have been granted the attention of many researchers including [9] whom studied the formation rocks in details and emphasized on the study of carbonate marker beds which included in the formation rocks in the region of Kirkuk. He also suggested a model that describes the sedimentary history of the formation rocks. He represented the model by a partially closed sea basin which was similar to the Red Sea in its climate conditions. According to [10] who has studied the geology of the area between Mosul and Fat'ha, he divided the formation into five limestone marker beds that lie in the lower zone of the formation while three others lie in the upper zone of the formation. These marker beds are characterized by distinguishing rock features and wide extensions that have been studied later by [11].

According to [12] have studied the sedimentology of the upper clastic unit for Fat'ha formation in the region between Hammamul Alil and Al-qaiyarah. They pointed out that the sediments of this unit contain structures and phenomenae that are similar to the ones present in bird foot fluvial dominated delta. This delta has developed over wide areas above Lagoonal sequences for Fat'ha Formation [13] has found in his study of Ichno fossils (marine and non-marine) that are formed in upper and middle Miocene sediments in the region between Mosul and Al-qaiyarah. Skolithos facies are the abundant ones in the sandy rocks that lie in the upper unit of Fat'ha formation. He also pointed out that these facies exist in sandy limestone sediments and markers of medium to high degrees of sedimentation rate in a shallow and coastal environment with a depth of (10-30 m).

According to [11] They have studied the sedimentology and mineralogy of the clastic sediments in the upper unit for Fat'ha formation in the region between Mosul and Khanouqa and concluded the depositional environment for it as a delta deposits.

Field study:

The field study, which was marked by tracking the beds that contain sedimentary structures represented by cross bedding as in Picture (1) A , B has shown that there are two types of beds that contain molluscan and trace fossils. These beds are arranged stratigraphically from the oldest one by the limestone bed that contains the mollusca fossils, which have light brown color and a rough surface with a thickness that reaches approximately (1 m) as in Picture (1)A. The rock also contains ichnofossils from the genus *Skolithus* with alength of more than (10 cm) and a diameter of about (1 – 2 cm), Figure (2) and Figure (3). They have shapes similar to the letter (L) as in (Picture 2 A – D) [14].



Picture (1) :- A- Distribution of the fossils within the bed (black arrows) and the direction of cross bedding (black lines).
B- The direction and size of cross bedding and presence of pores within the bed.

The field study also showed that there is a bed of limestone, below the main limestone bed, devoid of fossils and sedimentary structures. Above the main bed, there is a bed of evaporites that has callosity. The bedding surfaces between them are sharp that the bedding gradient is not observed clearly as in Picture (1), from [14], which represents the nature of bedding relations and the fossil content in these beds.

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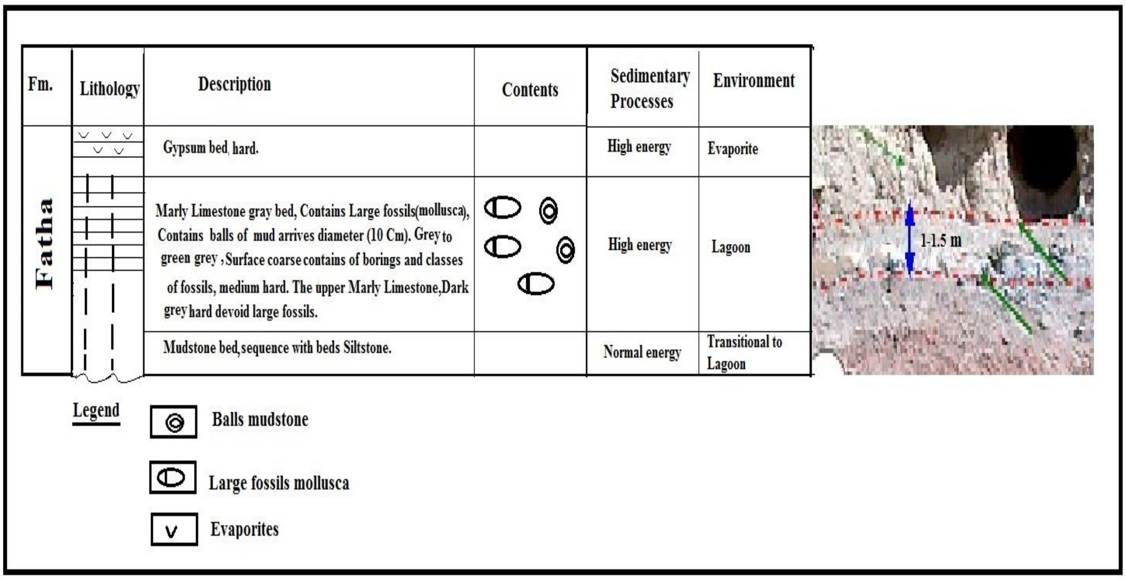


Figure (2):- Graphic sedimentary log shows the location and features of the bed that contain
mollusca fossils. Al - Shortania village Section

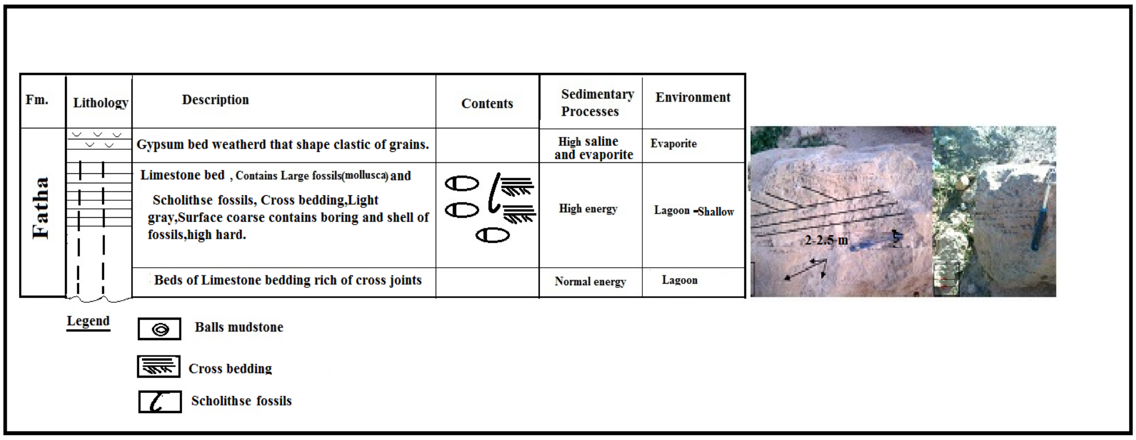
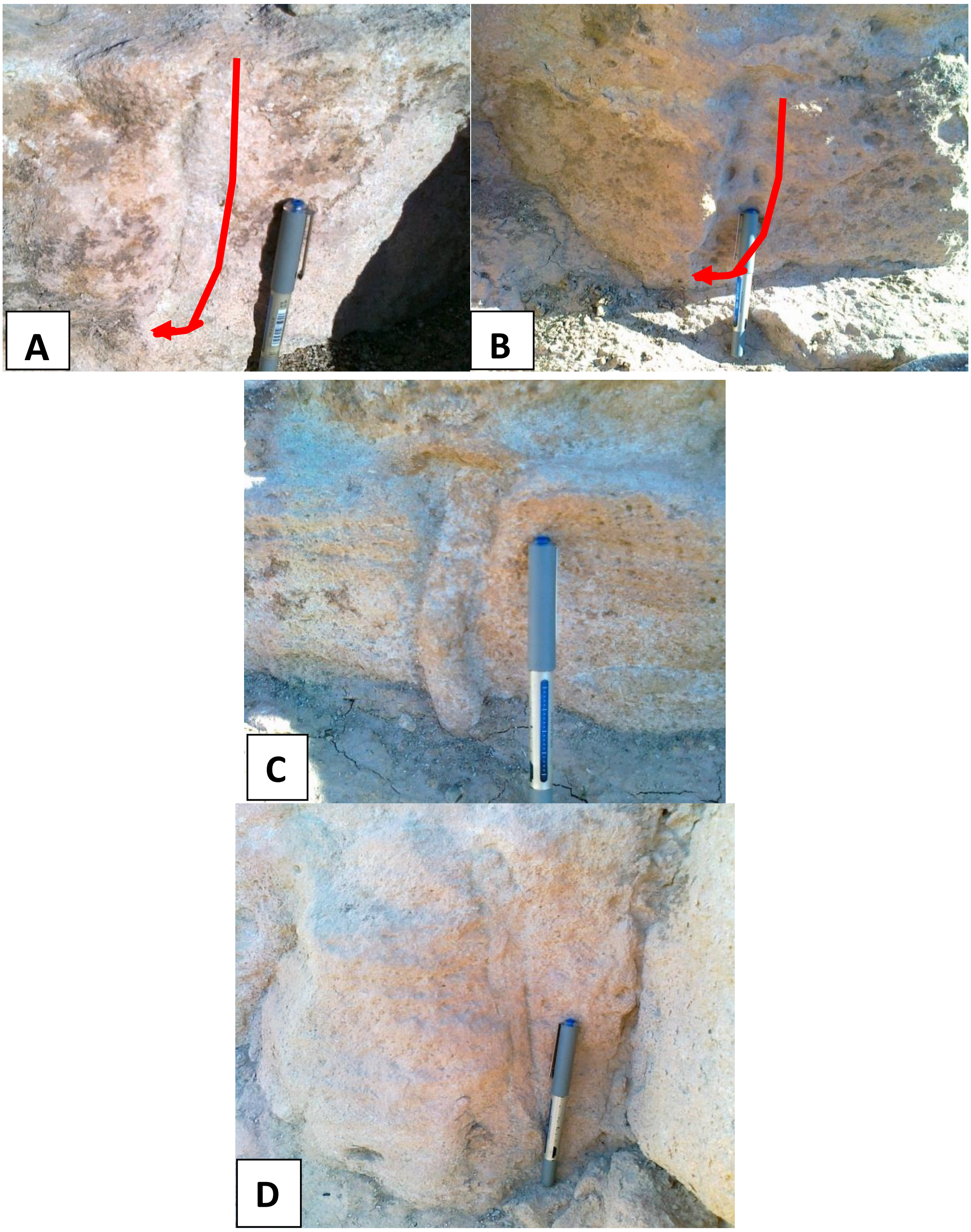


Figure (3):- Graphic sedimentary log shows the location and features of the bed that contain
molluscan fossils. Al- Meshtala village.



Picture (2):- The shape and dimensions of Ichnofossil traces (red arrows and pen) in Al-
Meshtala area section – A.
A and B: The ideal shape of (L) with a diameter (1.5 – 2mm).

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C: The second type of Ichnofossil traces with smaller diameter and longer plane or deeper.
D: The arch shape of Ichnofossil traces with larger diameter.

Petrography:

This study includes the petrography of the limestone beds of the formation that consist from clastic and non-clastic component and the study of its mineralogical components and the cement materials and their texture as well as the diagenesis processes effect. It also employs the results of the study of these rocks in order to identify the nature of the prevailing environmental conditions at the time of sedimentation of the formation.

This study includes a complete description of the mineralogical components and the texture of the limestone through making thin - sections for all parts of the bed in the sections of the study. The study revealed that they formed from beds that are rich in the following clastic and non –clastic components:

1-Clastic components:

A. Quartz:

Two types of quartz have been diagnosed. Monocrystalline quartz is composed of isolated grains of different sizes ranging from fine to medium and coarse size according to [15] as in Pl. 1 (A, B, C, D, E and F). The type of contact between the grains is bitmap and sometimes tangential. However, in many models, the quartz grains are floating inside the micrite cement material. The grains of monocrystalline quartz are mostly clear and devoid of inclusions and vacuoles which exist in either scattered or oriented way as in Pl. 1 (A, C, and D). The quartz grains are distinguished by being subhedral to anhedral, angled to semicircle, and sometimes the grains are perfectly circled. This marks that they have been exposed to reworking which signifies that they are transported and originated from sedimentary source [16] as in Pl.2 (A and B). Both types of extinction are observed, the straight and corrugated ones, but the straight one has a high percentage as the corrugated extinction results

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from the exposure of grains to strain because of cracking, folding, compaction, and diagenesis effect after sedimentation [17].

The second type is polycrystalline quartz. It is distinguished by being composed of two or more grains of different sizes with straight borders, irregular or tangled between the granules as in Pl.1 (B and D). Both [16] and [17] have explained that the type of the borders between the grains is so important in the determination of the rock origin. The tangled borders give a clue about the metamorphic origin or they have been formed inside the veins of volcanous rocks and so the arrangement of structured crystals into a regular row and taking an oriented direction is a clue about the metamorphic origin.

In the current study, we notice an increase in the percentage of grains with straight extinction. This decreases the possibilities of its metamorphic origin. In addition, it shows that the grains of monocrystalline quartz with straight extinction are more resistant to the transportations factors than the grains of polycrystalline quartz with corrugated extinction. The quartz grains are also more resistant to the natural factors (transportation and sedimentation factors) than other minerals. From that, we infer the igneous origin in which the sandstone was derived from, and observed in the studied facies.

B.Feldspar:

Feldspar exists into clastic-rich limestone as two types. The first type is Alkali feldspar which is composed of Orthoclase. It appears in the form of crystals of different grains sizes which are dusty as a result of decomposition into clay minerals such as Sericite and Kaolinite [17] Pl.1 (B and C).

The second type is Plagioclase which is distinguished by pajama twinning (Pl.1, A and E). It also underwent decomposition into clay minerals. The observed Feldspar grains have different sizes (fine to medium) and are subhedral to anhedral. Most of the grains have dusty shapes due to decomposition because of the effect of chemical and physical weathering [18]. Feldspar is derived mostly from igneous and metamorphic rocks; such as granite, gneiss, and schist as result of exposure to weathering factors and humid climate, which has helped in its weathering.

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C. Rock fragments:

The rock samples of limestone contain rock fragments which are spread noticeably in different sizes. They may belong to igneous, metamorphic, or sedimentary origins. Generally, they point to the near distance of transportation and immaturity of texture [19] [18]. In addition, they contain skeletal fragments of different fossils Pl. 2 (A, B, C, D, E and F).

2-Non-Clastic:

The non-clastic represented by skeletal compound, that related in petrographical (Miliolida, Rotaliida, Gastropods, Pelecypods, echinoderms, and ostracoda) Pl.3(A,B,C,D and E). The skeletal components gave the evidence to coastal environment as in [20] explained that the abundance of fossils in the rocks of formation point to the fact that their sedimentation occurred in a coastal environment behind the barrier in warm water or mixed water bodies with a high percentage of calcium carbonate and a depth that reaches 50 m.

Matrix:

In the research there is to types of matrix: the first one is composed of finer-grained sedimentary material, such as quartz, clay or silt (Pl.1, A, B, and C) and (Pl.3,F). The second represented by micritic matrix composed from fine grained of calcite matrix (Pl. 3,4). The matrix is composed of micrite and fine sizes of other grains in the facies [21]. It forms the ground for most studied samples and demonstrates the sedimentation in low energy environments [22].

Cementing material:

Calcite forms the essential cementing material in the samples under study. It appears in the form of fine grains of recrystallized micrite and sparry calcite as in (Pl.3,A). It may be spread widely so that the clastic grains appear as floating inside the cementation material.

Diagenesis:

The effect of diagenesis on the samples becomes minimal and it is represented by the process of silica crystallization in the form of secondary overgrowth surrounding quartz and feldspar crystals. The presence of the calcite cement as a replacement and

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the effect of physical compaction on the facies have helped in the convergence of grains and thus increasing the sediment ability to Lithified thus, rock formation. The effect of secondary decomposition on feldspar is noticed as well as some of the effect of dissolution which has helped in the formation of new pores in the facies.

The diagenesis in rocks represents all the processes that affect the sediments after sedimentation and before Lithification [23]. They may be either isochemical or allochemical [17]. The study of diagenesis processes are so important in the knowledge of what has happened to the sediments in the form of physical and chemical changes during and after sedimentation. The most important diagenesis processes in which the limestone beds were exposed to are the following:

A. Cementation:

We notice the formation of a number of types of cement in the studied rocks. They appear in the form of a linkage between the grains or in the form of cementing material that fill the gaps and other vacuoles resulting from dissolution. Cementation was represented by drusy cement in the form of crystals with semi regular sides. Their size are more than (10mµ) and they form in the vacuoles in the form of mosaic texture [24]. Drusy cement forms in Phreatic zone under the effect of pure water [25]. It represents the ideal cement resulting from the diagenesis processes of groundwater. It is distinguished by the growth of its crystals and increment of their size far away from the wall of cavitation and the vacuoles of dissolution sedimented in them. The largest size of crystals lies in the center [17] as in Pl.3 (A, B, and C). There is also sparite which appears in different sizes that reach mass sparite (Pl. 3,A).

B. Compaction:

The effect of compaction processes on rocks is represented by physical compaction (chemical compaction like Stylolite is not recorded yet). It appears mostly on fossils and represented by pointed and sutured contact. This is reflected in the formation of broken skeleton structures as in Pl.3 (A, B, C, and D). [26] have shown that this feature marked by the rearrangement of grains stems from compacted fabric that is supported granularly. This is the result of the effect of physical compaction (Pl.1,F).

C. Dissolution:

Dissolution occurs by the effect of carbonate unsaturated solvents that cause selective dissolution for some carbonate compounds [22]. The dissolution processes that occur in tidal or shallow-water environments act to decrease the rock hardness resulting in increased fragility by organisms [22]. This has increased the formation of secondary pores (porosity) in the rocks under study as in Pl.3 (D) and Pl.4 (A,B,C and D).

D. Recrystallization:

Neomorphism is considered as one of the processes with a wide effect on the studied rocks. The rocks were exposed to recrystallization resulting in a change in size, shape, and arrangement of crystals without a change in their minerals. The size of the recrystallized grains has increased to replace the fine crystals of Calcite [27]. These processes were detected in limestone with fine granules that changed into fine spar forming granules unequal in size as in Pl.3 (E and F) and Pl.4(C,E and F).

E. Mechanical breakdown:

The movement of waves causes the mechanical breakdown of large and small fossils which we observe throughout the rocks [28]. This process occurs in shallow-water environments especially at the coasts [22] as in Pl.3 (A and F), Pl.4(A).

Conclusions:

From the field and petrographic study of lithofacies, we concluded that Indicated sands Fatha composed of quartz monocrystalline and polycrystalline type, while the feldspar forming mostly of plagioclace feldspar and K-feldspar. The rocks and fragments mostly of igneous, metamorphic and sedimentary origins. Fatha Formation is affected by diagenetic process such as Cementation, Compaction, Neomorphism and Dissolution. limestone beds contain sedimentary structures and signs of living organisms formed by the effect of environmental factors on shallow environments, we infer that the rocks of formation contain fossils like benthic foraminifera including Rotaliida, Miliolida, and Pelecepods in different sizes. In addition, the presence of fossils as sedimentary forms in harmony with the nature of the current and sedimentation conditions point to the clear effect of waves on non-solid sediments. This effect occurs below the plane of the wave base. It appears on most large fossils that exist in the form of individual shells so that the valve lies on its back. This gives a clue about the increased magnitude of the current energy that acted to separate the valves from each other and form the sedimentary structures within limestone beds as Pl.5(A, B, and C).

We notice that the prevailing environmental conditions at the time of sedimentation were in the form of a sedimentary environment for non-clastic facies. This resulted in the sedimentation of different fossil structures but under the effect of external conditions at the time of sedimentation and at low accommodation space. This helped to make the sedimentation within the plane of the wave base with a presence of clastic supply that affected the orientation and gathering of shells and the sedimentation of clastic sediments. This was the reason behind the escape of organisms and lack of efficiency of the carbonate factory. As a result, the sedimentation of this facies in which there are clastic sediments and formation of igneous structures like crossed bedding resulted in the escape of some organisms to the under surface of the sediments and constructing the traces of housing.

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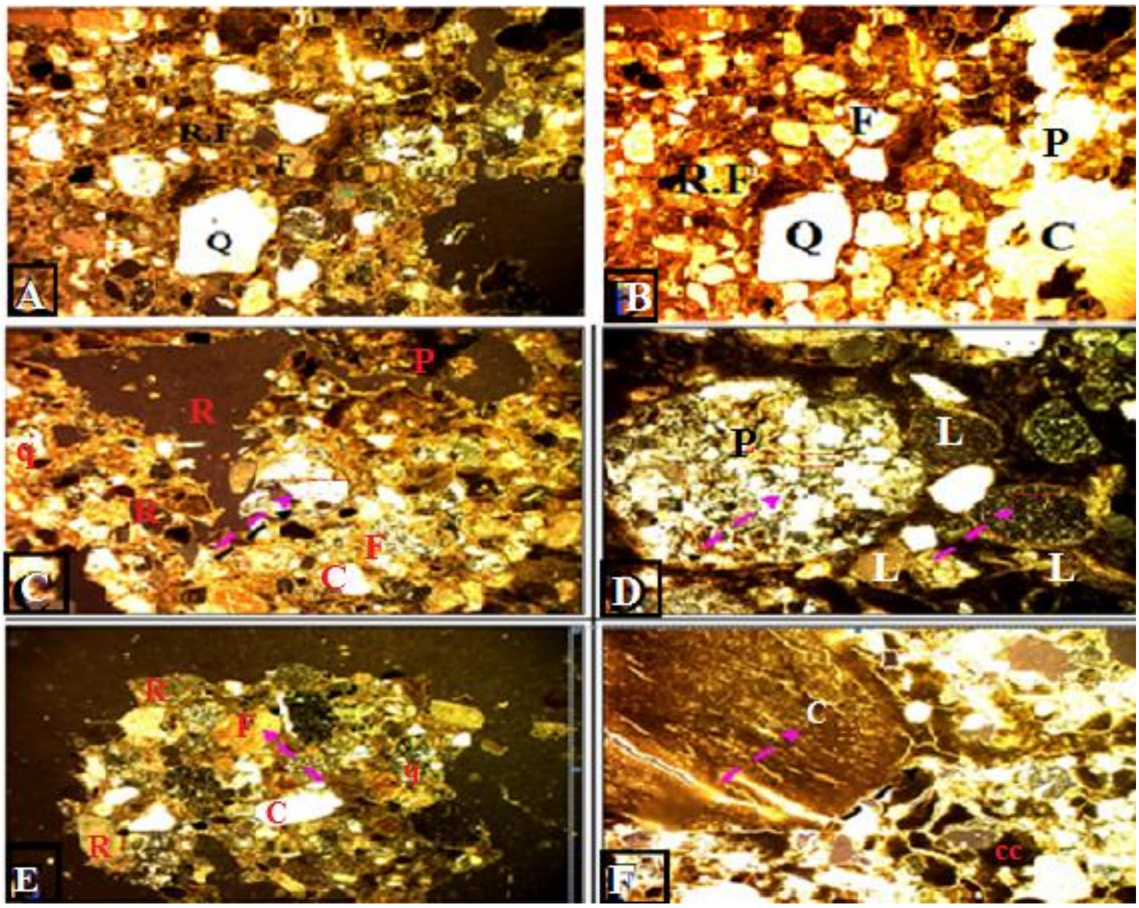
Plate – 1



A. Pieces of monocrystalline quartz (Q), Plagioclase Feldspar (F), rock fragments (R.F.). (5 * 10 X) C.N.

B. Pieces of quartz, Feldspar, rock fragments, and calcite. (5 * 10 X) C.N.

C. Pieces of quartz , Feldspar(F), rock fragments (R) , and calcite(C) with porosity (P) and dark minerals. (5 * 10 X) C.N.

D. Different sizes of limestone(L) granules that show rotation with little-rotation Polycrystalline quartz (P). (10 * 10 X) C.N.

E. Pieces of quartz(Q), Plagioclase Feldspar (F), rock fragments(R), calcite(C), and limestone(L) of different sizes. (5 * 10 X) C.N.

F. Pieces of quartz (mono and polycrystalline) and feldspar with large pieces of clay(C) and a ground that contains clastic clay(cc) and calcite (10 * 10 X) C.N.

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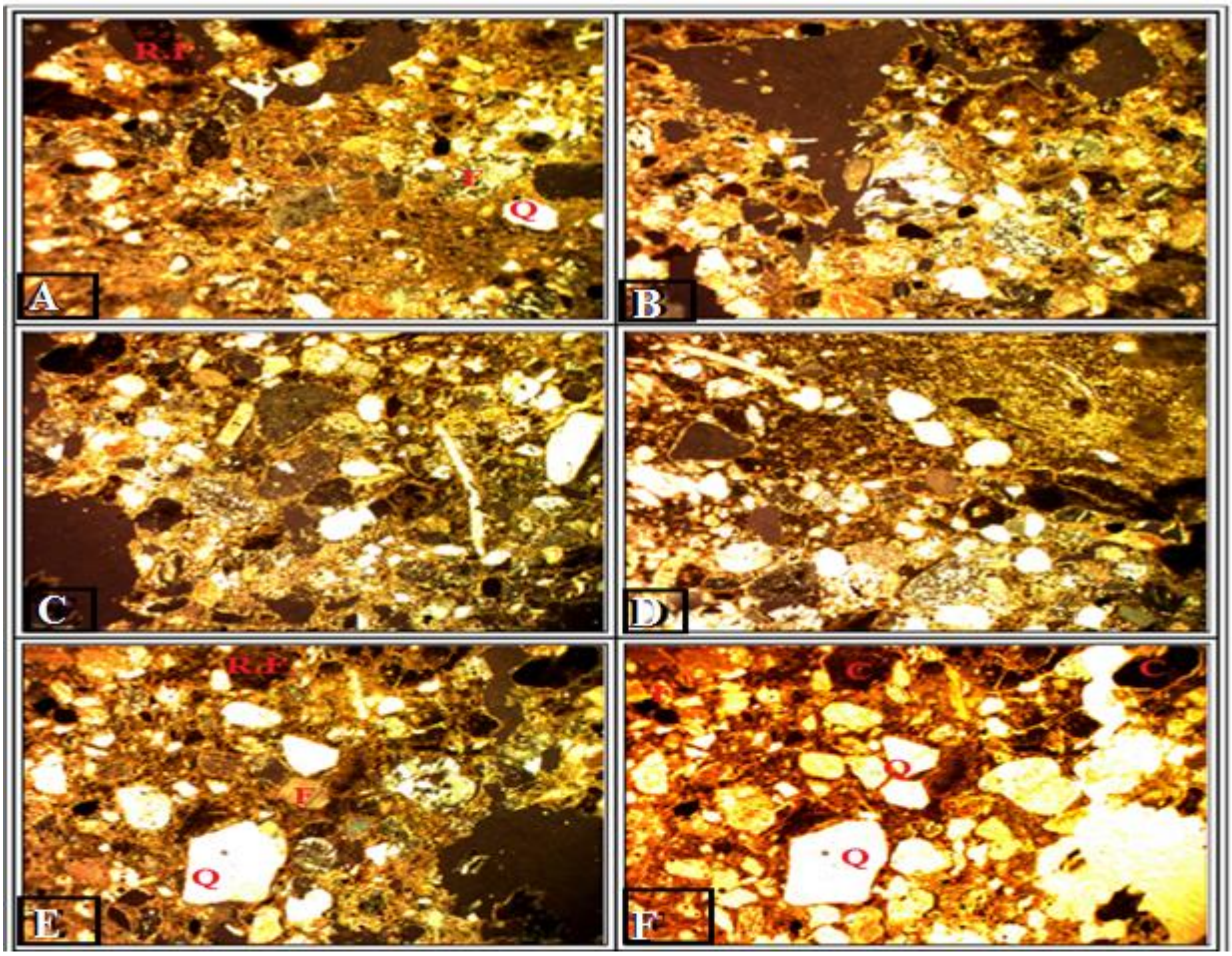
Plate – 2



A. Pieces of quartz(Q), feldspar(F), rock fragments(R.F.), and calcite that are exposed to separation after stone hardness with the notice of difference in sizes. (5 * 10 X) C.N.

B. The effect of dissolution on granules with the percentage of ground that is formed of calcite with pieces of rock fragments. (5 * 10 X) C.N.

C. The presence of fossil wrecks in addition to the essential clastic components. (5 * 10 X) C.N.

D. The arrangement of components in the form of sequences of rough and smooth components in the pattern of oriented beds with pieces of rock fragments. (10 * 10 X) C.N.

E. Pieces of quartz(Q), feldspar(F), rocks fragment(R.F.), and calcite of different sizes. Quartz gives a clue about stable sedimentation. (5 * 10 X) C.N.

F. Pieces of quartz(Q) of different sizes and feldspar(F) with large pieces of clay(C) and a ground that contains clastic clay. (5 * 10 X) C.N.

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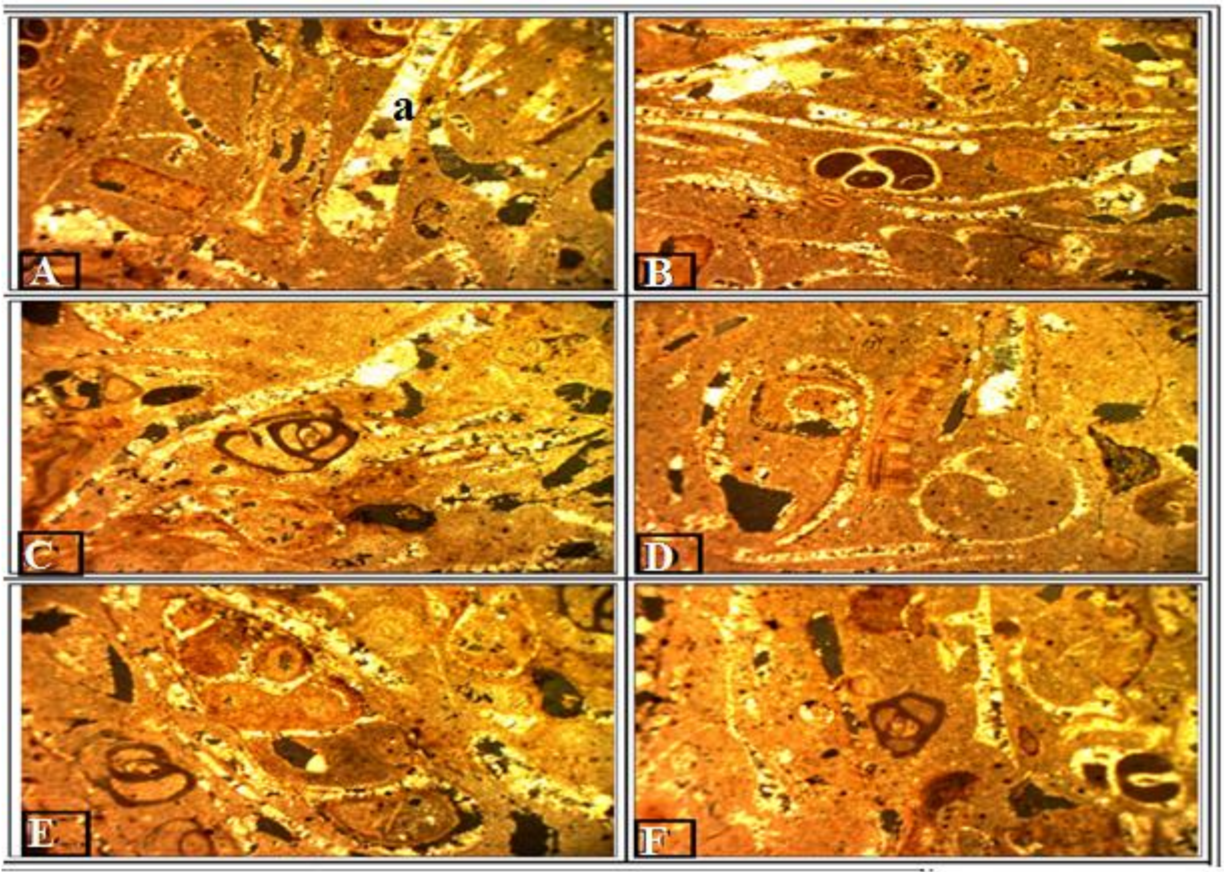
PLATE – 3



A. Bivalve fossil shells that are affected by diagenesis and resedimentation of secondary cement(a) with pieces of echinoderms and bioclasts. (5 * 10 X) C.N.

B. Bivalve fossils shells that are affected by diagenesis such as dissolution, pores formation, and resedimentation of secondary cement with pieces of echinoderms and benthic Foraminifera (Miliolida). (5 * 10 X) C.N.

C. Benthic Foraminifera fossils (Miliolida) and bioclasts which do not show the template pores as other fossils do with cement. (5 * 10 X) C.N.

D. Longitudinal and transverse sections of fossil shells of Gastropods and Pelecypods and bioclasts which show the Calcite beds of shells being unaffected by dissolution inside the granules. (5 * 10 X) C.N.

E. Longitudinal section of Gastropods shells with other benthic Foraminifera which show the differential response to diagenesis. (5 * 10 X) C.N.

F. Micrite (Clacite) ground shows that it has been affected by recrystallization with other unaffected fossils by diagenesis.

Plate – 4

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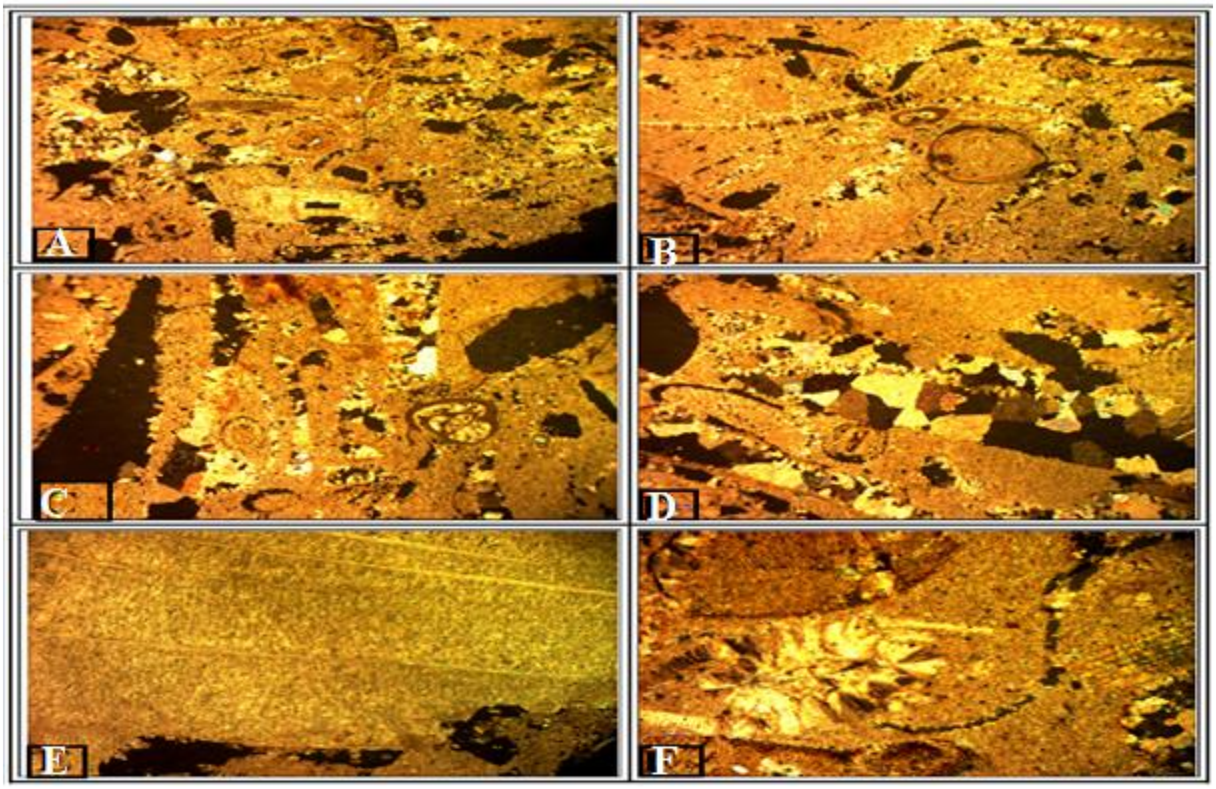

A. Pieces of shells and thorns of echinoderm fossils with shadows of non-skeletal pieces that are affected by diagenesis such as dissolution and sedimentation of cement (a). (5 * 10 X) C.N.

B. Bivalve fossil shells that are affected by diagenesis such as dissolution, pores formation (highly porous), and resedimentation of secondary cement with pieces of echinoderms, benthic Foraminifera (Miliolida), and heavy metals. (5 * 10 X) C.N.

C. The effect of diagenesis (dissolution) on skeletal components. (5 * 10 X) C.N.

D. Sedimentation of block cement within template pores. (5 * 10 X) C.N.

E. Transverse section of mollusc fossil shells which shows the differential response to diagenesis such as recrystallization. (5 * 10 X) C.N.

F. Rotaliida and Ostracod fossils with pieces of echinoderms that have been exposed to recrystallization. (10 * 10 X) C.N.

PLATE – 5

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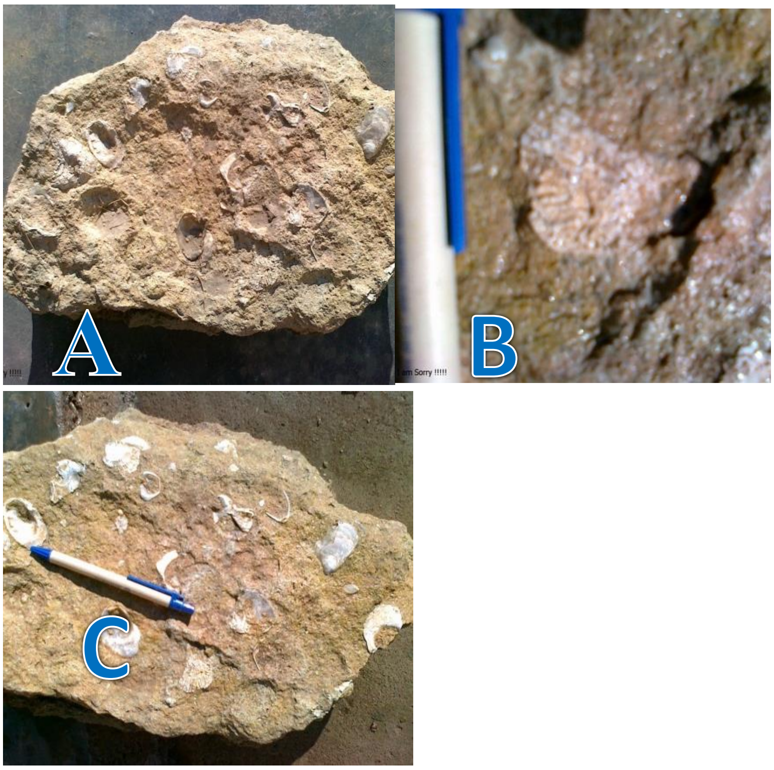

A. The regular orientation of separated shells

B. The arrangement of fossils on the sedimentation surface under the effect of the current

C. The arrangement of the fossil shells with the current under the sedimentation surface.

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