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The Consequences of Petrophysical Effects on Reservoir Properties of Hartha Formation at Balad Oil Field, Central Iraq

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Abstract

Hartha Formation (Upper Companian-Mastrechtian Sequence) consists mainly of detrital organic limestone and dolomitic limestone and may contains streaks of marl and through the petrographic study of the rocks of the formation, it was found that it consists of skeletal granules consisting of benthic foraminifera represented by fossils (orbitoid, rotalide and miliolide) and a few planktonic foraminifera belonging to the family of Globigerinacea and red, green algae, echinoderms, mollusks and the Formation also contained a few Calcispheres and these granules appeared affected by several modifying processes, the most important of which are Dolomitization, recrystallization, dissolution, Micritization and chemical compression and it was found through the analysis of the Microfacie that the Formation consists of four main, microfascies the upper limit of the Formation is conformable with the Formation of the Shiranish, while the lower limit represents unconformable with the Formation of Mashura. The present study focused on the effect of Diagenesis processes on the Hartha Formation in four subsurface sections within the Balad field in Salah al-Din Governorate in central Iraq, representing the first section (Ba-1) with a thickness of (443) m, the second section (Ba-5) with a thickness of (306) m, the third section (Ba-7) with a thickness of (306) m. (Ba-9) and thickness (307) m. Where (355) slides consisting of rock cutting and cores were studied, (144) slides for the well (Ba-1), (58) slides for the well (Ba-5), (54) slides for the well (Ba-7) and in the well (Ba-9). It was by (99) slides, as well as the logs of the above wells, through which the Formation was divided into three porous units.

Keywords: Hartha Formation, Balad Oil field, Diagenesis Processes, petrophysical effects.

التأثيرات البتروفيزيائية ونتائجها على الخواص المكمنية لتكوين الهارثة في حقل بلد، وسط العراق

الخلاصة:

تكوين الهارثة (Upper Companian-Mastrechtian Sequence) ويتالف بشكل رئيسي من الحجر الجيري العضوي الفتاتي والحجر الجيري المتدلمت واحيانا يحتوي على شرائط من المارل ومن خلال الدراسة البتروغرافية لصخور التكوين، تبين بأنه يتألف من الحبيبات الهيكلية المتكونة من الفورامنيفرا القاعية المتمثلة بمتحجرات (اوربيتويد، روتاليد والمليوليد) وقليل

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من الفورامنيفرا الطافية التابعة لفوق عائلة كلوبيجرناسيا والطحالب الحمراء و الخضراء وشوكيات جلد والرخويات واحتوى التكوين ايضا على الكريات الكلسية بشكل قليل و ظهرت هذه الحبيبات متأثرة بعدة عمليات تحويرية اهمها الدلمتة، السمنتة، اعادة التبلور، الإذابة، المكرتة والانضغاط الكيميائي وتبين من خلال التحليل السحني بان التكوين يتألف من أربعة سحنات دقيقة رئيسية، يتمثل الحد العلوي للتكوين بانه متوافق مع تكوين شيرانش، أما الحد الأسفل فيمثل عدم توافق مع تكوين مشورة. تضمنت الدراسة الحالية تأثير العمليات التحويرية لتكوين الهارثة في أربعة مقاطع تحت السطحية ضمن حقل بلد في محافظة صلاح الدين وسط العراق تمثل الأول بمقطع (Ba-1) بسمك (443) م) والمقطع الثاني (Ba-5) بسمك (306) م) والثالث (Ba-7) بسمك (306) م) اما المقطع الرابع متمثلة في (Ba-9) وسمكه (307) م). حيث تم دراسة (355) شريحة مكونة من الفتات الصخري واللباب بواقع (144) شريحة لبئر (Ba-1) وبواقع (58) شريحة لبئر (Ba-5) وبواقع (54) شريحة لبئر (Ba-7) أما في البئر (Ba-9) فكان بواقع (99) شريحة وكذلك تم تفسير مرتسمات المجسات للابار اعلاه والتي من خلالها تم تقسيم التكوين الى ثلاث وحدات مسامية.

1. Introduction:

The Upper Cretaceous Era considered as one of the important eras in terms of tectonic and sedimentary and includes similar facies within formations that aroused the interest of researchers to study the stratigraphy of this era in order to determine the differences of age and stratigraphy sequence up to the nature (morphology) of the sedimentary basin and the facies facsimile (intercalation) overlaps that reflect secondary environments within the main environment, the Hartha Formation was deposited within the (Upper Companian-Mastrechtian Sequence) deposition cycle, within a shallow to Lagoon marine environment, its sediments are widespread in central and northern Iraq[1]. [5] Indicated in his study to measure porosity and permeability the Hartha formation that the average porosity is between (15-23) % and permeability between (0.23-3.66). [6] Refer to The Hartha formation effected by diagentic such as dolomization, neomorphism, cementation dissolution, micritization, and compaction. The Hartha Formation is divided into two reservoir units: A and B depending on the relation of the water saturation with porosity, the reservoir unit B is better than A [13]. The formation was first recorded and described by [2] in an unpublished report and the Type section was described by [3] in al-Zubair well (3) within the Zubair oilfield in southern Iraq, as it consists of rock sequences composed of detrital organic limestone, sometimes dolomitized, marly limestone, and green shale and hard dolomitized limestone in some parts. The present research aims to study the effect of diagenetic processes of formation and to show the amount of correlation between these different changes and their relationship to the change of their reservoir properties and their importance as reservoir as the change of reservoir properties affects the amount of production and this is what called (led to) for studying the effect of diagenesis processes, where the study area included four subsurface sections in the Balad oilfield within the Salah al-Din province consisting of four wells (Ba-1, Ba-

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5, Ba7, Ba-9) It is located within central Iraq in the stable shelf according to divisions [1] Figure (1).

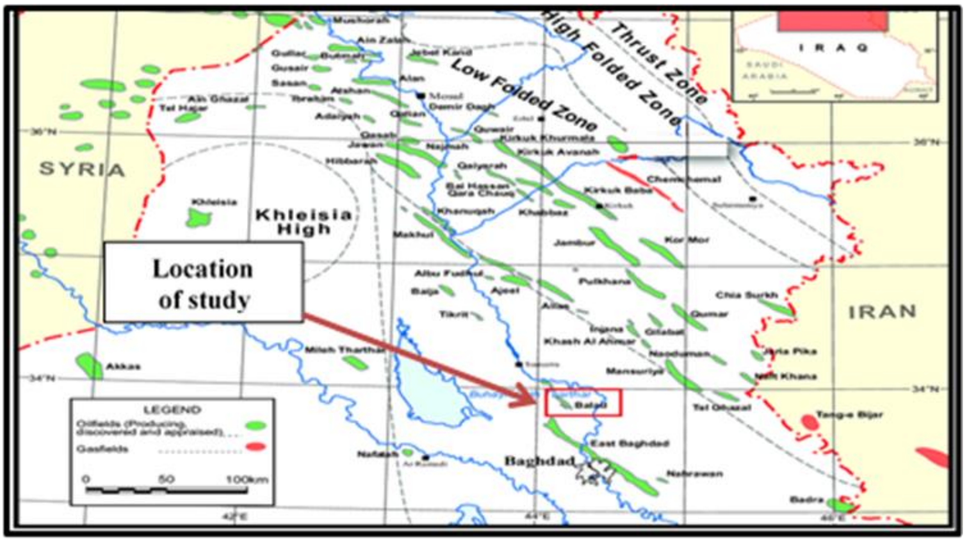

Fig. (1): Location map of the study area showing wells

2. Material and Methods

The present study depends on the 355 slides as well as through the recordings of FDC/CNL logs and gamma ray log. Ellis&Messina, 1940Catalogue of Foraminifera. In the classification of Foraminifera as well, the program (Techlog) was used to find porosity values, which were compared with petrographic tables. The final reports on the wells available at the North Oil Company have been reviewed also, and petrographic and diagenesis processes were studied under a polarized microscope to determine the reservoir properties

3. Results and Discussion

3.1 Diagenesis Processes

Diagenesis processes include all chemical, physical and biological changes that occur on calcareous rocks that affect sediments and sedimentary rocks during and after sedimentation until before the transformation process [4]. In general, Diagenesis processes lead to increased or decreased porosity and permeability, which are important in oil reservoirs, and one of the most important classification systems on which it depends [7, 8, 9] Where the modular processes were generally divided into two categories.

3.1.1 Constructive Diagenesis Processe

A- Isochemical Diagenesis Processes

These processes that do not lead to any change in the chemical composition of limestone rocks

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represented by each of the cementation processes (Cementation) The process of cementation is one of the most influential processes on the qualities of the reservoir, the process of cementation leads to a severe reduction in the porosity of rocks and may turn them into cap rocks, especially in high-energy environments, due to the increase in cementation in them [11]. Among the types of cement that have been diagnosed in the Hartha formation it is Blocky cement, and [14] this type of cement is found in the Phreatic environments plate (A-1). Granular cement is formed during the later stages of Diagenesis processes [10]. Plate (B-1). and Drusy cement is found in vadose and phreatic environments [16,15]. Plate (C-1). Syntaxial Rim Cement is the deposition of calcite crystals on the surfaces of the skeletal granules, usually with the Bioclastic of echinoderms and extended to the outer edges of the granule and the environments of Meteoric and Phreatic are characterized by this form of cement [10]. Plate (D-1). Anhydrite cement is calcium sulfate crystals formed as a result of changing gypsum by burial [17]. Plate (E-1) As for the Neomorphism is the process that affects the skeletal and non-skeletal components, as the micrite turns completely or partially into a microspar or a pseudsparite, the most suitable environments for the Neomorphism process are Phreatic, Meteoric Diagenesis environments [18]. The process of recrystallization in the sediments of the formation was observed through the presence of the recrystallized micrite, where part of it was transformed into a microspar. Plate (F-1), Figures (2) to (5).

B- Allochemical Diagenesis Processes

Chemically asymmetric Diagenesis processes are represented by the process of dolomitization, which change the mineral calcite into dolomite, which leads to reducing the size of the rock and increases its porosity [12], [19] Refer to that the intensity of the dolomitization process leads to an increase in secondary porosity as a result of a decrease in the size of the grains due to Substitution of magnesium to calcium The Dolomitization process occurs in conjunction with sediment deposition (early Dolomitization) or after sedimentation (late Dolomitization)[9]. The Dolomitization process has been distinguished during the current study sections in different parts, and a classification has been adopted [20] the most important dolomite texture that were distinguished in the rocks of the formation under study is the Floating rhomb in micrite or microspar matrix that indicate to early Dolomitization Plate (G -1).

Contact rhomb texture by subhedral to euhdral dolomite crystals, and it is of different sizes (H-1). Sutured mosaic texture is subhedral dolomite crystals that are compact It does not have intercrystalline

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porosity or is low in porosity of plate (I-1). While Authigenic minerals the (pyrite) formed inside fossil shells and benthic, planktonic skeletal and matrix were distinguished. Plate (J-1), Figures (2) to (5).

3.1.2 Destructive diagenesis processes

It is the processes that result in a change and destruction in the composition of the rock and are represented by the Compaction process that occurs as a result of the overburden sediment, as it leads to a reduction in thickness and a decrease in size and porosity [9]. And Compaction is divided into two type mechanical and chemical, physical compression is formed after a short period of sedimentation, while the chemical occurs after a long period of time and at depths of hundreds of meters of burial [4]. Chemical Compaction it is lead to formed Stylolite due to the compression of solutions, which have important effects on carbonate oil reservoirs and act as channel that allow migration [21, 22, 23] In the current study, the presence of hydrocarbon evidence was observed in the slides that were affected by the chemical Compaction process and which increased their permeability. Among the types of Stylolite that have been diagnosed are Smooth Stylolite, and this type of surface is semi-flat with a few simple curvatures, plate (K-1). Irregular Stylolite This type of surface is zigzag in the lateral section, plate (L-1), Parallel Sets This type of surface is in the form of parallel lines and overlapping each other (A-2).The process of Micritization has been observed to affect the walls of the skeletal grains as seen in some slides of the sections of formation, plate (2-B).As for the Dissolution process, which is one of the diagenesis processes that have been observed in the Formation, which led to the formed of secondary porosity as a result of the dissolution of soluble limestone components as well as fossil shells, which increase the petrophysical properties of the rock (porosity and permeability) plate (2-C, D) Figures (2) to (5).

3.2 Classification of porosity of the Formation

Porosity is one of the basic reservoir properties. The pores within the rock are generally filled with connate water in addition to oil or gas in the oil fields [25]. [24] refer to The secondary porosity is formed as a result of the exposure of the original carbonate sediment to diagenesis processes after sedimentation, the formation of secondary porosity depends on the presence of primary porosity which is responsible for the transfer of solutions and forms the secondary porosity. [25] He divided porosity into three types in formal terms: open-ended, closed-ended and closed, the open-ended pores and the closed-end pores forming the effective porosity this means that hydrocarbons, can

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move through them. The closed pores are unable to pass the hydrocarbons and the latter type of porosity is considered ineffective porosity. The porosity units of the formation were divided into three units depending on the divisions [25] Figures (6) to (9) as in the Table (1). [26] Has divided the porosity depending on the petrophysical properties into interparticle porosity and vugy porosity.

3.2.1 Interpartical porosity

This type was distinguished and represented by porosity between the grains and between the crystals and the researcher has combined these two types within one class despite the difference in the origin of their inception because they possess similar petrophysical properties, where both types were observed in the sections of the Formation within the Packstone, Wackestone and mudstone microfacies, which are a common porosity within the Formation, plate (F, E-2).

Table (1) The porosity units of the formation

Units	The properties	Ba-1	Ba-5	Ba-7	Ba-9
ha-1	Interval Porosity	1672-1780 0.11	1711-1825 0.011	1676-1810 0.0083	1708-1810 0.029
ha-2	Interval Porosity	1780-1910 0.21	1825-1890 0.019	1810-1850 0.029	1810-1970 0.083
ha-3	Interval Porosity	1910-2115 0.17	1890-2017 0.13	1850-1987 0.13	1970-2017 0.19

3.2.2 Vugy porosity

It is the porosity inside the grain or crystals, and differs from the porosity Interparticle, and this porosity takes distinctive forms sometimes take the form of fossils or dissolved grains as there are in the form of fractures or irregular cavern and wide size [26], this type of porosity has been divided depending on the nature of its contact with each other into two types [26].

A- Disconnected vugy porosity

This type of porosity is caused by the method of selective dissolution of the granules [24] both the porosity intrapartical plate (G-2) and the moldic plate (H-2) were diagnosed within the formation. This type of porosity has limited petrophysical importance because it (although it increases the total porosity) does not enhance permeability [1] but if moldic porosity develops, this leads to the formation of effective porosity, especially in rocks whose texture is grain support

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because the grain is contact to each other, which is important in reservoir and this does not apply in mudstone [27].

B- Connected vugy porosity

This type is represented by both vugy porosity, fracture porosity and cavern porosity [26]. All these varieties have been diagnosed within the formation and the vugy porosity is associated with fractures, where the porosity fractures are defined as pores formed in the form of longitudinal fractures in the matrix, it is play an important role in enhancing permeability by connecting them to the separate vugy porosity, and they appear through the rocks in longitudinal forms plate (I-2) and intersecting (channels) plate (J-2), and vugy porosity, which is a secondary porosity formed by early or late diagenesis processes represented by a dissolution process distributed in randomly[10] plate (K-2), and cavern porosity which is a porosity of large and irregular sizes formed by non-selective dissolution[28] plate (L-2) Figures (2, 3, 4 and 5).

4. Conclusions

The Hartha formation was affected by many diagenesis processes, the most important of which is the process of dissolution, it has contributed positively to the properties of the reservoir formation, as it led to the formed of secondary porosity as well as the connection of these pores with each other, moreover the process of cementation, which led to the closure of pores completely or partially, many types of porosity were distinguished in the formation, which is both porosity Interparticle and moldic, which appear in the Packstone and Wackestone microfacies, while the latter is isolated except in the case of Its connection through the porosity fractures, as the porosity of the type of vugy was observed within the mudstone, either the process of Dolomitization has appeared through the crystals of dolomite rhombic shape floating, contact and Sutured mosaic texture within the matrix and this may be attributed to the stage of early, medium and late Dolomitization seems to have contributed to increasing the porosity of the rocks, while the process of Neomorphism includes the process of recrystallization that led to the transformation of the micrite to the microsparite or pseudospar, where it forms corridors between the different pores and thus enhance the porosity and permeability. either the process of inversion led to the transformation of aragonite into calcite. as observed the process of chemical compaction and the presence of oil shows through the stylolite which indicates the formation of permeability, as for the process of Micritization, it affected the skeletal grain, where it was observed a Micritic cover surrounded by grains was observed, which contributed to the resistance of dissolution

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process in most formation sections but its effect on the formation was rare. The Formation was divided into three units: The First unit: We note through the porosity sensor that the corrected porosity rate ranges between (0.0083-0.11)%, where its percentage decreases in the wells (Ba-5, Ba-7 & Ba-9) The reason for the decrease in the percentage of porosity formation is the common of the cementation process despite the availability of all types of porosity and this unit represents the lowest percentage in porosity and is thus considered the worst units in terms of properties and physical. The Second unit: the porosity ratio is higher than the first unit, where the corrected porosity ratio ranges between (0.012-0.21) %, and the lowest percentage is in Ba-5 and in the two wells Ba-7.9 its percentage reaches between (0.029-0.083) % and its percentage is higher in Ba-1 where it reaches to (0.21) % and the reason for this increase is the presence of porous diversity, especially fracture porosity, as well as the decrease and sometimes lack of cementation process. The Third unit: It is considered one of the most heterogeneous units in the petrophysical properties, where the percentage of porosity corrected between (0.13-0.19) % and the porosity ratio in this unit decreases in the lower parts (in the sections of little thickness) for all wells. The petrophysical properties of well (Ba-1) is better compared to the rest of the wells.

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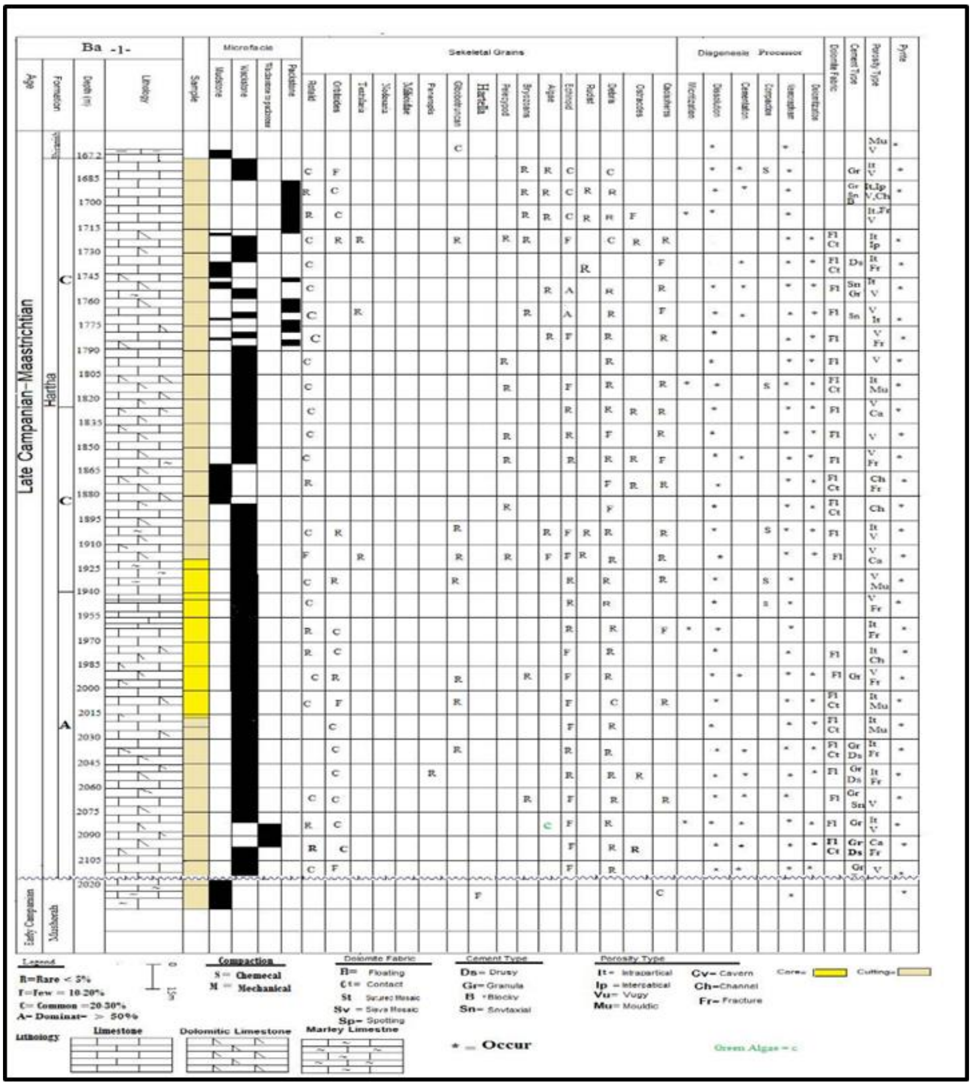

Fig. (2): Rock description of the composition of the well Ba-1

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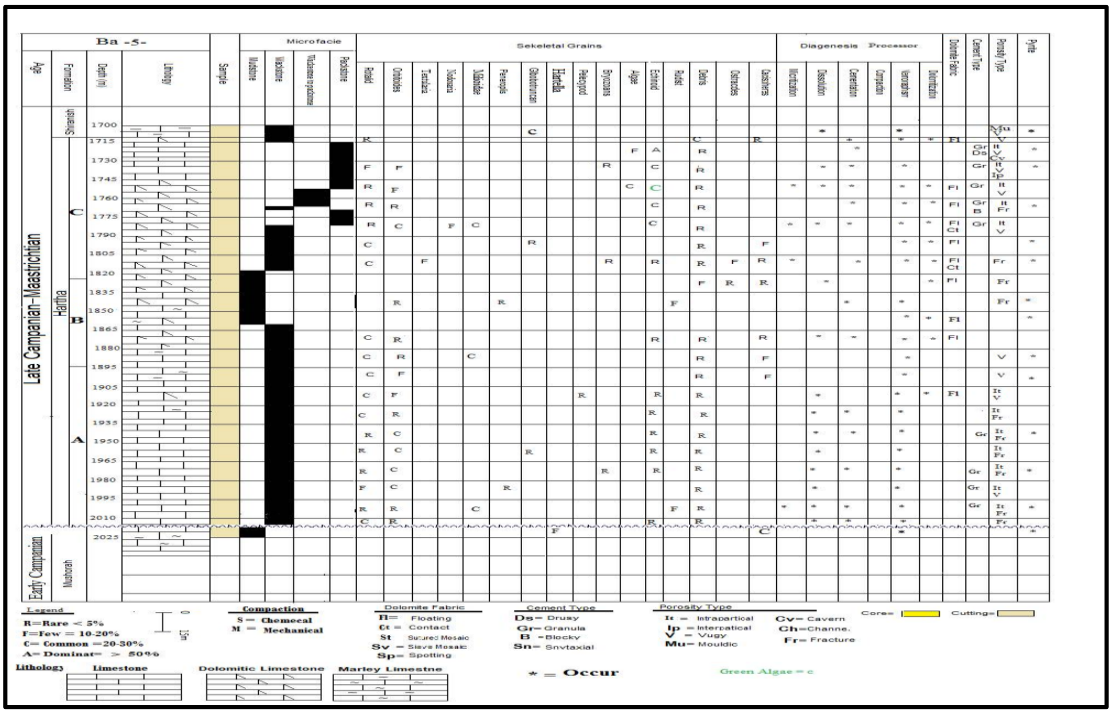

Fig. (3): Rock description of the composition of the well Ba-5

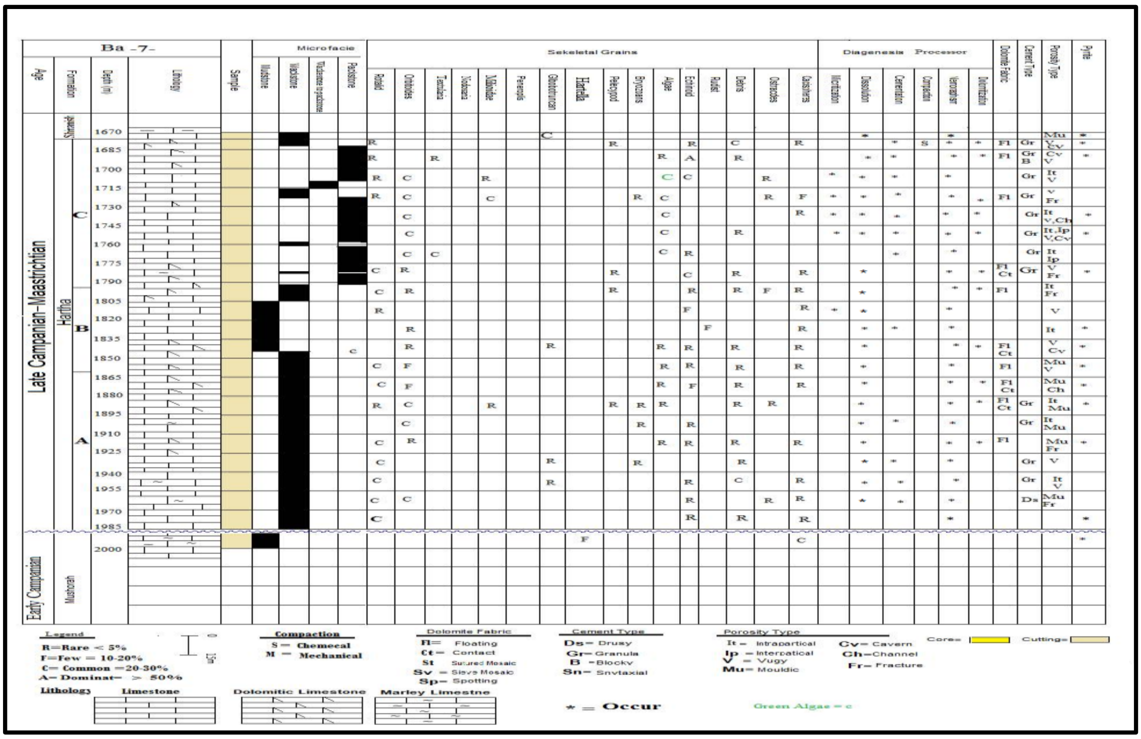

Fig. (4): Rock description of the composition of the well Ba-7

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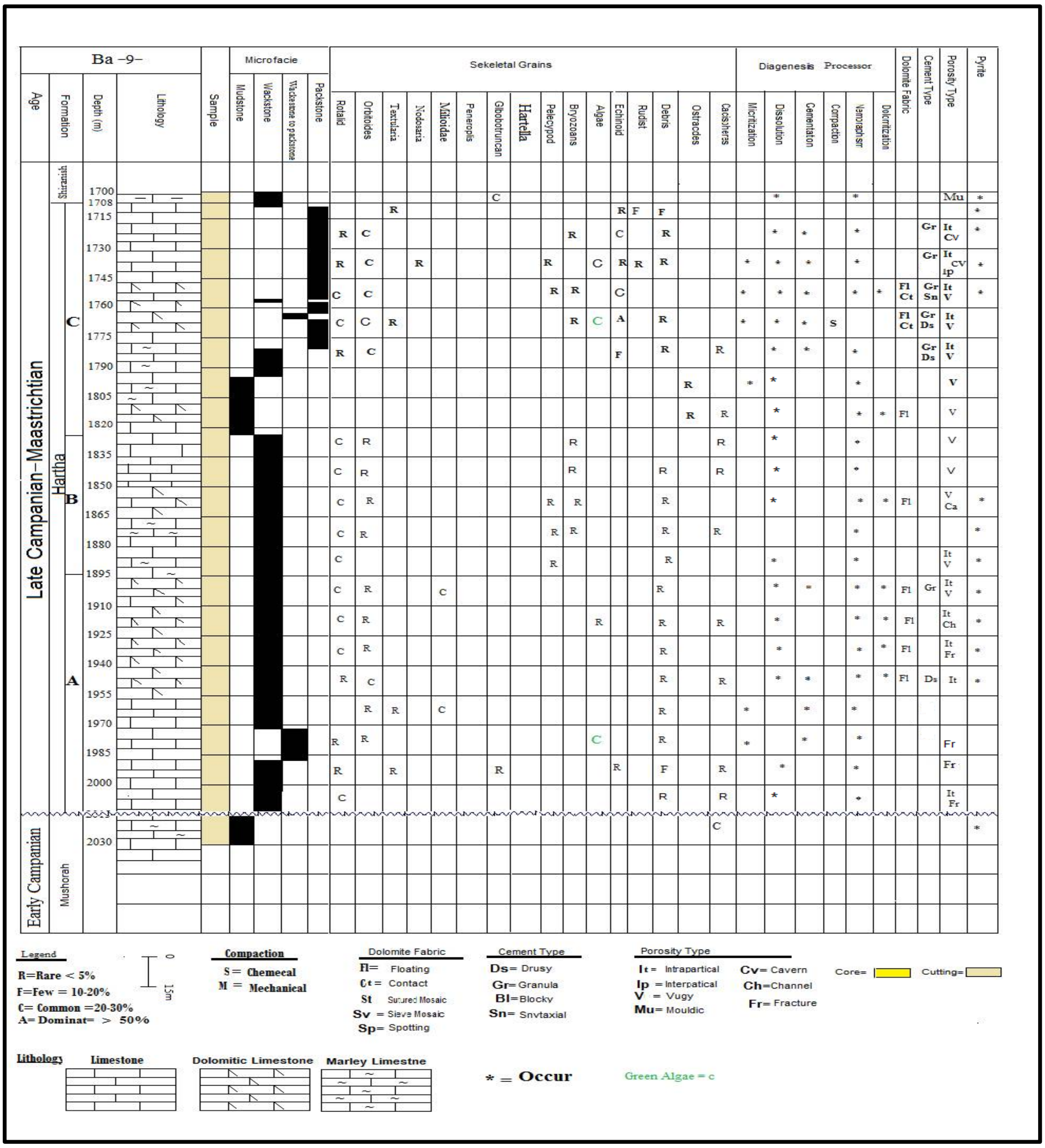

Figure (5) Rock description of the composition of the well Ba-9

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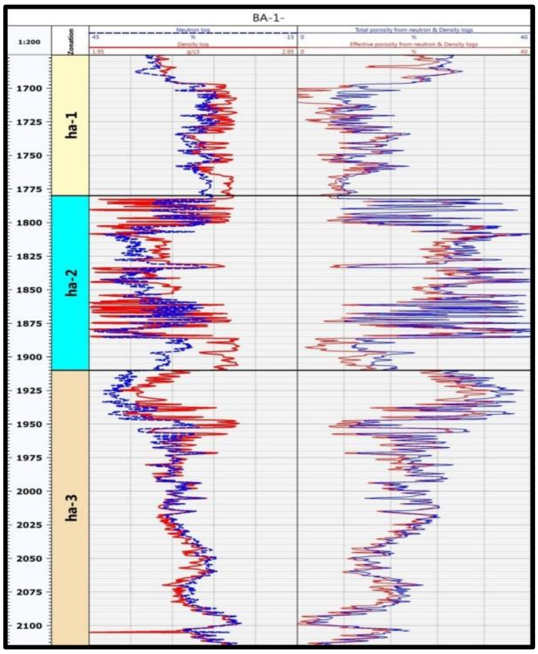

Fig. (6): Porosity Units for Hartha Formation for Ba-1

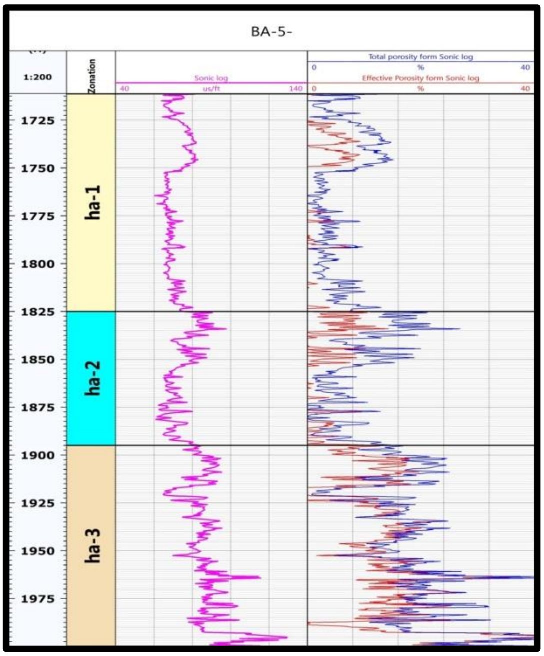

Fig. (7): Porosity Units for Hartha Formation for Ba-5

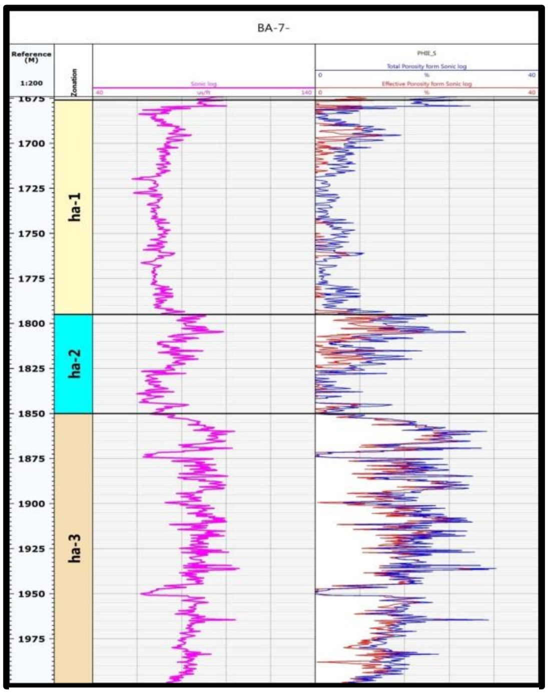

Fig. (8): Porosity Units for Hartha Formation for Ba-7

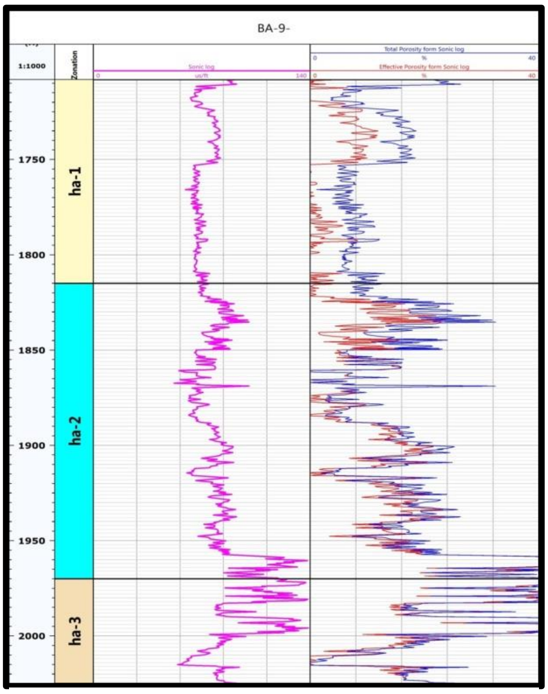

Fig. (9): Porosity Units for Hartha Formation of Ba-9

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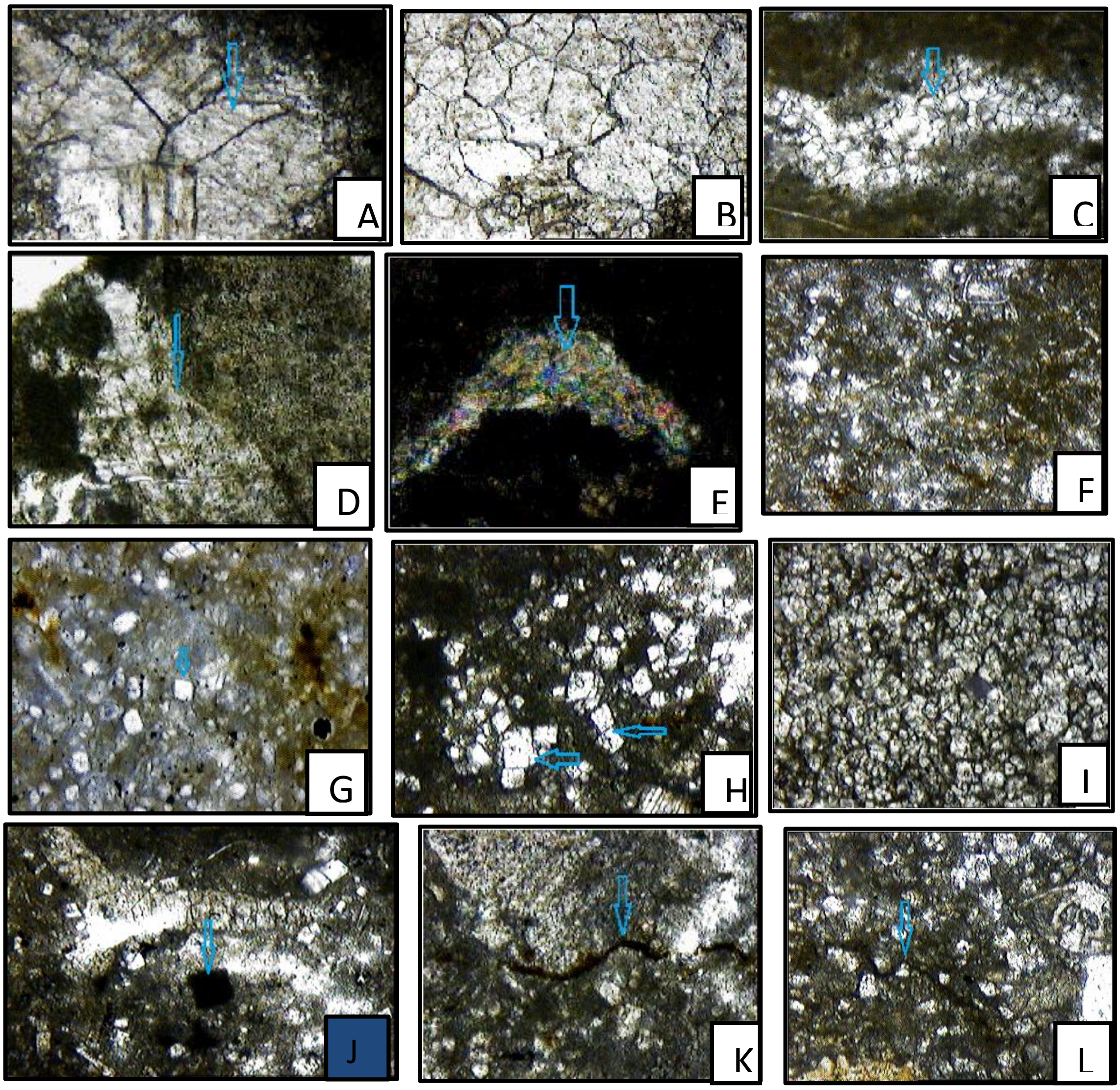

Plate(1)A- Block cement fills the pores of the well (Ba-1 at depth (1687) m with a magnification force of 4 * 10 x. B- Granular cement fills the pores of the well (Ba-7 at depth (1704) m with a magnification force of 4 * 10 x. C- Druze cement fills the pores of the well (Ba-7 at depth (1678) m with a magnification force of 4 * 10 x. D- Cement is visually superimposed fills pores with leather (Ba-5 at depth (1722) m with magnification force of 4 * 10 x. E- Cement anhydrite fills the pores of the well (Ba-5 at depth (1859) m with a magnification force of 4 * 10 x. F- Recrystallization process within the limestone facies well (Ba-1 at depth (1962) with magnification force 4 x 10 x. G- Dolomitization fabric floating within the well limestone (Ba-7 at depth (1842) m with magnification force 4 x 10 x. H- Dolomite contact fabric within the well limestone facies (Ba-9) at depth (1759) m with magnification force 4 x 10 x. I- Dolomite fabric mosaic within the well limestone facies (Ba-9 at depth (1716) m with magnification force 4 x 10 x. J-Athugenic mineral Origin Pyrite Cube within Limestone facies Well Facies (Ba-9 at depth 1755 m magnification force 10*4. K-stylolite of the wavy type observes oil well evidence (Ba-9 at depth (1761) m with magnification force 4 * 10x. L- stylolite of irregular ethnic type notes oil well evidence Ba-9) depth (1755) m with magnification force 4*10x.

A- Block cement fills the pores of the well (Ba-1 at depth (1687) m with a magnification force of 4 * 10 x

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B- Granular cement fills the pores of the well (Ba-7 at depth (1704) m with a magnification force of 4 * 10 x.

C- Druze cement fills the pores of the well (Ba-7 at depth (1678) m with a magnification force of 4 * 10 x

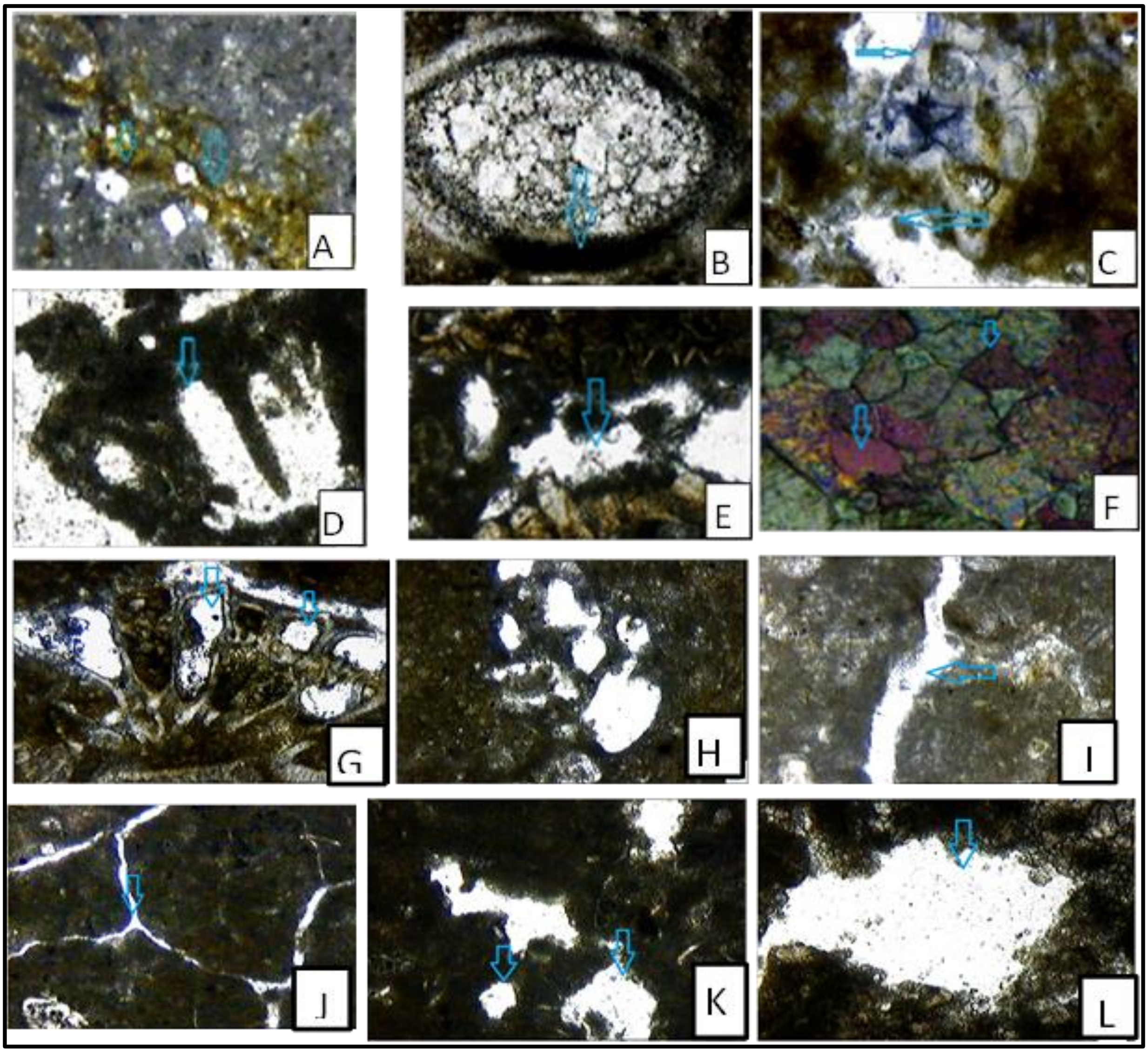

Plate (2) A- stylolite observes oil shown evidence, Ba-1 at depth (1805) m with magnification force 4 * 10x. B-The Micritization process led to the formed of the mecritite cover, Ba-5 at a depth of 1811 m with a magnification force of 4 * 10 x. C- Dissolution process on the matrix and rotalide, Ba-7 at depth 1826 m with magnification force 4 * 10 x. D- Dissolution process on the matrix, Ba-9 at depth 1748 m with magnification force 4 x 10 x. E-porosity interparticale, Ba-5 at depth 1739 m magnification force 4*10 x. F-porosity intercrystals under polarized light. Ba-7at depth 1704 m with magnification force X10 * 4. G-porosity intrapartical, Ba-5 at depth 1907 m, magnification force 10*4. H-Porosity moldic, Ba-7 at depth 1870 m, magnification force 4*10 x. I- Porosity fractures, Ba-1 at depth 1955 m magnification force 4 * 10 x. J-porosity of channels, Ba-7 at depth 1858 m magnification force 4*10 x. K-porosity vugy, Ba-7 at depth 1680 m magnification force 4*10 x. L-Porosity Cavern, Ba-7 at depth 1716 m magnification force 4*10 x.

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