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Sequence Stratigraphy and Reservoir Characterization of the Upper Campanian-Maastrichtian Succession, Buzurgan Field, Southeastern Iraqi

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Abstract

The Upper Campanian-Maastrichtian succession in Buzurgan oil field of Southeastern Iraq consists of Hartha and Shiranish formations. Three facies associations were distinguished in the studied succession. These include shallow open marine environment within the inner ramp, deep outer ramp and basinal environments. The Hartha Formation in the study area was deposited on a shallow carbonate platform with distally steepened ramp setting. The studied succession represents two 3rd order cycles. These cycles are asymmetrical and start with cycle A which is incomplete where the lower part of the Hartha Formation represents the deep outer ramp facies of the transgressive system tract and the upper part of the Hartha Formation reflects deposition within the shallow open marine condition of the highstand systems tract. The overlying Shiranish Formation represents the transgressive system tract of cycle B only where it is basinal extent to Aliji Formation. The lower part of the Hartha Formation characterized mainly by microporosity, whereas the middle and upper part of the formation are less porous with interparticle porosity. This high porosity zone include the lower part of the overlying Shiranish Formation. Where porosity is mainly intraparticle with moldic and fracture porosity being less dominant. The upper part of the Shiranish Formation is less porous.

Keywords: Campanian, Maastrichtian, succession, Buzurgan, Hartha, Shiranish, Aliji, highstand, transgressive.

طباقية التتابع والصفات المكنمية للكامباني الاعلى - الماسترختي في حقل بزركان, جنوب شرق العراق

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الخلاصة:

يتكون تتابع الكامباني الاعلى - الماسترختي في حقل بزركان النفطي جنوب شرق العراق من تكويني الهارثة والشرانش. تم تمييز ثلاث مجاميع للسحنات المجهرية تمثل: البيئة البحرية الضحلة وبيئة المنزلق الخارجية العميقة والبيئة الحوضية. يمثل تكوين الهارثة في منطقة الدراسة ترسيب في بيئة بحرية ضحلة على منزلق بعيد الانحدار. يمثل التتابع قيد الدراسة من دورتين ترسيبتين من الدرجة الثالثة. ظهرت هاتان الدورتان بشكل غير متناظر تبدأ الدورة A والتي تكون غير مكتملة و يكون فيها الجزء الاسفل من تكوين الهارثة يمثل الترسيب في بيئة المصطبة الخارجية العميقة وتمثل نظام التقدم البحري. أما الجزء الأعلى من تكوين الهارثة فيمثل ترسيب بيئة بحرية ضحلة والذي يمثل نظام الترسيب العالي. أما تكوين الشرانش فيمثل فترة ارتفاع مستوى سطح البحر للدورة B حيث تستمر البيئة العميقة الى تكوين العليجي الذي يعلوه. الجزء الاسفل من تكون

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الهائلة يتميز بالمسامية المجهرية، بينما الجزء الاوسط والاعلى يكون اقل مسامية والتي تكون بشكل مسامية بين الحبيبات. نطاق المسامية العالية تميز الجزء الاسفل من تكوين شرانش والتي تكون مسامية داخل هياكل المتحجرات بصورة رئيسية بالاضافة الى مسامية قلبية والشقوق التي تكون اقل شيوعا. الجزء الاعلى من تكوين الشرانش يكون اقل مسامية.

Introduction:

The Upper Campanian –Maastrichtian succession in Southeastern Iraq is represented by the Hartha and Shiranish formations, The Hartha Formation is considered as an important carbonate formation deposited during the Upper Campanian – Maastrichtian. This formation acquires special importance because of its petrographic and petrophysical characteristics that makes it an oil reservoir in some regions. The Shiranish Formation comprises the globigerinal marls and limestone of the Upper Campanian –Maastrichtian transgressive cycle [1].

The study area (The Buzurgan oil Field) is located in Southeastern Iraq figure.1. The structure is composed of two domes runs along a NW-SE direction.

Detailed petrographic study and microfacies analysis were carried out to interpret paleoenvironments and diagenesis through the study of more than 256 thin sections from the selected wells. This was followed by sequence stratigraphic analysis and interpretation of basin development. The impact of diagenetic changes on porosity development was also predicted in order to reveal the effect of sequence development on reservoir characterization.

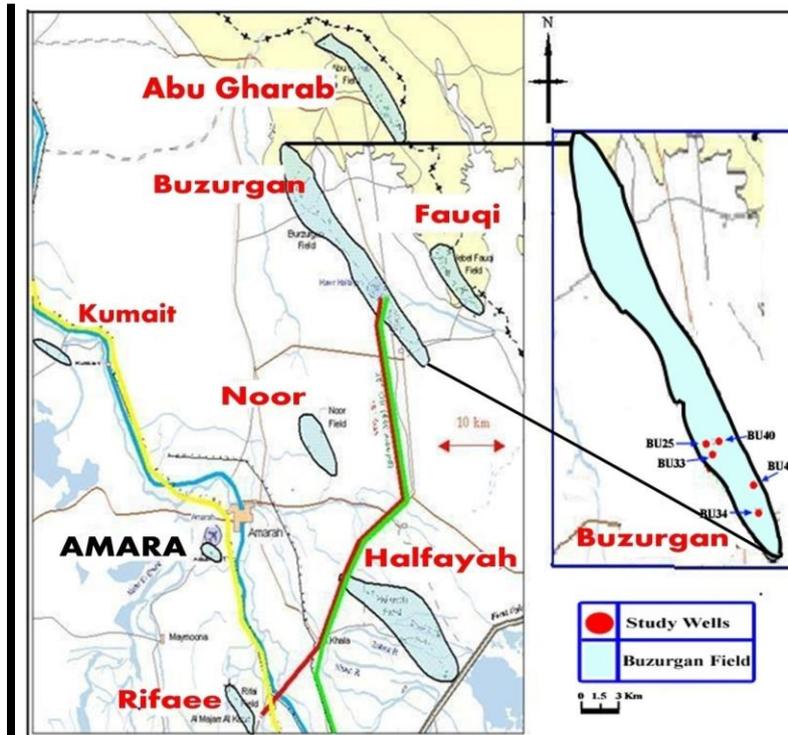


Figure 1- Location map of the study area.

Stratigraphy and Tectonic Setting

The Upper Campanian –Maastrichtian Cycle begins with a widespread transgression that almost covers the whole region figure. 2. This cycle was terminated by another uplift and regression, caused by the paroxysmal phases of the Laramide orogeny around the Cretaceous –Tertiary boundary [2].

The Hartha carbonate shoals were deposited on a carbonate platform bordering the open sea to the East. The Shiranish Formation was deposited in outer shelf to basinal environment.

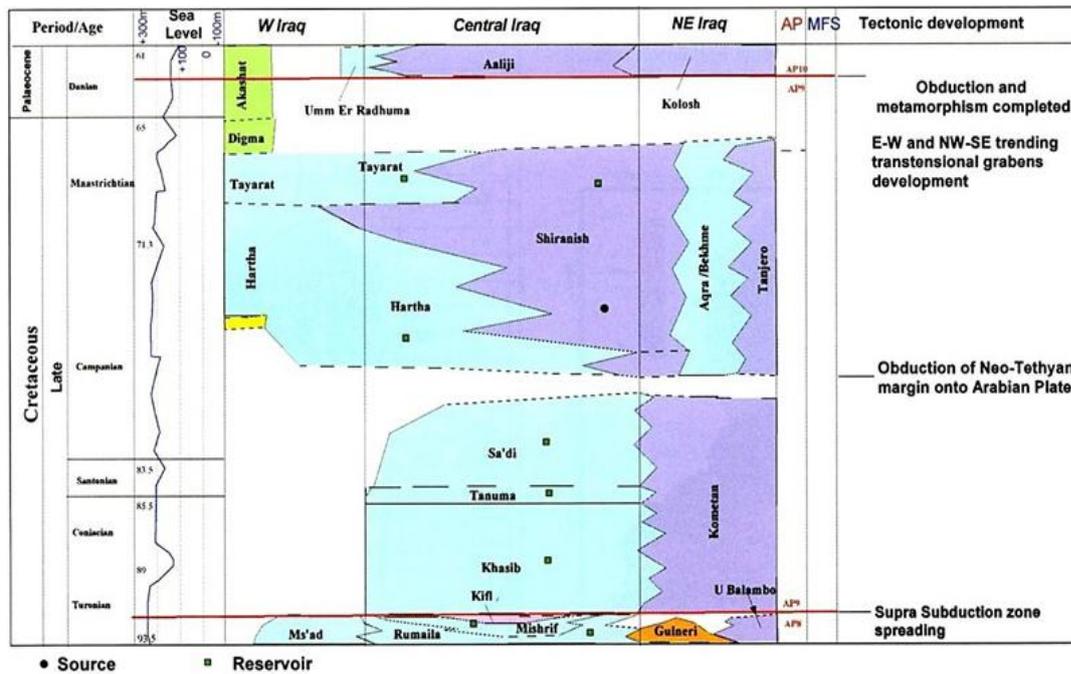


Figure 2- Stratigraphic correlation of the Late Cretaceous [4].

Hartha formation

The Hartha Formation was defined by Rabanit in 1952 from well Zubair-3 in the Mesopotamian Zone of South Iraq [3]. It comprises organic detrital and glauconitic limestones with beds of grey and green shale; the limestones are locally strongly dolomitized. Beds of chalky limestone occur frequently (for example in the following wells: Buzrgan. Ghalalsan, Dujalla, Kifl, Musayab, Siba, Ubaid). Argillaceous limestones occur more frequently in the East parts of the Mesopotamian Zone where the formation passes into the Shiranish Formation (for instance in the Abu Ghirab well)[4].

The Hartha Formation often occurs intertonguing with, or forming single tongues within the Shiranish Formation too. The average thickness of the formation in South Iraq ranges between 200 to 250 m. In North Iraq, thickness is up to (350 m) was recorded [2]. The Hartha Formation was deposited in foreereef to shoal environment. Locally lagoonal and backreef facies around the margins of the Stable shelf.

The Hartha Formation and its facies and age correlatives extend beyond the Iraqi territory. They are widespread in Saudi Arabia, Kuwait and the Syrian territories[2]. The Aruma Formation of Saudia Arabia partly correlates with the Hartha Formation [4]. In northwest Kuwait, the Hartha Formation including the Tayarat facies is recognized. It is correlative with the Bahrah Formation towards the Southeast [3]. Toward the East and Southeast of Iran, the formation has no age and facies equivalents[2]. In Iraq, Shiranish, Tanjero, Agra- Bekhme and Digma formations are the equivalents [5].

The contacts of the Hartha Formation differ from one area to another, in South Iraq, the boundary is conformable and the formation is often overlain by pelagic sediments of the Shiranish Formation (referred to as the Qurna Formation by Owen and Nasr, 1958. Which is assigned to *gansseri* Zone of latest Campanian age[6], and the lower contact is conformable with the Sa'di Formation[2].

Shiranish Formation

The Shiranish Formation was defined by Henson (1940) from the High Folded Zone of N Iraq near the village of Shiranish Islam, Northeastern of Zakho. The Shiranish Formation, in its type area, comprises thin bedded argillaceous limestones (locally dolomitic) overlain by blue pelagic marls [1].

The Shiranish Formation comprises the globigerinal marls and limestone of the Upper Senonian (Upper Campanian –Maastrichtian) transgressive cycle. The upper part of the Shiranish Formation has been proved to contain small oil accumulation in the Baba Dome of Kirkuk field [1].

The Shiranish Formation has few correlatives to the West and Northwest of Iraq. In Southeastern Turkey, the Shiranish Formation is equivalent to the Kermav marls of the Mardin area [2]. Towards, the Southeastern of Iran, the formation is equivalent to the upper part of pelagic Grupi Formation [2].

The Upper Cretaceous Marl Group is equivalent to Tayrat Formation in Kuwait and the upper part of Aruma Formation in Saudi Arabia [4]. The lower part of Shiranish Formation is equivalent to Bahrah Formation in Kuwait, Hadiena Formation in Iraq, the upper part of the Shiranish Formations is equivalent to Tayarat, Hartha, Aqra-Bekhme, Tanjero and Digma formations [5].

The close lithological similarity of the Shiranish and Aaliji formations in this section makes distinction of the formation-boundary difficult in the field. Nevertheless, it is argued that the palaeontological break, the glauconitization and appearance of derived Cretaceous fossils in the basal Palaeocene, and the occurrence of pebbles of sedimented bitumen immediately above the palaeontological break, together constitute demonstration of a significant unconformity [1]. In the present study no evidence of such a break was detected; this may be due to the fact that the study area lies distally basinward where deposition continuous.

Paleoenvironments

The paleoenvironments of the Upper Campanian – Maastrichtian succession was interpreted depending on the type of texture and carbonate grains and considering the standard microfacies classification suggested by [7] with latest version adopted by [8].

Three major environments can be recognized within the studied succession, these include shallow open marine, deep outer ramp and basinal environments figure.3.

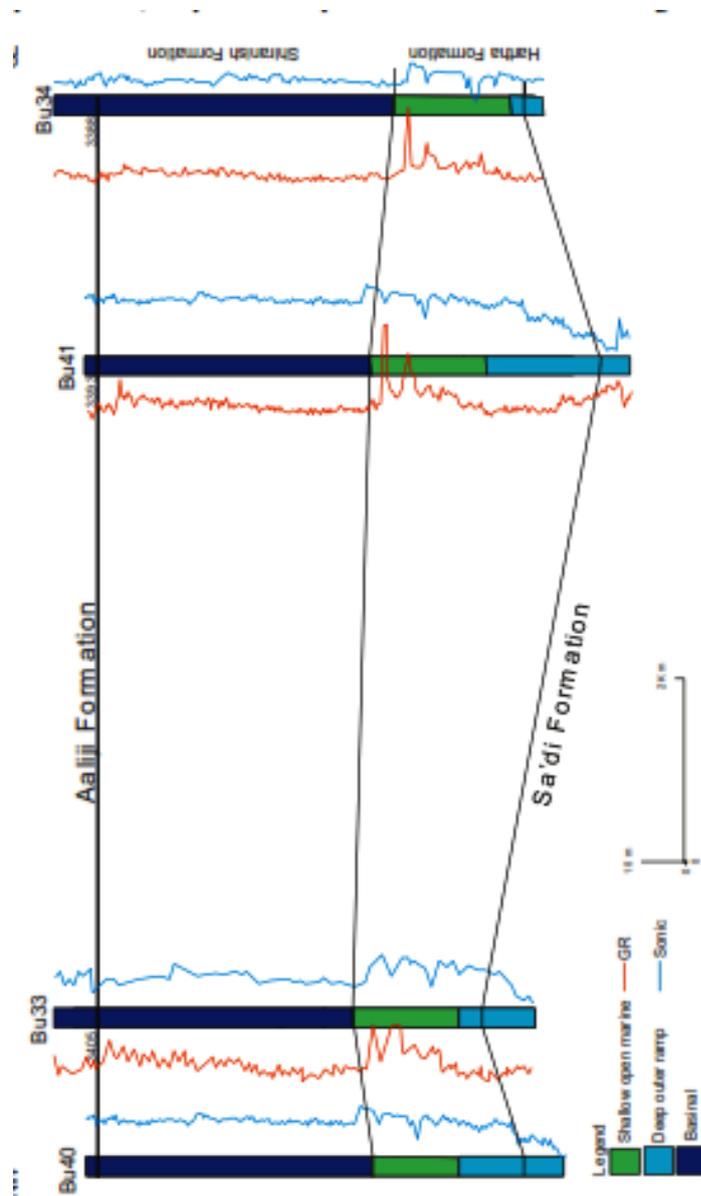


Figure 3-Stratigraphic cross section in the study area

Shallow Open Marine Environment

Four major microfacies characterized the shallow open marine conditions, they include:

Bioclastic wackestone to packstone, Orbitoide bioclastic wackestone to packstone, Echinodermal bioclastic wackestone, Peloidal bioclastic wackestone to packstone.

The **bioclastic wackestone to packstone** is the most dominant in the Hartha Formation at different levels, this microfacies is principally dominated by a specific type of bioclasts of various sizes such as pelecypods, echinoderm plates, calcareous algae association with few peloids, It has been affected by neomorphism, cementation, presence of authigenic iron oxides, glauconite. Stylolitization processes also occur. In addition, the effect of dolomitization occurs at various levels as scattered rhombs of fine to medium size dolomite crystals.

The **Orbitoide bioclastic wackestone to packstone** is the main microfacies in the Hartha Formation, which reflects open marine conditions, *Orbitoides* taxa are semi-sessile benthonic fauna, and they are restricted to shelf environment (0-100m) within the photic zone, where they indicate shallow open marine environment characterized by high diversity of components [8] where *Orbitoides* as the major components in addition to echinoderms, shell fragments, bryozoa, and peloids. Neomorphism and authigenic iron oxides are the main diagenetic features present.

Echinodermal bioclastic wackestone represents the upper part of the Hartha Formation in some wells where echinoderms represent the main skeletal component. Few shell fragments and algae were associated. This microfacies is influenced mainly by cementation (syntaxial cement) and neomorphism.

Peloidal bioclastic wackestone to packstone is less common and characterizes the middle part in some wells where peloids are the main constituents of this microfacies. It is associated with few shell fragments and echinoderms. Neomorphism, iron oxides and authigenic quartz are the main diagenetic features; floating dolomite rhombs are less common.

Deep Outer Ramp Environment

The lower part of the Hartha Formation is characterized by Peloidal planktonic bioclastic wackestone to packstone. This microfacies consists mainly of peloids with small bioclasts of echinoderms and shell fragments, planktonic foraminifera being less abundant. The main diagenetic changes affecting this microfacies are neomorphism. Dolomitization is less common.

Basinal Environment

It is the most common facies in the Shiranish Formation and represented by planktonic mudstone, planktonic mudstone to wackestone, planktonic wackestone, planktonic wackestone to packstone, and planktonic packstone. These microfacies are characterized by the dominance of planktonic foraminifera, with very few benthonic foraminifera, ostracoda and small shell fragment. Argillaceous mudstone to wackstone can be observed in some wells. The main diagenetic processes affecting these microfacies are neomorphism, Other common diagenetic changes include compaction, dissolution, cementation, and dolomitization that occurs as floating subhedral to euhedral medium size scattered rhombs.

Depositional Setting

Generally, facies distribution of the Hartha Formation in the study area represents deposition on a shallow carbonate ramp setting. A carbonate ramp is a gently sloping surface with generally less than one degree, on which high-energy shoreline environment passes gradually into deeper water with no detectable change in slope [9].

Two categories of ramp can be distinguished; homoclinal ramp where slopes are relatively uniform and distally-steepened ramp where there is an increase in gradient in the outer, deep ramp region [10, 11].

Distally steepened ramp can be subdivided into inner, mid, and outer ramp [10]. The inner ramp is the zone above the fair-weather wave base where the wave and current activity are almost continuous [12]. The mid-ramp zone lies between the fair-weather wave base and the storm wave base where the sea floor is affected by storm waves but not by fair-weather waves. According to that, sediments show evidence of the frequent storm reworking. The outer ramp zone extends from below the normal wave base to the basin floor. Carbonate ramps are common on passive (extensional) continental margins and in epicontinental seas [13].

The studied succession of the Hartha Formation has some certain facies characters which may indicate the distally-steepened ramp setting, These are:

- 1- Gentle slopes on which updip near shore shallow water deposits (packstone) pass gradually downslope without marked break into progressively deeper water and low energy deposits and finally into basinal sediments.
- 2- Continuous carbonate production takes place in shallow inner ramp settings; this may be reflected by a keep up carbonate sequence, which is characterized by grain- rich, mud-poor texture.
- 3- Shallow water sediments are transported into deeper water ramp parts. This was reflected by the presence of small bioclastic and peloid within the deep facies.

Sequence Development

The subdivision of the Upper Campanian - Maastrichtian succession into cycle was based on the scale of [14] figure. 4. The development of the studied succession depended on the rate of relative sea level rise and subsidence. Accordingly two asymmetrical 3rd order cycles were recognized figure.5, these cycles are characterized by a facies stacking pattern showing mud-poor-grain-rich texture that indicate keep up carbonate succession. This may indicate that the relative sea level rise kept pace with the rate of carbonate production. Cycle A, which is incomplete where the underlying Sa'di Formation represented the deep outer ramp facies of the transgressive system tract that continuous with the lower part of the Hartha Formation figure.5. The upper part of the Hartha Formation reflects deposition within the shallow open marine condition of the high systems tract.

The overlying Shiranish Formation represents the transgressive system tract of cycle B only where it is the basinal extent to the Aliji Formation.

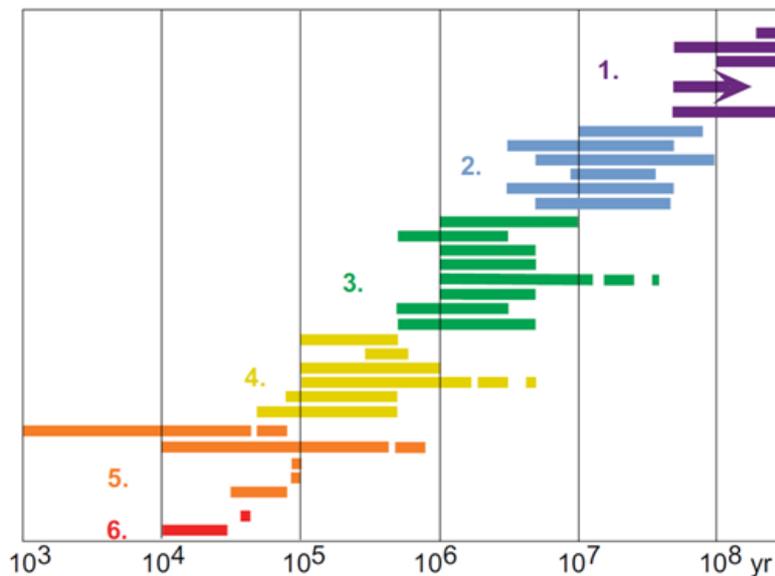


Figure 4- Order of stratigraphic sequence. In each category, the oldest publication is on top. Differences are about 1/2 order at each boundary in the 4th -6th orders are even larger; opinions do not seem to converge with time [14].

Reservoir Characterization

The study of porosity microporosity and using the a variable well logs (SWE-CPX(V/V),US/F and CPX-MD) reveal the effect of eustatic control on diagenesis and its effect on the distribution of porosity and cementation. The lower part of the Hartha Formation by dominated microporosity, this can be attributed to meteoric lens basinward shift during the sea level stillstand, whereas the middle and upper part of the Formation is less porous with interparticle porosity due to the landward shift of the meteoric lens during the next transgressive at the beginning of cycle B. The lower part of the Shiranish Formation represents a relatively high porosity zone, where porosity is mainly intraparticle with moldic and fracture porosity being less dominate. The upper part of the Shiranish Formation is less porous due to the effect of cementation where cementation destroyed the porosity produce by the meteoric lens basinward shifting due to the following sea level stillstand.

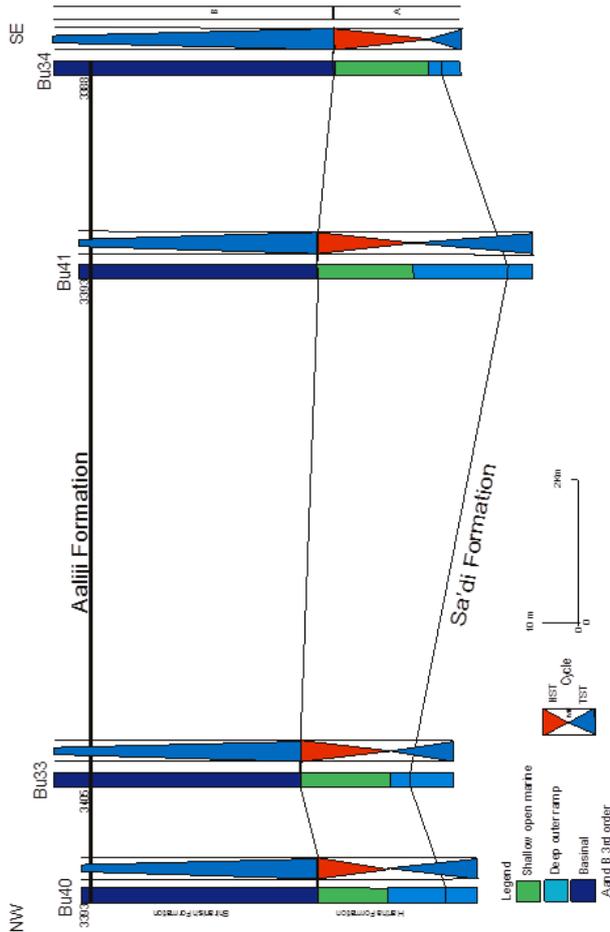


Figure 5-Sequence stratigraphic subdivision at the studied succession

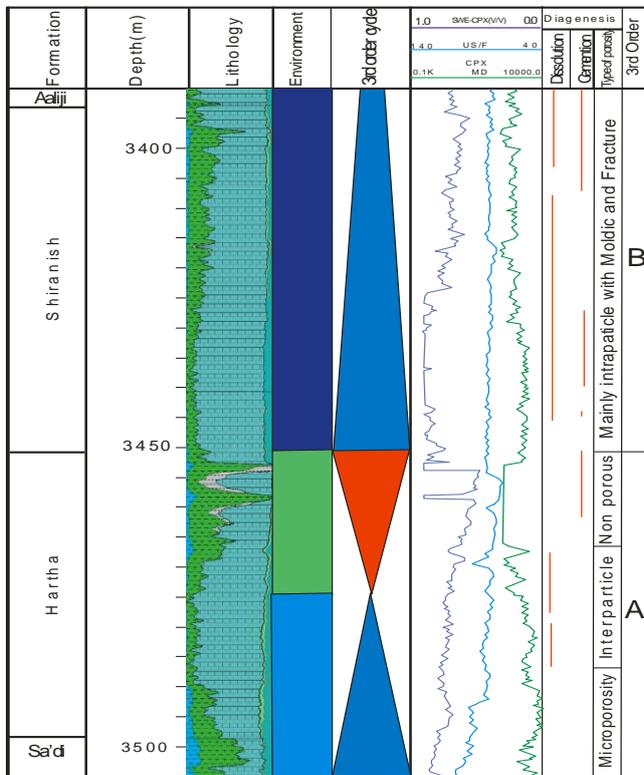


Figure 6- Sequence stratigraphic subdivision of the studied succession showing the porosity type of BU41.

Conclusions

Petrographic study and microfacies analysis of the Upper Campanian –Maastrichtian succession in Buzurgan field enable the recognition of three main paleoenvironments. These are: shallow open marine, deep outer ramp and basinal environments. The shallow open marine environment within the upper part of the Hartha Formation, it is characterized by bioclastic wackestone to packstone, Orbitoide bioclastic wackestone to packstone, echinoderm bioclastic wackestone , peloidal bioclastic wackestone to packstone. The deep outer ramp environment is represented by the lower part of the Hartha Formation which is characterized by peloidal planktonic foraminifera bioclastic wackestone to packstone. The basinal environment is represented by the most common facies in the Shiranish Formation and characterized by planktonic mudstone, planktonic mudstone to wackestone, planktonic wackestone, planktonic wackestone to packstone and planktonic packstone. Argillaceous mudstone to wackstone can be observed at certain intervals within the Shiranish Formation.

Facies association and distribution of the Hartha Formation in the study area may represent deposition on a distally steepened ramp setting.

The studied succession represents two 3rd order cycles. These cycles are asymmetrical and start with cycle A which is incomplete where the underlying Sa'di Formation represents the deep outer ramp facies of the transgressive system tract that continuous through the lower part of the Hartha Formation. The upper part of the Hartha Formation reflects deposition within the shallow open marine condition of the highstand systems tract. The overlying Shiranish Formation represents the transgressive system tract of cycle B only where it is basinal extent to Aliji Formation. The succession as a whole is characterized by mud-poor, grain-rich texture reflecting keep up carbonate sequence.

The study of porosity microporosity and using the a variable well logs (SWE-CPX(V/V),US/F and CPX-MD) reveal the effect of eustatic control on diagenesis and its effect on the distribution of porosity and cementation. The lower part of the Hartha Formation by dominated microporosity, this can be attributed to meteoric lens basinward shift during the sea level stillstand, whereas the middle and upper part of the Formation is less porous with interparticle porosity due to the landward shift of the meteoric lens during the next transgressive at the beginning of cycle B. The lower part of the Shiranish Formation represents a relatively high porosity zone. The upper part of the Shiranish Formation is less porous due to the effect of cementation.

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