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Facies Analysis and Geological modeling of Euphrates Formation in Ajeel Oil Field, Northern Iraq

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Abstract

The current study summarized the construction of a three-dimensional geological model of the Aquitanian sediments age, which represented by the Euphrates and Serikagni formation in Ajeel Oil Field, where Ajeel Oil Field has structural closure towards northwest - southeast. Sedimentary of the current study consist of limestone, dolomitic limestone, dolomite (compose of skeletal grains, non-skeletal grains and cement) and the appearance of some anhydrite rocks.

The petrographic study of the Euphrates Formation were prepared using a thin section of wells (Aj-1, Aj-4, Aj-5, Aj-6 and Aj-7), Previous studies and geological reports, as well as use well logs data in the statistical analysis by Petrel software using the Neural Network and Train Estimation Model, for divide sedimentary environments of Euphrates Formation. The petrographic analysis showed mudstone, wackstone, packstone and grainstone facies. The sedimentary environment was then determined and the sedimentary model of the current study rocks in the Ajeel field which compared with Wilson scheme where represented by zones (FZ-6, FZ-8, FZ-7) extend through lagoon environment, back shelf and open shelf, through the sedimentary model was determined the type of Euphrates Formation platform(Rimmed Platform).

Keywords: Facies Analysis, Geological modeling, Euphrates Formation, Ajeel oil Field

التحليل السحني والموديل الجيولوجي لتكوين الفرات في حقل عجيل النفطي، شمال العراق

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قسم الجيولوجي، كلية العلوم، جامعة بغداد، بغداد، العراق

الخلاصة

تلخصت الدراسة الحالية ببناء موديل جيولوجي مكمني ثلاثي الابعاد لرسوبيات عمر (Aquitanian) والمتمثل بتكوينات (الفرات، السيريكاكني والذيبان) في حقل عجيل النفطي، ويمثل حقل عجيل انغلاق تركيبي باتجاه شمال غرب ــ جنوب شرق. تتألف الدورة الرسوبية من الحجر الجيري (الحبيبات الهيكلية والحبيبات غير الهيكلية) والحجر الجيري الدولومايتي والدولومايت وظهور بعض صخور الانهيدرايت.

من خلال الدراسة البتروغرافية (Petrography) لدورة رسوبيات العمر اعلاه وللابار (Aj-1, Aj-4, Aj-5, Aj-6, and Aj-7)، اظهر التحليل السحني ان التتابع الطباقي لتكوين الفرات يتالف من (سحنة الحجر الجيري الطيني ، سحنة الحجر الجيري الواكي ، سحنة الحجر الجيري المرصوص وسحنة الحجر الجيري الحبيبي)،اما تكوين السيريكاكني فيتالف من الحجر الطيني.

من خلال الدراسة البتروغرافية، الدراسات السابقة، التقارير الجيولوجية ومعلومات مجسات الابار تم اجراء تحليل احصائي ضمن برنامج (Petrel) باستخدام تطبيق (Neural Network and Train Estimation Model) امكن تقسيم البيئات الرسوبية لتكوين الفرات الى ثلاث بيئات (الضحضاحية، المنحدر والمستنقع، اما تكوين السيريكاكني فانه يمثل رسوبيات مركز الحوض الرسوبي، والمكافئ الحوضي العميق لتكوين الفرات.

تم اعداد موديل جيولوجي لرسوبيات العمر (Aquitanian) في حقل عجيل ومقارنتها بتقسيمات (Wilson schame) للبيئات الرسوبية حيث تمثلت بالانطقة السحنية (FZ-9, FZ-8,FZ-7 and FZ-6)، ومن خلال بناء الموديل الرسوبي بين نوع منصة تكوين الفرات بـ (Rimmed Platform).

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1. Introduction

The Euphrates Formation is one of major reservoir interval in Ajeel oil field where it is, for the most part, a dolomite reservoir with limestone only marl preserved at the base of the formation (Serikagni Formation).The type locality is located in Wadi Fuhaimi in Anah through within the Stable Shelf [1]. The Euphrates and the underlying Serikagni formations belong to a single generic stratigraphic unit that together represents the transgressive and high stand system tracts of a major depositional sequence. Fossils from the base of the Euphrates and Serikagni indicate a very latest Oligocene (late Chattian) age for the base of the unit and a Miocene (Aquitanian) age for the top of the Euphrates Formation. It represents the progradation of a shallow-water carbonate platform, with shelf morphology, across the location of Ajeel [2].The age of the Euphrates Formation is late Early Miocene (Burdigalian), proved by the presence of *Miogypsina globulina* and *Miogypsina intermedia* [3]. *Miogypsina globulina* appears to be restricted to the Early Miocene (early-mid Burdigalian); M. *intermedia* to the Early- Mid Miocene (Burdigalian-early Langlhan). [2] argued that only *pre-Orbulina* beds are present (pre-Middle Miocene).

The formation usually unconformable overlies Oligocene and Eocene formations. In the type area the basal beds of the formation comprise conglomerates and residual clays which infill an uneven surface at the top of the Oligocene Anah Formation. In areas where, the underlying unit is the Serikagni Formation, the lower boundary is conformable [4]. The upper boundary at the type locality is not exposed. The investigations of GEOSURV revealed that the upper members of the formation are overlain by a brecciated or conglomeratic horizon above which the *Orbulina* with the index fossil *Borelis melo eurdiea* of the Middle Miocene Jeribe Formation limestones occurs [4].

The Ajeel Anticline is located approximately 30 km to the northeast of Tikrit city and it lies just to the southwest of the Hamrin Anticline Figure -1(A), which is a major surface feature. In contrast to Hamrin, Ajeel has no surface expression and the structure is entirely confined to the subsurface.

The aims of present study are petrographic and microfacies analysis of Euphrates Formation and to identify the main depositional environment and geological modeling.

Ajeel Anticline consists of unsymmetrical subsurface anticline in southwest Hamrin Anticline. The first well was drilled in 1977 in the crest and gas appears in Tertiary formations at a depth (834 m) (Final geological report of Ajeel-1 [5].Fifteen wells are selected from Ajeel Field to use in this study (Aj-1, Aj-4, Aj-5, Aj-6, and Aj-7) and the structure contour map of Euphrates Formation in Ajeel Oil Field shows in Figure-1(B).

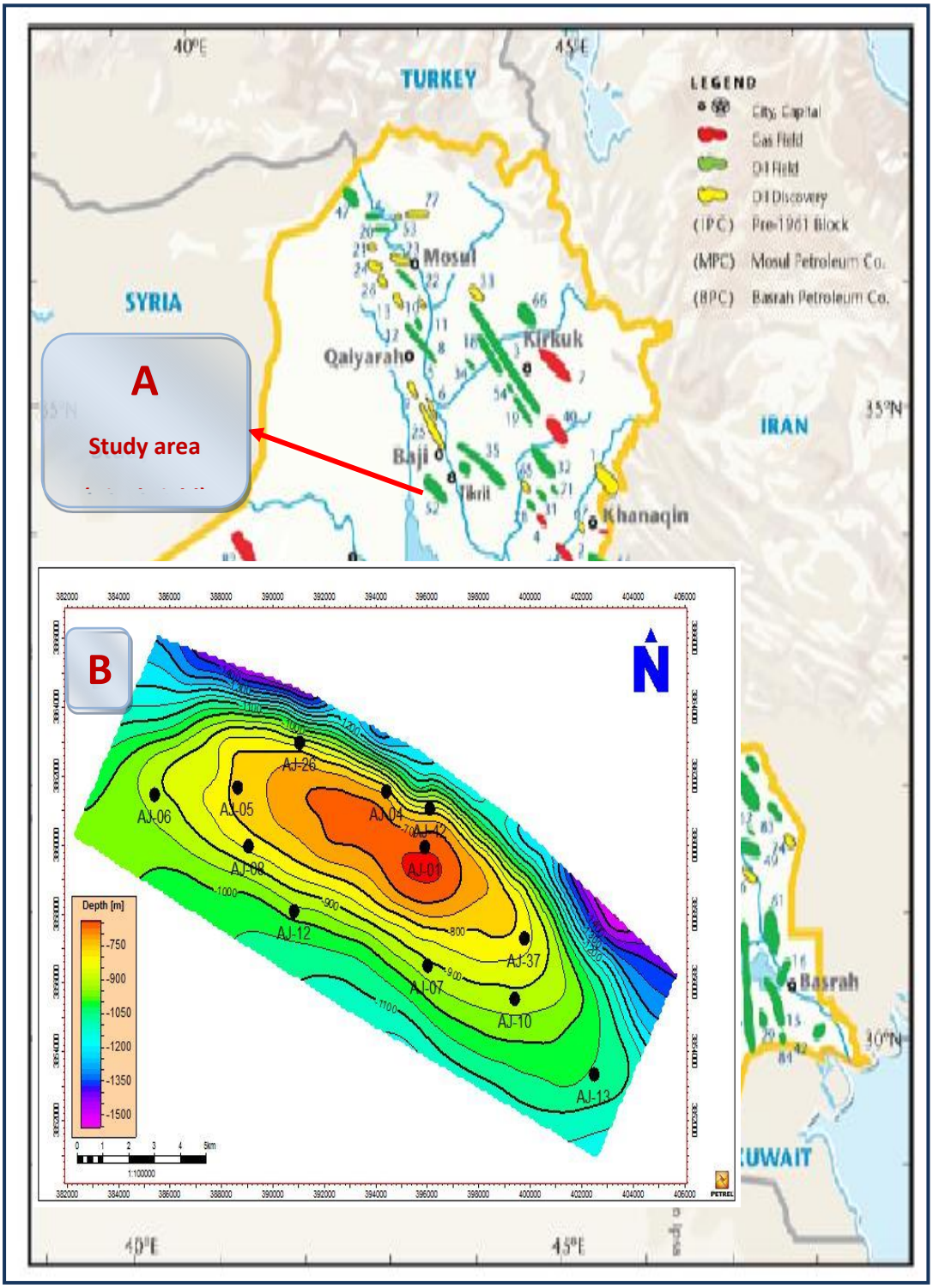


Figure 1-Iraq map shows location of the study area (www.tradearabia.com/OGN) with structure contour map of Euphrates Formation in Ajeel Oil Field [5]

2. Tectonic sitting:

The study area (Ajeel field) is located north of Tikrit Governorate in north of Iraq, which represents the north and north-eastern part of the Arabian plate which is adjacent the two blocks from the north are the Turkish block (Bitlis block) and from the east the Central Iranian block (Figure-2), and the relationship between the Arabian Plate and two blocks played a major role in the design of the Tectonic Sitting during geological history [6].

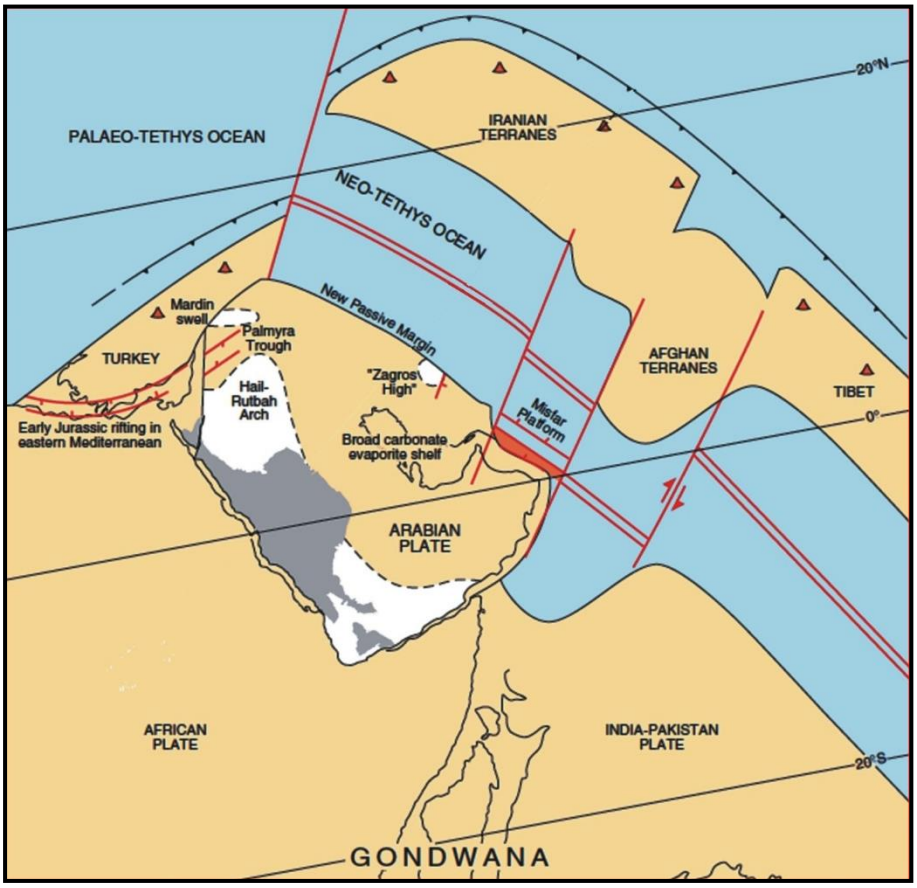


Figure 2-the separation between Arabian plates and the Iranian plates and creation of the Neo-Tethys Ocean {6}

Murris (1980) [7] mention the basic tectonic phases of the Arabian plate into three stages:
The first stage is the tectonic quiescence period that followed the Hercynian Orogeny in Latest Paleozoic, when the Iranian and Turkish plates moved away from the Arabian plate, led to an encounter the Neo-Tethys. The second stage is extended from the middle to the end of the Cretaceous (Maestrichtian), is described as a transitional phase representing the transition from the extensional system to the Tectonic Compressional System because of the convergence between the Arabian plate and adjacent plates (Iranian and Turkish plates formed together the Eurasia Plate).This resulted in convergence subduction of oceanic crust of the Arabian plate below the Iranian plate. The third tectonic stage extends during the Tertiary period is represented compressional tectonic system which contributed to the closure of the Neo-Tethys and created a narrow seaway connecting the Indian Ocean to the south and the Mediterranean Sea Zagrose foreland basin (Figure- 3) [8].Continued convergent between the plates leading to the closure of the Tethyan seaway as a result of the collision between the Arabian Plate and Eurasian Plate. This is called the Terminal Tethyan Event [9].

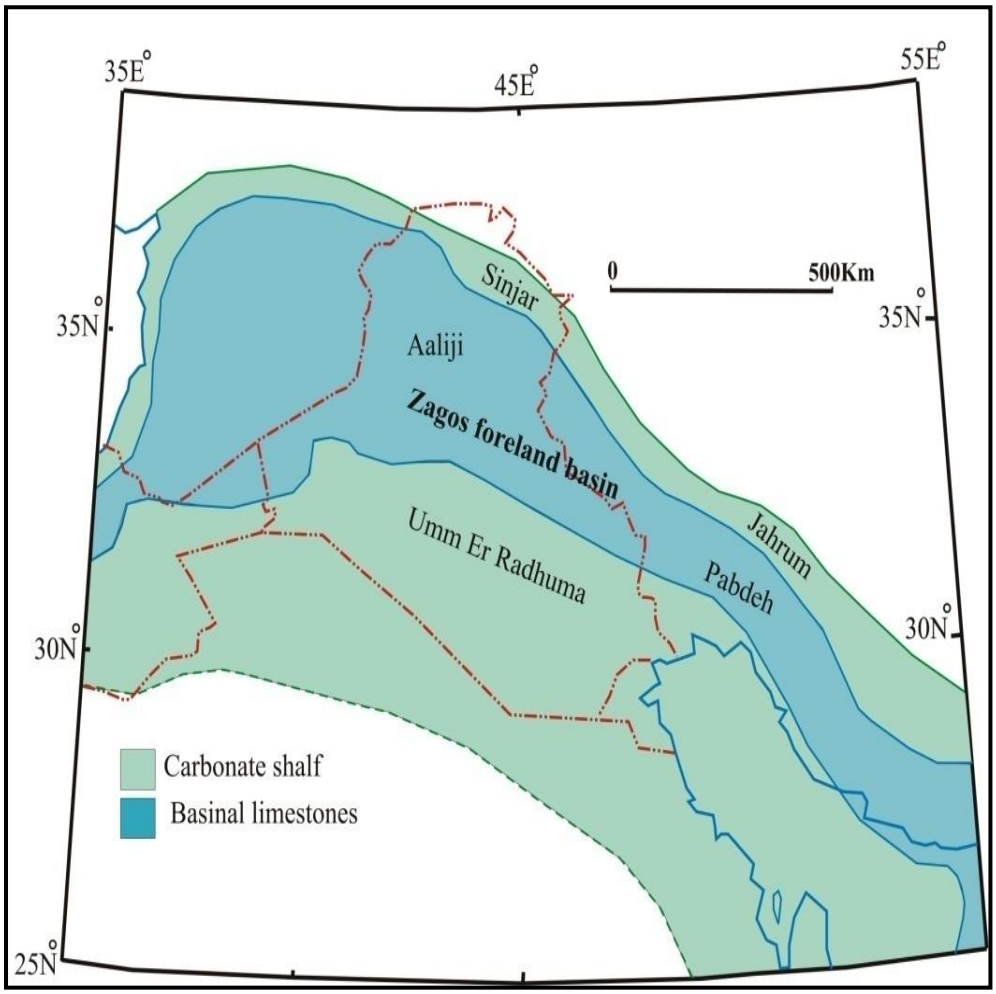


Figure 3-Transformation of the Neo-Tethys into a seaway linking the Mediterranean Sea in the north and the Indian Ocean in the south, which defines the Zagros Foreland Basin, which Sediments age (Paleocene -Early Eocene) [9].

Euphrates Carbonate Microfacies and Depositional Environment interpretation

Euphrates facies association in vertical and lateral sequence is a way to find the depositional environment. The study of microfacies and depositional environment study of Euphrates Formation have been carried out depending on thin section and previous studies (sedimentological and geological) and well logs data to cover the depositional environment of Euphrates Formation in Ajeel oil field. therefore, firstly describe facies association then depending at well logs data by using neural network in petrel software as well as the result used to establish depositional environment diagrams.

Facies Association:

Four facies association were recognized in the Euphrates succession. These facies include basin (related Serikagni Formation), slope, shelf margin and lagoon facies associations depending on petrographic study and rocks contain from skeletal and non-skeletal grains.

1. A-Bioclast Mudstone Microfacies:

Micrite is the major element of these facies, while the percentage of skeletal grains is 10% according to Dunham (1962) [10]. These are founded in the upper part of the Euphrates Formation and appear in all the wells, (P.1-A) which, composed of micrite a less of fossils then (10%) miliolids and remains of mollusca (P.1-C). these facies are presented in the Haypersaline tidal and restricted bays and ponds in the restricted Platform (SMF-19 & SMF-23, FZ-8 & FZ-9) [11].

1. B-Bioclast Wackestone Microfacies:

There are shown in the upper parts of the Euphrates Formation in the most study wells. These are characterized by containing of the following fossils: (miliolids, mollusca and Peneroplis). The most important diagensis processes are affected on these facies is recrystallization, dolomitization and

dissolution. According to [11] this facies located in the shelf lagoonal and upper slope environments (SMF-19, FZ-8) (P.1-F)**.**

C-Bioclast Packstone Microfacies:

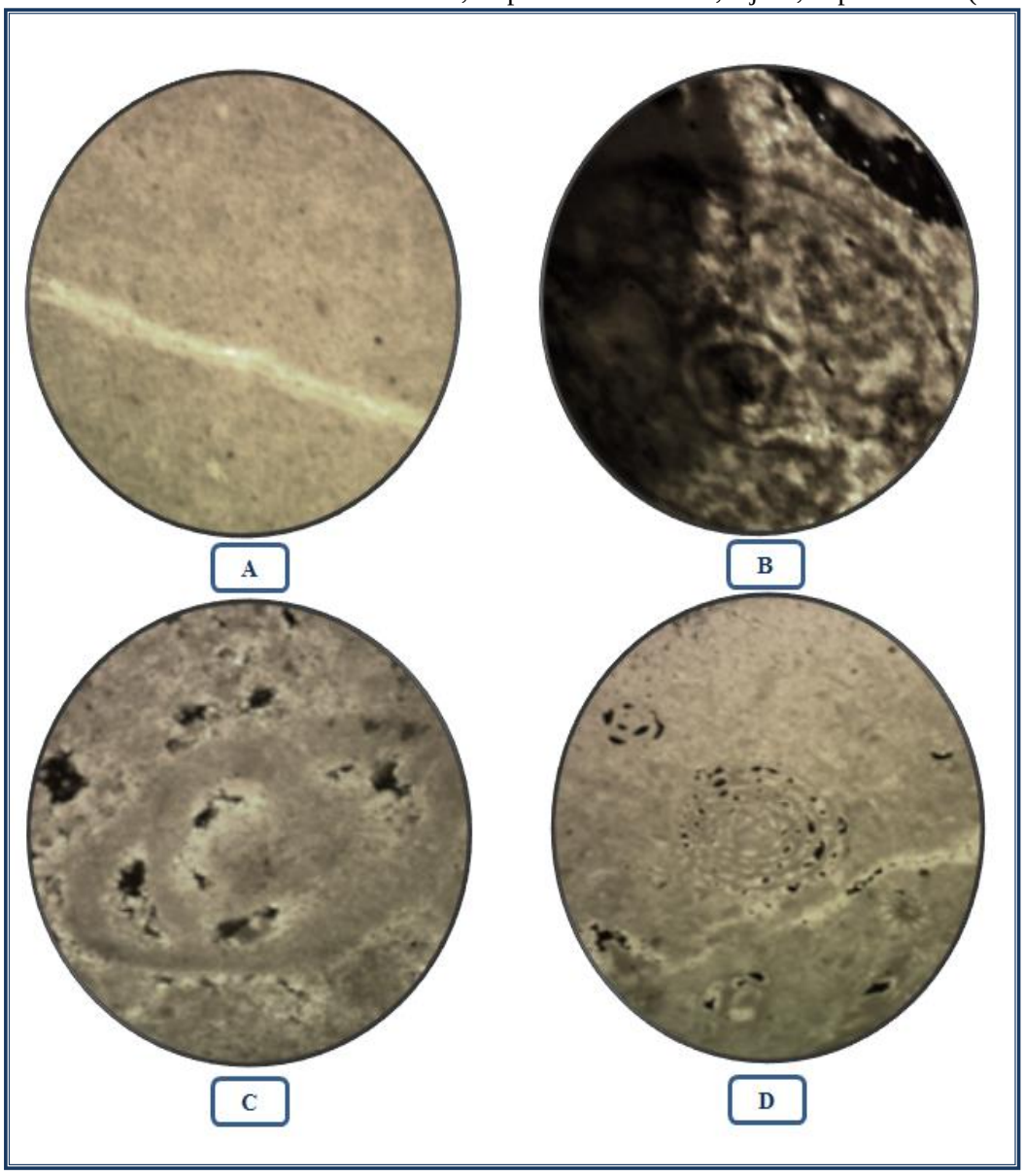
These are consisting of skeletal or non-skeletal Bioclast about 90% in the texture. Euphrates Formation composed of benthic deposits with miliolids and Peneroplis, there are also secondary ratios of Pelecypoda and Gastropoda, as well as Ostracoda and algae (p.2-A). The most important diagensis processes affecting are cementation, recrystallization as well as dolomitization (P. 2- B, C). This facies similar to Shallow Subtidal Ramp according to their biological content (SMF-16, FZ-7) [11].

1. D-Bioclast Grainstone Microfacies:

This facies is characterized with high ratio more than 90% of skeletal and non-skeletal grains (Dunham, 1962) [10]. These are located in the middle part of the Euphrates Formation and main components of peloids which sizes between (0.1-0.6 mm) as well as contain fossils (miliolids, Peneroplis and Gastropoda) (P.2-F).The diagensis processes are affected on this facies is recrystallization, cementation and dissolution .This facies association with Inner Ramp (SMF- 15, FZ-6) [11].

Plate 1

A: Facies Mudstone without fossil, Euphrates Formation, Aj-13, depth 1243m (X10).
B: Facies Mudstone contain fossil of Gastropoda, Aj-3, depth 925m(X10).
C: Facies Wackstone was affected with dissolution, Aj-13, depth 1247m (X10).
D: Facies wackstone with benthic foraminifera, Euphrates Formation, Aj-13, depth 1251m (X10).



Well logs indicator and depositional environment:

Data well logs are principal indicator to subsurface geology. They provided significant information on texture, minerals composition, sedimentological and petrophysical characterization by collecting data from different well logs to distinguish sedimentary environment with comparable log properties. The sedimentary environment that is defined on this way and properties from wire line logs are known as Electrofacies [12].

The current study predicate depositional facies and environment which made from facies modeling using logs response (GR, DT, ROHB, NPHI and RESISTIVITY LOGS) and use neural network in (petrel software) to define facies of Euphrates Formation.

Firstly, facies of depositional study from logs included test the response of curves for indication of the type facies deposition.

Depend on the study thin sections can be recognized four main microfacies for Euphrates Formation, these microfacies are: mudstone, wackestone, Packstone and grainstone, which consist of four depositional environments basin (related Serikagni Formation which take from previous study) slop, shelf margin and lagoon, the latest three type environments carried out by use neural network in petrel software.

Neural Network and Train Estimation Model:

Artificial neural networks are computer algorithms inspired by the way biological neural networks, such as the brain, process information. They typically consist of simple processing units that are wired together in a complex communication network. Artificial neural networks can be roughly categorized into two types: supervised and unsupervised [13].

Train estimation model process gives you access to neural network methods. Based on the input data you provide, this process computes an estimation model that will respond in a similar way when presented with similar input data. If use training unsupervised neural networks in this case, we supply input data and the number of classes that the input data should be subdivided into. The train estimation model process will then makes a model that divides the input data into separate classes; while the training supervised neural networks we must provide training data as input-output pairs. The train estimation model process uses the data pairs to make a model that estimates the correct output data when presented with the given input data. The idea is that the same model can then be applied to similar input data to compute reasonable output [13]. Therefore in this study take thin section and full set of logs of Ajeel wells and previous study and use train supervised estimation model to describe the depositional model of Euphrates Formation. Neural network to calculate estimation environment model take code1with Lagoon, code 2 with shelf margin, code 3 with slope and code 4 with basin Figures-(2, 3, 4, 5, 6, 7 and 8).

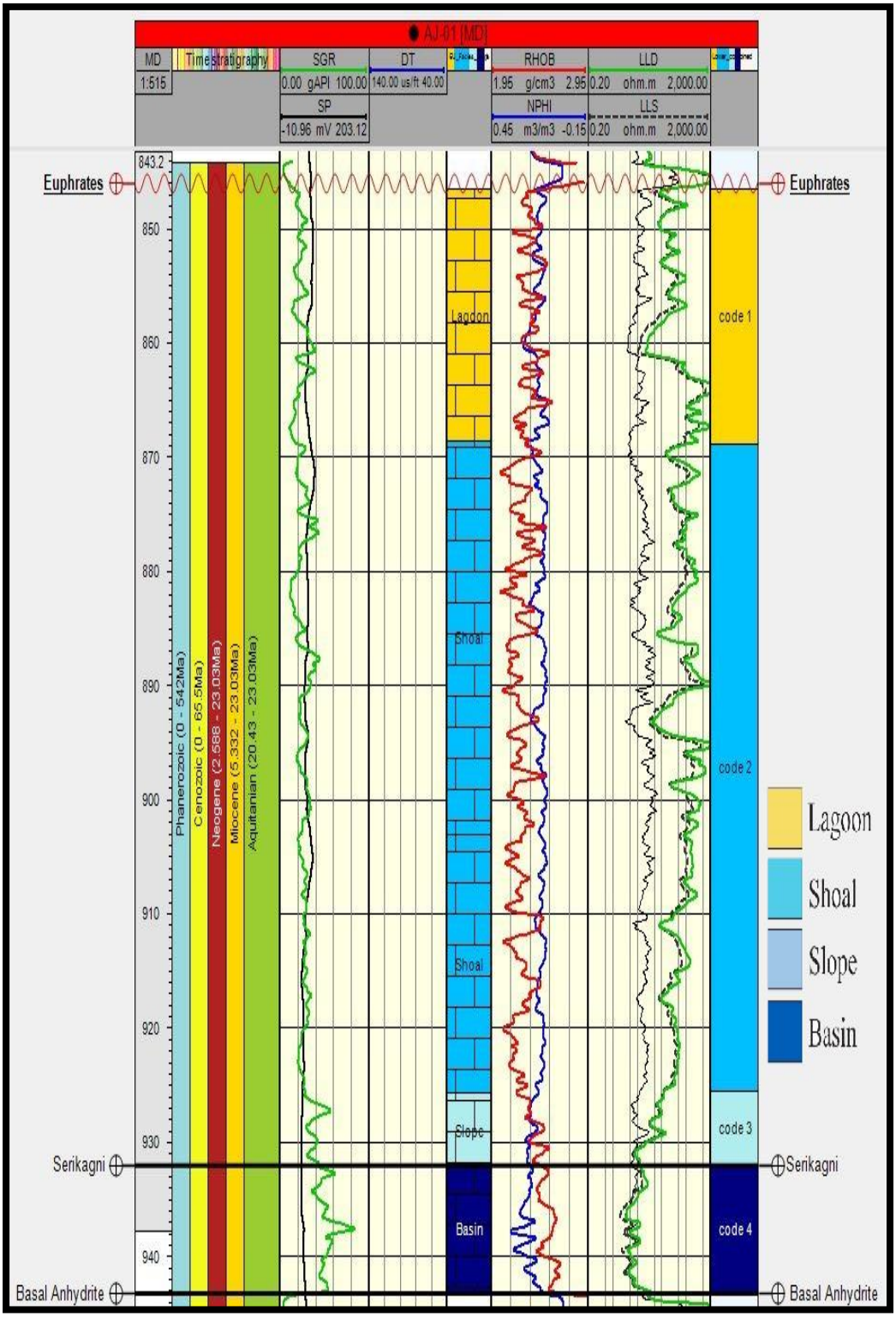


Figure 4-Stratigraphic Column of the Euphrates Formation at Aj-1showing codes neural network with environments

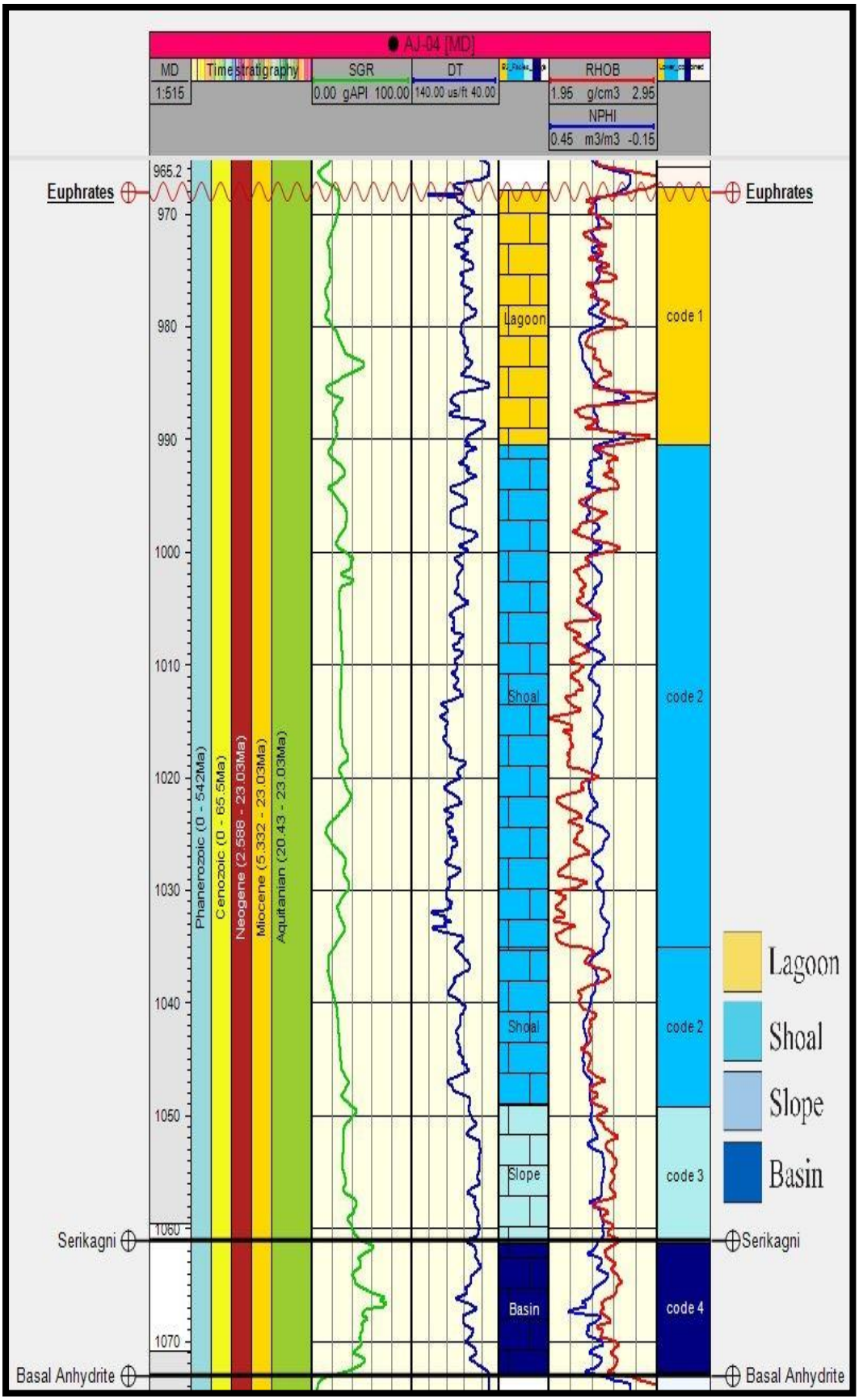


Figure 5-Stratigraphic Column of the Euphrates Formation at Aj-4 showing codes neural network with environments

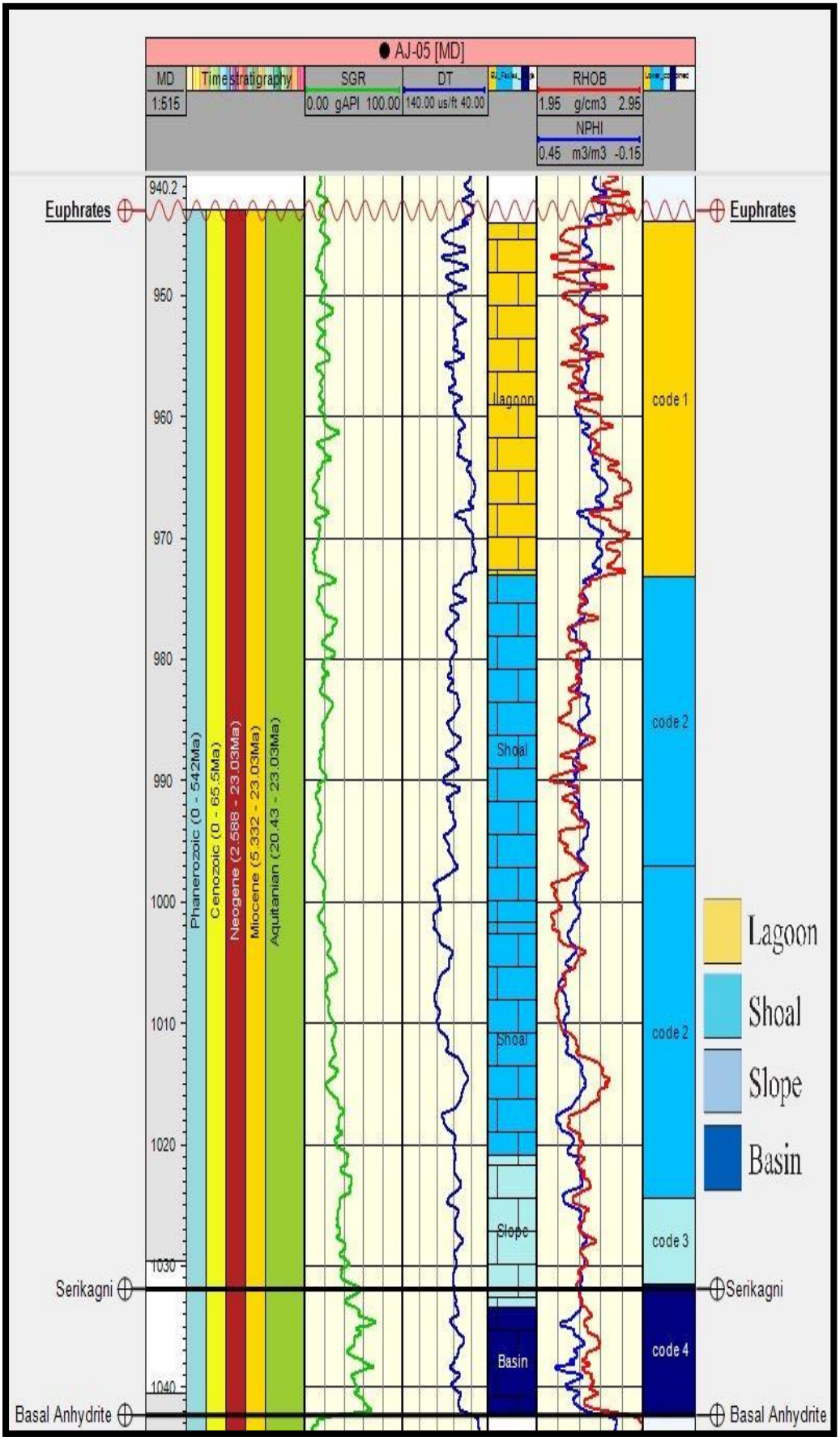


Figure 6-Stratigraphic Column of the Euphrates Formation at Aj-5 showing codes neural network with environments

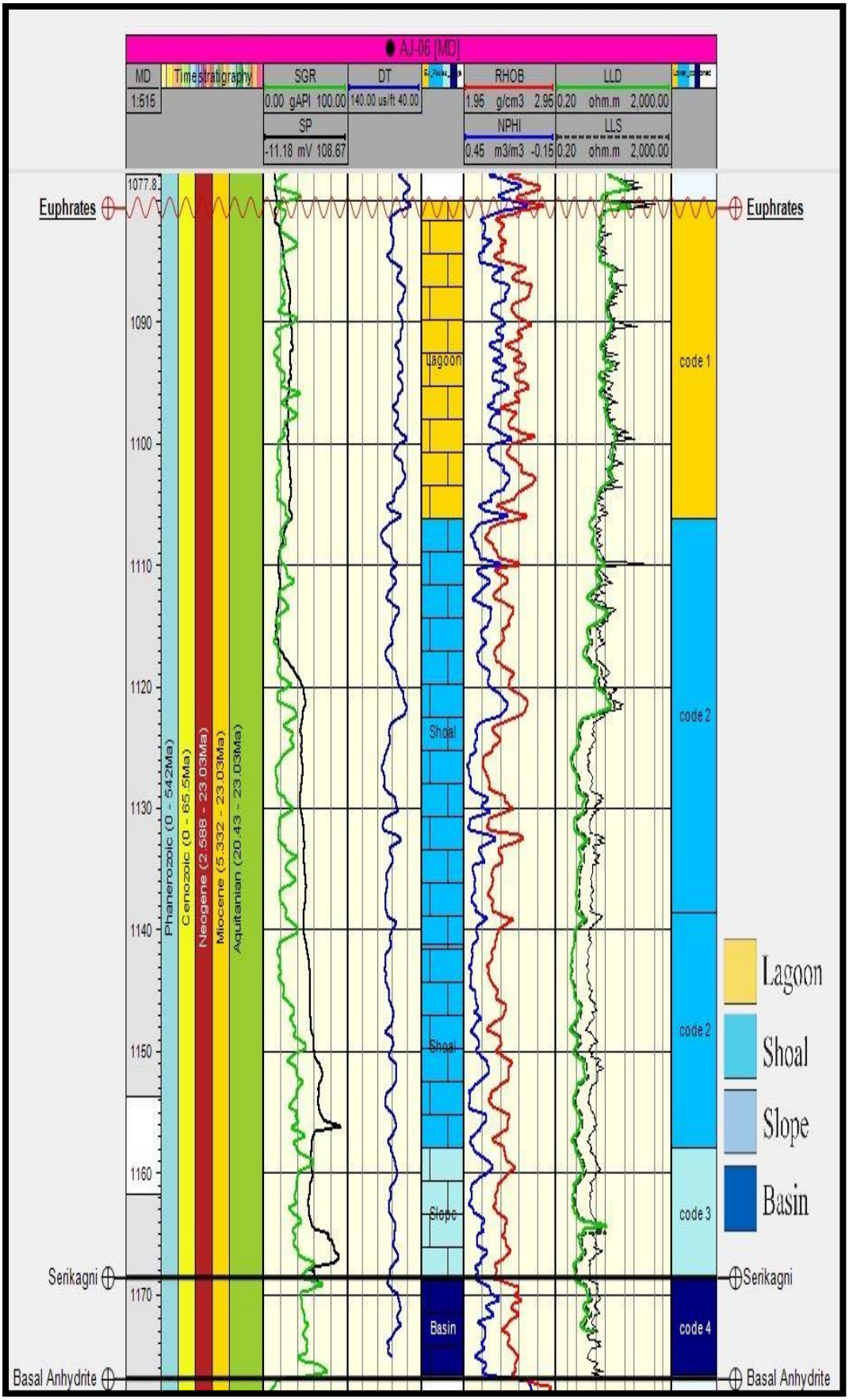


Figure 7-Stratigraphic Column of the Euphrates Formation at Aj-6 showing codes neural network with environments

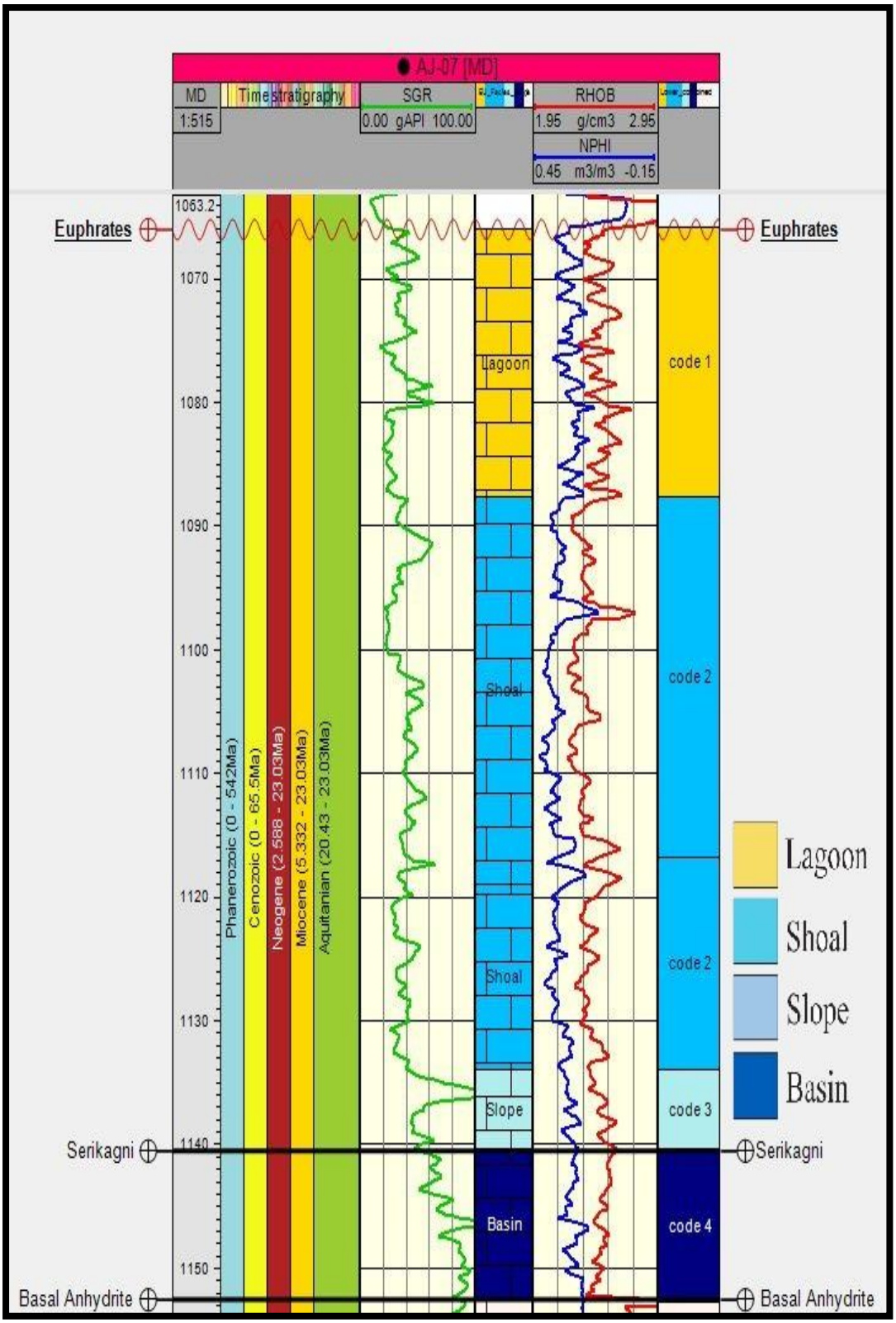


Figure 8-Stratigraphic Column of the Euphrates Formation at Aj-7 showing codes neural network with environments

Discussion and Conclusions

The results of the petrographic study, previous study and well logs response with a description of the most important microfacies and compare with the (SMF) stander microfacies of Wilson, 1975; It can be distinguished the sedimentary environments of the Euphrates Formation in the current study wells. Several studies have examined the sedimentary environments of the Euphrates Formation, most

of which have been reported to be deposited in shallow marine environments and lagoonal environments[1] mention to the Euphrates Formation was deposited in shallow marine environments isolated by an organic barrier.

The current study shows the sedimentary environments of the Euphrates formation extend from the shelf environment through the appearance of the grainstone (SMF-15 and FZ-6) to the lagoonal restricted environments by the appearance of mudstone and wackstone. Lagoon sedimentary environment is part deposition of the Euphrates Formation through of large-sized miliolids found. Brasier, 1975[14]; mention to the high diversity and found species of this family is indicative of the open lagoonal environment and shallow environment in the tropics, and shallow waters. The existence of benthic fossils which indicate to located in the shallow environments.

In addition to absence some of facies in this succession and the appearance small-sized miliolid (Dwarf) in the well (AJ-6). The model of the Euphrates Formation represents Rimmed Platform Environment as [15] Figures-(9 & 10).

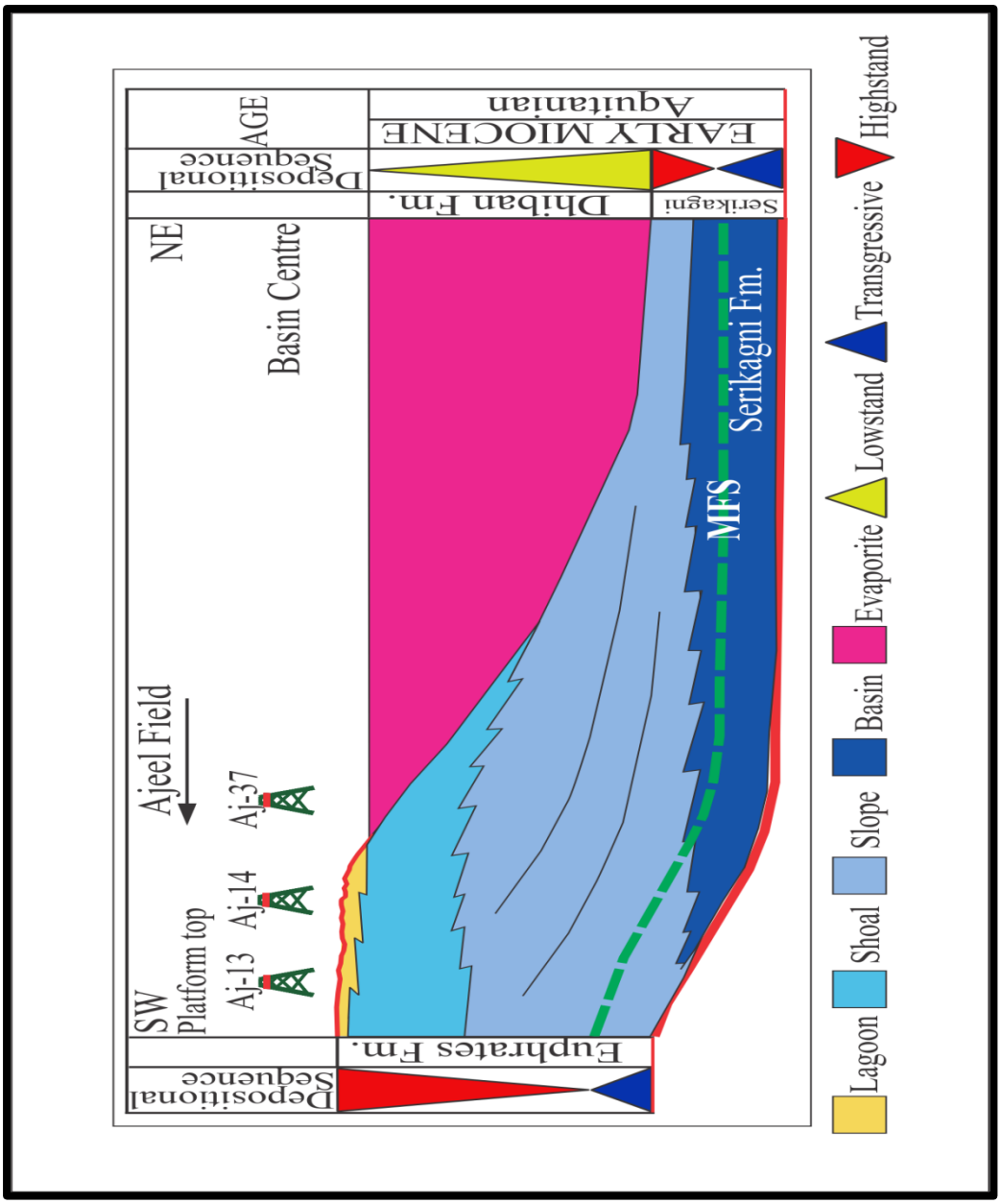


Figure 9-Lithostratigraphic interpretation of the principle Euphrates Reservoir, Ajeel is developed higher on the Euphrates carbonate platform and has a much thinner interval of Dhiban evaporites.

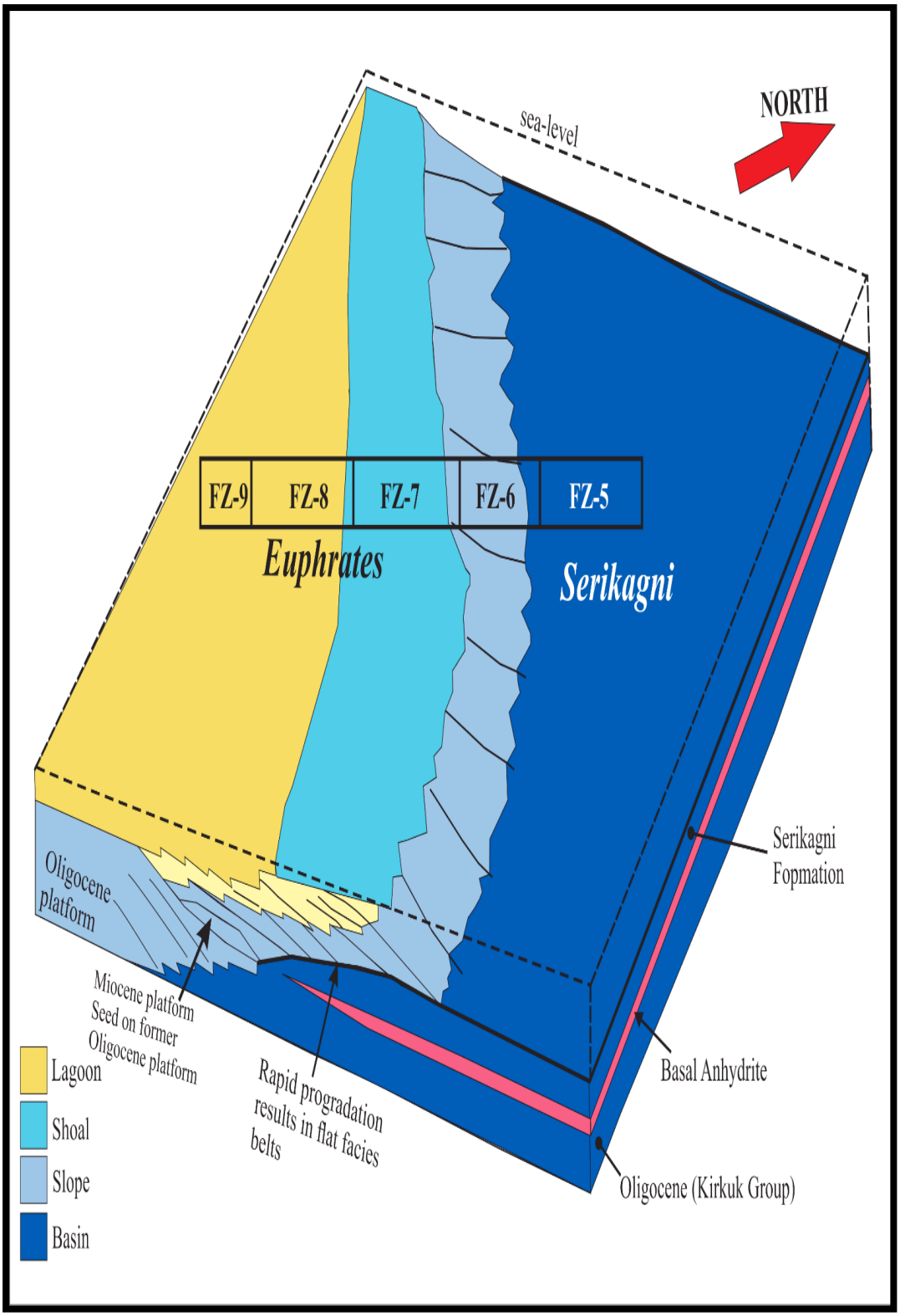


Figure 10-Serikagni - Euphrates depositional setting. Sketch illustrating how the carbonate platform represented by the succession of carbonates that comprise them interval prograded across Ajeel

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