

Depositional setting of the Jaddala Formation at Kirkuk and Bai Hassan Fields, Kirkuk Area

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Abstract

The Jaddala Formation in Bai Hassan and Kirkuk oil fields was deposited on a carbonate platform with an open shelf setting. Microfacies analysis revealed that deposition took place within three zones; they include the Toe of slope, Deep shelf, and Deep basin. The succession consists of four third order cycles representing successive intervals of relative sea level rises and stillstand. The nature of cycle symmetry and thicknesses suggest that the tectonic component is the main controlling factor on cycle development in highly subsiding basin.

Key words: Depositional setting, Jaddala Formation, Kirkuk area.

الخلاصة

يمثل تكوين الجدالة في حقول كركوك وبيي حسن ترسيب على مصطبة جيرية على شكل رف مفتوح. أظهر تحليل السحنات المجهرية أن الترسيب كان ضمن ثلاثة مناطق وهي: الرف العميق وأسفل المنحدر والحوض العميق. يتكون الجدالة من أربع دورات ترسيبيه ذات الرتبة الثالثة، وتمثل هذه الدورات تعاقب فترات لارتفاع مستوي سطح البحر وثباته. يمكن الاستنتاج من طبيعة التماثل وسمك هذه الدورات بأن التأثير التكتوني هو العامل الرئيسي المسؤول عن تطور هذه الدورات في حوض ذو معدل تجلس عال.

الكلمات المفتاحية: مصطبة جيرية سحنات مجهرية، تكوين جدالة.

1. Introduction

The Jaddala Formation (Eocene) is a widespread formation in Iraq, it extends into the Mesopotamian zone, foothill zone and into the northern and western parts of the stable shelf area (Jassim and Karim, 1984). Bellen *et. al.* (1959) considered this formation is of Mid-Late Eocene age. However, the formation may be partly of latest Early Eocene age on the basis presence of *Globorotalia aragonensis*, the index fossil of the Early Eocene (Ponikarov *et. al.*, 1967). The Jaddala Formation and its equivalents of northern Arabia as well as in Iran (Dammam and Pabdeh respectively) represent AP10 2nd order sequence . (Sharland *et. al.* 2001).

The Middle-Late Eocene sequence was deposited to the SW of an emergent uplift during the endgame interval of subduction and closure of the remnant Neo-Tethys Ocean. The Jaddala was deposited within an open marine basin in many areas of Iraq (Jezira subzone and Rutba basin where nummulitic shoals formed westward).The Jaddala Formation was first referred by Henson (1940) in Bellen *et. al.* (1959) the type locality lies near Jaddala village at Sinjar area, Northwest Iraq (Buday, 1980). The Jaddala Formation consist in the type section of 342 meters of marly limestones and marls and intertonguing with the Avanah Formation. In the Late Eocene, the Pila Spi-shelf facies latterly change to Avanah-Jaddala Formations (Ameen Lawa and Ghafur, 2015). The recognizable facies in Jaddala Formations deposits reflect the deep marine environments without benthonic foraminifera in contrast with the high percentage of planktonic foraminifera, which refers to deep marine environment (Al-Banna *et. al.*, 2015). The Sinjar Formation underlies the Jaddala is unconformable (marked by concentration of glauconite in the type locality),

and the upper contact with the Serikagni Formation and the Palani Formation is unconformable (Al Mutwali and Al Banna, 2002; Al Juboury, 2011).

A detailed petrographic study, microfacies analysis, and study of the available well log (Gamma ray) and relating the log response to facies are carried out for the studied sections. In Kirkuk and Bai Hassan, oil fields in Kirkuk area (Fig.1; Table.1).

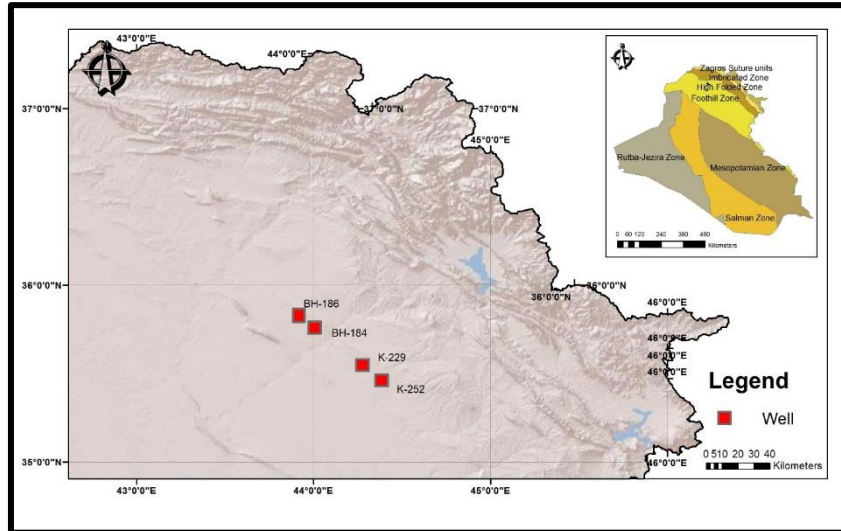


Fig. 1: Location map of the study area after (Jassim and Goff, 2006).

The study of these wells revealed detailed information about the different aspects of petrography, depositional environment, and the sequence of developments of the formation. Generally, at the study area the Jaddala Formation lithology consists of alternation of grayish brown limestone, chalky, marly limestone and argillaceous limestone with some glauconite and pyrite. The formation shows variations in thickness from well to another in the studied area. The Aaliji Formation underlies the formation is unconformable. This contact is characterized by the presence of glauconite, pyrite, and dissolution as well as the Gamma ray increase. These characters are also present at the unconformable contact between the Jaddala and Palani Formations.

Table (1): Geographic coordinates and thickness of the Jaddala formations at the study area.

Well No.	Top (M)	Bottom (M)	Thickness (M)	Longitude	Latitude
BH-186	1157	1261	104	E 35° 50' 54"	N 43° 53' 48"
BH-184	1190	1304	114	E 35° 46' 58"	N 43° 59' 55"
K-252	573	674	101	E 35° 28' 25"	N 44° 22' 38"
K-229	524	668	144	E 35° 33' 25"	N 44° 16' 13"

2. Methodology

Three hundred and twelve samples were carefully selected from the studied sections based on sample condition and the location. 94 thin sections were used for microscopic study and the staining carbonate minerals were made for numerous thin sections with Alizarin Red Solution to recognize calcite and dolomite.

The study of vertical changes and lateral distribution of the successions, and sequence stratigraphic framework was made by interpolating between wells Sequence boundaries, maximum flooding. Various scales of sequences or parasequence were picked on logged well sections (Gamma ray and Sonic Logs).

3. Microfacies

The depositional texture and types of carbonate grains are handled within a detailed petrographic study. An extended Dunham classification (Dunham 1962) was used for describing the carbonate rock classification; four carbonate microfacies are recognized within the studied sections. These are:

3.1. Planktonic Foraminiferal Mudstone (PFM).

The Main skeletal components of the planktonic mudstone include Globigerinid and *Globigerapsis kugleri* in Globorotalid and *Rotalia viennoti*, rare calcispheres and sponge spicules (plate1A). The diagenetic features common in this microfacies are compaction, micritization, and cementation including cement filled fractures and geopital structures. It has low intraparticles porosity. The planktonic foraminiferal mudstone is found in the lower part of all sections. It belongs to the standard microfacies (SMF3) in (FZ1) and it represents the basinal environment as compared with the standard microfacies types of Wilson (1975).

3.2. Bioclastic planktonic wackestone (BPW).

The Jaddala Formation is characterized by the dominance of bioclastic planktonic wackestones. The main components of this microfacies are *Morozovella* and *Globigerina* (Plate 1B). Few benthos and rare radiolarian were also noticed. The diagenetic processes affecting these microfacies are mainly cementation, compaction dissolution, and dolomitization. The bioclastic planktonic wackestone microfacies is similar to the standard microfacies (SMF2) of (FZ-1) and characterizing the basinal environment as in Wilson (1975).

3.3. Planktonic Foraminiferal Wackestone (PFW).

Planktic foraminifera represents the main components. These components are of small size and these have a low diversity in some intervals through the sections. Benthonic foraminifera appears with low density represented by *Eponides*, *Uvigerina*, *Nodosaria* and *Lenticulina*. Micrite matrix and microspare cement filled the foraminifer's chambers. Depending on the observation of benthic foraminifera and its percentage with planktic forams indicates that the microfacies deposited in outer shelf to upper parts of the upper bathyal environments ranges in depth between 100m and 300m (Berggren and Miller, 1989). The planktons of this microfacies include *Globigerina*, *Globorotalia* and *Chillo gumbilina* Sp., *Hantkenina*, and *Ammodiscus* (plate-1C) and rare sponge spicules. It may indicate a low energy environment below the wave base (Flugel, 2004). The effective diagenetic features include compaction (Deformation of plankton shells), micritization, and cementation (filling fractures). Authigenic minerals such as glauconite and pyrite are identified within the upper part of the Jaddala, they may reflect the unconformable boundary with the overlying Palani Formation. Low percentage of Intraparticle and micro porosities are recorded. These microfacies reflect deposition within the deep shelf (SMF-8 of FZ.2).

3.4. Bioclastic Foraminiferal wackestone (BFW).

The main components in this case are benthos such as *Nodosaria*, *Rotalina* and *textularia*. Planktons are represented *Globigerina*, *Morozovella*. Echinodermata fragments, bioclasts, and red algae as also present (plate-1D).

All are rooted in micrite cement and patchy altered in spary calcite cement. This microfacies is distinguish in the all sections. The main diagenetic processes that affected this microfacies is cementation. Other diagenetic processes that acted on this microfacies are neomorphism, dolomitization, compaction, and authigenic minerals. This microfacies is similar to the standard microfacies (SMF-3) and (FZ-3) characterizing the (Toe of Slope) i.e. shallow open environment (Wilson, 1975).

3.5. Planktonic Foraminiferal packstone (PFP):

It consists mainly of diverse Eocene planktonic foraminifera belonging to *Acarinina*, *Morozovella*, *Globigerina*, and *Globigerina theka*, their percentages ranging from 70% to 85% (plate-1E). Benthic foraminifera shows a low distribution. Their dominated genera represented in this microfacies are *Bolivina*, *Bulimina*, and *Tritaxia*. The abundance of planktonic foraminifera and the diversity of benthic foraminifera indicate the middle bathyal environment, which represented the deepest part of the microfacies (Berggren and Miller, 1989). Most evidences indicate upper to middle bathyal environment with water depth ranges between 300m - 700 m. These microfacies appeared in all sections. The diagenetic features in this microfacies are compaction, and cementation including glauconite and pyrite filled skeletal grains. This microfacies is similar to the standard microfacies (SMF-2) and (FZ-2) which characterize the (Deep Shelf) environment (Wilson, 1975).

4. Depositional Environment

The Jaddala Formation in Kirkuk and Bai Hassan oil fields was deposited within three facies zones FZ-1 (Deep Sea), FZ2 (Deep Shelf) and FZ3(Toe of Slope) according to the (Wilson, 1975).The classification is then modified by Flugel (2004). It was represented by three standard microfacies (Wilson's SMF 1, SMF2, and SMF3).As a results; this may indicate the fluctuation of the relative sea level. It also may reflect the variations in paleotopography of the basin. The increase in benthonic foraminifera in the lower and middle parts of Bai Hasan 184 and the upper part of Kirkuk 252, referred to shallowing episodes.

Three types of the environments can be recognized within the Jaddala Formation, These are:

4. 1. Toe of Slope

This environment consists of the bioclastic foraminiferal wackestone that is rich in benthic and planktonic foraminifer's debris with less amounts of the Echinoderms. This environment lies within the deep zone according to the Standard microfacies Wilson (1975) and Flugel (2004).

According to the similarities between this zone with the standard microfacies of the Wilson's (1975). And its modification by Flugel (2004),this was based on the presence of reworked grains and presence the grains of the Kaolinite mineral that are related with the shells of planktonic foraminifera, Echinoderms and Ostracods. In addition to, there are some species of the large and small of benthic foraminifera within these units. The presence of red algae Scholle, *et.al*, (1983) refers to the low rates of deposition in the top slope. Sliter,(1972) noticed that the presence of some species of the benthic foraminifera like *Bulimina*, *Nodosaria* and *Bolivina* with the planktonic

foraminifera in Jaddala Formation, is the evidence for the processes of the sedimentation within toe slope in Wells K252 and BH184 (figs.3,4).

4.2. Deep Shelf

This environment consists of the fine materials like micrite, silicate deposits and calcareous material and biological constituents that are represented by the shells of planktonic organisms. Based on the matrix and constituents grains, the depositional environment of Jaddala Formation was deposited in the deep marine zones. Furthermore, the fine sediments with common planktonic foraminifera and presence of less amounts of the benthic foraminifera indicate the pelagic conditions and show that the environments is the deep and quiet.

The planktonic foraminifera that are present within Jaddala Formation facies consist of *Globigerina* and *Globorotalia*, these species are found in the deep marine environment. On the other hand, the presence of pyrite and phosphate minerals within the planktonic foraminifera wackestone, is regarded a clear evidence of the deep sedimentation.

4.3. Deep Sea or cratonic deep basin

This environment is represented by bioclastic wackestone and planktonic foraminiferal mudstone. The similarity between these microfacies and standard microfacies is based on the skeletal grains and Radiolarian shells. In addition, there are faults which lead to the formation the deep trench as a result of the oscillation movements in this area.

5. Sequence Development

The studied succession represents four third order cycles (A, B, C, and D) (Figs. 2, 3, 4, 5), they are bounded by Type-1 sequence boundaries. These cycles are asymmetrical. Each cycle starts with a transgressive systems tract (TST) with planktonic foraminiferal mudstone and bioclastic planktonic wackestone microfacies or by one of these microfacies deposited as a retrogradational parasequence within the deep sea environment.

The upper boundary is characterized by the maximum flooding (MF) followed by the highstand systems tract (HST). It consist of planktonic foraminiferal wackestone and planktonic foraminiferal packstone microfacies or by one of them as a progradational parasequence deposited within the deep shelf in BH-186 and K-229(figs.2,5). Whereas in BH-184 cycles(A,B,) and K-252 cycle (C) the highstand systems tract (HST) is represented by the deep shelf and toe of slope(figs.3,4).

The asymmetry of cyclicity is due to the changing magnitude and symmetry of the relative sea level fluctuation. The changeable magnitudes represent the successive intervals of the sea level rises and its stillstands. The Jaddala succession in the study area was developed in an area of high rate subsidence, which reflect that the subsidence was the main controlling factor on sequence development. The Jaddala Formation was deposited on a highly subsidence carbonate platform as a result of a major transgression.

6. Conclusions

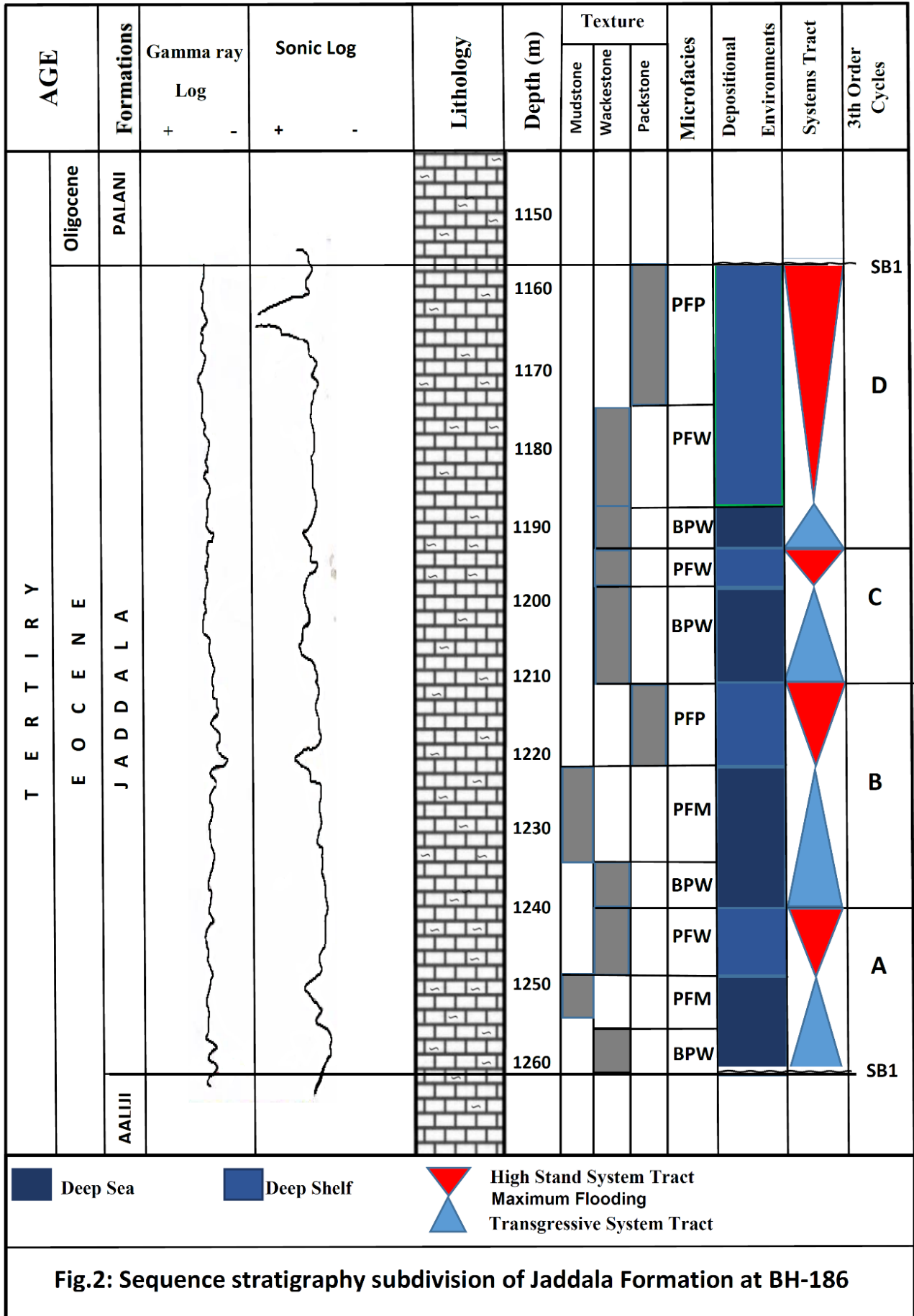
The detailed petrographical study and microfacies analysis are carried out for the Jaddala Formation in addition to using information from four wells BH-184, BH186, K-229, and K-252, representing two oil fields Kirkuk and Bai Hassan in Kirkuk area northern Iraq reveal detailed information about the different aspects of

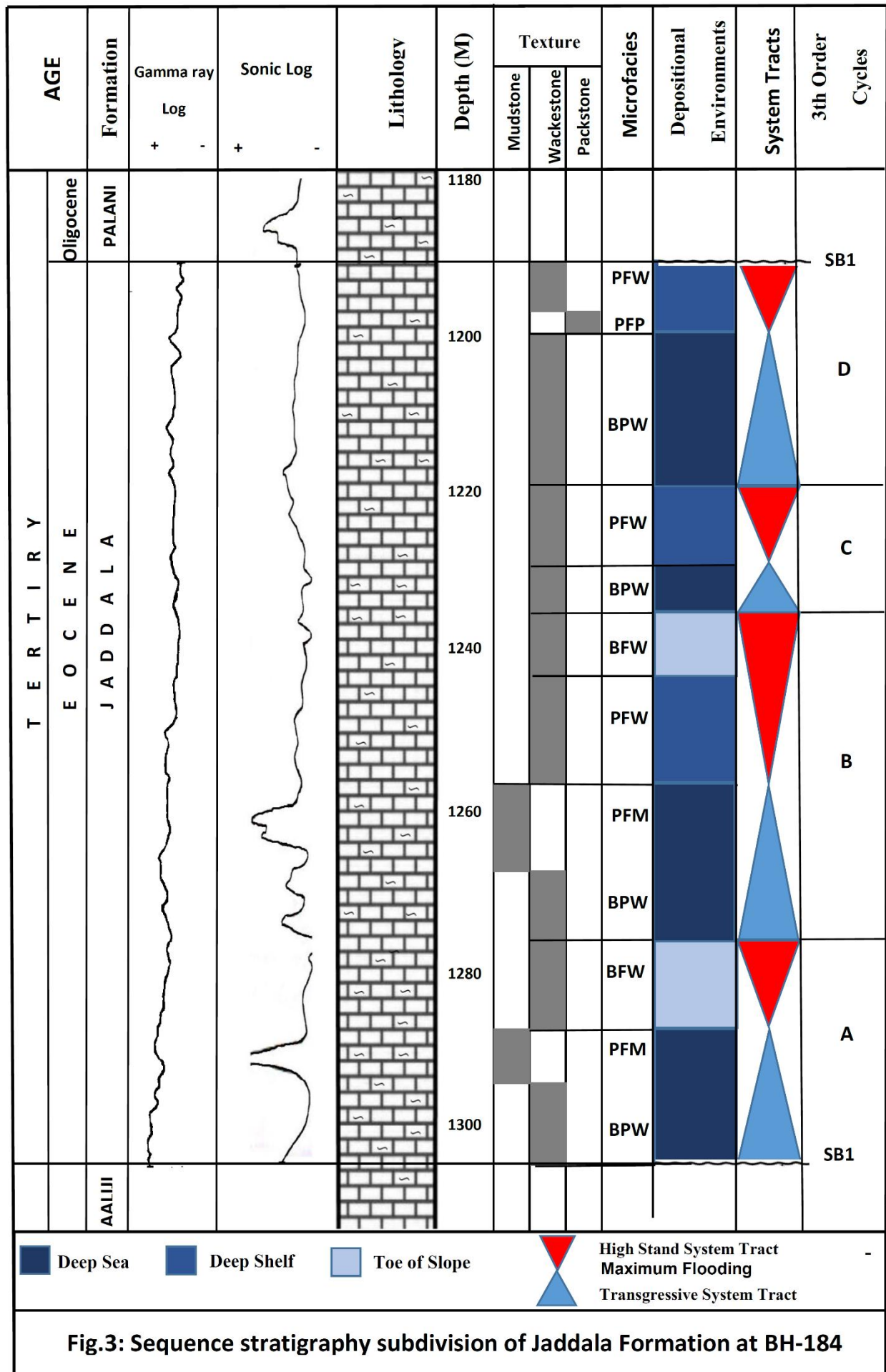
petrography, depositional environment, and sequence developments of these successions.

The Jaddala Formation consists of alterations of grayish brown limestone, chalky, marly limestone and argillaceous limestone with some content of glauconite and pyrite, the formation shows variations in thickness from well to another in the studied area might be due to configuration of the basin. The Aaliji Formation underlies the formation unconformably. This contact is characterized by the presence of glauconite, pyrite, and dissolution as well as the Gamma ray increase. These characters are also present at the unconformable contact between the Jaddala and Palani Formations.

The facies analysis shows that Jaddala Formation was deposited in Deep Sea, Deep Shelf, and Toe of Slope environments and five microfacies have been identified these are: Bioclastic planktonic microfacies, Planktonic foraminiferal Mudstone microfacies, Planktonic foraminiferal Packstone microfacies, planktonic foraminiferal wackestone microfacies and Bioclastic foraminiferal wackestone. Diagenetic processes affecting this formation include compaction, micritization and cementation.

Four third order cycles are recognized in the Jaddala succession in the study area above and below Type-1 sequence boundaries. These cycles are asymmetrical; the asymmetry of cyclicity is due to the changing magnitude and symmetry of the relative sea level fluctuation. They represent successive episodes of sea level rise and stillstands. The Jaddala succession in the study area is developed in an area of high subsidence, which reflect the high subsidence as the main controlling factor in sequence development. The Jaddala Formation was deposited on a highly subsidence carbonate platform as a result of a major transgression, where succession episodes of sea level rises and stillstands.





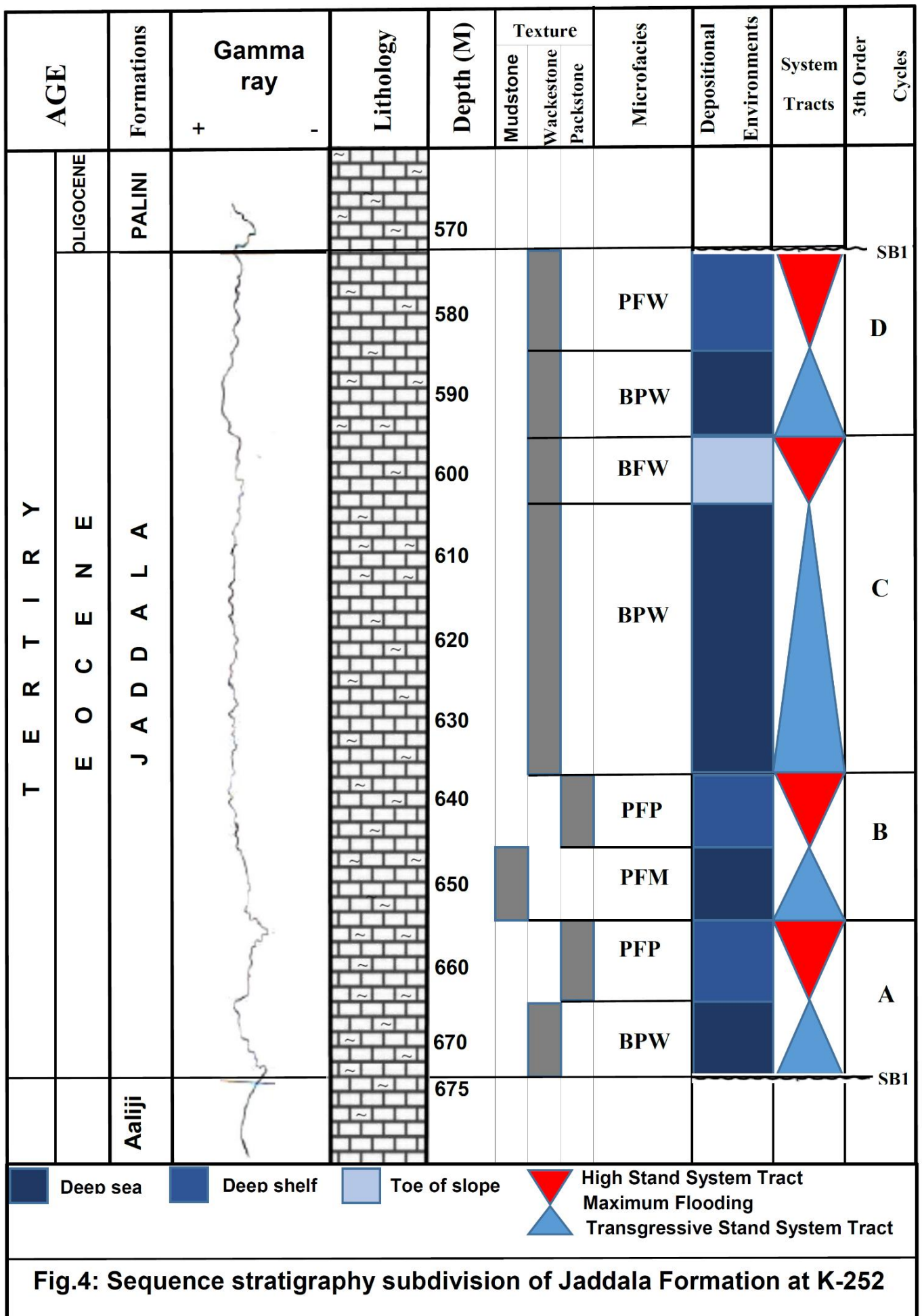
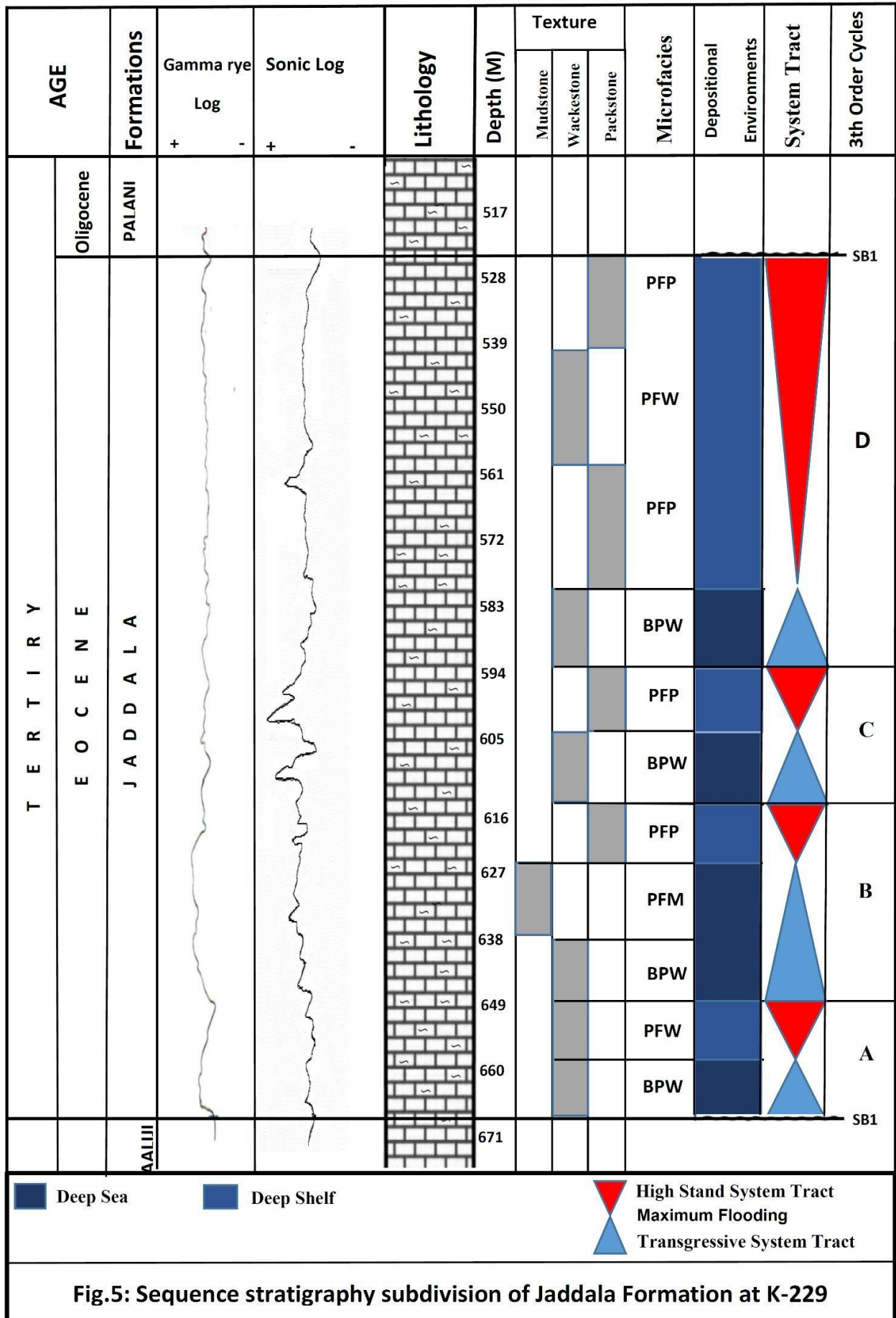


Fig.4: Sequence stratigraphy subdivision of Jaddala Formation at K-252



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