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Microfacies Evidences for Eocene Sequence Stratigraphy of Jaddala/Avanah Formations, Sinjar Area, Northwest Iraq

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ABSTRACT

Surface section of the Jaddala-Avanah Formations (Lower-Middle Eocene) is studied in Sinjar area. Three microfacies were recognized throughout Jaddala Formation, their depositional environment represented outer shelf-middle bathyal zones, likewise three microfacies were recognized within Avanah Formation representing environmental stretch from inner-middle shelf zones. Seven sequences were distinguished in the studied section, six sequences of 4th to 5th order and one of 3rd order. According to sequence stratigraphic analysis the south limb of Sinjar anticline formed part of shelfal deposit of the Eocene Sinjar basin; with repetitive shallowing cycles.

السحنات الدقيقة ودلائلها في الطباقية التتابعية للايوسين–تكويني جدالة وآفانة، منطقة سنجار، شمال غرب العراق

الملخص

درس مقطع سطحي لتداخلات تكويني جدالة وافانة (الايوسين الاسفل–الاوسط) في منطقة سـنجار، ركزت الدراسة على السحنات الدقيقة للتكوينين حيث ميزت ثلاث سحنات دقيقة في كل تكوين، وامتـدت البيئات الترسيبية لتكوين جدالة من الرصيف الخارجي الى الباثيال الاوسط، اما تكوين آفانة فقـد شـملت البيئات الترسبية له مناطق الرصيف الداخلي والاوسط. وعلى ضوء ما افرزته السحنات الدقيقة من تباين في البيئات الترسيبية للصخور فقد امكن دراسة الطباقية التتابعية للمقطع، حيث اظهـرت وجـود سـبعة تتابعات ست منها من المرتبة الرابعة والخامسة وواحدة من المرتبة الثالثة. ومن نتائج الطباقية التتابعيـة فان الجناح الجنوبي لطية سنجار مثل جزءاً من ترسبات الرصيف لحوض سنجار ولعدة مـرات خـلال الايوسين.

INTRODUCTION

Surface section of Jaddala Formation with interfingering beds of Avanah Formation has been studied near Sinjar city, Northwest Iraq (Fig. 1). Jaddala Formation is the most

widespread formation of the Eocene age in Iraq, extending into the Mesopotamian zone, foothill zone and into the northern and western parts of the stable shelf area (Jassim and Karim , 1984). Previous stratigraphic and paleontologic studies (Al-Senjery, 1983; Al-Mutwali, 1992; Al-Mutwali and Al-Banna, 2002) indicated that Jaddala Formation was deposited in deep open marine basin during Early-Late Eocene, while Avanah Formation was deposited in shallow marine platform (inner-outer shelf zone) during the Eocene. (Maala et al., 1977; Al-Hashimi and Amer, 1985; Sharbazheri, 1983).

This research is based on 37 samples collected from section of 215m thickness Based on foraminiferal assemblages and sedimentary line of evidence six microfacies were recognized. These are alloted to a wide range of environment extending from shallow marine to deep marine environment. These results were used in the contex of sequence stratigraphic analysis.

MICROFACIES

One of the aims of microfacies studys is to interprete the depositional environment of the rock body. Microfacies analysis of the rock concerned show a wide range environment extending from deep marine environment (Jaddala Formation.) to shallow marine environment (Avanah Formation).

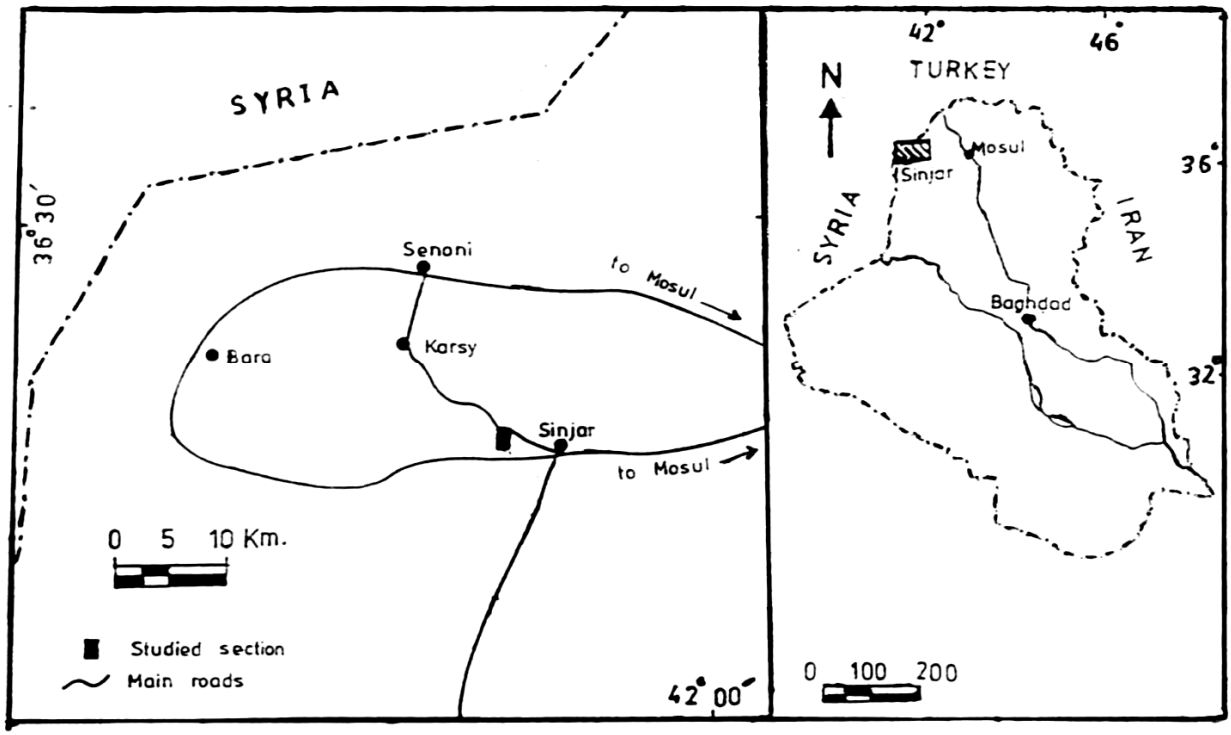


Fig.1: Location map.

Jaddala Formation:

LithologicalIy, the formation consists of pale brown to greenish brown marly limestone and pale brown limestone, with chert nodules. Three microfacies were recognized:

Planktic foraminiferal wackestone microfacies (J-l):

It consists of light brown limestone and marly limestone, revealing 10-40% allochems, with planktic foraminifera (40-70% of the total foraminifera) representing the

main contents, planktic foraminifera are of small size and having low diversity in some intervals especially at 20m and 50m through the section.

Bentfaic foraminifera appear with low density represented by *Eponides, Uvigerina, Nodosaria and Lenticulina.*

Micrite matrix and microspare cement filled the foraminiferal chambers. Depending on the observation of benthic foraminifera and its percentage with planktic forams it seems that the microfacies deposited in outer shelf to upper parts of the upper bathyal environments in depth ranging between 100m - 300m (Berggren and Miller, 1989).

Planktic foraminiferal packstone microfacies (J-2):

It consists of pale brown to greenish brown limestone and marly limestone with chert nodules. Allochems are consisting mainly of diverse Eocene planktic foraminifera belonging to *Acarinina, Morozovella, Globigerina,* and *Globigerinatheka,* their percentages are ranging from 70% to 85% of the total foraminifera (plate-1 Fig.l).

Benthic foraminifera show low distribution and variable diversity depending on the water depth. Their dominated genera represented in the microfacies are *Lenticulina, Bulimina, Cibicidoides, Neoflabellina, Nodosaria, Clavulina, Tritaxia,* and *Dorothia*. At thickness 184m, the presence of radiolaria (mostly belonging to *Spumellaria*), abundance of planktic foraminifera and diversty of benthic foraminifera indicated middle bathyal environment which represented the deepest part of the microfacies (Miller et al., 1985; Berggren and Miller, 1989).

Most evidences indicate upper to middle bathyal environment with water depth ranging between 300m - 700 m.

Benthic foraminiferal packstone microfacies (J-3) :

It consists of greenish brown to yellowish brown marly limestone. Allochems are ranging from 50% to 70% of the microfacies content. Benthic foraminiferal percentage are ranging from 50% to 70% of the total foraminifera, their dominated genera are *Nonionella, Lenticulina, Lagena, Eponides* and *Anomalina,* in addition to a low distribution of larger benthic foraminifera (*Discocyclina* and *Nummulites*) (plate-1 Fig.2) found in the microfacies at thickness 104 and 124m. The diversity of benthic foramimfera, and low distribution of planktic foraminifera is an attribute of water are ranging between 50m - 100m (Gibson, 1989). The presence of *Discocyclina* and *Nummulites* in the microfacies evidenced its occurrence near the shallow environment, where *Nummulites* transported by gravity below the storm wave base (Bartholdy. 2000).

All the evidences point out that the microfacies were deposited in the middle-upper part of the outer shelf environment.

Avanah Formation:

The formation consist of white to pale brown limestone beds, which can be divided into three microfacies:

Alveolina wackestone microfacies (A-l):

It is representing the first interfingering of Avanah Formation displayed as one metre of tough white limestone, composed of allochems, matrix and cement. Allochems with 10-30%, embraced large benthic foraminifera (*Alveolina globosa* Leymeria), (plate-1 fig.3) Miliolid (*Triloculina* and *Quinqueloculina*) with mollusca and shell

fragments.The matrix consists of micrite and microspare in which drusy cement filled vuggs.

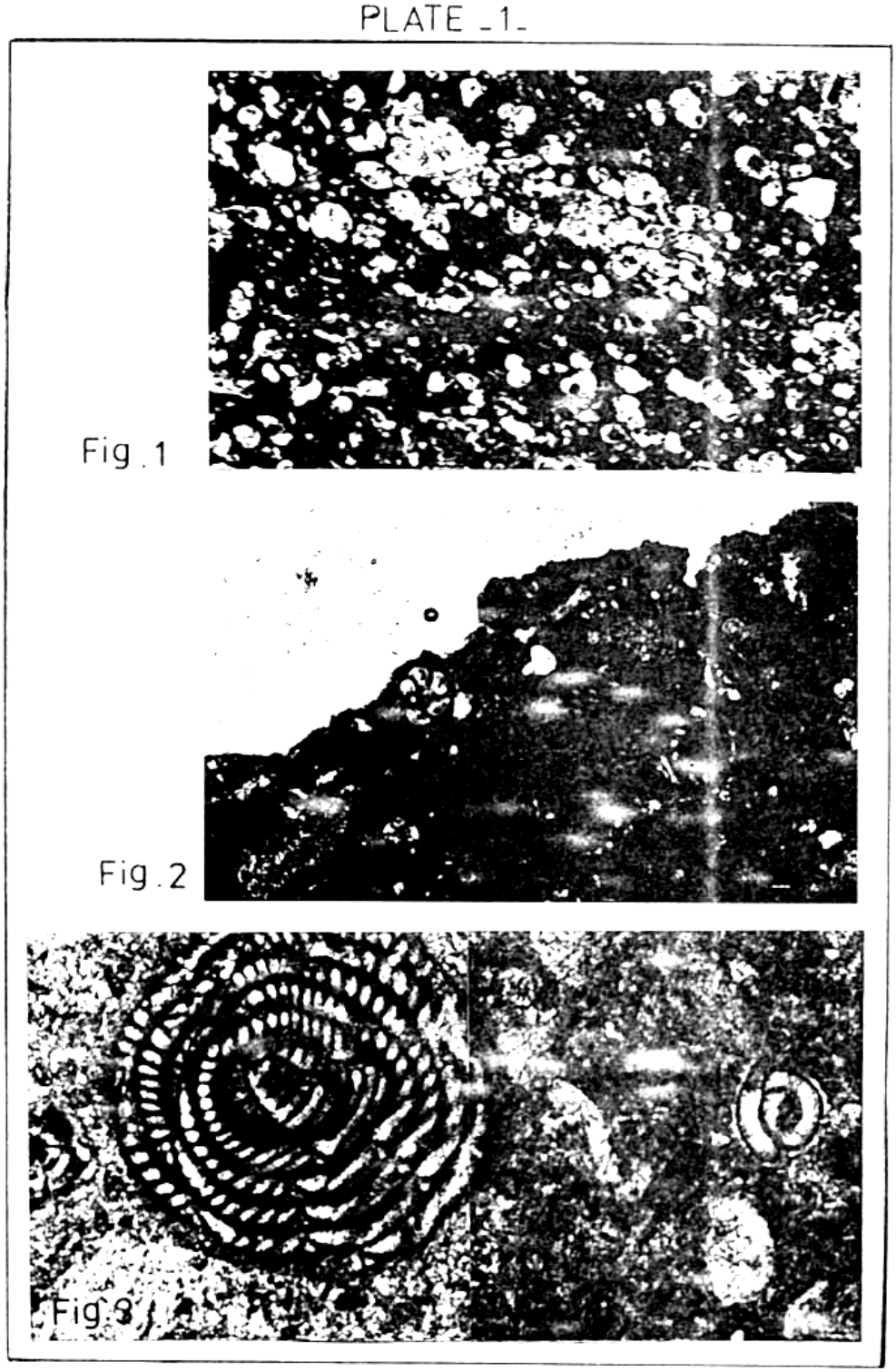


Plate –1:
Fig.l: Planktic foraminiferal packstone microfacies (J.2), X40, Jaddala Formation.
Fig.2: Benthic foraminiferal packstone microfacies, (J.3), X40, Jaddala Formation.
Fig. 3; Alveolina wackstone microfacies (A.I), X40, Avanah Formation.

Generally, *Alveolina* and Miliolid persist in the shallow inner shelf or lagoon (Henson, 1950). During the Eocene *Alveolina* is distributed in back reef, fore reef and in quite water (Ghose, 1977; Pautal. 1987), in which Miliolid found in tropical shallow shelf or lagoon environment (Murray, 1973; 1987).

The sedimentological and paleontological evidences favour the deposition of these facies in the inner shelf environments with a depth less than 30m.

Bioclastic grainstone microfacies (A-2):

It consists of white to pale brown limestone beds (1-2) m thick, more than 90% of the allochems embraced shell fragments of *Nummuliies*, *Discocyclina*, small benthic foraminifera, red algae and Echinoderms were persist in well sorting fashion having spherical to semispherical shape (plate-2, Fig.1).

Bioclasts accumulated as bars by storm wave action (Bartholdy, 2000). The sedimentological evidences assigned that the facies were deposited in a warm water inner shelf within wave action zone (less than 30 metres) (Ghose, 1977; Aigner, 1984; Moody, 1987).

Nummulitic packstone microfacies (A-3):

The facies are consisting of pale to yellowish brown limestone beds less than 2m thick. Allochems were forming 60-80% of the total contents. They embraced *Nummulites* [*N. discorbinus* (Schlotheiun), *N. bayhariensis* (Checchia- Rispoli) *N. globulus* Leymerie], *Discocyclina* [*D. sella* (D Archiac*), D. varians* (Kaufman)] and *Asterocyclina stellatus* (D Archiac) (plate-2 Fig. 2&3).

The facies were affected by partial dolomitization and syntaxial cement. The wave action may form nummulitic bank with recognized nummulitic packstone-garinstone facies (Aigner, 1984; Moody, 1987).

In accordance with Hauptmann et al., (2000) , the development of *Nummulites* accumulations is not really favoured by depositional environment in range of the storm wave base only, therefore a wide distribution of NummuIites may be accumulated in deep neritic marine water also; (Bartholdy, 2000).

Taking all attributis into consideration the facies was deposited in the inner - middle shelf environment.

SEQUENCE STRATIGRAPHY

Sequence stratigraphy is that branch of stratigraphy which subdivides the rock record using a succesion of depositional sequence composed of genetically related strata as regional and interregional correlative units. Sequence stratigraphic nomenclatures had been established by Haq et al., 1988; Weimer, 1992; Hardford and Louckes. 1993; Pomar and Ward, 1995; Emery and Myers, 1996; Ehrenberg et al., 1998; Strasser et al,1999 and Pittet et al., 2000.

PLATE -2-

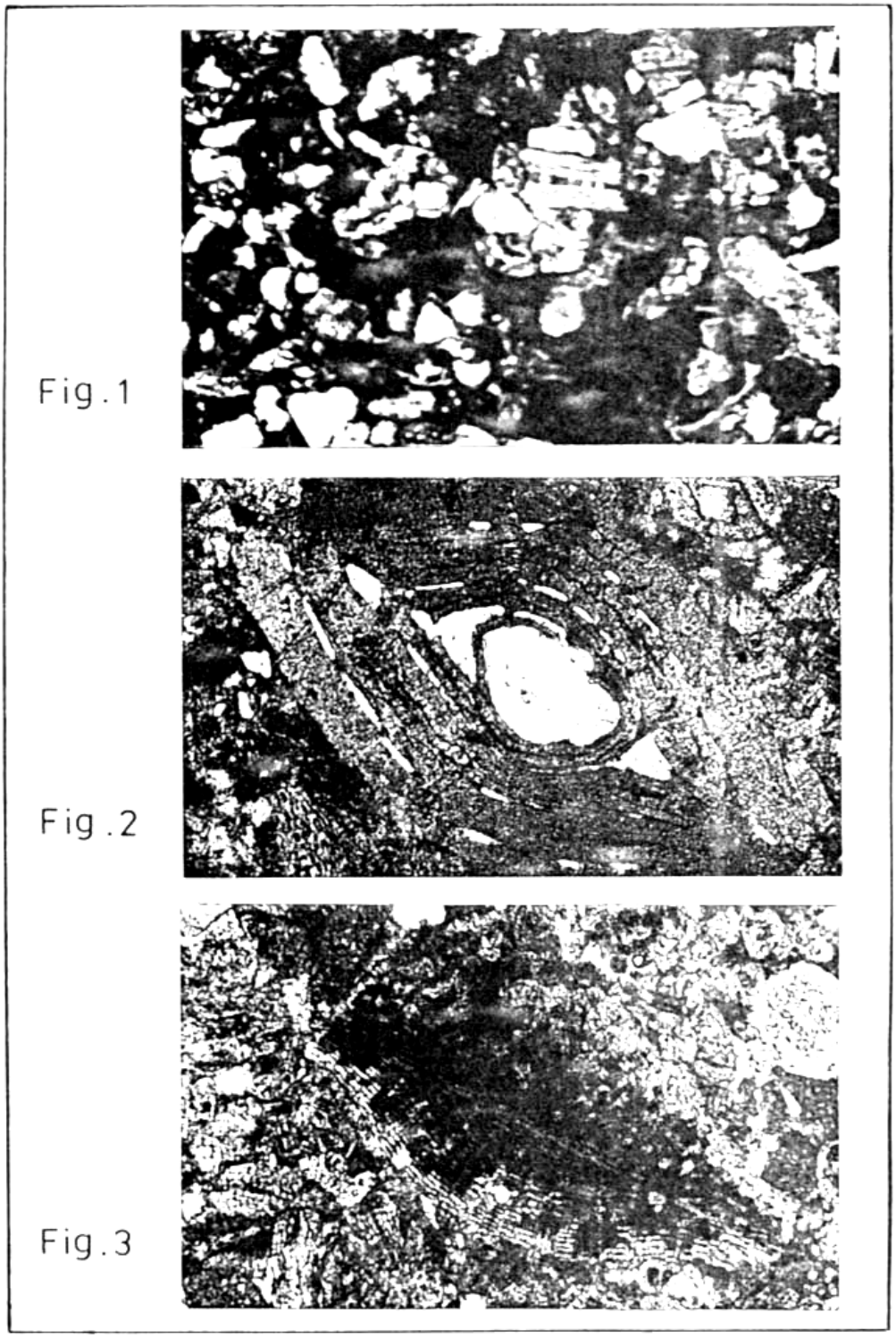


Plate-2:

Fig. 1: Bioclastic grainstone microfacies (A.2), X40, Avanah Formation.

Fig.2: *Nuummulites globulus* Leymerie in Nummulitic packstone microfacies (A.3), X40, Avanah Formation.

Fig.3: *Discocyclina varians* (Kaufman) in Nummulitic packstone microfacies (A.3), X40, Avanah Formation.

The sequence will be terminate by sequence boundary, the rate of relative fall in sea level determine the type of sequence boundary, if the rate of eustatic fall exceeds the rate of subsidence at the depositional shore line break, the entire shelf may be exposed and type-1 sequence boundary will result. When the rate of relative sea level fall is less than the rate of subsidence at the depositional shoreline break (the entire shelf) will not be exposed and type -2 sequence boundary will result. All sequence boundaries of this study are of type-2.

Sequence is limited by two boundaries and are divisible into half-cycles of base level rise followed by base level fall. They are separated by a maximum flooding surface (MFS). The base level rise half-cycle embraces the lowstand system tract (LST) and succeeding transgressive system tract (TST) while the base level fall half-cycle is equevailent to the highstand system tract (HST), The (LST) deposits are absent in the studied section.

The present work identify seven main sequences designated S-1 through S-7 which are related to Early - Middle Eocene age (52.5 - 44Ma)(Fig. 2), the first six sequence are made up of small scale cycles (l-39) m thick and general <1 MY. duration). According to Goldhammer et al., (1990) smaller scale sequence are viewed as product of 4th-5th order fluctuations, while the 7th sequence is made up of 69m thick and approximately 4Ma duration and regarded as the 3rd order. The study is depending on the biozones of Al-Mutwali and Al-Banna (2002) of the same section.

Sequence S-1

The sequence begins with unconformity surface between shallow deposits of Sinjar Formation and 15m of marine deposits of planktic foraminiferal packstone microfacies (J-2) reflected (TST). The (J-2) microfacies overlain by 17.5m of planktic foraminiferal wackestone microfacies (J-l) and 1m of alveolinal wackstone microfacies (A-l), the last two microfacies are forming the (HST). The classical MFS represent the boundary between J-2 and J-l. The sequence ended by a sharp surface (SB-2), The total thickness 38.5m and their time duration <1MY.

Sequence S-2

The sequence is bounded by two surface boundaries of SB-2 type, the lower unit embraced microfacies (J-2) showing upward increasing in water depth (TST) until J-l microfacies appears which reflected the begining of HST deposit, the (J-l) microfacies overlain by the bioclastic grainstone microfacies (A-2) of shallow marine environment. The MFS of the sequence is difficult to define because of the covering part of the section. The total thickness is 31.5m and time duration <1MY.

Sequence S-3

The sequence begins with the deposition of microfacies (J-2) 15.5m thick reflecting upward increasing in the water depth, it is identified as the base level rise hemicycle (TST) of the sequence. The HST embraced one metre of bioclast grainstone microfacies (A-2). The MFS is clearly separating the TST and HST. The total thickness is 15m and is of <l MY. duration. The sequence is bounded by two SB2 -Type.

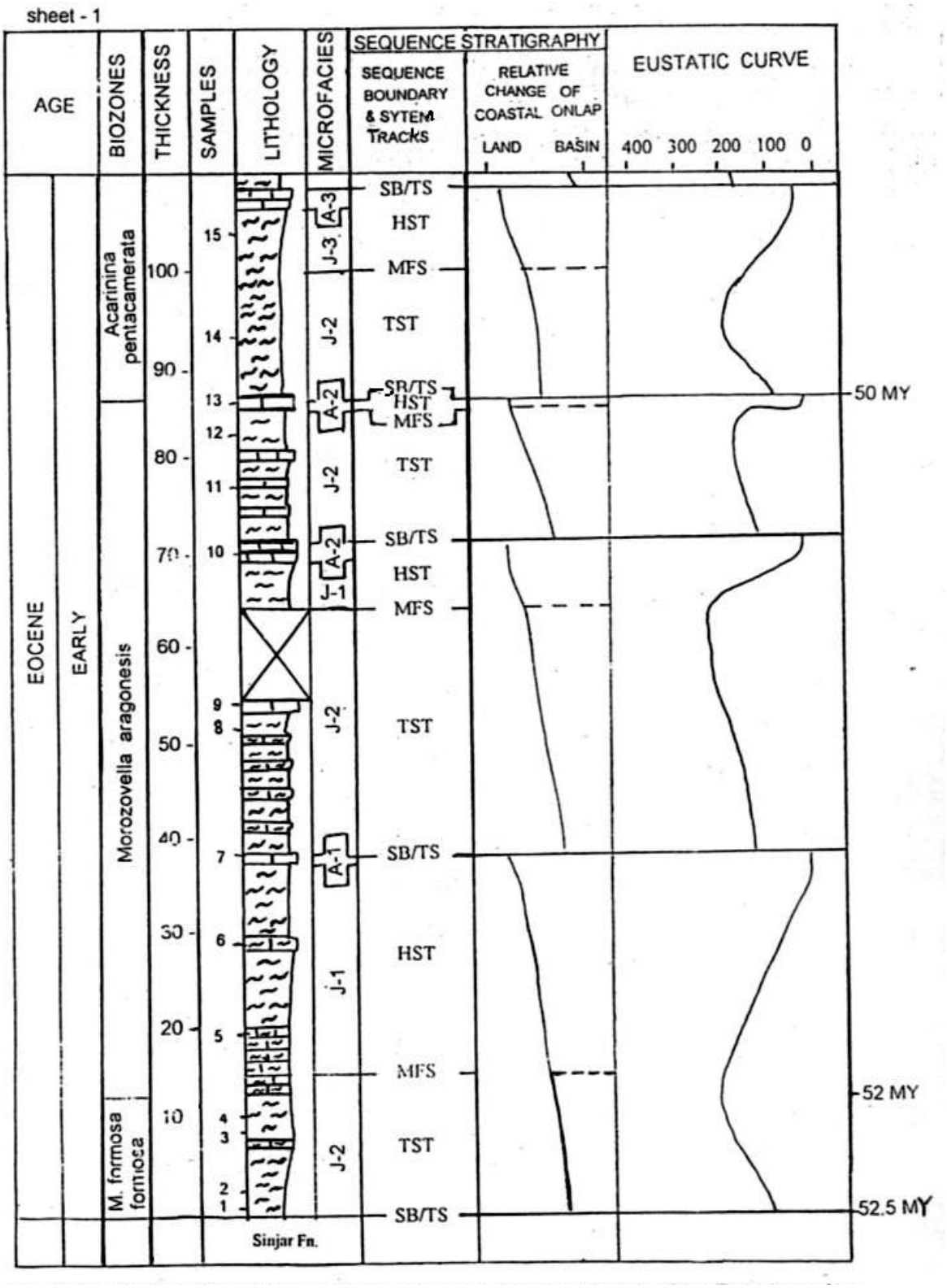
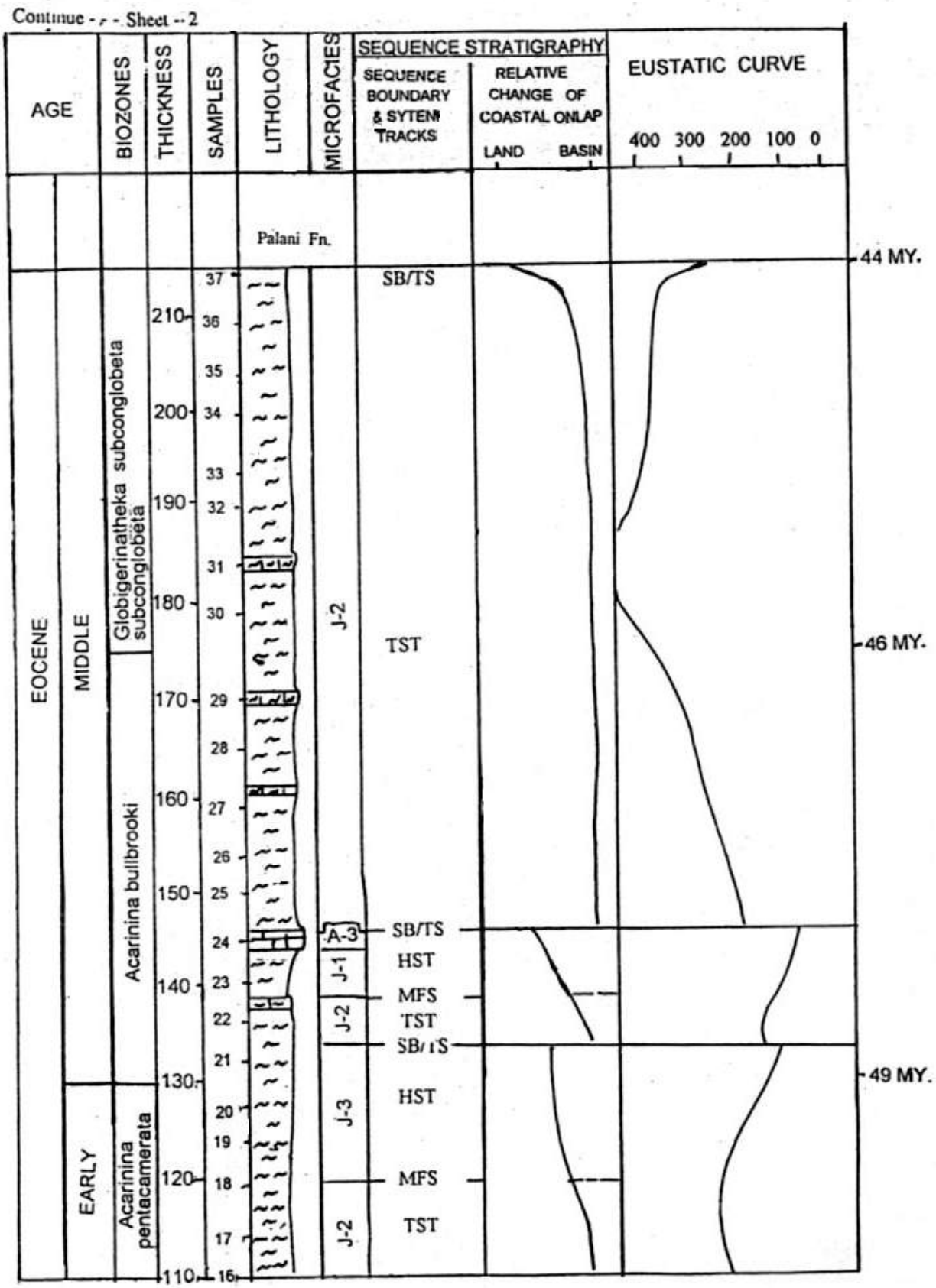


Fig.2: Lithostratigraphic, paleontologic and sequence stratigraphic data of the Eocene section at Sinjar area. Paleontological zonation after Al-Mutwali and Al-Banna (2001).


Continue - - Sheet -- 2
AGE
BIOZONES
THICKNESS
SAMPLES
LITHOLOGY
MICROFACIES
SEQUENCE STRATIGRAPHY
SEQUENCE BOUNDARY & SYTEM TRACKS
RELATIVE CHANGE OF COASTAL ONLAP
LAND
BASIN
EUSTATIC CURVE
400 300 200 100 0
Palani Fn.
EOCENE
MIDDLE
EARLY
Globigerinatheka subconglobeta subconglobeta
Acarinina bullbrooki
Acarinina pentacamerata
SB/TS
TST
HST
MFS
J-2
J-1
J-3
A-3
44 MY.
46 MY.
49 MY.

Sequence S-4

The sequence includes 13.5m of .microfacies (J-2) identified the base level rise in the cycle (TST). The base level fall hemicycle reveal two microfacies (J-3 and A-2), they show shallowing upward. The MFS is clearly seperated the microfacies (J-2 and J-3) at 94m thick. The total thickness of the sequence is 22m and their time duration < IMY. The lower and upper boundary of SB2-Type.

Sequence S-5

The sequence embraces microfacies (J-2 and J-3), the lower hemicycle is consisting of (J-2) microfacies. It is indicating deep marine environment and reflecting the TST of the sequence, at 120m the planktic foraminifera decrease and the facies changes to benthic foraminifera packstone microfacies (J-3) with the appearance of large foraminifera (*Discocyclina* and *Nummulites*). Their percentage increase upward and the facies become nearest to the shallow environment (middle shelf). Therefore it is assigned to the base level fall hemicycle (HST) .The total thickness 25m and is of <1 MY. duration.

Sequence S-6

The sequence reveal limestone and marly limestone, the lower part consist of microfacies J-2 of deep marine enviroment represinting TST. It is overlained by microfacies J-3 and A-3 which are reflect the HST, the MFS separated microfacies J-2 and J-l at thickness 139m, the two surface boundary of SB2-Type. Total thickness 12m and is of < 1 MY. duration.

Sequence S-7

The sequence begins with the deposition of microfacies (J-2), the first few metres of the microfacies indicated outer shelf environment, then it shows high diversity and percentage of planktic foraminifera where the environment become more deeper (upper bathyal). At thickness 184m the presence of Radiolaria with high percentage of planktic foraminifera and benthic foraminiferal diversity indicated depth ranging between 500m to 700m. The base level rise may be mention up to thickness l90m which reflect the TST. Above thickness 190m the Radiolaria disappear and J-2 mirofacies show upper bathyal to outer shelf environment up to the end of the sequence, it reflect the base level fall but it isn't strong enough to form typical HST. Total thickness 69m and is of<4 MY.duration. The upper boundary of the sequence is sharp and overlained by 4m of friable glauconitic marly limestone bed representing Early Oligocene Palani Formation

CONCLUSION

Jaddala Formation with interfnigering beds of Avanah Formation were recognized in the studied section, six microfacies were recognized in the two formations, their depositional environment represented innershelf-middle bathyal zones.

Seven sequences were recognized in Jaddala / Avanah Formations (52.5 - 44 Ma), five sequences in Lower Eocene (52.5 - 49 Ma) and two sequences in Middle Eocene (49 - 44Ma). The section shows good correlation with Cenozoic chronostratigraphic and eustatic - cycle chart of Haq et al. (1988). Therefore we believe that the Eocene basin was affected by the global sea level change. All the sequences ended by surface boundary of SB-2 type and the periodic regression subdued upward which is clearly reflected by microfacies of HST. Further evidence lends itself by observing the interfingering of Alveolina wackestone beds of Avanah Formation within the type section of Jaddala

Formation (15 km west Sinjar city). According to these results we believed that shore line located to the south of the studied area, which is contiguous to the positive area further southward as suggested by AL-Eisa and Mohammed (1997).

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