------ Iraqi Jour. Earth Sci., Vol. 5, No. 2, pp. 19-31, 2005 ------

# Evolutionary Aspects of *Lepidocyclina (Nephrolepidina)* from Baba and Azkand Formations (Oligocene-Miocene) in Kirkuk area, Iraq

**Imad M. Ghafor**
*Department of Geology*
*College of Science*
*Sulaymanya University*

**Qahtan A. Muhammed**
*Kirkuk Technical College*
*Kirkuk*

(Received 27/3/2005 , Accepted 6/9/2005)

## ABSTRACT

Biometric investigation of the megalospheric individuals of *Nephrolepidina* assemblages from several sections in Kirkuk area, Iraq led to recognize three morphometrically defined species by the combination of two parameters. The degree of embracement of the protoconch by the deuteroconch (Factor A) and number of accessory auxiliary chambers on the deuteroconch (factor C). On the basis of generally accepted theory which is called embryonic and nepionic acceleration. The succession of these three species corresponds to the phylogenitic lineage in the European–Mediterranean area which started at some level in the middle part of the Oligocene and continued upward into the Early Miocene. The slow numerical progress in this lineage and especially the double morphometric definition of the species limits have led to the recognition of a wide array of morphologically intermediate assemblages.

---

# الخط التطورى لـ *Lepidocyclina (Nephrolepidina)* من تكويني بابا وأزقند (الأوليكوسين–المايوسين) في منطقة كركوك، العراق

## الملخص

جرى البحث علي تتابعات من الصخور الكاربوناتية الحياتية المنكشفة (مقطع قرة جوغ داغ السطحي والتحت سطحية فى ابار (كركوك-19، باى حسن-4 وخباز-3). ترسبت هذه الصخور الكاربونايتية فى بيئات بحرية ضحلة مفتوحة خلال فترة الاوليكوسين المتاخر–المايوسين المتأخر، وان اصداف فورامينفيرا الكبيرة من تحت الجنس *(Nephrolepidina)* *Lepidocyclina* تكون شائعة في الجزء العلوي والسفلي من هذه التتابعات الصخرية، ان الخط التطوري للأنواع التابعة لتحت الجنس *Lepidocyclina* *(Nephrolepidina)* مطابق للخط التطوري الموصوف من منطقة البحر الابيض المتوسط واوروبا والذي يبدأ في الجزء الأوسط للاوليكوسين، حيث هذا الخط يرينا التقدم في تعقيدات الغرف الاولية الجنينية وان هذه التعقيدات ممثلة بزيادة في قيم عوامل (C,A) ونقصان في عامل (α).

---

## INTRODUCTION

The succession of *Lepidocyclina(Nephrolepidina)* assemblages in Baba and Azkand Formations (Oligocene–Miocene) carbonates of Kirkuk well-19; Bai-Hassan well-4; Khabaz well-3 and Qarah chauq Dagh sections, provides us with unique proof for the general validity of the principle of nepionic acceleration (Tan Sin Hok, 1936), in the evolution of the *Lepidocyclina(Nephrolepidina)* Douvillé.

The evolutionary patterns in our *Lepidocyclina(Nephrolepidina)* lineages will be dealt with in more detail, which was actually the main purpose of our investigation. The morphometric series will be the results of earlier published studies on the other orbitoidal foraminifera and with current evolutionary.

## PREVIOUS INVESTIGATION

Biometric investigations of the megalospheric individuals of *Nephrolepidina* assemblages from several places in Europe by Van der Vlerk (1959); Drooger and Socin (1959); Drooger and Freudenthal (1964) led to De Mulders' classification (1975), in which three morphometrically defined species are recognized by the combination of two parameters: the degree of embracement of protoconch by the deuteroconch (factor A) and the number of accessory auxiliary chambers (Factor C). On the basis of general theories which are called embryonic and nepionic acceleration, depending on the combinations of ($A^-$) and ($C^-$) values:

The names and morphometric delimitation of the species are:

| | $C^-$ | $A^-$ |
|---|---|---|
| *Lepidocyclina(N.) praemarginata* Douvillé | $1 < C^- < 3$ | $35 < A^- < 40$ |
| *Lepidocyclina(N.) morgani* Lemoine and Douvillé | $3 < C^- < 5.25$ | $40 < A^- < 45$ |
| *Lepidocyclina(N.) tournoueri* Lemoine and Douvillé | $C^- > 5.25$ | $A^- > 45$ |

The overall acceleration trends appear to be in accordance with the stratigraphic order of these three species, but the rate of evolution must have been very low, if one takes into account that the development lasted throughout the entire second half of the Oligocene (Chattian) and well into the Miocene (Aquitanian). The latest published review papers (Drooger and Rohling, 1988, Adam1987, Drooger, 1993, Saraswati and Kumar, 2000, Muthukrishnan and Saraswarti, 2001, Saraswati, 2003), on all morphometrically determined *Nephrolepidina* associations of the European regions show that all data fit in with a single lineage that shows a development in the ($A^-$-$C^-$) relation.

## MATERIALS AND METHODS OF INVESTIGATION

Larger foraminifera *(Lepidocyclina)* are typically associated with shallow water carbonate sediment during the Oligocene-Miocene (e.g. Baba and Azkand Formations). The facies change typically evolved continuously in this environment, so that it is seldom to find typical Miocene carbonate facies (Azkand Formation) directly overlying Oligocene carbonates (Baba Formation) in the same sequence section, therefore the sampling are carried out from many surface and subsurface sections such as (Qarah chauq Dagh, Khabaz well-3, Bai-Hassan well-4, and Kirkuk well-19 sections) (Fig.1), to recover the contemporaneous of Oligocene-Miocene sequence. Equatorial thin sections were made from megalospheric individuals of *Lepidocyclina(Nephrolepidina).*

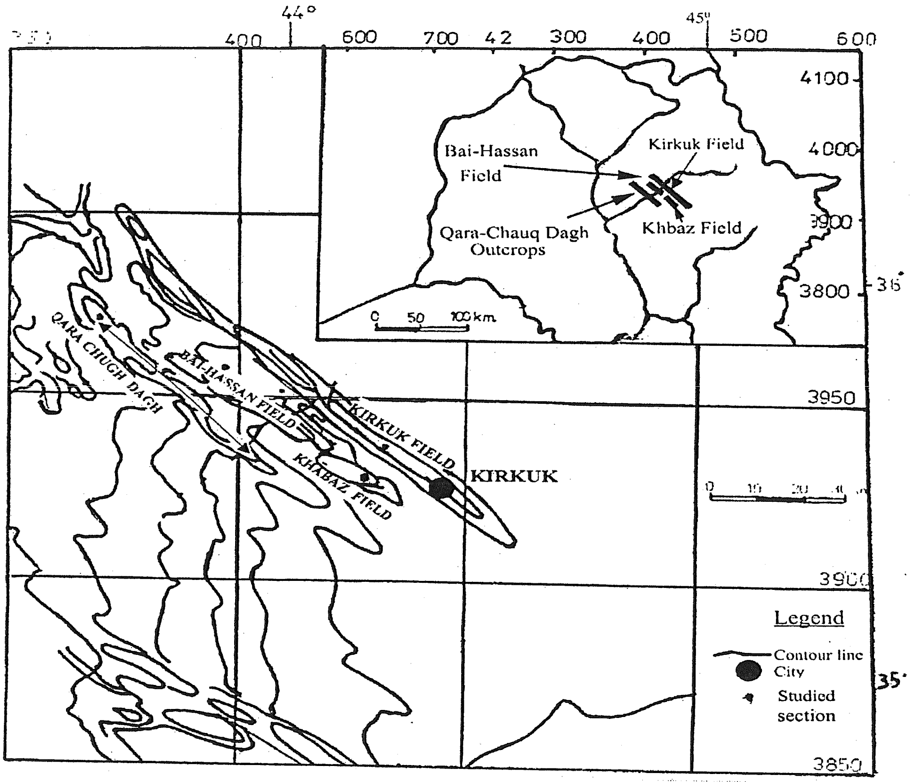


Fig.1: Location map of the studied area.

Counts and measurements on the early chambers of *Lepidocyclina (Nephrolepidina),* were performed according to the procedures by De Mulder (1975) and Drooger (1993) (Fig.2).

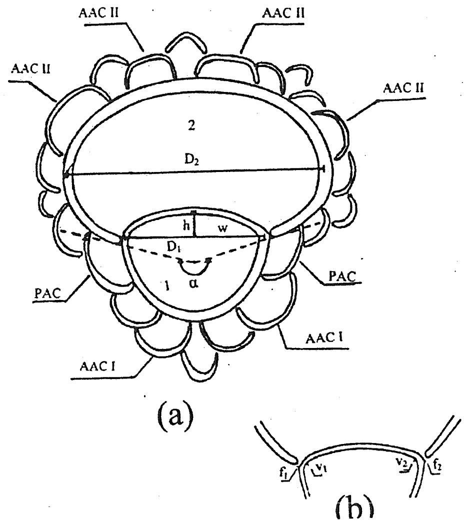


Fig.2: a- Schematic drawing showing the methods of measuring and counting the internal features in *Lepidocyclina(N.)*. b- Methods of measureing the degree of embracement in the embryonic chambers, $A_i$, the length of common wall is measured from $v_1$ to $v_2$, $A_o$ from $f_1$ to $f_2$ (after De Mulder, 1975 and Drooger, 1993).

Protoconch: Iinitial chamber (1), deuteroconch: second chamber (2) formed from 1, Nucleoconch. (embryon): 1 and 2 together..
PAC: Principal auxiliary chambers formed from 2, and resting on 1 and 2.
AACI: Accessory auxiliary chamber; formed from 1, AACII : Ad-auxiliary chambers formed from 2.

Embryonic stage: consists in our *Lepidocyclina(N.)* forms of all chambers directly encircling the nucleoconch.(1 and 2 together)
Neanic stage: All later chambers.
These successive ontogenetic stages are recognized in a single plane of growth, called the median or equatorial layer. The parameters are:
**A** : Degree of embracement of the protoconch (1) by the deuteroconch (2) .

$$A = 100 \times \frac{\text{Length of common wall between 1 and 2}}{\text{Total circumference of the protoconh}}$$

A is calculated from measurements along the outer wall of the protoconch (; ($A_o$) from measurements along the inner wall (Fig.$2_b$, $v_1$-$v_2$).

This is expressed as a percentage, calculated as the ratio of the length of the common wall between 1 and 2, and the total circumference of the protoconch, multiplied by 100.
$A_i$: is calculated from the values obtained along the outer wall of the protoconch, and was introduced by Van Der Vlerk (1959).
Since it is supposed (Drooger and Freudenthal, 1964, and De Mulder, 1975) that $A_o$ and A. differ no more than twice the standard error, also A was calculated, which is $\frac{1}{2}(A_0 + A_i)$, and therefore (A) lies in between ($A_o$)and ($A_i$) differs no more than once the standard error of ($A_o$)and ($A_i$)each. The difference between ($A_i$ )and ($A_o$) is relatively small. De Mulder(1975) found that in practice both methods produce the same result.

**C** : Number of accessory auxiliary chambers on the deuteroconch (AACII).
$D_1$: Maximum diameter of the protoconch in µm, measured at right angles to a line connecting the centers of 1 and 2 half of the thickness of the wall is included.
**$D_2$** : Maximum diameter of the deuteroconch, measured at right angles to the connection line between the centers of 1 and 2. Also in ($D_2$) values, half of the thickness of the wall is included.
**$D_2/D_1$**: reflects the relative size of both embryonic chambers.
**R**: degree of curvature, calculated from the formula:-
**R** = 100 h/w. In this equation (w) is taken along the line connecting the attachment points of the deuteroconch to protoconch. Generally, (w) and (h) are measured along the maximum height of the protoconch that is inclosed by the deuteroconch, measured at right angle to w.
**α** : Introduced here. It reflects the degree of embracement of the protoconch by the deuteroconch, expressed by the protoconchal angle which is formed by the two hypothetical

line from the center of the protoconch through the outer attachment points of the deuteroconchal walls with the protoconch (Fig.2 b, $f_1$ and $f_2$). α can be measured easier than A, but in not well-rounded protoconches the position of the center is rather arbitrary.

## COMPARISION OF VARIOUS BIOMETRIC SPECIES IN DIFFERENT SECTIONS

The Oligocene carbonate (Baba Formation) in Kirkuk well-19 and Bai-hassan well-4 sections subdivided into I,II,II and IV units (Fig.3). The lower part of the Baba Limestone represented by unit (I) in Kirkuk well-19 and lower part of unit (II) in Bai-Hassan well-4 sections, characterized by occurrence of the first primitive type of *Lepidocyclina (Nephrolepidina) praemarginata* depended upon the mean values of the ($C^{-}$-$A^{-}_{i}$ , $C^{-}$-$D^{-}_{2}$ and $C^{-}$-$\alpha^{-}$) relation (Tables 1 and 2). From unit (II) and the lower part of unit (III) which represent the middle part of Baba Formation. Another species is distinguished that situated in characters between *Lepidocyclina praemarginata* and *Lepidocyclina morgani* which is represented by *Lepidocyclina* ex.interc. *praemarginata-morgani*, and the mean values of the ($C^{-}$, $A^{-}$) and ($\alpha^{-}$) are recorded from the Unit (II) and the lower part of the Unit (III). The Miocene carbonate (Azkand Formation) in well Khabaz well-3 and Qarah Chauq Dagh sections subdivided into units (V,VI,VII,VIII) (Fig.4). The *Lepidocyclina (Nephrolepidina) morgani* shows an increase in these parameters in comparing with the previous species, and this species is continued to the Units (V and VI), represented as the lower part of Azkand Formation (Miocene), whereas in Unit (VII), the biometric analysis shows an increasing in the values of ($C^{-}$,$A^{-}$) and decreasing the (α) values that distinguished another species situated in mideposition in their character between *L .morgani* and *L .tournoueri* which is named as *L.ex. interc. morgani-tournoueri.* the lower part of unit(VII) and unit (VIII) characterized by presence of *L.(N.)tournoueri* which has the highest value of the ($C^{-}$,$A^{-}$) and minimum values for the (α) (Tables 3 and 4).

Summarizing, it can be stated that mean values of (C) and (A) show successive increasing but the (α) values decreased from Unit (I) (Lower part of Baba Formation), toward the Unit (VII) (Upper part of Azkand Formation) while no clear trend is observed in the average size of Protoconch ($D_1$) and Deuteoconch ($D_2$) from the lower to the upper part of the sequence, unit VIII (Upper part of Azkand Formation).

## EVOLUTIONARY LINEAGE OF *LEPIDOCYCLINA (NEPHROLEPIDINA)* IN IRAQ

The evolutionary trend in this study from Oligocene-Miocene carbonate sequence, as mentioned above based on biometric investigations of the megalospheric individuals of *Nephrolepidina* assemblages from several section, in which several morphometric species are recognized on combination of ($A^{-}$) and ($C^{-}$) values, in addition, the third factor (α) is used which shows a clear decreasing from the lower part to the upper part of the section (Tables 1, 2, 3, 4, Fig. 5).

In the scatter diagram of ($C^{-}$) versus ($A^{-}$) values from Iraqian *Lepidocyclina (Nephrolepidina* assemblages (Fig.6), in which European and Mediterranean assemblages are entered , show that all data fit in with a single lineage that shows a development along a broad band in the ($A^{-}$-$C^{-}$) relation , the fairly wide variation along this road cause quiet a few ex. interc. determinations, it is clear that the assemblages of the lineage fit to one end the same, general trend of increase in the diameters of both embryonic chambers (Table 5).

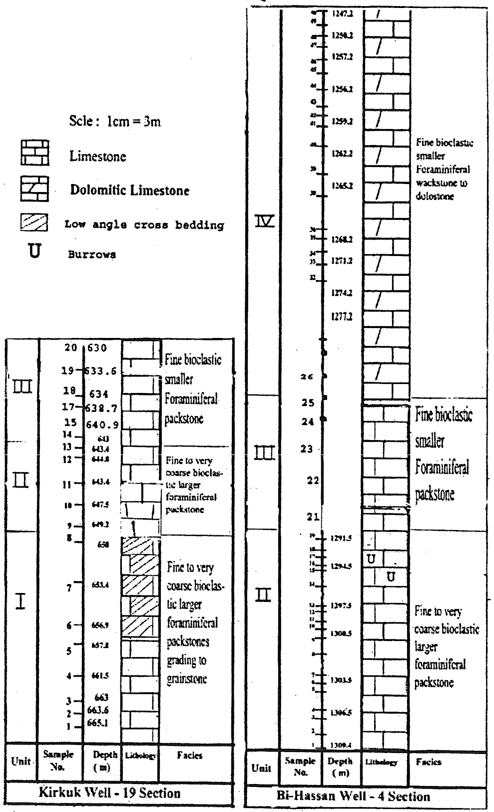


Fig.3: Lithostratigraphic column of the sections, Kirkuk well-19 and Bai-Hassan well-4, Oligocene carbonates (Baba Formation).

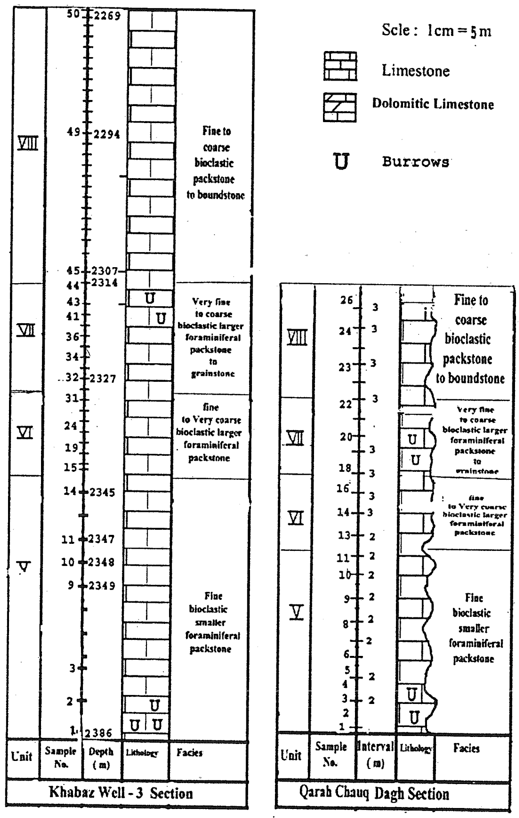


Fig.4: Lithostratigraphic column of the sections, Kirkuk well-3 and Qara Chauq Dagh, Miocene carbonates (Azkand Formation).

Table 1: Results of Counts and measurements on seven *L.(N.)* assemblages from the Oligocene carbonates (Baba Formation) in Kirkuk well-19 section. M=Mean of the value, N =Number of observation.

| Series | Stage | Unit | Thickness (m) | Sample Number | $A_i$ | C | $D_1$ | $D_2$ | $D_2/D_1$ | R | α | Species |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oligocene | Chattian | III | 9 | M 20 N | 42.5<br>13 | 4.9 | 297.3 | 324.6 | 1.09 | 29.4 | 193.9 | *L.morgani* |
| | | | | M 18 N | 44.1<br>12 | 4.8 | 220.1 | 285.83 | 1.5 | 28.4 | 198.6 | *L.morgani* |
| | | II | 8 | M 16 N | 40.7<br>10 | 2.9 | 272 | 320.9 | 1.2 | 25.5 | 207.7 | *L.ex.interc praemarginata-morgani* |
| | | | | M 14 N | 40.8<br>12 | 3.5 | 283.3 | 345.8 | 1.2 | 23.5 | 202.5 | *L.ex.interc praemarginata- morgani* |
| | | I | 18 | M 11 N | 36.4<br>11 | 2 | 260.7 | 298.1 | 1.1 | 17.4 | 239.1 | *L.praemarginata* |
| | | | | M 3 N | 38.1<br>11 | 2.3 | 240.9 | 312.4 | 1.3 | 14.1 | 238.2 | *L.praemarginata* |
| | | | | M 1 N | 36.8<br>12 | 2.1 | 219 | 315.9 | 1.4 | 15.3 | 238.8 | *L.praemarginata* |

Table 2: Results of Counts and measurements on seven *Nephrolepidina* assemblages from the Oligocene carbonates (Baba Formation) in Bai-Hassan well-4 section. M=Mean of the value, N=Number of observation.

| Series | Stage | Unit | Thickness (m) | Sample Number | $A_i$ | C | $D_1$ | $D_2$ | $D_2/D_1$ | R | α | Species |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oligocene | Chattian | IV | 35 | M 32N | 42.8<br>14 | 4.7 | 266.3 | 341 | 1.2 | 30.1 | 194.9 | *L.morgani* |
| | | III | 11 | M 22 N | 42.4<br>12 | 4.6 | 206 | 274.9 | 1.4 | 25.4 | 196.8 | *L.morgani* |
| | | | | M 20 N | 39.8<br>10 | 3.2 | 318.5 | 361.5 | 1.14 | 25 | 204.5 | *L.ex.interc praemarginata- morgani* |
| | | II | 19 | M 19 N | 40.2<br>13 | 3.3 | 230.5 | 314.6 | 1.3 | 26.8 | 200.8 | *L.ex.interc praemarginata- morgani* |
| | | | | M 18 N | 39.1<br>13 | 3.4 | 281.8 | 287.7 | 1.02 | 30.6 | 201.8 | *L.ex.interc praemarginata-morgani* |
| | | | | M 16 N | 36.7<br>13 | 2 | 236.6 | 265.5 | 1.1 | 15.2 | 226.9 | *L.praemarginata* |
| | | | | M 15 N | 36.7<br>10 | 2.1 | 213.2 | 257.7 | 1.2 | 16.2 | 226.3 | *L.praemarginata* |

Table 3: Results of Counts and measurements on twelve *Nephrolepidina* assemblages from the Miocene carbonates, (Azkand Formation) in Khabaz well-3 Section. M=Mean of the value, N=Number of observation.

| Series | Stage | Unit | Thickness (m) | Sample Number | $\bar{A}_1$ | $\bar{C}$ | $\bar{D}_1$ | $\bar{D}_2$ | $D_2/D_1$ | $\bar{R}$ | $\bar{\alpha}$ | Species |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Miocene | Aquitanian | VIII | 34 | M 50 N | 45.6<br>14 | 5.9 | 318.1 | 386.1 | 1.2 | 35.5 | 172.4 | *L.tourenourii* |
| | | | | M 49 N | 47.9<br>12 | 5.6 | 244.1 | 320.4 | 1.3 | 34.9 | 178.2 | *L.tourenouri* |
| | | VII | 15 | M 42 N | 50.5<br>15 | 6.9 | 339.7 | 403.9 | 1.2 | 40.9 | 178.4 | *L.-tourenouri* |
| | | | | M 37 N | 46.7<br>14 | 6.3 | 329.3 | 409 | 1.2 | 44.9 | 189.2 | *L.-tourenouri* |
| | | | | M 36 N | 46<br>11 | 5.2 | 285.9 | 371.2<br>4 | 1.3 | 32.3 | 190.1 | *L.ex.interc-morgani-tournouri* |
| | | | | M 35 N | 45.9<br>11 | 5 | 232.8 | 311.8 | 1.3 | 36 | 190.3 | *L.ex.interc-morgani-tournouri* |
| | | | | M 32 N | 46<br>11 | 5.2 | 311.5 | 365.9 | 1.2 | 31.3 | 190.6 | *L.ex.interc-morgani-tournouri* |
| | | VI | 13 | M 31 N | 46<br>12 | 5.2 | 271.4 | 378.7<br>8 | 1.4 | 31.2 | 190.8 | *L.ex.interc-morgani-tournouri* |
| | | | | M 28 N | 45.5<br>11 | 5.1 | 300 | 339.2 | 1.13 | 28.5 | 191.1 | *L.ex.interc-morgani-tournouri* |
| | | | | M 22 N | 41.8<br>15 | 4.4 | 213.5 | 280.3 | 1.3 | 27.4 | 197..8 | *L.morgani* |
| OLigocene | Chattian | | | M 16 N | 44.2<br>9 | 4..9 | 248.9 | 326.3 | 1.3 | 25.6 | 198.7 | *L.morgani* |
| | | V | 36 | M 7 N | 44.5<br>10 | 5 | 233.6 | 320.7 | 1.4 | 26.3 | 196.3 | *L.morgani* |

Table 4: Results of Counts and measurements on seven *Nephrolepidina* assemblage from the Miocene Formation) in Qarah Chauq Dagh section.

| Series | Stage | Unit | Thicknes (m) | Sample Number | $\bar{A}_1$ | $\bar{C}$ | $\bar{D}_1$ | $\bar{D}_2$ | $D_2/D_1$ | $\bar{R}$ | $\bar{\alpha}$ | Species |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Miocenee | Aquitanian | VIII | 15 | M 26 N | 47.6<br>10 | 5.6 | 260 | 330.2 | 1.27 | 36.3 | 172.7 | *L.tourenouri* |
| | | VII | 12 | M 21 N | 46.3<br>14 | 5.4 | 269.9 | 325.9 | 1.2 | 28.9 | 192.1 | *L.ex.interc.morgani .tourenouri* |
| | | | | M 20 N | 42.8<br>16 | 4.5 | 255.8 | 300.5 | 1.17 | 24.7 | 195.125 | *L.morgani* |
| | | | | M 18 N | 40.9<br>12 | 3.5 | 236 | 292.3 | 1.2 | 28.5 | 196.5 | *L.morgani* |
| | | | | M 17 N | 42.3<br>13 | 4 | 293 | 371.5 | 1.3 | 27.5 | 197.5 | *L.morgani* |
| | | VI | 10 | M 12 N | 41.4<br>13 | 4 | 301.9 | 381.9 | 1.3 | 29.2 | 198.8 | *L.morgani* |
| Oligocene | Chattian Chattian | V | 24 | M 3 N | 44.7<br>11 | 4.1 | 253.4 | 303.3 | 1.2 | 27.1 | 198.8 | *L.morgani* |

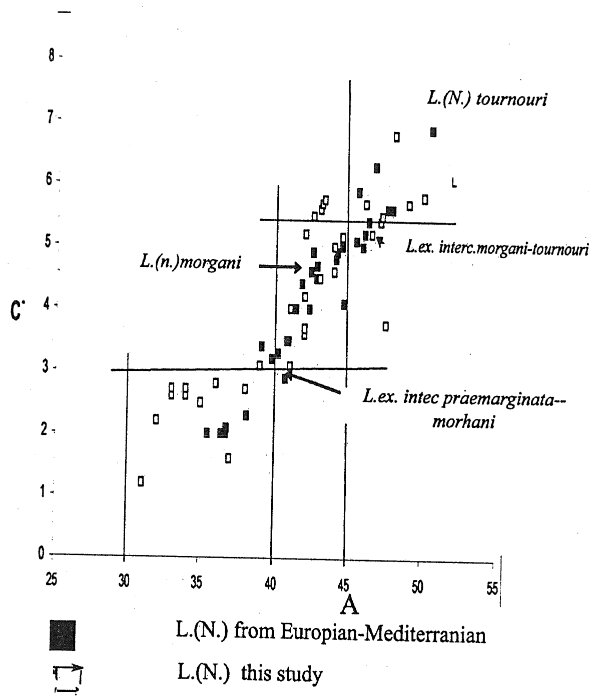


Fig.5: Scatter dtagram of C' versus A' values for Iraqi *L(N.)* assemblages, with the assemblages of European-Mediterranean *Lepidocyclina.* (Literature from Drooger and Rholing, 1987 and Drooger, 1993).

Table 5: Stratigraphic distribution of *Lepidocyclina (Nephrolepidina)* species of the studied area, based on the mean values of (C, $A_i$ and $\alpha$ )

| Formation | Stage | Species | C' | A' | α' |
|---|---|---|---|---|---|
| Azkand | Aquitanian | *L (N.).tournoueri* | C'>5.25 | $A_i$'>45 | α'<189.5 |
| | | *L.ex.interc.morgani-tournoueri* | 5<C'<5.5 | 44<$A_i$'<46 | 189.5<α<1925 |
| | Chattian | *L(N.).morgani* | 3<C<5.25 | 40<$A_i$'<45 | 192.5<α<199 |
| Baba | | *L.ex.interc.praemargi nata-morgani* | 2<C'<4 | 39<$A_i$'<41 | 199<α<208 |
| | | *L(N.).praemarginata* | 1<C'>3 | 30<$A_i$<40 | 208<α' |

The evolutionary and morphometric delimitation of the species with corresponding age are plotted in Fig. (6) and pointed out in table (5). The succession of these species corresponds to the lineage in the Europe-Mediterranean area which started at same level in the phylogenitic middle part of the Oligocene continued upwards into the early Miocene. The lineage shows progressive complication in periembryonic chambers ranges from Chattian to Aquitanian within that time an increasing is recorded in (Factor C) and (Factor Ai), incontrast decreasing is recorded in (Factor α).

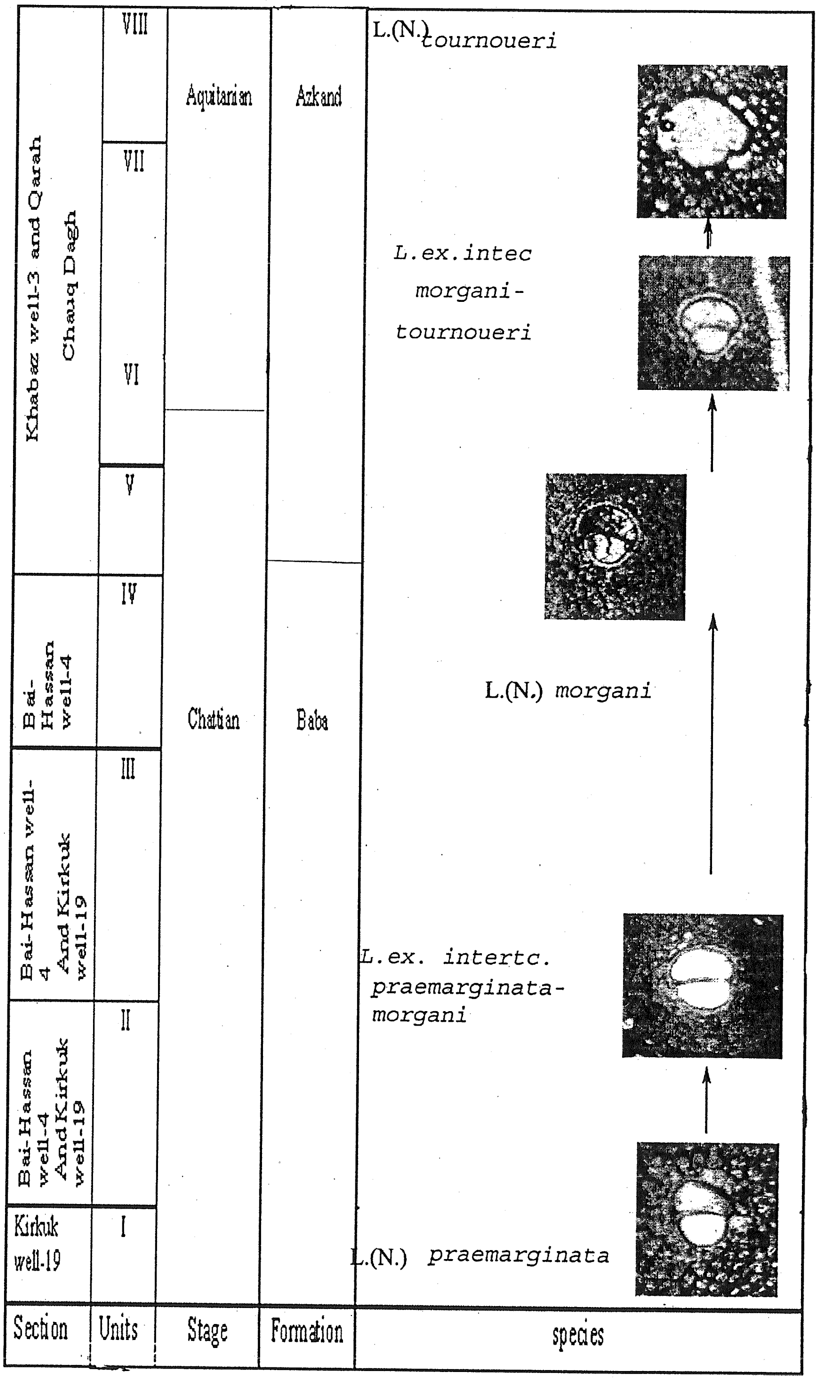


Fig.6: Evolution of *Lepidocyclina (Nephrolepidina)* of the units (I,II,III,IV,V,VI,VII and VIII) from the sections Kirkuk well-19, Bai-Hassan well-4, Khabaz well-3 and Qara Chauq Dagh.

Butterlin (1987) follows the suggestion of Bronnimann (1940) normally the European Mediterranean *praemarginata morgani-tournoueri* lineage the endemic evolutionary continuation of the *L. muretanica / pustulosa*, but we think this lineage in Iraq and surrounded areas originated independently from primitive *Nephrolepidina* represented by *L.(N.)praemarginata* and the *L.(N.).morgani* which distinguished from Morocco is a variation of the *praemarginata* because of having the same (Factor C) while the factor ($A_i$) is lesser than as in *praemarginata*.

## CONCLUSION

Many morphometric series of *Lepidocyclina (Nephrolepidina)* were distinguished for the first time from Iraq by using biometric analysis of *Lepidocyclina (Nephrolepidina)* individuals, based on the mean values of (C, $A_i$ and $\alpha$ ).

The evolutionary trend in *Lepidocyclina(Nephrolepidina)* shows progressive complication in embryonic chambers represented by an increasing in factor ($C^-$ and $A^-$) and decreasing in ($\alpha$) factor in grading from Chattian (Baba Formation) upward into Early Aquitanian (Azkand Formation).

## REFERENCES


Adams, C.G., 1987. On the classification of the Lepidocyclinidae (Foraminifera) with re-description of the unrelated Paleocene genera *Actinosiphon* and *Orbitosiphon*. Micropaleontology, Vol.33, No.4, pp.289-317, pls. 1-4.

Bronnimann, P., 1940. Über die tertiären Orbitoidides und die Mioypsiniden von Nordwest-Marokko. Schweiz. Pal. Abh., Band 63, pp.1-113.

Butterlinm, J., 1987. Origin et evolution des *Lépidocyclines* de la région des Caraibes. Comparaison et relation avec les *Lépidocyclines* des autres region du monde. Revue Micropal., Vol.29, pp.203-219.

De Mulder, E.F.J., 1975. Microphona and sedimentary tectonic history of the Oligo-Miocene of the Joniane Islamnd and Western Europe (Greece). Ulrecht. Micropal. Bull., Vol.13, 140.pp.

Drooger, C.W., 1993. Radial Foraminifera Morphometrics and Evolution, verhamd, Kon. Ned. Akad. Wetensch. Amesterdam, pp.1-241.

Drooger, C.W. and Freudenthal, Th., 1964. Associations of *Miogypsina* and *Lepidocyclina* at some Europian localities. Ecl. Geol. Helv., Vol.57; pp.509-528.

Drooger, C.W. and Socin, C., 1959. Miocene Foraminifera from Rosignano, Northern Italy. Micropaleontology, Vol.5, p.415-426.

Drooger, C.W. and Rohling, E.J., 1988. *Lepidocylina* migration across the Atlantic. Jour. Paleontology, Procceedings loninklijike Nederlandse Academie van wetenschappen, (B), Vol.91, pp.39-52.

Muthukrishnan, S. and Saraswati, P.K., 2001. Shape analysis of the nucleoconch of *Lepidocyclina* from Kutch-ataxonomic interpretation. Micropaleontology, Vol.47, No.1, pp.87-92, text figures, 1-33, plate 1.

Saraswati, P.K., 2003. Progress in the morphometrics of Foraminifera Goud. Geol. Mag., spt. Vol.6, pp.11-18.

Saraswati, P.K. and Kumar, A., 2000. Morphometrics of some *Lepidocyclina* Foraminifera: applications in Taxonomy and Biostratigraphy. Geological dat analysis statistical methods. Hindistan Publishing Corporation (India) New Delhi, pp. 63-70, Fig.6.

Tan Sin Hok, 1936a. Zur Kenntnis der Miogypsiniden. De Ingenieur in Ned. Indië, Jaarg. 3, No. 3, pp.45-61. No.5, pp.84-98, No.7, pp.109-123.

Vlerk, Van Der I.M, 1959a. Modification de I'ontogénése pendant I'évolution des Lépedocyclines (Foraminifers). Soc. Géol. France Bull., 7; vol.1, pp.669-673

**Plate -1-**

Figure (1): *Lepidocyclina (Nephrolepidina) praemarginata*, Unit (I),sample(1), Kirkuk well-19 section, Baba Formation, (40X),axial section.

Figure (2): *Lepidocyclina (Nephrolepidina) praemarginata*, Unit (II), sample (16), Bai-Hassan well-4 section, Baba Formation, (40X).equatorial section.

Figure (3): *Lepidocyclina (Nephrolepidina) ex. interc. praemarginata-morgani* Unit (III), samples (18), Bai-Hassan well-4 section, Baba Formation, (40X). Equatorial section.

Figure (4): *Lepidocyclina (Nephrolepidina) ex. interc. praemarginata-morgani* Unit(II), sample(16),Bai-Hassanwell-4section, Baba Formation (5X) Kirkuk well-19 section, Baba Formation, (40X). Axial section.

Figure (5): *Lepidocyclina (Nephrolepidina) morgani* Unit II), sample (22), Bai-Hassan well-4 section, Baba Formation, (35X). Equatorial section.

Figure (6): *Lepidocyclina (Nephrolepidina) morgani*, Unit (IV), sample (23) Bai-Hassan well-4 section, Baba Formation.(30X). Equatorial section.

Figure (7): *Lepidocyclina (Nephrolepidina) morgani* Unit (VI) sample (28), Bai-Hassan well-4 section, Baba Formation. (40X). Equatorial section.

Figure (8): *Lepidocyclina (Nephrolepidina) ex. interc. Morgani* Unit (VII), sample, (35), Qarah chauq Dagh section, Azkand Formation. (30X). Equatorial section.

Figure (9): *Lepidocyclina (Nephrolepidina) tournoueri*, Unit (VII), sample (42). Khaba well-3 section, Azkand Formation. (40X). Equatorial section.

Figure (10): *Lepidocyclina (Nephrolepidina) tournoueri* Unit (VIII), sample (26), Qarah Chauq Dagh section, Azkand Formation.(35X). Equatorial section.

**Plate -1-**