An Investigation Of Pliocene-Pleistocene Boundary By Using Foraminiferal Markers In The Southern Part Of Nc - 41 Concesstion Of Tripoli-Sabrata Basin Offshore Libya

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Abstract:

The aim of this study is to investigate the Pliocene-Pleistocene Boundary of the southern part of the NC-41 Concession of Tripoli-sabrata basin Offshore Libya.

Data used are mainly electric logs, stratigrtiaphic reports, and ditch samples of seven wells that have located in the study area. A detailed lithological and biostratigraphic studies of seven wells R1, L1, F1, N1, G1, P1, and K1 located in the study area were done. The study of these data yield to investigate the Pliocene-Pleistocene Boundary which has different width where the earliest Pliocene marine invasion covered Messinian substratum quit heterogeneous.

The Earliest Pliocene marine successions in the study area were found a topographic surface quite heterogeneous. This resulted to the contact between Messinian and Pliocene is unconformable and increased toward the west even reach its maximum in the k1 well is about (3.2 m.a, *Globorotalia margaritae Zone*). Also this study led to identify the paleobathymetry of water that was dominant in that time where in the Late Miocene (Messinian stage), restricted conditions was dominant all over the study area (during *Ammonia beccari zone*), then water transgression took place started from eastern side of the study area where minimum hiatus was recorded (*Globorotalia margaritae zone*),therefore, that area characterized by deep marine (epibathyl), R1 well area at the same time the rest of the study area was shallow marine conditions was dominated except at K1 and P1 areas restricted conditions were recorded.

1. Introduction:

The best understanding of big sedimentary sequence require dividing its geological time into small periods. Therefore the Pliocene-Pleistocene sedimentary sequence in the South-Western Libyan Offshore, which has not investigated before, is being studied in this paper.

1.1 Aim of the work:

This study is aimed to investigate The Pliocene- Pleistocene Boundary in the, (NC-41 Concession), South-Western Libyan Offshore.

1.2 Location of the study area:

The study area includes seven wells located in the southern part of the NC41 Concession. They are R1, L1, F1, N1, G1, P1, and K1 (figure1).

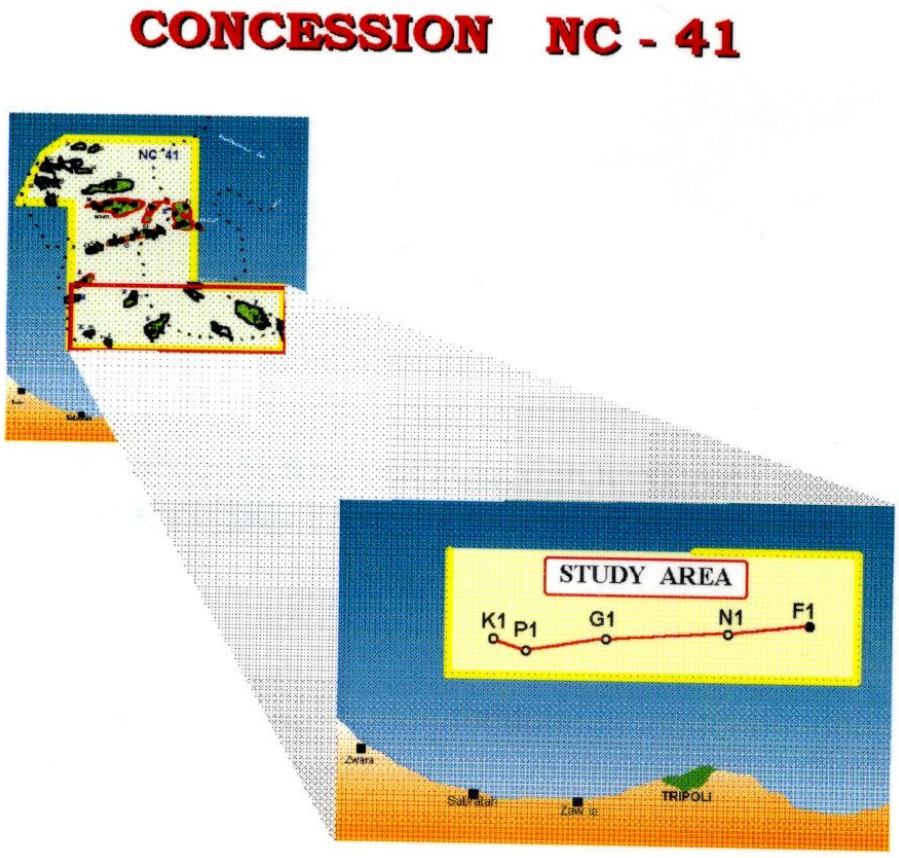


figure 1 location map of the study wells

1.3 Material and methods:

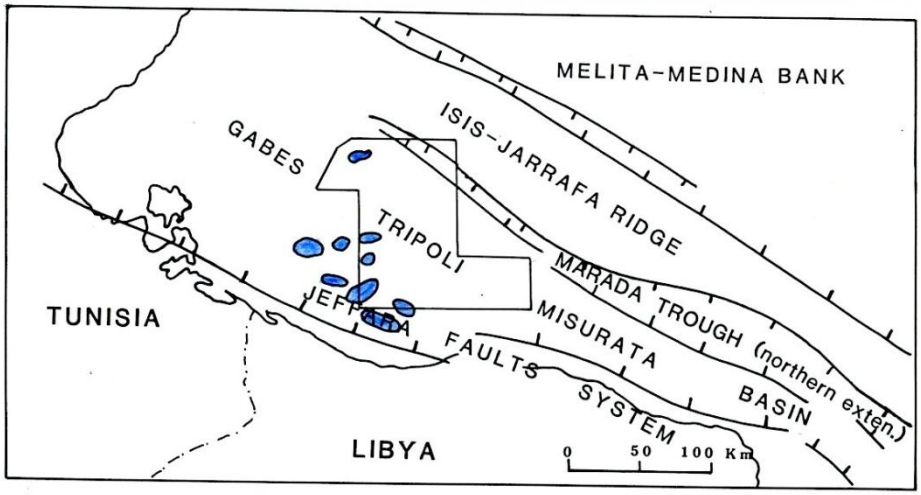
Documentation and materials used are mainly electric logs, stratigraphic reports and ditch samples. the study intervals are according to well sampling and are as follows:

R1-NC41 from 1616 (first sample) to 3608 feet
L1-NC41 '' 1417 '' '' 3571 ''
F1-NC41 '' 1300 '' '' 2672 ''
N1-NC41 '' 1300 '' '' 3571 ''
G1-NC41 '' 975 '' '' 1710 ''
P1-NC41 '' 970 '' '' 1502 ''

K1-NC41 '' 880 '' '' 1642 ''
A detailed microscopic analysis was carried out to investigate the lithology and faunal content of each sample.

2. Geological setting:

Since the Triassic tectonic phase, the Libyan offshore and its surrounding areas seemed to be marked by a rigid, block fault pattern, probably due to deep seated rifting affecting the substratum, with a clear NW-SE trend (Jeffara fault system to the south and Isis Jerrafa ridge- Kerkenneh uplift to the north) (figure 2). (figure 3 show the geologic setting of the study area).



(figure 2 the geologic setting of the study area)

This rifting produced a symmetric basin and the main tectonic elements have been rejuvenated during the Middle Juarssic and Upper Cretaceous (Breschi and Gaith, 1989).
The Sirtic direction of the mentioned structural features intersected the WSW-ENE oriented ''Salt'' trend, which affected the basin since the Late Cretaceous (Lazzari, 1990).

The Latest phase of the salt tectonics is Late Miocene in age and is responsible for the present morphology of the study area.

3. Rock Stratigraphic Units:

Rock stratigraphic units have been established by lithological, biostratigraphical and electrical logs analysis. The main lithological characteristics of the study sequence, which belongs to the Oued Bel Khedim and Raf-Raf Formations, are as follows:

Oued Bel Khedim Formation mainly consists of gypsum,white grey, sometimes grading to sandy clayey gypsum, grey to dark grey.

Raf-Raf Formations mainly consist of clay, light grey, plastic, very fossiliferous; occasionally grading to clayey marl, green to light green, medium hard to soft, locally silty, sometimes with sand inclusions, quartizose, reddish to glassy, fine to very fine grained, subangular to subrounded grains, wiyh shale interbeds.

The recovery of a thick interval in the area comes from the well K1-41 (from 880 to 1102 feet). This sandy sequence does not exhibit any relation with the Raf- Raf Formation, both in terms of lithology and faunal content. Niether does it belong to the Porto Farina Formation because its type-sequence is very far (northern Tunisia). There, Libyan and Tunisia sandy sequences could represent two separate basins. Nevertheless, the litho-biofacies of this sequence seems to be well comparable with the Porto Farina formation. The described succession is Late Miocene to Early Pleistocene in age.

In R1,G1 and K1 the Raf-Raf Formation was found to be underlain by a thick sequence of evaporates belonging to Oued Bel Khadim Formation. It is characterized by the presence of microfaunal assemblage.

On the contrary, the Miocene-Pliocene boundary succession described from wells L1, F1 and N1 did not exhibit any significant lithologic variation. In fact, the lowest beds of the Raf-Raf Formation

cap The Late Messinian sequence made up by shale/sand interbeds (figure 3). However they are characterized, in terms of biofacies, by the same Ammonia-Elphidium assemblage which typify the nearby evaporitic facies.

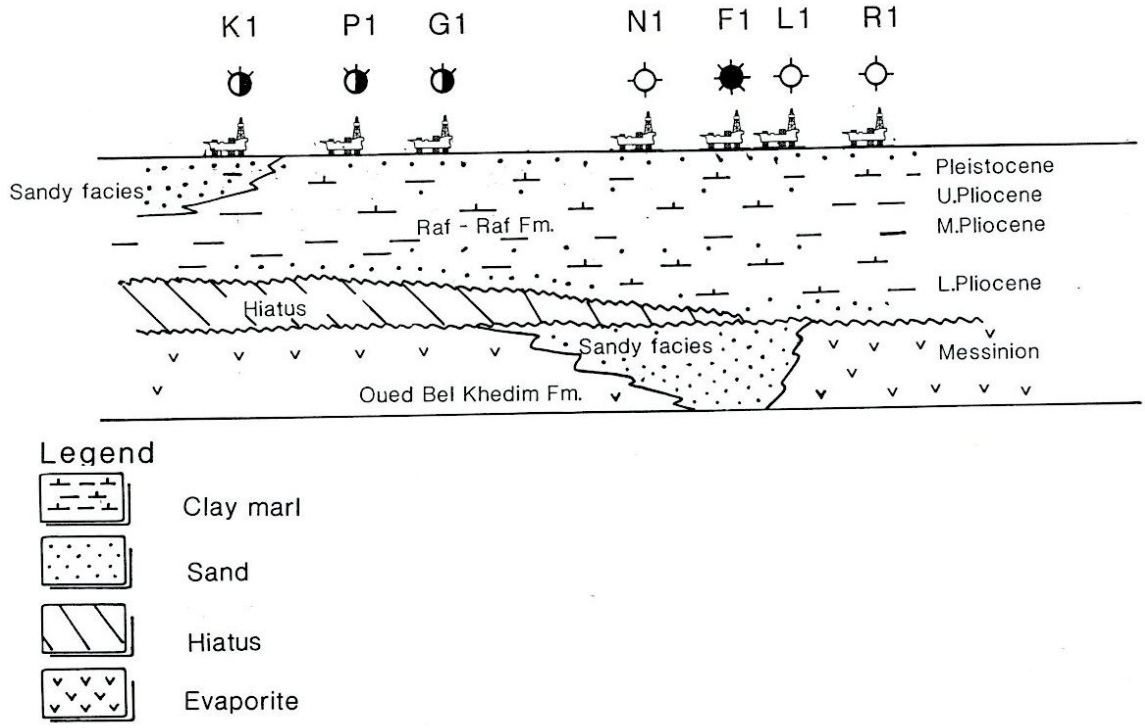


Fig. 3 –Scheme of the lithostratigraphical relations in the study area.

4. Biostratigraphic Summery:

4. 1. Early Pleistocene (Globorotalia truncatulinoides excelsa and Neogloboquadrina pachyderma).

It is represented by sandy clay and marl with abundant foraminiferal assemblaes.

4.1.1. *Globorotalia truncatulinoides excels Zone*:

Definetion: Interval from the first occurrence of G. truncatulinoides excelsa to Recent.

This zone is present only in the N1-NC41 well. The marker is associated with *Hyalina balthica, Bulimina marginata, Cibicidoides ungerianus, Uvigerina pergerina Planulina ariminensis, Sphaerodina bulloides, Melonis padanum, Globigerinoides ruber, Globigerinoides elongates and Globigerina bulloides.The local abundance of Hyalina balthica and G. truncatulinoides* indicates cold water environment.

4.1.2. *Neoglboquadrna pachyderma Zone*:

Definetion: Interval from last occurrence of *Globigerinoides extremus* to first occurrence of *Globorotalia truncatulinoides excelsa*. It is present the study well except P1 and K1 wells with maximum thickness in N1 well where it reaches 317 feet and with minimum thickness in N1 well (58 feet). It associated With *Hyalina balthica, Bulimina marginata, Cibicidoides robertsonianus, Uvigerina pergerina, Sphaeroidina bulloides, Globorotalia inflata, Neogloboquadrina pachyderma, Globigerinoides ruber.*

4.2. Late Pliocene (*Globorotalia inflata Zone*):

Definetion: Interval from the first occurrence of *Globorotalia inflata* to the last occurrence of *Globigerinoides extremus*.

The Pliocene is characterized by the lithology described above: clay, marl with sand inclusions except K1 well, which cosists of quartzose sand, fine to very fine grained angular to subrounded, sometimes with clay interbeds.

This interval is mainly associated with high frequency of shallow organisms such as: *Gastropoda, Pelecypoda, Bryozoa, Echinoidea fragments, Ammonia, Elphidium, Miliolidae and Textularia*.

The shaly-marly facies is characterized by high frequency of deep-water taxa, such as: *Flourilus boueanum, Melonis padanum, Cibicides lobatulus, Heterolepa floridana, Marginulina costata and Globorotalia inflata*.

4. 3. Middle Pliocene (*globorotalia crassaformis group Zone*)

Definetion:

Interval from the first occurrence of *Globorotalia aemiliana* to last occurrence of *globorotalia crassaformis*.

The lithology of this interval mainly consists of clay, marl and shaly marl in all the wells, except in K1 well, where the uppermost part of this zone consists of sandy facies. This Zone is characterized by Bulimina minima,Cibicidoides robertsonianus, Anomalinoids helicinus, Sphaerodina bulloides, Neoeponides schreibersii, Marginulina costata, Bulimina placentina, Brizalina dilatata, Planulina arimnensis, Melonis padanum, Cassidulina carinata-neocarinata group, Pullenia bulloides, Heterolepa floidana, Globorotalia crassaformis, Globorotalia aemiliana, Neogloboquadrina humerosa, Glbigerina bulloides, globigerina druryi group, Globigerinoides extremus, Globigerinoides ruber and Sphaeroidinellopsis spp.

4. 4. Early Pliocene :

This interval includes most of the Pliocene stage and it consist of clay, marl and sandy shale all over the study area. It includes four zones as follows:

- *Globorotalia bononiesis Zone.*
- *Globorotalia puncticulata Zone.*
- *Globorotalia margaritae Zone.*
- *Sphaeroidinellopsis spp. acme Zone.*

Globorotalia bononiesis Zone :

Definetion: Interval from the last occurrence of *Globorotalia puncticulata* to the first occurrence of *Globorotalia aemiliana*.

This Zone is clearly recognized in R1, L1, F1,N1 and G1 wells, but it is not defined in P1 and K1 wells where the lower boundary has not been identified because of the lack of the zonal markers.

It seems clear that the *globorotalia bnoniesis* is an ecologically controlled species.

This Zone is associated with *Heterolepa bellincionii, Heterolepa floridana, Cibcidoides pseudoungerianus, Cibcidoides ungerianus, Cibcidoides robertsonianus, Eponides schreibersii, Anomalinoides helicinus, Sphaeroidina bulloides, Pullenia bulloides, Brizalina punctata, Bolivina placentina, Bulimina minima, Uvigerina peregerina group, Uvigerina rutila, Marginulina costata, Melonis soldanii, Melonis padanum, Hopkinsina bononiesis, Globorotalia bononiesis, Neogloboquaderina pachyderma, Globorotalia padana, Globorotalia acostaennsis, Globigerina bulloides, Globigerina druryi group, Globigerinoides ruber, Globigerinoides extremus ,Globigerinoides elongates, Globigerinoides sacculifer and Sphaeroidinellopsis seminulina.*

Globorotalia puncticulata Zone:

Definetion: Interval from the first occurrence of *Globorotalia puncticulata* to the last occurrence of *Globorotalia puncticulata* and the first occurrence of *Globorotalia bononiensis.*

This Zone represents a wide range, if compared to other Pliocene zones. It does not seem to be affected by environmental conditions, so it is good marker for world-wide correlations. It is distributed all over the study area, but with different thicknesses. It is associated with *Uvigerina rutila, Cibcidoides robertsonianus,Eponides schreibersii, Melonis padanuminm, Sphaeroidinellopsis seminulina Globigerinoides ruber, Globigerinoides extremus ,Globigerinoides elongates, Globigerinoides helicinus, Globigerinoides,Cibcidoides robertsonianus, Globigerinoides sacculifer, Globigerinoides trilobus, Globigerinoides bolli, Sphaeroidinellopsis seminulina, Sphaeroidinellopsis dehiscens, Sphaeroidinellopsis subdehiscens.*

Eponides schreibersii,Melonis padanum, Bulimina costata, Bulimina minima, Planulina ariminensis, Hopkinsina bononiesis,Anomalinoides helicinus,Globorotalia puncticulata, Globorotalia acostaensis, Globorotalia margaritae, Globorotalia scitula (which is indicative of a deep water environment)*, Globigerina druryi group.*

***Globorotalia margaritae Zone**:*

Definetion: Interval from the end of *Sphaeroidinellopsis spp. Acme* Zone to the first occurrence of *Globorotalia puncticulata*.

This Zone can be well correlated among the wells located in the eastern side of the study area where both upper and lower boundaries are present (R1, L1, F1, and N1 wells, see figure 1).

On the contrary, in the western side the quality of the correlation is less significant because of the relative scarcity of the zonal markers and because of a partial lack of the *Globorotalia puncticulata Zone*, together with the complete lack of the *Globorotalia margaritae Zone.*

The association of the *Globorotalia margaritae Zone* includes: *Uvigerina rutila, Cibicidoides robertsonianus, Anomalinoides helicinus, Bulimina placentina, Planulina ariminensis, Hoeglundina elegans, Melonis padanum, Melonis soldani, Globicassidulina subglobosa, Oridorsalis ubonatus, Brizalina dilatata group, Anomalinoides ornatus,*

Globorotalia margaritae, Globorotalia acostaensis,

Globigerina bulloides, Globigerina druryi group, Sphaeroidinellopsis seminulina, Sphaeroidinellopsis dehiscens, Sphaeroidinellopsis subdehiscens. Globigerinoides ruber, Globigerinoides extremus Globigerinoides bolli, ,Cibcidoides, Globigerinoides elongates, Globigerinoides helicinus.

Sphaeroidinellopsis spp Acme Zone:

Definetion: Interval from the initial acme of the *Sphaeroidinellopsis spp Acme* to the end of the *Sphaeroidinellopsis spp Acme*.

This zone is distribution in the part of the area, in R1,L1,F1 and N1 with remarkable thickness while it is thinning out toward the western part of the study area. It is missing in G1,P1 and K1 wells as a result of the emergence of the area.

This zone is associated with *Heterlopa bellincionii, Heterlopa floridana, Bulimina costata, Uvigerina rutila, Uvigerina pergerina group, Planulina ariminensis, Anomalinoides helicinus, Marginulina costata, Florilus boueanum, Melonis padanum, Melonis soldani, Cibicidoides robertsonianus, Cibicidoides pachyderma, Cibicides lobatulus, Hoeglundina elegans, Oridorsalis umbonatus,Cassidulina carinata-neocarinata group, Globigernoides elongates, Globigernoides bollii, Globigernoides helicinus, Sphaeroidinellopsis seminulina, Sphaeroidinellopsis subdehiscens, Sphaeroidinellopsis dehiscens* (all the *Sphaeroidinellopsis spp* are abundant).

5. Discussion and Conclusion

The main results achieved by this study are:

1. The lithostratigaphic sequence is quite homogeneous all over the study area, mostly belonging to Oued Bel Khdim and Raf-Raf Formations. The only one exception represented by the uppermost part of the K1 well, where asandy facies was recorded. This interval can be attributed to any described unit.

   The earliest Pliocene marine invasion covered a Messinian substratum quite heterogeneous. Evaporitic deposits are present in R1, G1, P1, and K1 wells, while in L1, F1 and N1 wells a sandy/shaly facies has been recovered.

2. Pliocene Paleobathymetric Evolution of the area can be summarized into three parts:

The Earliest Pliocene marine succession of the study area found a topographic surface quite heterogeneous. Remarkable difference were between eastern and western parts. Toward the eastern area the transsgretion occurred very early (*Sphaeroidinellopsis spp Acme Zone*). While to the western area, which was a topographical high (wells G1, P1 and K1), the basal transsegretion took place during the part of the *Globorotalia puncticulata Zone*. Therfore during the *Sphaeroidinellopsis spp Acme Zone, Globorotalia margaritae Zone*, the western part was emerged. In the eastern area the transgression seems to be very sharp. In fact, epibathyal conditions were established since the beginning of the Pliocene sedimentation(figure 4).

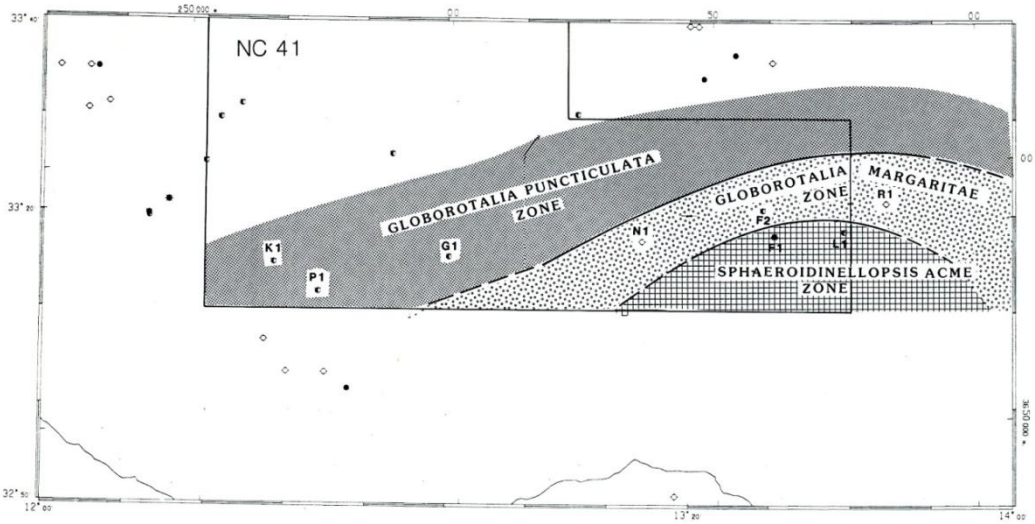


figure 4 Zones Distribution of Early Pliocene in the study area

The Pliocene-Early Pleistocene boundary has been established by a number of markers, such as: the first occurrence of the *Globigerina cariacoensis* and last occurrence of the *Globigerinoides extremus*. Biostratigraphic analysis led to identification of all the Pliocene and Early Pleistocene Zones according to the biostratigraphic

scheme proposed by Agip (1985) for the Mediterranean area (table 1 and 2)

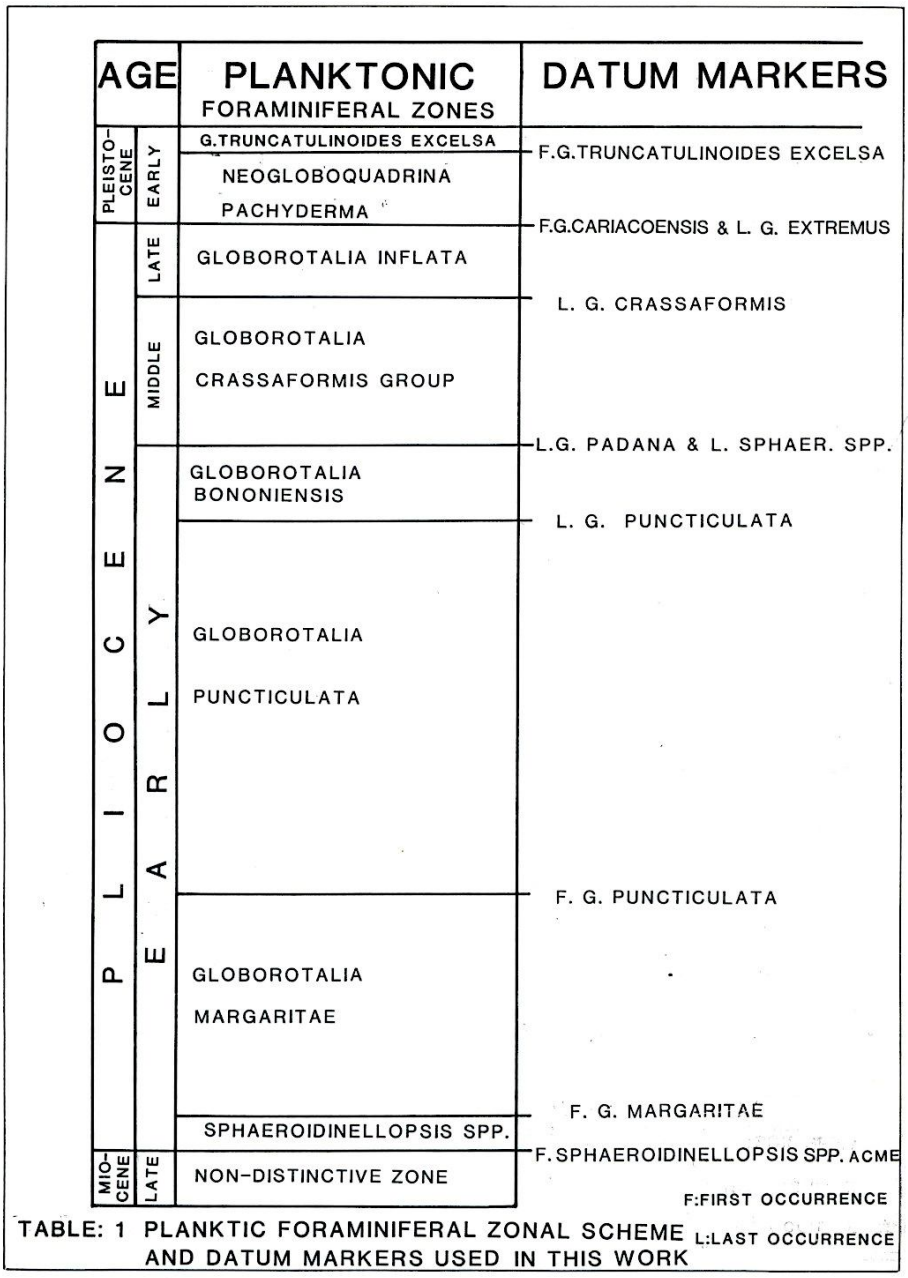


TABLE: 1 PLANKTIC FORAMINIFERAL ZONAL SCHEME AND DATUM MARKERS USED IN THIS WORK

Age		Agip, 1985 and this study			Iaccarino , 1985
Pleisto.	Early	G.truncat. excelsa	Pleisto.	Early	G.truncatulinoides excelsa
		Neoglob. pachyderma			Globigerina cariacoensis
Pliocene	Late	Globorotalia inflata	Pliocene	Late	Globorotalia inflata
	Middle	G.crassaformis group			Globorotalia aemiliana
	Early	G.bononiensis			Globorotalia puncticulata
		G.puncticulata		Early	G.puncticulata-G.margaritae
		G.margaritae			G.margaritae
		Sphae. Spp. acme			Sphae. seminulina Zone
Miocene	Messinian	Non-distinctive Zone	Miocene	Messinian	Non-distinctive Zone

Table 2. Correlation Between two Mediterranean Zonal Schemes

3. In the study area the Lowest Pliocene transgression is diachronous. In fact, from east to west the width of the Messinian/Pliocene hiatus increases. The southeastern side of the NC-41 Concession (wells R1, L1, F1 and N1) has a complete lower Pliocene zonal succession. On the contrary, in the southwestern side (wells G1, P1, and K1) the Pliocene succession started with the upper part of the *Globorotalia puncticulata Zone*. During most of the Early Pliocene that part of the study area was therefore emerged. In well P1-NC41 the top of the *Globorotalia margaritae* has been recovered from the basal beds of the Raf-Raf Formation (= base of the Pliocene succession). Absolute age for the last occurrence of the above mentioned taxon is 3.2 million years approximate the Lower Pliocene transgressive event in the western part of the study area.

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