Planktonic Foraminiferal Biostratigrahy of the Oligocene-Pliocene Succession in the Offshore Well A1-89, Sirt Basin, Libya

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This Thesis was Submitted in Partial Fulfillment of the Requirements for Master's Degree of Science in Science in Geology

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بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

(إِنَّ فِي خَلْقِ السَّمواتِ والأَرضِ واختلافِ اللَّيلِ والنَّهارِ لآياتٍ لأولي الألباب الَّذين يَذْكُرون اللهَ قياماً وقعوداً وعلى جُنوبهم ويتفكَّرون في خَلْقِ السَّمواتِ والأَرضِ ربَّنا ما خلَقْت هذا باطلاً سبحانَك فَقِنا عذابَ النَّار)

إهداء

إلي أبي وأمي واخوتي الاعزاء علي قلبي (انس وعبدالله وحمزه) إلي أختي العزيزه إلي كل أعمامي وأخوالي عرفانا بفضلهم وعطائهم ودعمهم اللامحدود.

الي كل أصدقائي وأحبائي وزملائي وفاء واعتزازا.

الي كل أساتذتي الافاضل تقديرا واحتراما.

أهديكم هذا العمل

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ABSTRACT

The present study deals with Oligocene-Pliocene planktonic foraminiferal biostratigraphy of the studied succession at Well-A1-89 in the offshore of Sirt Basin. One hundred and forty one ditch cutting samples have been used for this study, covering the interval from 1050' – 9000'. The examination of the studied samples has led to the identification of fifty-one species and eleven subspecies belong to twelve genera. On the basis of the vertical stratigraphic distribution of the planktonic foraminiferal species, with particular attention to last occurrence (LO) of the marker species, ten planktonic foraminiferal biozones have been identified through the studied succession following Bolli and Saunders (1985) and Iaccarino (1985) zonal schemes, in descending order as follows: *Sphaeroidinellopsis seminulina s.l* (Zanclean); *Praeorbulina glomerosa* (Langhian); *Globigerinoides trilobus* (Burdigalian); *Catapsydrax dissimlis* (Aquitanian-Burdigalian); *Globigerinoides primordius* (Aquitanian); *Globorotalia kugleri* (Chattian); *Globigerina ciperoensis ciperoensis* (Chattian); *Globorotalia opima opima* (Chattian); *Globigerina ampliapertura* (Rupelian); *Cassigerinella chipolensis/ Pseudohastegrina micra* (Rupelian). The Oligocene–Miocene (O/M) boundary is found to be conformable and is placed at the top of the *Globorotalia kugleri* Biozone. However, the Miocene/Pliocene (M/P) boundary is unconformable and is placed at the top of *Praeorbulina glomerosa* Biozone. Additionally, the established biozones have been regionally correlated with their equivalents in Tunisia and Egypt.

CHAPTER ONE
INTRODUCTION

1. 1 General

The Foraminifera are unicellular free living, marine organisms, with an external calcareous shell, or test and represent an important order of single celled protozoa (i.e the first animals) (Boudagher-Fadel, 2015). Their distribution is global, they inhabit all marine environments, and they have a continuous fossil record from the Cambrian to the present day and has reached its acme during the Cenozoic (Milsom and Rigby, 2004). The structure and composition of the test wall is important to classify the foraminifera, in which they divided to five suborder, Organic-walled forms belong to the suborder Allogromiina. The suborder Textulariina encompasses forms with agglutinated tests. Porcelaneous imperforate tests are characteristic of the suborder Miliolina. Tests of the suborder Fusulinina are Calcareous microgranular. The last suborder is Rotalina characterized by calcareous hyaline wall (Armstrong and Braiser, 2005). Most of the previous suborders have a benthonic mode of life (live on the sea floor) and vary in size from less than 100 μm in diameter to a many centimeters, with wall composition may be agglutinated (quartz or other inorganic particles being stuck together by calcitic or organic cements), or may be primarily secreted and composed of calcite or aragonite. The only exception is belong to latter suborder (Rotalina), which is subdivided according to (Loeblich and Tappan, 1964) into twelve superfamiles, amongst them a single superfamily known as Globigerinicea characterized by its plankton mode of life (i.e. planktonic foraminifera). This mode of life is suggested by thin shelled or inflated globular champers and is confirmed by the presence of same genera in modern planktonic assemblages (Stainforth *et al*., 1975). Planktonic foraminifera have tests that are made of relatively globular chambers (buoyancy tool) composed of secreted calcium carbonate and hyaline radial wall type (Armstrong and Braiser, 2005). They float freely in the upper water of the world's oceans, with species not exceeding 600 μm in diameter (Boudagher-Fadel, 2015). Planktonic foraminifera have undergone significant evolution since their first development from benthic forms in the Late Triassic or Jurassic (Fig. 1.1).

The planktonic foraminifera are considered ideal index fossils due to their small size, rapid evolution, cosmopolitan distribution and their great abundance in several marine rocks, in addition to their distinctive ornamentation, which make them excellent biostratigraphic tool. Therefore their study is essential for the exploitation of economically vital deposits of oil and gas. They play an important role to overcome the problems, which appear during oil exploration and widely used in oil industry for precise dating, well to well correlations and sedimentary basin analysis in order to facilitate interpretation and prediction of important structures (eg. Faults, Anticlines folds….etc.) and location of oil accumulations. They are also involved in paleoenvironmental, paleobathemetry, palaeoclimatic and palaeoceanographic analysis (Milsom and Rigby, 2004). There are several published studies interested in planktonic foraminiferal biostratigrahy in the onshore of Sirt Basin and most of them focus on the older intervals (Cretaceous and Early Paleogene), and this is probably due to their containment of most of the oil accumulations, which prompted many researchers and oil companies to study them in detail. On the contrary, the planktonic foraminiferal biostratigrahic studies in the offshore are limited in general, especially those concerning with Oligocene-Pliocene interval. Therefore, the present study is primarily concern with an analysis of Oligocene-Pliocene planktonic foraminifera retrieved from the studied succession at Well-A1-89 in the offshore of Sirt Basin. The recovery of many well-preserved planktonic foraminiferal species from the studied ditch cutting samples provides an excellent basis for the taxonomy and biostratigraphy. The objectives of the present study can be summarized as follows:

1) Identifying and Classifying the most important planktonic foraminifers from the penetrated Oligocene-Pliocene successions of Well Al-89.
2) Establishing the planktonic foraminiferal biozones following Bolli and Saunders (1985) and Iaccarino (1985) zonal schemes.
3) Delineate the Oligocene-Miocene and Miocene-Pliocene boundaries in the studied interval by using the resulting biozones.
4) Correlating the established biozones with the neighbor countries (Tunisia and Egypt) to follow their spatial distribution.

To achieve these objectives the offshore Well A1-89 was chosen for this study because of the following: firstly its highly recommended by exploration division management of Arabian Gulf Oil Company (AGOCO). Secondary its location in the offshore of Sirt Basin, where the Oligocene-Pliocene biostratigraphic studies are very limited. Third the Well A1-89 penetrate probably the thickest Oligocene-Pliocene deep marine sediments in the whole area with lithology's suitable to preserve foraminifera, which offer a better chance to find a complete section for the study.

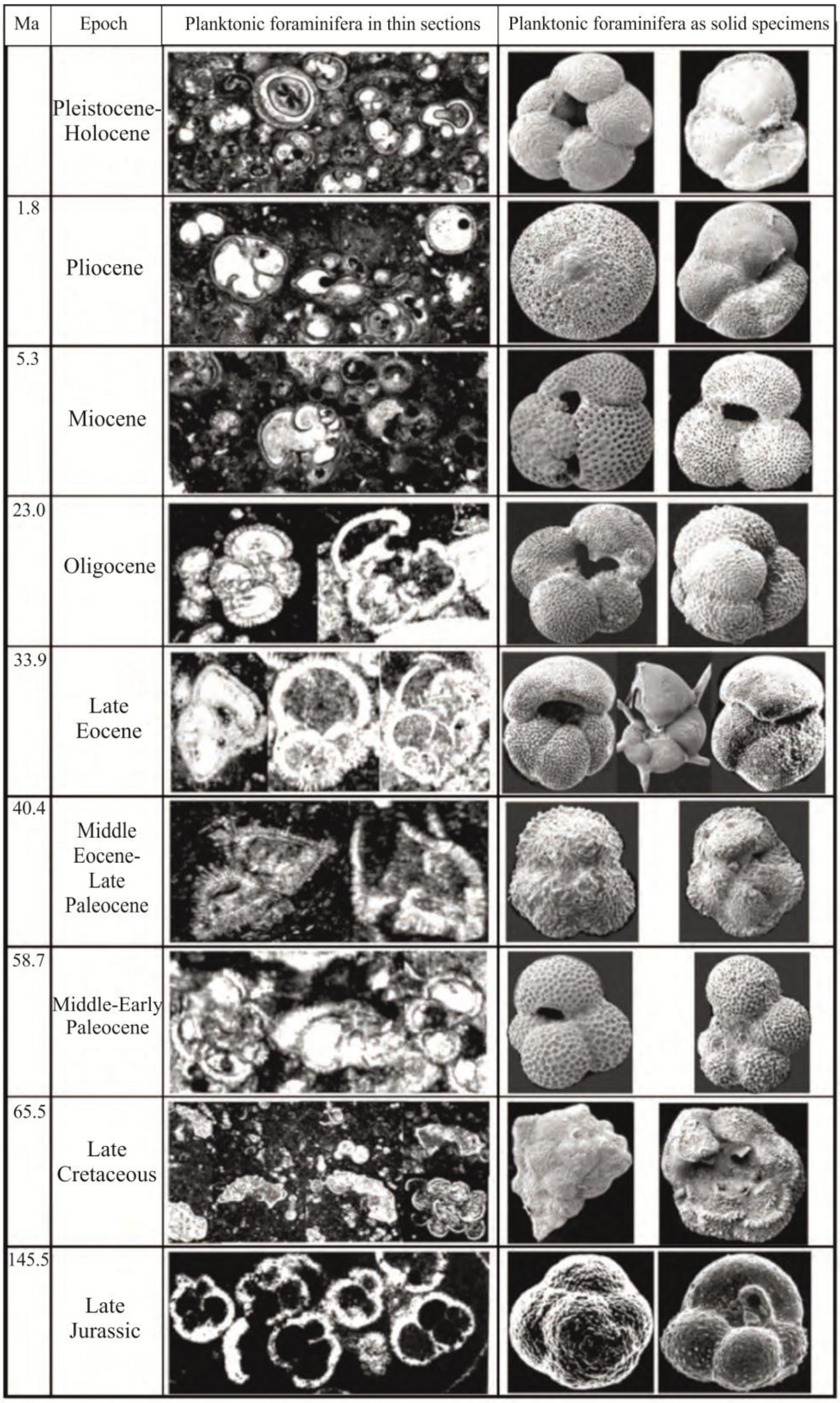

Fig. 1.1 The evolution of main planktonic foraminiferal assemblages through the geological time (Boudagher-Fadel, 2015).

1.2 Location of the Studied Well A1-89

The offshore Well A1-89 is an exploratory well was drilled in 1966 by Libyan-Atlantic company in the western offshore of Cyrenaica, about 120km southwest Benghazi city. The studied Well A1-89 is tectonically situated at Sirt Basin area, near the center of offshore part of Ajdabiyah Trough, and exactly located at the geographic coordinates (Lat. 31° 06' 22"N, Long. 19° 50' 01.00"E) as shown in (Fig. 1.2).

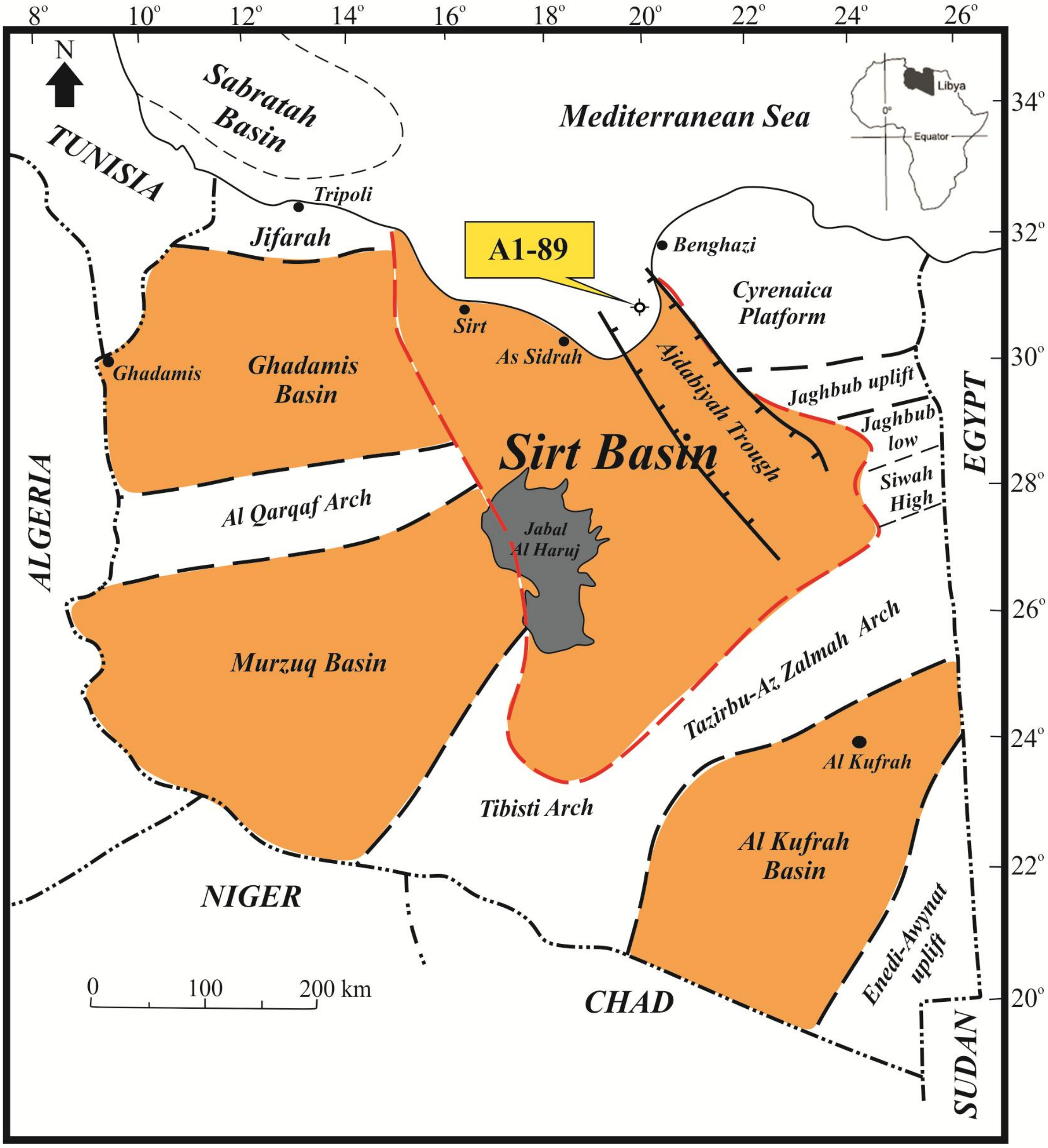

Fig. 1.2 Location map of the studied Well A1-89 in offshore Sirt Basin, Libya (Tmalla, 1996).

1.3 Geologic Setting of Sirt Basin

The Sirt Basin is the most important petroleum province in north Africa and one of the most important worldwide, with estimated reserves in excess of 45 billion BOE (Selley, 1997; MacGregor and Moody, 1998). The Sirt Basin representing the youngest sedimentary basin in Libya and covers an area of 600,000 km^2 in central part of Libya and consists of a system of horsts and grabens, which extend from Hun Graben in the west to Cyrenaica platform in the east. The Sirt Basin structures (i.e. horsts and grabens) are obscured by a thick sedimentary cover, which is almost entirely Mesozoic and Tertiary in age with a total thickness of over 23,000 ft in troughs. (Hallett and Clark-Lowes, 2016). The Sirt Basin is located along the north African continental margin and bounded by Gulf of Sirt along the Mediterranean coast and extend to beyond Lat. 26^o N south, and bordered by a group of tectonic and geographic boundaries; to the north by Mediterranean sea, to northeast by the Cyrenaica Platform, to the southeast by the Tazirbu- Az Zalmah Arch, to the south by the Tibisti Arch, and to the west by the western Tibisti spur and the Al Qarqaf Arch. (Hallett, 2002).

1.3.1 Tectonic

The Sirt Basin is considered to be a holotype of a continental rift (extensional) area and is referred to as part of the Tethyan rift system (Ahlbrandt, 2002). It reflects significant rifting in the Early Cretaceous and syn-rift sedimentary filling from Cretaceous to Eocene, and post-rift deposition in the Oligocene-Miocene periods (Ahlbrandt, 2002 and Abadi *et al*., 2008). Selley (1968) reported that the Sirt Basin developed at the end of the Cretaceous, but began to form in the Late Jurassic-Early Cretaceous. According to Goudarzi (1980), the Sirt Basin generally remained a positive element until nearly the end of Cretaceous at which time movement and block faulting took place. Then the Sirt Basin was generally submerged probably for the first time since the Early Paleozoic area. The period of the Late Mesozoic-Early Cenozoic appears to have been relatively active tectonically and sedimentologically (Sinha and Mriheel, 1996). According to Hallett and Clark-Lowes (2016) the main episode of rifting occurred in the Late Cretaceous and was essentially completed by the end of the Cretaceous and this lead to the fragmentation of the basin into a series of E-W structural highs and troughs, which stretches 600km from Hun Graben in the west to Cyrenaica Platform in the east (Fig. 1.3 and 1.4). Thereafter the basin developed as a sag basin with its axis in the Ajdabiyah Trough, which is the deepest trough in the Sirt Basin characterized by NW-SE trending structures and represents the axis of the Tertiary post-rift sag basin which has developed continuously since the end of the Cretaceous and is still subsiding until the present time (Hallett and Clark-Lowes, 2016). It extends for 300 km from the Kalanshiyu area to the coastline, and continues into the offshore where it is known as the Sirt Trough. It contains a Late Cretaceous and a thick Paleogene/Neogene rocks exceeds 14,000ft at the center as in the Well A1-88 and Well A1-89 (Fig. 1.5). The trough is flanked to the west by the Zaltan Platform and to the east by the Cyrenaica Platform, Amal Ridge, Jalu High and the Messlah High. To the north-east it passes into the Ash Shulaydimah Trough, a reentrant to the south of the Al Jabal al Akhdar Uplift (Hallett and Clark-Lowes, 2016).

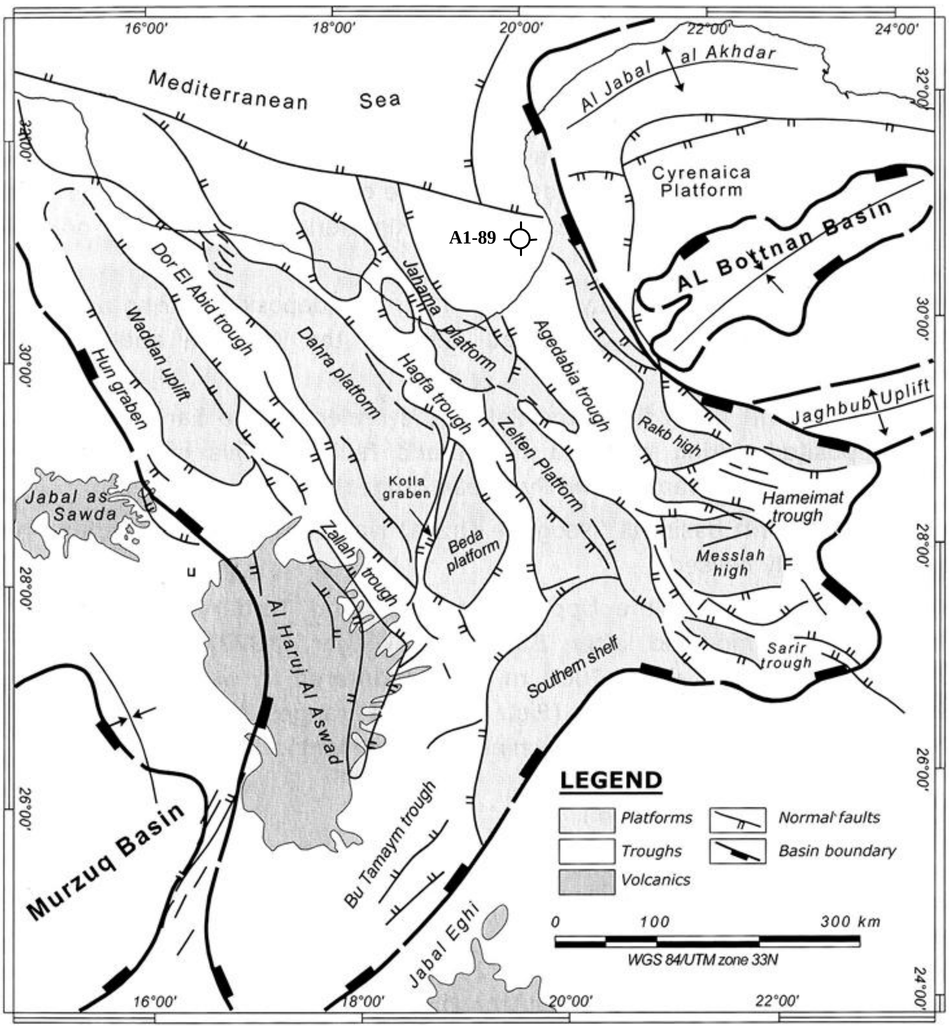

Fig. 1.3 Structural map shows the tectonic framework of Sirt Basin complex (Abadi, 2002).

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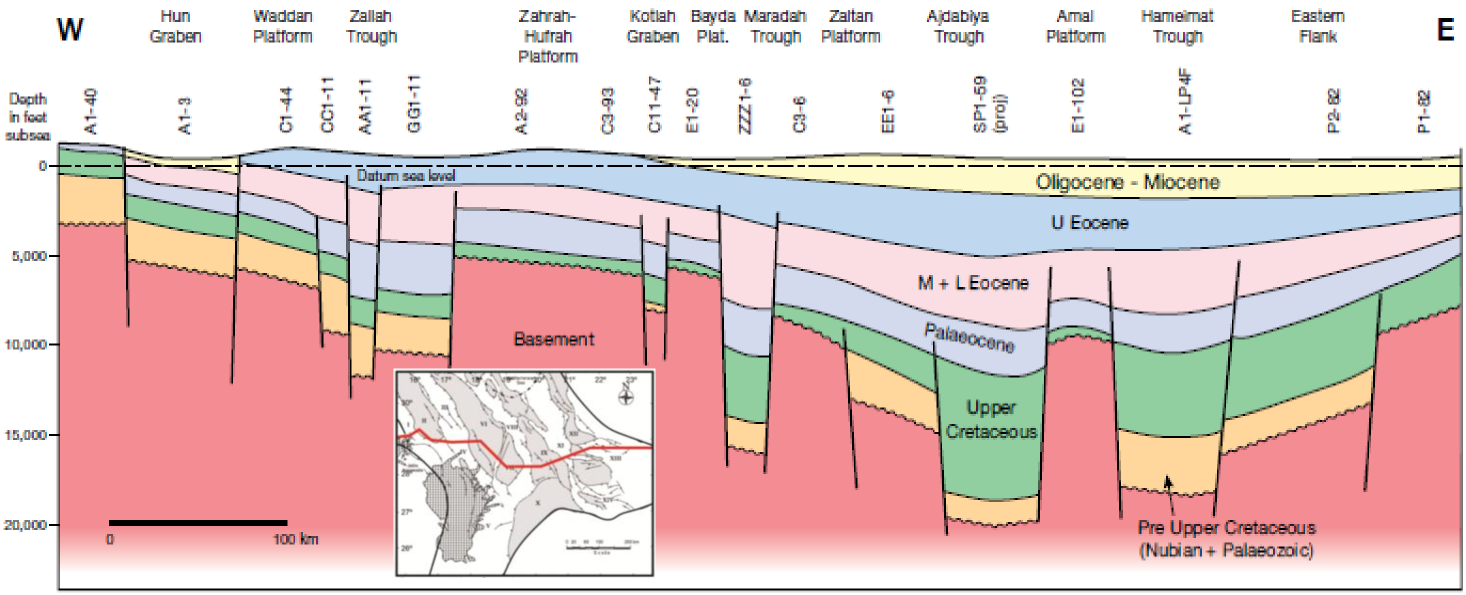

Fig. 1.4 Sirt Basin W–E regional cross section (Hallett and Clark-Lowes, 2016).

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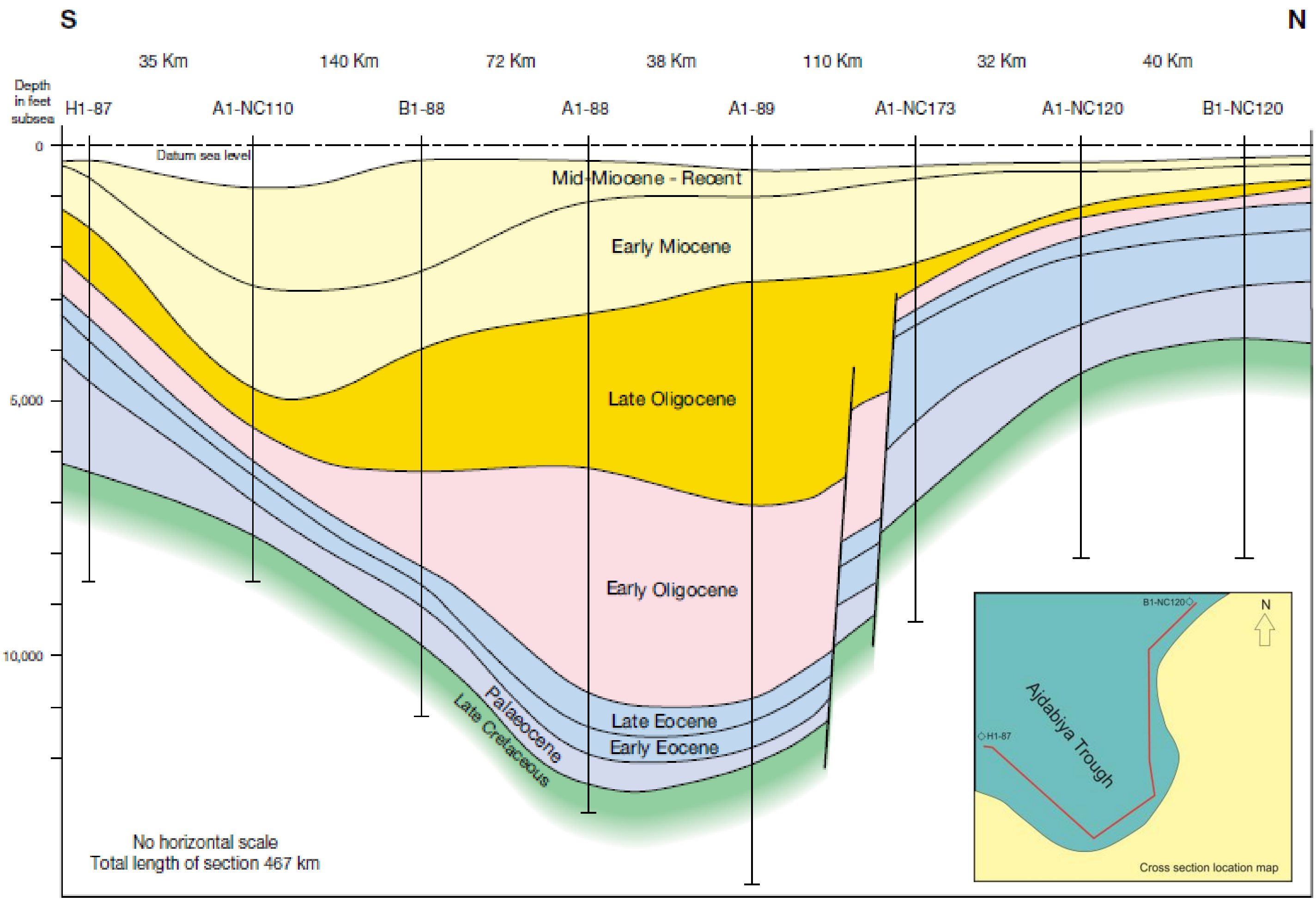

Fig. 1.5 Offshore Ajdabiyah Trough cross section (Hallett and Clark-Lowes, 2016).

1.3.2 General Stratigraphy

The sedimentary rocks of this basin range in age from Cambro-Ordovician to recent (Sinha and Mriheel, 1996 and Abouessa, *et al.*, 2012). The Early Paleozoic history of the basin reflects a relatively undisturbed intracratonic sag basin (Bellini and Massa, 1980) as part of the Gondwana continent. Cambro-Ordovician siliciclastic sedimentary rocks are only locally preserved. (El-Hawat *et al*., 1996). These rocks occur today as erosional remnants occupying some parts of the basin floor. Rocks of Silurian- Devonian age are known only from few localities in the basin. Furthermore, there are no reports as yet of rocks of Carboniferous- Permian age (Sinha and Mriheel, 1996). Devonian to Triassic rocks are evident in some parts of the basin (Tawadros, 2001). The area was probably positive during these periods, attributed to the Hercynian Orogeny (Conant and Goudarzi, 1967). Jurassic to Lower Cretaceous sandstones known Nubian Sandstones uncomformably overlies Lower Paleozoic rocks (Abouessa, *et al.*, 2012).

Sediments of Upper Cretaceous to Upper Miocene age include marine carbonates, evaporites and shales, and paralic non-marine sandstones and shales (Selley, 1968 and Sinha and Mriheel, 1996).

The Sirt Basin is divided into three lithostratigraphic sequences by Saheel, *et al*., (2010) as shown in Figure (1.6)

The first sequence (pre-rift): The Cambro - Ordovician sediments is represented by Hofra (Gargaf) Formation which consisted of continental sandstone, conglomerate and shale beds (Goudarzi, 1970; Barr and Weegar, 1972). The Gargaf Formation bounded by two unconformable boundaries, the upper boundary with Bahi Formation or Sarrir (Nubian) Formation and the lower boundary with Basement igneous rocks (Fig. 1.5) (Saheel, *et al*., 2010).

The second sequence (syn-rift): This sequence is represented by the Upper Cretaceous– Upper Eocene sediments (basin fill stage). These sediments were mainly marine in origin of different depositional settings as a result of fluctuation in sea level during Late Cretaceous to Late Eocene timess. The Cretaceous sediments unconformably overlain by the Hofra Formation. These sediments (Fig. 1.5) are ordered from bottom to top are represented by Sarir, Bahi, Maragh, Lidam, Etel, Argub, Rachmat, Tagrifat, Sirte, Kalash, Satal, Waha, Hagfa, Beda, Khalifa, Zelten, Harash, Kheir, Al Gir, Gialo and Aujilah formations, (Barr and Weegar, 1972; Saheel, *et al*., 2010).

The third sequence (post-rift) This sequence is represented by the Oligocene - Miocene sediments which are made of mainly shallow marine carbonates of (tidal to supra-tidal environment) as result of regional lowering in the sea level (regression). These sediments are represented by Arida, Diba and Marada formations, (Fig. 1.6) (Barr and Weegar, 1972; Saheel, *et al*., 2010).

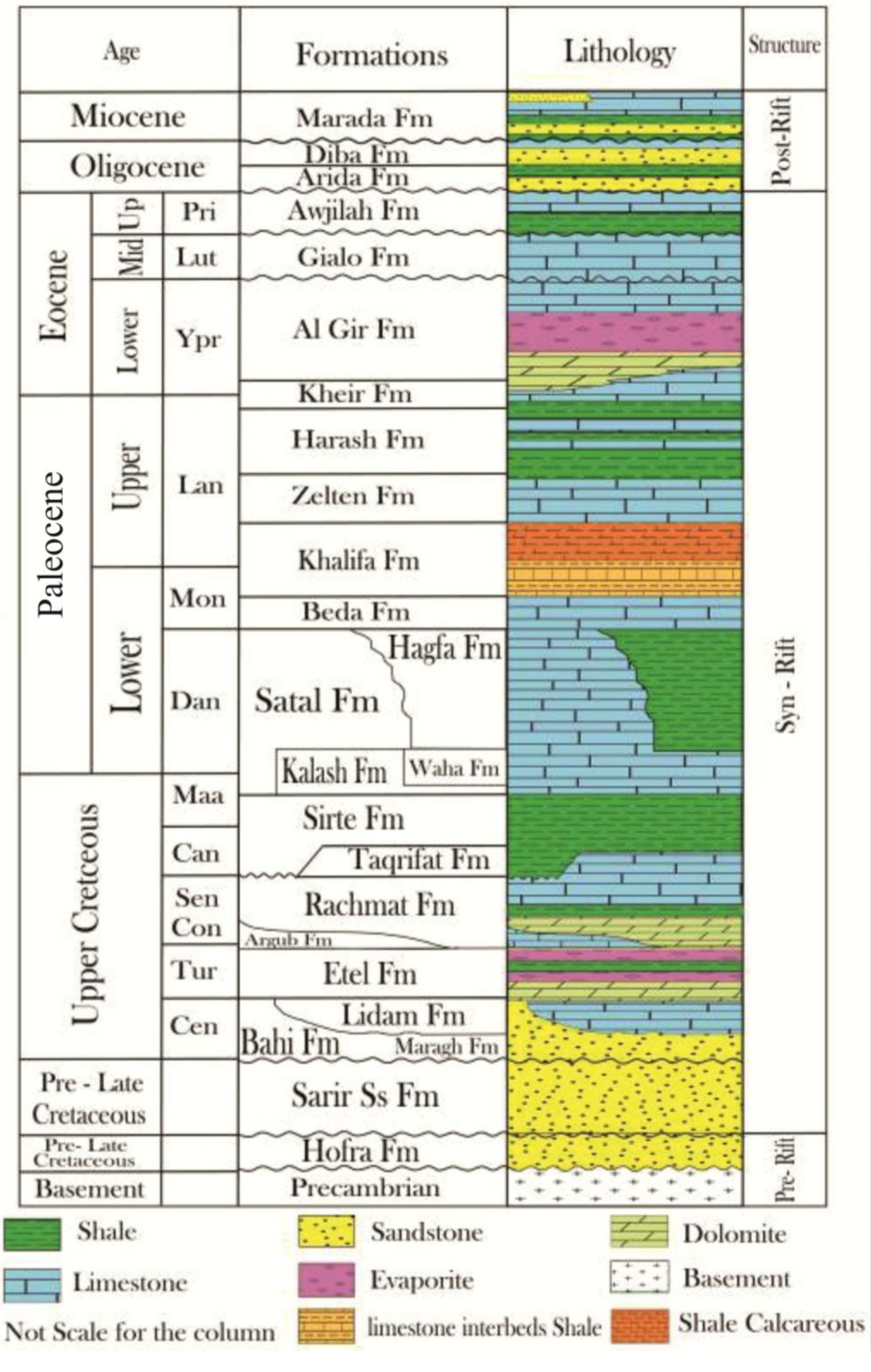

Fig. 1.6 General stratigraphic section of Sirt Basin (Saheel, *et al*., 2010).

1.4 Previous Works

In Sirt Basin various geological studies have been carried out for different purposes by many researchers over the last century due to its economic oil potentialities. Most of these studies focus on the lithostratigraphy, subsidence history and tectonic framework of the basin. This study will focus on the study of foraminifera from the Oligocene - Pliocene sediments in Sirt Basin. The published papers on foraminifers in Sirt Basin are few in comparison with other geologic studies, and unfortunately most of these studies focus on the older rocks (Late Cretaceous and Early Paleogene) because of it is economic importance. However, the following is a summary of some foraminifera studies in Sirt Basin, which is interconnected with the purpose of the thesis:

Berggren (1969) studied the Biostratigraphy and planktonic foraminiferal zonation of the Tertiary System of the Sirt Basin of Libya and within his conclusions he found that planktonic foraminiferal zones which have been established in the Caribbean region (Bolli, 1957a, b, c; Blow, 1959) can be recognized and applied in the Sirt Basin with some modifications, also he founds that the Oligo-Miocene benthic foraminifers of the Sirt Basin contain strong affinities withn those described from the Oligo-Miocene of Italy, the Aquitaine Basin and the Caribbean area, particularly the well-documented Dominican Republic and Trinidad sections. The foraminifers of the younger part of the Miocene (post-*Orbulina*-datum) contain strong affinities with those found in the basins of northern Italy and the Vienna Basin.

Berggren (1974) studied the Paleocene benthonic foraminiferal biostratigraphy, biogeography and paleoecology of Libya and Mali and concluded that the foraminiferal assemblages in Mali are dominated by shallow-water cibicidids, rotaliids, Rosalina, nonionids, Elphidiella, and various larger foraminifera, while planktonic foraminifera are rare or absent. The foraminiferal assemblages in Libya are developed in two lithotopes, one similar to that in Mali and containing numerous elements in common, the other, developed in a deeper-water basinal shale environment, containing a "Midway" type of fauna, together with planktonic foraminifera. Vertical and horizontal relationships between benthonic assemblages in the Sirte Basin are shown and paleoenvironmental reconstructions are made at approximately 2-million-year intervals. The Paleocene of Mali was deposited in a broad, shallow shelf sea at water depths probably less than 50 m. The Paleocene of the Sirte Basin of Libya was deposited in a transgressive sequence characterized by basin infilling at maximum depths somewhat in excess of 200 meters.

Eliagoubi and Powell (1980) studied the biostratigraphy and paleoenvironment of Upper Cretaceous (Maastrichtian) foraminifera of northcentral and northwestern Libya and they reported twenty-six cosmopolitan planktonic and benthic genera and three, more restricted genera *(Omphalocyclus, siderolites* and *Siphogenerinoids)* and proposed two assemblage zones, The Zone of *Globotruncana fornicata* and the younger Zone of *Globotruncana conica*. Also they Suggested paleoenvirnments for the lower Maastrichtian limy sequence (Waha and Kalash limestones) as shallow shelf and possible offshore carbonate banks and for the upper argillaceous beds (lower Tar Marl) outer shelf-middle slope environment.

Muftah (1991) used the foraminifera to study the biostratigraphy and paleoenvironment of the Upper Cretaceous and Lower Tertiary sequence of the Well A1-41 in Sirt Basin, and he identify about one hundred and forty two foraminifera species throughout a sequence from Late Cretaceous to Middle Miocene and reported about fifteen planktonic foraminifera biozones, which correlated with the zonal schemes of Bolli *et al*., (1989) and Blow (1969) with a possible hiatus at Cretaceous/ Tertiary boundary due to the absence of the diagnostic Maastrichtian and Campenian species. Paleoenvironmentally he used the P/B ratio and the assemblage characterization to deduce the environment of deposition and he suggested a range of environments from very shallow lagoonal environment and open marine, in addition to lower bathyal for sediment deposited at the K/T boundary.

Barbieri (1994) used planktonic and benthic foraminifers as a tool in determining biostratigraphy and palaeoecologic setting in the Sirt Shale (Late Campanian-Early Mastrichtian) transegresive succession of the Hameimat Basin and he suggested a depth stratification of the planktonic taxa, with intermediate (epi- to mesopelagic) water exchange with the main Sirt Basin from the latest Campanian.

Muftah (1996) studied the Agglutinated Foraminifera from Danian sediments of the northeastern Sirt Basin and reported for the first time Twenty-two species assigned to sixteen genera of flysch-type cosmopolitan agglutinated foraminifera, associated with radiolarian and concluded that the studied Danian deposits were deposited in a poorly-oxygenated environment at upper to lower bathyal depths. Duronio (1996) defined a new species *Nummulites jamahiriae* n. sp. from the Sirt Basin and reported the occurrence of *Nummulites jamahiriae*, is associated with *Nummulites vascus*, *Globorotalia opima* and *Turborotalia ampliapertura*. This association characterizes the Early and Middle parts of the Oligocene age.

Ashour (1996) analysed the Campanian–Maastrichtian strata in some wells in Sirt Basin using foraminiers and established four biostratigraphic zones, they are from the base upwards the Campanian *Globotruncanella havanensis* Zone; The early Maastrichtian *Globotruncana fornicata fornicata* Zone; The middle Maastrichtian *Globotruncana gansseri gansseri* Zone; The late Maastrichtian *Abathomphalus mayaroensis* Zone. The analysis of the foraminiferal species indicates deep marine, lower shelf, middle shelf and outer shelf palacoenvironments associated with the deposition of the Campanian-Maastrichtian strata.

Barbieri (1996) studied the micropaleontology of the Rakab Group (Cenomanian to early Maastrichtian) in the Hameimat Basin, northern Libya, and observed the lack of uniformity in microfaunal record due to prevailing shallow marine environment of deposition throughout the studied successions. Tmalla (1996) studied the Late Maastrichtian and Paleocene planktonic foraminiferal biostratigraphy of well A1a-NC29A, northern Sirt Basin and he proposed a new biozones, which are *Eoglobigerina minutula* Zone, *E. fringa* Zone, *E. edita* Zone, *Globoconusa* Zone, *Subbotina spiralis* Zone and *Planorotalites compressa compressa* Zone.

Tshakreen et. al, (2002) studied Late Cretaceous and Early Paleogene foraminiferids of the Western Sirt Basin.

Imam (2003) contributed to the stratigraphy and paleoecology of the Miocene sequence at Al Khums area, Sirt Basin, NW libya and recognized three foraminiferal zones from base to top: *Elphidium macellum/ Miogypsina intermedia* and *Globigerinoieds trilobus* zones within Al Faidiyah Formation and assigned it to Early Miocene (Burdigalian) age and the *Borelis melo melo* zone which includes Al Khums Formation and dated it to Middle Miocene (Langhian to Early Serravallian) age and suggest that the sequence was deposited in transgressive- regressive cycles ranged from near shore, warm shallow inner to middle shelf marine environments.

Tshakreen and Gasiñski (2004) studied the Cretaceous–Paleogene boundary problem in western Sirt Basin and they recognized the latest Maastrichtian zonal marker *Abathomphalus mayaroensis* from two wells in the western Sirt Basin, also they concluded that latest Maastrichtian sediments were deposited in outer shelf–upper slope and influenced by organic flux to the basin floor, which caused oxygen deficiency in the depositional environment.

Abdulsamad *et.al* (2008 and 2017) studied the biostratigraphy of Palaeocene to Miocene Foraminifera in Concession 65, Sirt Basin in Libya. They are concluded that the Palaeocene sequence consists of a lower shale unit of Early Palaeocene age (Danian Stage), which corresponds to the planktonic foraminiferal zones P1 and P2 and an upper carbonate unit of Late Palaeocene age (Selandian-Thanetian),which corresponds to the planktonic foraminiferal zones P3-P5 and benthic biozones SBZ3-SBZ6. The Eocene sequence is represented by badly preserved nummulitids in the Ypresian. The Middle Eocene (Lutetian-Bartonian) which correspond to the SBZ14-SBZ16 in the Lutetian and the SBZ17-SBZ18 in the Bartonian. The Late Eocene has been dated on the presence of *Nummulites fabianii* representing SBZ19. The Oligocene sequence has been attributed to the SBZ21 (Rupelian) and to the SBZ22 (Chattian) The uppermost deposits of the studied successions (mainly sandstones) belong to the Miocene with hardly any fossils.

Tshakreen *et.al* (2017) studied the Campanian–Maastrichtian foraminiferal stratigraphy and palaeoenvironment of the Lower Tar Member in the Wadi Tar section in Western Sirt Basin and recorded four standard planktonic foraminiferal zones, i.e. the *Radotruncana calcarata* Zone, *Globotruncana aegyptiaca* Zone (late Campanian), the *Gansserina gansseri* Zone (Late Campanian–Middle Maastrichtian) and *Racemiguembelina fruticosa* and one standard large benthic foraminiferal *Siderolites calcitrapoides* for the Middle–Late Maastrichtian. Also they interpreted from foraminiferal assemblages that the highest sea-level is located in the late Campanian, followed by significant shallowing in the Middle/Late Maastrichtian, followed by a deepening and again shallowing in the late Maastrichtian on the western margin of the Sirt Basin.

1.5 Materials of study

The Well Al-89 is an offshore well, which was drilled for exploration in 1966 by the Libyan Atlantic Company in the western offshore of Cyrenaica along the offshore part of the Ajdabiya Trough in Sirt Basin, with a total drilled depth (TD) of 14570 ft.. The offshore Well Al-89 has no cores or side wall core samples, therefore this study has been preformed based only, on ditch cutting samples (small rock cuttings brought to the surface in suspension by drilling fluid); which are provided for this study by exploration division managment of Arabian Gulf Oil Company (AGOCO) and limited to one hundred and forty one samples covering the interval from 1050' – 9000' with mostly 50’ apart interval (i.e. total thickness of 7950’). These samples are subjected to foraminiferal preparation for the current micropaleontological study. The age, depth and lithology of these samples are given on (Table 1.1) (see Appendix B).

1.6 Methods of study

1.6.1 Preparation Techniques

The foraminiferal tests has a range of sizes from several millimeters to a few tens of microns and are preserved in a set of lithologies. The foraminiferal preparation techniques depend largely on the rock type and the predicted type of foraminifera which expect to find. Very hard rocks, which is very difficult to disaggregate such as many limestones in particular the recrystallized limestones are best thin-sectioned as normal petrographical slides, except instead of grinding to a set thickness (commonly 30 microns) the sample is ground very carefully by hand until the optimum thickness is obtained for each individual sample. This is a skilled job and requires expensive equipment but provides excellent results and is particularly used in the study of larger benthic foraminifers.

The rocks with low degree of hardness (soft rocks) such as shale, clay, marl and argillaceous limestone and others, as in the case of the present studied samples are prepared for the planktonic and benthonic foraminifers content, according to standard foraminiferal preparation techniques described by Kummel and Raup (1965), which is illustrated on (Fig. 1.7 and 1.8). The preparation of the studied samples (each weighing 50g) is described step by step in detail as follows:

1- Crushing: The sample is crushed gently into a fragments does not exceed roughly 5 mm to facilitate the separation of the foraminifers, by using pestle and mortar.

2- Washing: The sample is then washed by gentle current of tap water through 63μm sieve (British standard mesh) until the liquid coming through the sieve is clean (i.e the unwanted materials such as clay fractions and other sediments including juvenile foraminifer-tests have been removed).

3- Drying: After that, the sample residue poured out in an evaporating dish and placed on a hotplate set at approximately 70°C, until its completely drying.

4- Picking: The dried sample has yeldied mostly a rich assemblages of planktonic and small benthic foraminifers, which are generally well preserved. These assemblages picked carefully by scattering on a black picking tray divided into squares (it simplify the looking and searching under the steriomicroscope). All the planktonic and benthonic foraminiferal tests picked out from the sample residue with fine needle into micropaleontological slides for further, analysis and identification. The picked foraminifera specimens were in range between 70 -500 for each sample. Special attention was given to the index planktonic foraminiferal specimens, because of thier importance in determination of age. The abundance terminology used by (Muftah, 2004) (Table, 1.2), was adopted in this study.

5- Mounting: The picked specimens, especially of planktonic foraminiefea species can then be mounted in a card slides (i.e. adhere to the gummed surface upon contact) divided into numbered-squares with sliding glass covers. Then a where possible well-preserved representative specimens of diagnostic planktonic foraminiferal species were selected, and transferred into single–hole micropaleontological slides with well name, depth and species names write down on each slide for reference and imaging.

Remarks: All this process was done in the laboratory of the Department of Earth Sciences, Benghazi University and the samples were handled carefully and all the equipment's including sieve, pestle and mortar and other materials used, are cleaned between the preparation of each sample to avoid contamination.

Table 1. 2 Abundance terminology used in this study.

Abundance	**Specimens**
Rare	1-2
Frequent/Few	3-5
Present	6-10
Common	11-20
Abundant	≥ 21

1.6.2 Photographing

Representative specimens of planktonic foraminifera were selected for photography, to illustrate all stratigraphically important taxa (i.e marker species) as well as the common associated species, using Am scope; ultra-compact 5MP USB digital microscope eyepiece camera, model MD500 connected with steriomicroscope (Micros-Austria) at the laboratory of the Department of Earth Sciences, Benghazi University. Both assemblages and individual species slides coded and added to the microfossil collection of the Department.

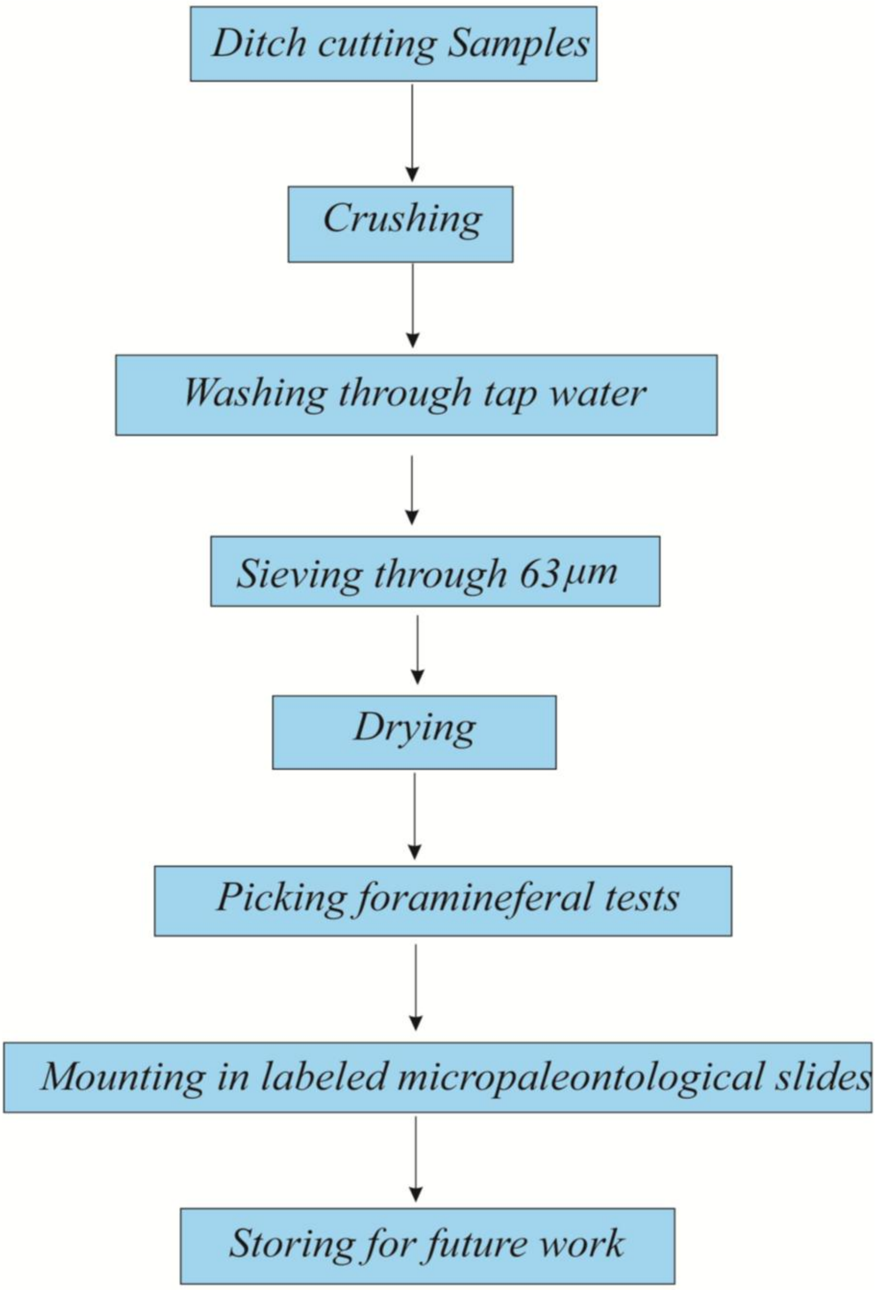

Fig. 1.7 Flow chart shows the foraminiferal preparation technique used in this study.

Fig. 1.8 A) the received quantity of ditch cutting sample; B) crushing the sample; C) washing the sample through 63 µm sieve; D) drying the sample on a hotplate; E) examining the sample residue under a stereomicroscope and picking up the foraminifers; F) mounting the foraminifers in a labeled micropaleontologic slides.

CHAPTER TWO
SEDIMENTOLOGY AND STRATIGRAPHY

2.1 Introduction

The deposits of the Sirt Basin range in ages from Cambro-Ordovician to Quaternary (Sinha and Mriheel, 1996). These sediments have a great thickesses, which is completly obsecured the basin horst and grapens (i.e troughs). In the troughs of the basin, the thickness of these sediments to the basement exceeds 7500 m. (Abouessa, *et al.*, 2012). The sediments of Sirt Basin have been classified into three sequences; Pre-rift sequence, which is domiated by continental rocks of Cambro-Ordovician age, which is unconformable overlain by Upper Cretaceous to Upper Eocene marine sediments of various deppositional environments represent the Syn-rift sequence (basin fill stage) following by marine sediments represent the Post-rift sequence (Saheel, et al., 2010). However, During the Oligocene and Miocene times the Sirt Basin witnessed a decreasing in the tectonic subsidence rates and the basin was developed as sag basin, its axis in Ajdabyiah Trough (El Hawat and Pawllek, 2004). During Oligocene time, the subsidence in the offshore area is continued, probably because of sediment loading and thermal relaxation (Abadi, *et al*., 2008), with localised rifting creating an accomodation space for in excess of 10000 ft. of marine sediments as in the studied well A1-89 and the adjacent Well A1-88, which situted in the centre of offshore Ajdabyiah Trough (Smith and Karki,1996). This rifting was also associated with the Alpine tectonisim resulted in regional uplift of the African Craton, which triggered a change in both rate of subsidence and type of sediments, where the sediments changed from carbonate to clastic and rapid subsidence (Fig, 2.1) allowed the filling of offshore area with enormous amounts of Oligocene fine-grained clastic sediments (El Hawat and Pawllek, 2004). The subsidence is continued during Miocene to the present time and the input of fine grain clastics is decreased and this is probably due to reduced of sediment supply and this resulted in a thining of the Miocene and younger strata in comparison to Oligocene (Hallett and Clarck-loews, 2016). The detailed stratigraphic and sedimentologic analysis of Oligocene-Pliocene strata, which is penetrated by the Well-A1-89 in the offshore of Ajdabiyah Trough is the main target of this chapter.

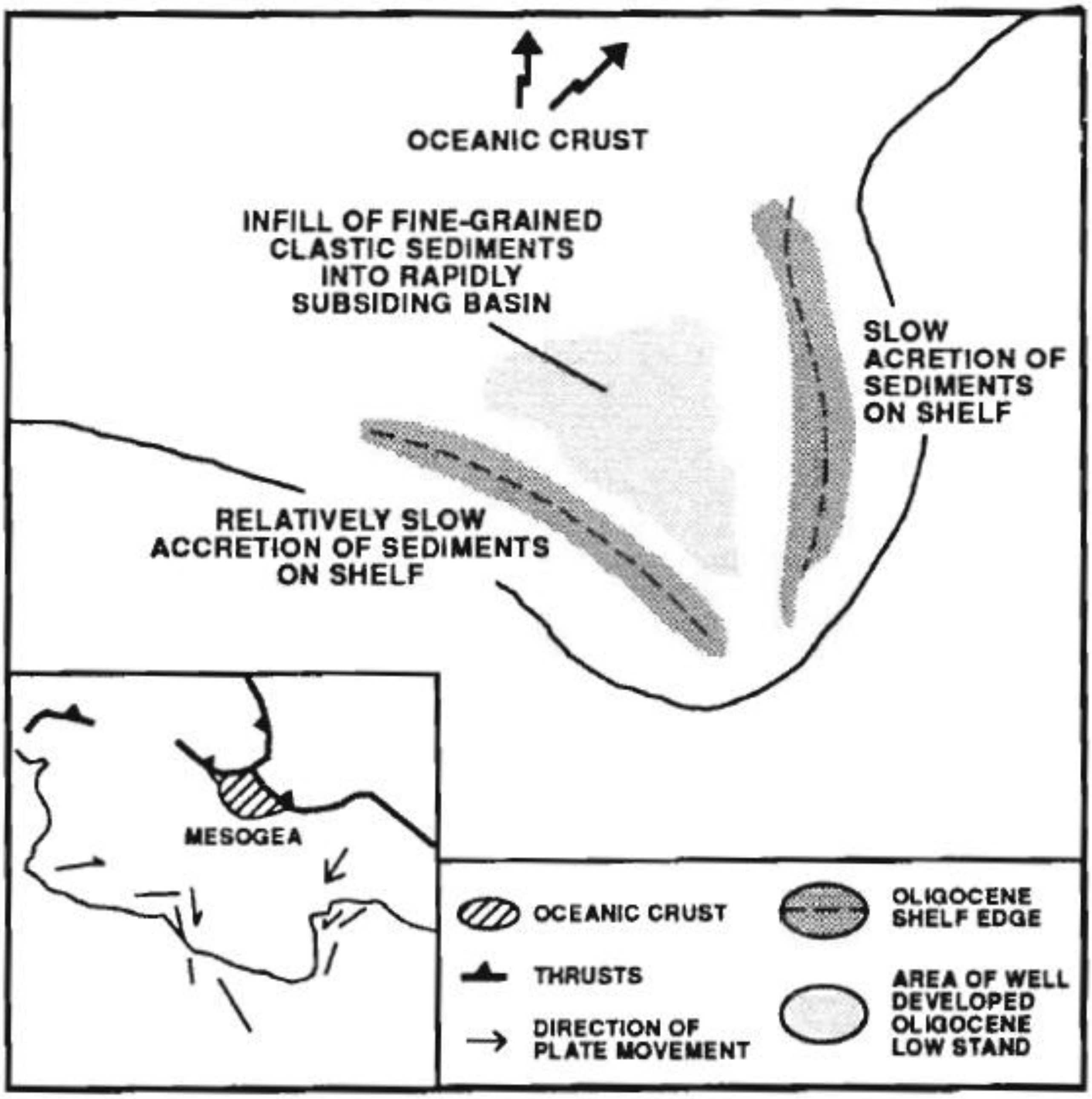

Fig.2.1 Paleogeographic map of offshore Sirt Basin during Oligocene- Miocene times (after Smith and Karki,1996).

2.2 Stratigraphy of the Studied Well A1-89

The studied succession in well A1-89 is represented by a sequence of carboante and clastic rocks ranging in age from Early Oligocene to Early Pliocene with a total thickness of about 7950'. These successions were deposited in deep marine environment, displaying a different lithologies and paleontologic assemblages in comparison to the equivelant rock units in Sirt Basin and Al Jabal al Akhdar areas, which are deposited in relatively shallower marine environments. Therefore, the stratigraphic nomenclatures introduced by different authors for the Oligocene and Pliocene rock units in Sirt Basin and Al Jabal al Akhdar areas would not be used in this study. Also the stratigrahic nomenclature introduced by Starkie *et al*., (2007) for subsurface rock units in Northeast libya is not followed here (Fig. 2.2). Hence, only the ages will be used for the studied rock units. The stratigraphic column with relevant lithological description of the penetrated Oligocene-Pliocene rock units has been constructed based on data from AGOCO includes, the Well-A1-89 log and ditch cuttings samples (Fig. 2.3). The studied Oligocene-Pliocene succession has been subdevided based on the lithoogical changes into the following lithological units from; base to top:

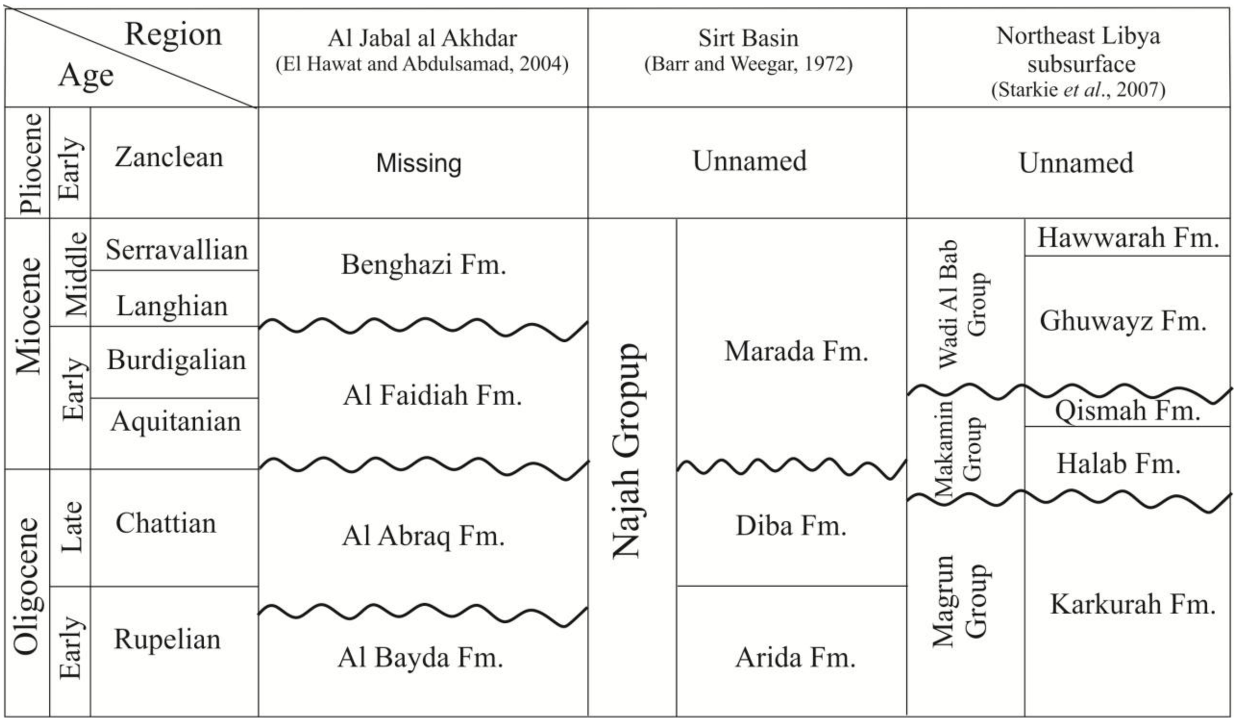

Fig. **2.2** The stratigraphic nomenclature chart of the Oligocene-Pliocene rock units of northeast parts of Libya by different authors.

2.2.1 Lower Oligocene

The Lower Oligocene rocks occupy the interval from 9000 to 6450' and composed of alternation of shale interbedded with calcareous claystone with thin streak of Limestone (unit1) at lower part grades into calcareous claystone (unit 2) in the upper part. This successions are the lateral equivalent to the Al Bayda Formation in Al Jabal al Akhdar area and to Arida Formation in Sirt Basin. However, the studied rock units are much deeper than both rock units. The established Lower Oligocene rock units in this well are:

Unit 1

It is composed of shale sub-fissile, dark grey, medium hard changing upward to claystone grey, medium hard and calcareous. Thin streak of slightly chalky limestone are also present. This unit yielded common planktonic and benthonic foraminifers with rare ostracods. Pyrite is present in form of crystals and replaced few foraminiferal tests (Fig. 2.3). It is 850 ft. thick.

Unit 2

It is composed of claystone grey, medium hard, highly calcareous interbedded at the upper part with limestone, creamy, medium hard and argillaceous. This unit yielded abundant planktonic and benthonic foraminifers with common ostracods (Fig.2.3). It is 2500 ft. thick.

2.2.2 Upper Oligocene

The Upper Oligocene rocks occupy the interval from 6450 to 4350' and composed of calcareous claystone interbedded with argilaceous Limestone in the lower part, which representing the top part of (unit 2), it is overlain by beds of argillaceous Limestone (unit 3), which representing the middle part. The upper part is composed of calcareous claystone interbeded at the top with thick beds of shale and limestone (unit 4). This successions are the lateral equivalent to the Al Abraq Formation in Al Jabal al Akhdar area and to Diba Formation in Sirt Basin. However, the studied rock units are much deeper than both rock units. The established Upper Oligocene rock units in this well are:

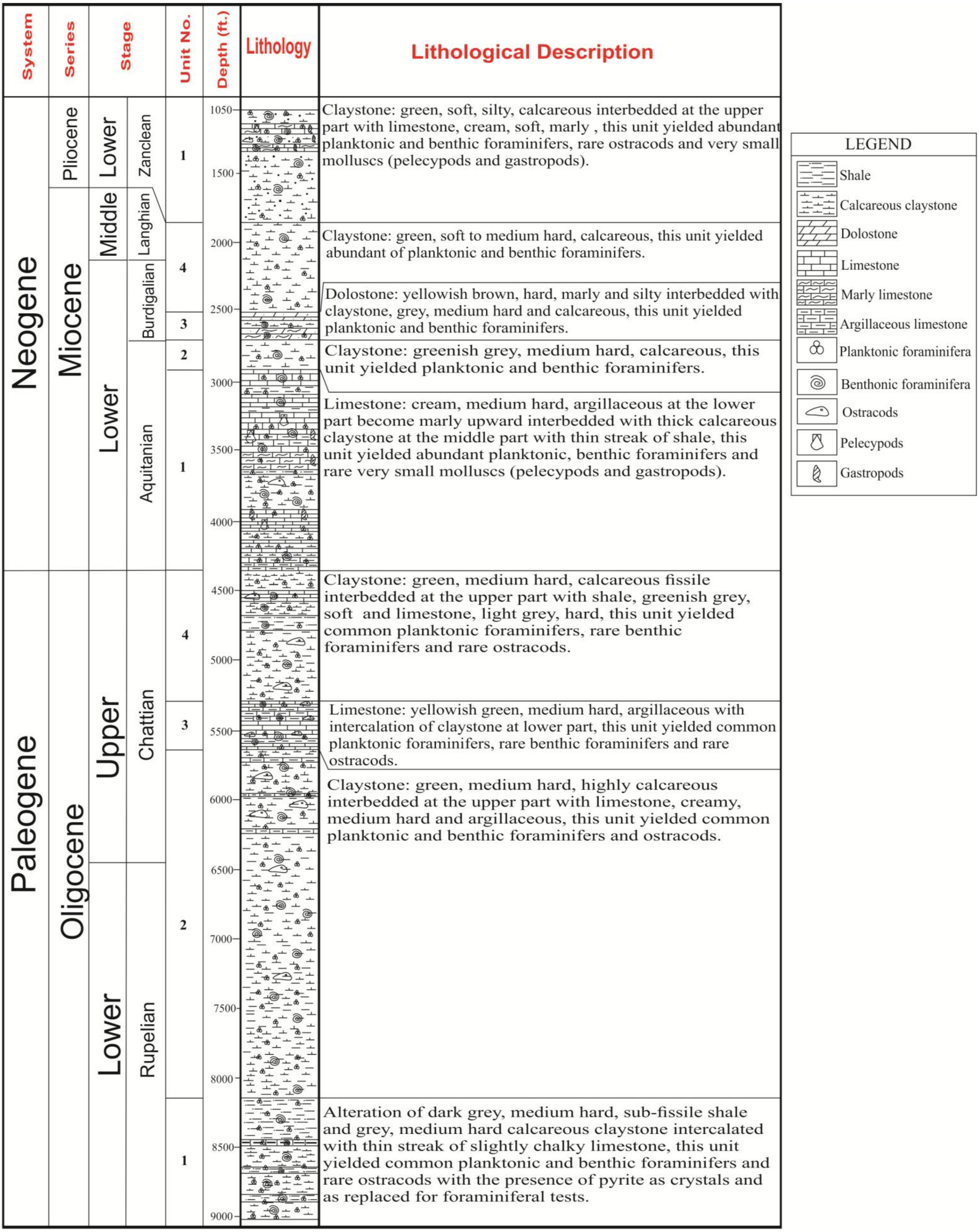

Fig. 2.3 The stratigraphic columnar section of the studied succession at well A1-89 (after AGOCO, 1966).

Unit 3

It is composed of Limestone yellowish green, medium hard, argillaceous intercalated with claystone grey, soft. This unit yielded common planktonic foraminifera and rare benthonic foraminifers with rare ostracods. (Fig. 2.3) It is 300 ft. thick**.**

Unit 4

It is composed of claystone, green, medium hard, calcareous, fissile interbedded at the upper part with shale, greenish grey, soft. Thin beds of limestone, characterized by light grey and hard are also present locally. This unit yielded common planktonic foraminifera and rare benthonic foraminifera with rare ostracods (Fig. 2.3). It is 1000ft. thick.

2.2.3 Lower Miocene

The Lower Miocene rocks occupy the interval from 4350 to 2050' and consist of thick sequence of argillaceous limestone interbedded with calcareous Claystone and thin streak of shale (unit 1), which forming the lower and middle part overlain by of calcareous claystone (unit 2), dolostone (unit 3). The lower portion of calcareous Claystone of (unit 4), is also included in this series. This successions are the lateral equivalent to the Al Faidiah Formation in Al Jabal al Akhdar area and to lower part of Marada Formation in Sirt Basin. However, the studied rock units are much deeper than both rock units. The established Lower Miocene rock units in this well are:

Unit 1

It is composed of limestone cream, medium hard, argillaceous become marly upward, interbedded with claystone, grey, medium hard, calcareous. Thin streak of shale, grey, soft and fissile are also present. This unit yielded abundant planktonic and benthonic foraminifers with rare very small mollusks pelecypods and gastropods as recovered at the upper part (Fig. 2.3). It is 1450 ft. thick.

Unit 2

It is composed of claystone, greenish grey, medium hard and calcareous. This unit yielded planktonic and benthonic foraminifers (Fig. 2.3). It is 180 ft. thick.

Unit 3

It is composed of dolostone, yellowish brown, hard, marly and silty interbedded with claystone grey, medium hard and calcareous. This unit yielded planktonic and benthonic foraminifers (Fig.2.3). It is 170 ft. thick.

2.2.4 Middle Miocene

The Middle Miocene rocks occupy the interval from 2050 to 1850' and composed of calcareous claystone, this unit represented by the middle part of unit (4). This successions are the lateral equivalent to the lower part of Benghazi Formation in Al Jabal al Akhdar area and to the upper part of Marada Formation in Sirt Basin. However, the studied rock unit is much deeper than both rock units. The established Middle Miocene rock unit in this well is:

Unit 4

It is composed of claystone, green, soft to medium hard and calcareous. This unit yielded abundant planktonic and benthonic foraminifers (Fig. 2.3). It is 650 ft. thick.

2.2.5 Lower Pliocene

The Lower Pliocene rocks occupy the interval from 1850 to 1050' and composed of calcareous claystone interbedded with marly limestone. The established rock unit, in this well is:

Unit 1

It is composed of claystone green, soft, silty and calcareous interbedded at the upper part with limestone cream, soft and marly. This unit yielded abundant planktonic and benthonic foraminifers, rare ostracods and rare very small mollusks (pelecypods and gastropods) (Fig. 2.3). It is 800 ft. thick.

CHAPTER THREE

BIOSTRATIGRAPHY

3.1 Introduction

This chapter dealing with the biostratigraphic zonation of the Oligocene-Pliocene rock units recorded in the studied Well-A1-89. The foraminiferal biostratigraphic zonation is very important aspect in oil industry, because it's an excellent tool for chronological dating and highlighting the chronological boundaries for foraminiferal bearing rocks, especially the planktonic in the outer shelf to bathyal sequences as in the case of the entire sequence in Well A1-89. The zonation schemes of Bolli and Saunders (1985) for the Oligocene-Early Miocene interval and Iaccarino (1985) for younger horizons have been followed here in (Fig. 3.1). The latter is adopted, as the Mediterranean biozonation scheme is more suitable in accordance to the retrieved fauna-type.

3.2 Planktonic Foraminiferal Biozonation

The planktonic foraminifera is used in this study to define the biozonation from ditch cutting samples due to lack of any core or sidewall core samples in the studied Well A1-89. This study is restricted to the available number of samples (i.e. 141) given by the Arabian Gulf Oil Company (AGOCO) management. Samples are covering the interval from 1050' – 9000'. As all the studied samples are ditch cuttings, (i.e. collected during drilling in open hole conditions), the effect of extensive caving is a major problem for such biostratigraphic study. Therefore only Last Occurrence (LO) (= the first Downhole Appearance (FDA)) of the diagnostic taxa were used to recognize the top of each biozones in this study. Many biostratigrapher consider the last Occurrence more applicable and reliable for biostratigraphic analysis based on ditch cuttings samples (e. g. Mudge and Bujak, 1996; Qin, 1996a; Lin *et al.*, 2004; Li *et al.*, 2007a). fifty-one species and eleven subspecies belong to twelve genera have been identified and its vertical stratigraphic distribution throughout the studied succession allowing the recognition of ten planktonic foraminiferal biozones within the Oligocene-Pliocene sequence of the concerned interval in Well-A1-89. The identified biozones in this study are briefly described below in descending order (Fig. 3.2):

PLANKTONIC FORAMINIFERAL BIOZONES

Bolli and Saunders, 1985

AGE		Biozone	Subzone	Zone
PLIOCENE	LATE	*Gt. tosaensis tosaensis*		N21
PLIOCENE	LATE	*Globorotalia miocenica*	*Gr. exilis*	N21
PLIOCENE	LATE	*Globorotalia miocenica*	*Gs. trilob. fistulosus*	N20
PLIOCENE	EARLY	*Globorotalia margaritae*	*Gr. marg. evoluta*	N19
PLIOCENE	EARLY	*Globorotalia margaritae*	*Gr. marg. margaritae*	N18
MIOCENE	LATE	*Globorotalia humerosa*		N17
MIOCENE	LATE	*Globorotalia acostaensis*		N16
MIOCENE	MIDDLE	*Globorotalia menardii*		N15
MIOCENE	MIDDLE	*Globorotalia mayeri*		N14
MIOCENE	MIDDLE	*Globigerinoides ruber*		N13
MIOCENE	MIDDLE	*Globorotalia foshi robusta*		N12
MIOCENE	MIDDLE	*Globorotalia foshi lobata*		N11
MIOCENE	MIDDLE	*Globorotalia foshi foshi*		N10
MIOCENE	MIDDLE	*Globorotalia foshi peripheroronda*		N9
MIOCENE	EARLY	*Praeorbulina glomerosa*		N8
MIOCENE	EARLY	*Globigerinatella insueta*		N7
MIOCENE	EARLY	*Catapsydrax stainforthi*		N6
MIOCENE	EARLY	*Catapsydrax dissimilis*		N5
MIOCENE	EARLY	*Globigerinoides primordius*		N4
OLIGOCENE	LATE	*Globorotalia kugleri*		P22
OLIGOCENE	LATE	*Globigerina ciperoensis ciperoensis*		P22
OLIGOCENE	LATE	*Globorotalia opima opima*		P21
OLIGOCENE	EARLY	*Globigerina ampliapertura*		P19/20
OLIGOCENE	EARLY	*Cassigerinella chipolensis/ Pseudohastigerina micra*		P18

Iaccarino, 1985

AGE		Biozone	Subzone	Zone
PLIOCENE	LATE	*Gr. inflata*		N22
PLIOCENE	LATE	*Gr. aemiliana*		N21 N20
PLIOCENE	EARLY	*Gr. puncticulata*		N19
PLIOCENE	EARLY	*Gr. puncticulata - Gr. margaritae*		N19
PLIOCENE	EARLY	*Gr. margaritae*		N19
PLIOCENE	EARLY	*S. seminulina s.l*		N18
MIOCENE	LATE	*non-destinctive zone*		N17
MIOCENE	LATE	*Globorotalia conomiozea*		N17
MIOCENE	LATE	*Globogerinoides obliqus extremus*	*Globorotalia suterae*	N17
MIOCENE	LATE	*Globogerinoides obliqus extremus*	*Globogerinoides obliqus extremus/Globogerinoides bulloides*	N16
MIOCENE	LATE	*Globorotalia acostaensis*		N16
MIOCENE	MIDDLE	*Globorotalia menardi*		N15
MIOCENE	MIDDLE	*Globorotalia siakensis*	*Globorotalia siakensis/ Globogerinoides obliqus obliqus*	N14
MIOCENE	MIDDLE	*Globorotalia siakensis*	*Globogerinoides subquadratus*	N13
MIOCENE	MIDDLE	*Globorotalia siakensis*	*Globoquadrina altispira altispira*	N12 N11
MIOCENE	MIDDLE	*Orbulina suturalis/ Globorotalia peripheroronda*	*Globorotalia praemenardi/ Globorotalia peripheroronda*	N10
MIOCENE	MIDDLE	*Orbulina suturalis/ Globorotalia peripheroronda*	*Orbulina universa*	N9
MIOCENE	MIDDLE	*Orbulina suturalis/ Globorotalia peripheroronda*	*Orbulina suturalis*	N9
MIOCENE	MIDDLE	*Praeorbulina glomerosa*		N8
MIOCENE	EARLY	*Globogerinoides trilobus*		N7
MIOCENE	EARLY	*Globoquadrina dehiscens dehiscens/ Catapsydrax dissimilis*	*Globoigerinoides altiapertures/ Catapsydrax dissimilis*	N6 N5
MIOCENE	EARLY	*Globoquadrina dehiscens dehiscens/ Catapsydrax dissimilis*	*Globoquadrina dehiscens dehiscens*	N4

Fig. 3.1 The Oligocene-Pliocene planktonic foraminiferal zonation schemes (after Bolli and Saunders, 1985 and Iaccarino, 1985).

3.2.1 *Sphaeroidinellopsis seminulina s.l* Biozone

Category: Interval zone .

Age: Early Pliocene (Zanclean).

Author: Iaccarino and Salvatorini (1982).

Definition: Interval from first occurrence (FO) of prominent open marine conditions in the Mediterranean after the Late Miocene salinity crisis to last occurrence (LO) of *Globorotalia margaritae*.

The biozone marker species: *Sphaeroidinellopsis seminulina***.**

Remarks: The upper boundary of this subzone is defined by the last occurrence (LO) of the zonal marker *Sphaeroidinellopsis seminulina* and its lower boundary defined by the last occurrence (LO) of *Praeorbulina spp.* and cover the interval from 1050' to 1850'. The associated planktonic foraminiferal species in this biozone include *Sphaerodinellopsis disjuncta, Sphaerodinellopsis sphaeroides, Sphaerodinella dehiscens, Globorotalia crassaformis, Globorotalia inflata, Orbulina universa, Orbulina bilobata, Orbulina suturalis, Globigerinoides obliquus obliquus, Globigerinoides obliquus extremus, Globigerinoides sacculifer, Globigerinoides trilobus, Globigerinoides immaturus, Globigerinoides ruber, Globigerinoides subquadratus, Globorotalia mayeri, Globorotalia obesa, Globigerina praebulloides praebulloides, Globigerina praebulloides occlusa, Globigerinita napariamaensis, Globigerinita incrusta, Globoquadrina dehiscens, Globigerina woodi woodi, and Globigerina falconensis* (Fig. 3.3).

Geographical Correlation:

This biozone is equivalent to *Sphaeroidinellopsis spp*. biozone recorded by Ouda, (1998) from the Pliocene strata in the subsurface sections north of Qattarah Depression in the northern part of the Western Desert of Egypt.

However in Tunisia, this biozone is equivalent to *Sphaeroidinellopsis spp*. Biozone recorded by Hooyberghs, (1977), Ben Ismaïl-Lattrache, (1981) and Hooyberghs and El Ghali, (1990) from segui formations at the Kairouanais and Sahel regions (Sidi el Hani block) in northeastern Tunisia.

3.2.2 *Praeorbulina glomerosa* Biozone

Category: Lineage zone.

Age: Middle Miocene (Langhian)

Author: Bizon and Bizon (1972)

Definition: Interval from the first occurrence (FO) of *Praeorbulina glomerosa s.l.* to the first occurrence (FO) of *Orbulina suturalis*.

The biozone marker species: *Praeorbulina glomerosa*

Remarks: The upper boundary of this biozone is defined herein, by the last occurrence (LO) of the primary zonal marker *Praeorbulina glomerosa,* in addition to (LO) of the associated species *Praeorbulina transitoria* and the lower boundary of this biozone defined by the first occurrence of *Praeorbulina glomerosa* and covers the interval from 1850' to 2050. The associated planktonic foraminiferal species in this biozone include *Praeorbulina transitoria, Praeorbulina sicana, Orbulina suturalis, Globigerinoides obliquus obliquus, Globigerinoides sacculifer, Globigerinoides trilobus, Globigerinoides immaturus, Globigerinoides ruber, Globigerinoides subquadratus, Globorotalia mayeri, Globorotalia obesa, Globorotalia continuosa, Globoquadrina altispira altispira, Globoquadrina dehiscens, Globigerinita napariamaensis, Globigerinita incrusta, Globigerina praebulloides, Globigerina woodi* and *Globigerina falconensis* (Fig. 3.3).

Geographical Correlation:

This biozone is equivalent to *Praeorbulina glomerosa* Biozone (MMi 4) of Hamad and El Gamal, (2015) from the lower part of Kareem Formation (Markha Member) at Gabal Zeita section in west-central Sinai of Egypt. Also is well correlated with *Globigerinoides bisphericus* Biozone (M4b) of Hewaidy *et al*., (2013) from the upper part of the Hawara Member of the Rudeis Formation at Gabal Sarbut El-Gamal and from the lower part of Asl Member at Wadi Sudr section in the Gulf of Suez region.

However in Tunisia, this biozone is equivalent to *Globigerinoides sicanus / Praeorbulina glomerosa* Biozone recorded by (Hooyberghs, 1973; 1977) and

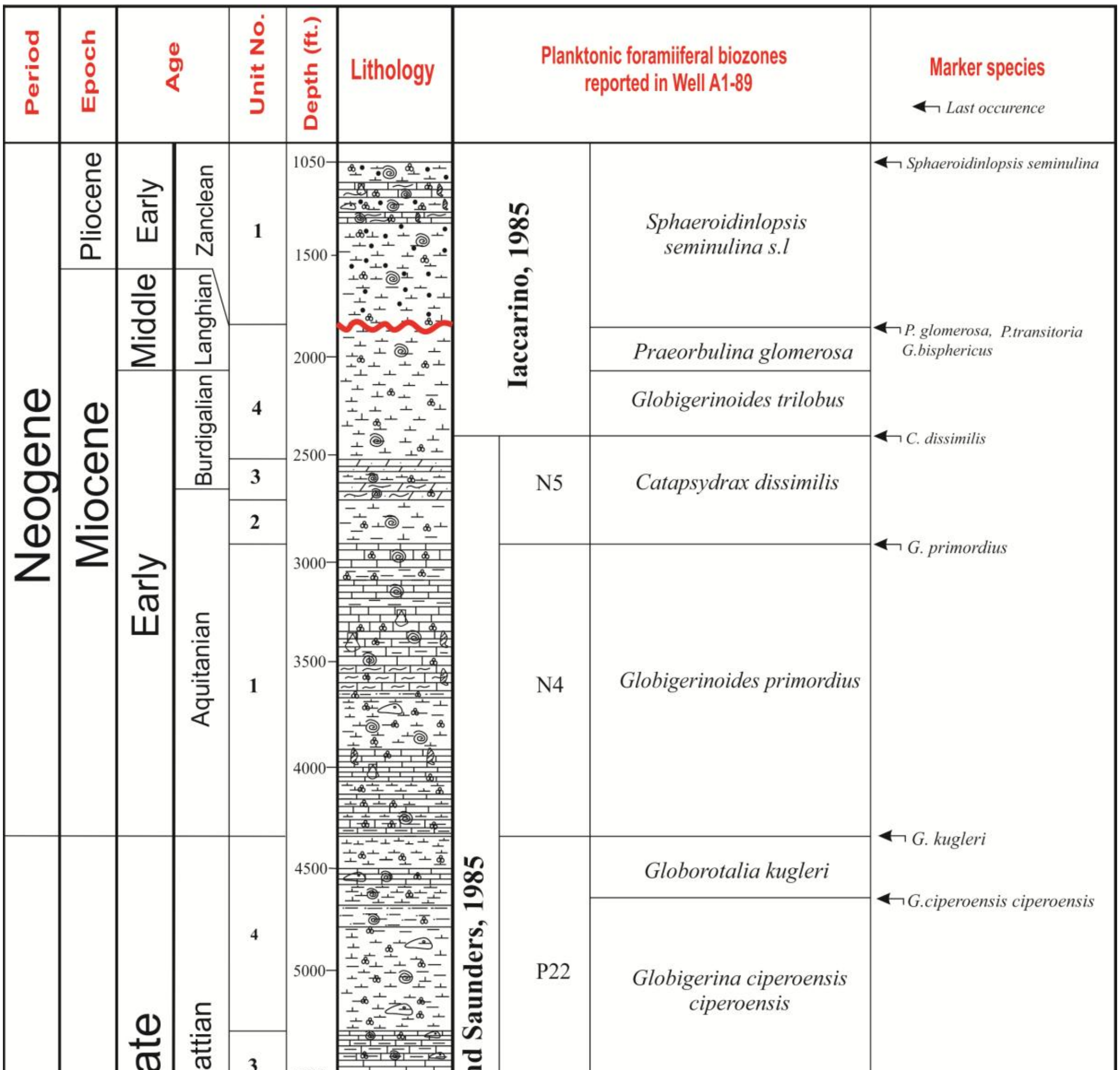

Fig. 3.2 The Oligocene-Pliocene planktonic foraminiferal biozones reported from the studied Well A1-89 after zonation schemes of Bolli and Saunders (1985) and Iaccarino (1985).

Hooyberghs and El Ghali (1990) from Oued Hammam Formation at Oued Sidi Hamouda section in central Tunisia.

3.2.3 *Globigerinoides trilobus* Biozone

Category: Interval zone.

Age: Early Miocene (Burdigalian)

Author: Bizon and Bizon (1972)

Definition: Interval from the last occurrence (LO) of *Catapsydrax dissimilis* to the first occurrence (FO) of *Praeorbulina glomerosa*

The biozone marker species: *Globigerinoides trilobus*

Remarks: The upper boundary of this biozone is defined herein with care, by the approximate first occurrence (FO) of the *Praeorbulina glomerosa*, due to using ditch cutting samples, however this boundary is an approximation. The lower boundary defined by the last occurrence (LO) of *Catapsydrax dissimilis* and covers the interval from 2050' to 2400'. The associated planktonic foraminifera species in this biozone include *Praeorbulina transitoria, Praeorbulina sicana, Globigerinoides obliquus obliquus, Globigerinoides obliquus extremus, Globigerinoides sacculifer, Globigerinoides immaturus, Globigerinoides ruber, Globigerinoides subquadratus, Globorotalia mayeri, Globorotalia obesa, Globorotalia continuosa, Globorotalia siakensis, Globoquadrina altispira altispira, Globoquadrina dehiscens, Globigerinita napariamaensis, Globigerinita incrusta, Sphaeroidinellopsis disjunccta Globigerina praebulloides occlusa, Globigerina praebulloides Leroy, Globigerina woodi woodi* and *Globigerina falconensis* (Fig. 3.3).

Geographical Correlation:

This biozone is equivalent to *Globigerinoides trilobus* Zone (MMi3) of Hamad and El Gamal (2015) from the Rudeis Formation at Bir El Haleifiya section (topmost of the section) in west-central Sinai of Egypt.

However in Tunisia, this biozone is equivalent to N6-N7 Biozone of Blow, (1969) recorded by Glaçon and Rouvier (1967) and Belayouni *et al*,. (2013) from Babouch Member at Babouch and Cap-Serrat areas.

3.2.4 *Catapsydrax dissimlis* Biozone

Category: Interval zone

Age: Early Miocene (Aquitanian-Burdigalian)

Author: Cushman and Renz (1947), emended by Bolli (1957)

Definition: Interval with zonal marker from last and its lower boundary is defined by last occurrence (LO) of *Globorotalia kugleri* to the first occurrence (FO) of *Globigerintella insueta.*

The biozone marker species: *Catapsydrax dissimlis*

Remarks: The upper boundary of this biozone in the present study is defined by the last occurrence (LO) of the zonal marker *Catapsydrax dissimlis*. However, the lower boundary defined by the last occurrence (LO) of *Globigerina primordius*. This biozone covers the interval from 2400' to 2900'. The associated planktonic foraminiferal species in this biozone include *Globigerinoides obliquus obliquus, Globigerinoides sacculifer, Globigerinoides trilobus, Globigerinoides immaturus, Globorotalia mayeri, Globorotalia obesa, Globorotalia continuosa, Globoquadrina altispira altispira, Globigerina venezuelana, Globigerina praebulloides, Globigerina euapertura, Globigerina falconensis, Globigerina ouachitaensis jnaucki, Globigerinita napariamaensis, Globigerinita incrusta* and *Hastigrina praesiphonifera* . (Fig. 3.3).

Geographical Correlation:

This biozone is equivalent to *Globigerinoides altiaperturus/ Catapsydrax dissimilis* Subzone (MMi 2b) recorded by Hamad and El Gamal (2015) from Rudeis Formation at Bir El Haleifiya section in west-central Sinai of Egypt, and is well correlated with *Catpsydrax dissimilis* Biozone (M2) of Hewaidy *et al*., (2014) from the Mheiherrat Member of the Rudeis Formation at Wadi Wasit and in the lower part of the Hawara Member of the Rudeis Formation at Wadi Sudr in the west-central Sinai.

However in Tunisia, this biozone is equivalent to *Catpsydrax dissimilis* Biozone recorded by Riahi *et al*., (2010) from the upper part of Zouza Member at the Balta-Bou Goutrane section in the Balta–Bougoutrane area in northern Tunisia.

3.2.5 *Globigerinoides primordius* Biozone

Category: Concurrent range zone

Age: Early Miocene (Aquitanian)

Author: Blow (1969), emended by Bolli and Saunders (1985).

Definition: Interval from first occurrence (FO) of frequent *Globigerinoides primordius/trilobus* s.l. to last occurrence (LO) of *Globorotalia kugleri*.

The biozone marker species: *Globigerinoides primordius*

Remarks: The upper boundary of this biozone is defined herein, by the last occurrence (LO) of the zonal marker *Globigerinoides primordius* while the lower boundary is defined by last occurrence (LO) of *Globorotalia kugleri* and covers the interval from 2900' to 4350'. The associated planktonic foraminiferal species in this biozone include *Globigerinoides sacculiefer, Globigerinoides trilobus, Globigerinoides immaturus, Globorotalia mayeri, Globorotalia obesa, Globorotalia siakensis, Globoquadrina altispira altispira, Globigerina venezuelana, Globigerina praebulloides, Globigerina euapertura, Globigerina falconensis, Globigerina ouachitaensis jnaucki, Globigerinita naparimaensis, Catapsydrax dissimlis, Hastegrina praesiphonifera* and rare *Cassigerinella chipolensis* (Fig. 3.3). In Sirt Basin including the present study the *Globigerinoides primordius* biozone represents the oldest Miocene planktonic foraminiferal biozone.

Geographical Correlation:

This biozone is equivalent to *Globigerinoides primordius* Biozone (MMi1), recorded by Hamad and El Gamal (2015) from Nukhul Formation at Bir El Haleifiya section in west-central Sinai of Egypt, and is well correlated to *Globigerinoides primordius* Biozone (N4) recorded by Hewaidy *et al*., (2012) from the upper part of the Nukhul Formation at Wadi Baba in southwest Sinai Peninsula.

However in Tunisia, this biozone is equivalent to *Globigerinoides primordius* Biozone recorded by Riahi *et al*., (2010) from the upper part of Zouza Member at Tebaba and El Gassa–Msid sections in the East of Jebel Zouza in northern Tunisia.

3.2.6 *Globorotalia kugleri* Biozone

Category: Interval zone.

Age: Late Oligocene (Chattian).

Author: Bolli (1956), emended by Bolli and saunders (1985).

Definition: Interval with zonal marker, from first occurrence (FO) of *Globorotalia kugleri* to the first occurrence (FO) of frequent *Globigernoides primordius* and/or *Globigernoides trilobus* s.l.

The biozone marker species: *Globorotalia kugleri*

Remarks: The upper boundary of this biozone is defined herein, by the last occurrence (LO) of the zonal marker *Globorotalia kugleri* and the lower boundary is defined by last occurrence (LO) of *Globigerina ciperoensis ciperoensis*. It covers the interval from 4350' – 4650'. The associated planktonic foraminiferal species in this biozone include *Globigerinoides primordius, Globigerina venezuelana, Globigerina tripartita, Globigerina euapertura, Globigerina praebulloides, Globigerina ouachitaensis jnaucki, Catapsydrax dissimilis* and *Cassigerinella chipolensis* (Fig. 3.3).

Geographical Correlation:

This biozone is equivalent to *Globorotalia kugleri* Biozone, recorded by Cherif *et al*., (1993) from the upper part of the Qantarah Formation in the wells Temsah-II, San El Hagar-lX, Boughaz-l and Mallaha-lX in the isthmus of Suez and the North-Eastern reach of the Nile Delta of Egypt**.**

However in Tunisia, this biozone is equivalent to the upper part of *Globigerina ciperoensis* Biozone recorded by Belayouni *et al*., (2012) from the intermediate interval in the sub-Numidian succession at Zahret-Mediene area in northwestern Tunisia.

3.2.7 *Globigerina ciperoensis ciperoensis* Biozone

Category: Interval zone

Age: Late Oligocene (Chattian).

Author: Cushman and stainforth (1945), emended by Bolli (1957)

Definition: Interval with zonal marker, from last occurrence (LO) of *Globorotalia opima opima* to the first occurrence (FO) of *Globorotalia kugleri*.

The biozone marker species: *Globigerina ciperoensis ciperoensis*

Remarks: The upper boundary of this biozone is defined herein, by the last occurrence (LO) of the zonal marker *Globigerina ciperoensis ciperoensis*. However the lower boundary is defined by last occurrence (LO) of *Globorotalia opima opima* and cover the interval from 4650' – 5750'. The associated planktonic foraminiferal species in this biozone include *Globorotalia opima nana, Globorotalia opima opima, Globigerina venezuelana, Globigerina euapertura, Globigerina praebulloides, Globigerina euapertura, Globigerina ouachitaensis jnaucki* and *Cassigerinella chipolensis* (Fig. 3.3).

Geographical Correlation:

This biozone is equivalent to *Globigerina ciperoensis* Biozone (P22), recorded by Hewaidy *et al*. (2014) from the lowermost part of the Nukhul Formation at Wadi Wasit section in west-central Sinai of Egypt, and is well correlated with the subsurface *Globigerina ciperoensis ciperoensis* Biozone, recorded by Cherif *et al*., (1993) from the upper part of the Qantarah Formation at the wells Temsah-II, San El Hagar-lX and Boughaz-l in the isthmus of Suez and the north-eastern reach of the Nile Delta respectively.

However in Tunisia, this biozone is equivalent to *Globigerina ciperoensis* Biozone recorded by Ben Ismail-Lattrache (2000) from the upper part of Souar Formation in northern Tunisia, and is well correlated with lower part of *Globigerina ciperoensis* Biozone recorded by Belayouni *et al*., (2012) from the intermediate interval in the sub-Numidian succession at Zahret-Mediene area in northwestern Tunisia.

3.2.8 *Globorotalia opima opima* Biozone

Category: Taxon range zone.

Age: Late Oligocene (Chattian).

Author: Bolli (1957).

Definition: Total range of the zonal marker *Globorotalia opima opima*, from its first occurrence (FO) to its last occurrence (LO).

The biozone marker species: *Globorotalia opima opima.*

Remarks: The upper boundary of this biozone in the present study is defined by the last occurrence (LO) of the zonal marker *Globorotalia opima opima* and its lower boundary is defined by the last occurrence (LO) of *Globigerina ampliapertura* and covers the interval from 5750' – 6450'. The associated planktonic foraminiferal species in this biozone include *Globigerina opima nana, Globigerina venezuelana, Globigerina ciperoensis ciperoensis, Globigerina euapertura* and *Cassigerinella chipolensis* (Fig. 3.3).

Geographical Correlation:

In Egypt, this biozone is also recorded by Ouda (1998) from the upper part of the Dabaa Formation and lower part of Shushan Formation at the subsurface sections north of Qattarah depression in the northern part of the western desert of Egypt. Also is well correlated with *Globorotalia opima opima* Biozone, recorded by Cherif *et al*., (1993) from the lower part of the Qantarah Formation at the wells Temsah-II, San El Hagar-lX and Boughaz-l in the isthmus of Suez and the North-Eastern reach of the Nile Delta.

However in Tunisia, this biozone is equivalent to *Globigerina opima opima* Biozone recorded by Riahi *et al*. (2010) from the lower part of Zouza Member at the Tebaba section in the east of Jebel Zouza in northern Tunisia.

3.2.9 *Globigerina ampliapertura* Biozone

Category: Interval zone.

Age: Early Oligocene (Rupelian).

Author: Bolli (1957), redefined by Bolli (1966a).

Definition: Interval with zonal marker, from last occurrence (LO) of *Pseudohastigrina micra* to the first occurrence (FO) of *Gloporotalia opima opima*.

The biozone marker species: *Globigerina ampliapertura.*

Remarks: The upper boundary of this biozone in the present study is defined by the last occurrence (LO) of the zonal marker *Globigerina ampliapertura* and its lower boundary is defined by last occurrence (LO) of *Pseudohastigrina micra* and covers the interval from 6450' to 7450'. The associated planktonic foraminifera species in this biozone include *Globigerina ciperoensis ciperoensis, Globigerina opima nana, Globigerina venezuelana, Globigerina tripartita, Globigerina angiporoides, Globigerina linaperta, Globigerina eocaena, Globigerina cryptomphala, Globigerina euapertura, Cassigerinella chipolensis* and *Catapsydrax dissimlis* (Fig. 3.3).

Geographical Correlation:

In Egypt, This biozone is reported by Ouda (1998) from the lower part of the Dabaa Formation at the subsurface sections north of Qattarah depression in the northern part of the Western Desert of Egypt, and is well correlated with *Globigerina ampliaperture* Biozone, reported by Cherif *et al*., (1993) from the lower part of the Qantarah Formation at the wells Temsah-II, San El Hagar-lX and Boughaz-l in the isthmus of Suez and the North-Eastern reach of the Nile Delta.

However in Tunisia, this biozone reported by Riahi *et al*., (2010) from the lower part of Zouza Member at Tebaba and El Gassa–Msid sections in the East of Jebel Zouza in northern Tunisia.

3.2.10 *Cassigerinella chipolensis/ Pseudohastegrina micra* Biozone

Category: Concurrent range zone.

Age: Early Oligocene (Rupelian).

Author: Blow and Banner (1962), renamed by Bolli (1966a).

Definition: Joint occurrence of the two zonal markers.

The biozone marker species: *Cassigerinella chipolensis* and *Pseudohastegrina micra*.

Remark: It is the oldest biozone defined in the present study and its upper boundary defined by the last occurrence (LO) of the zonal marker *Pseudohastegrina micra,* as well as the associated species *Globigerina angiporoides, Globigerina linaperta,* and *Globigerina eocaena.* The lower boundary however, cannot be delineated herein. This biozone covers the interval from 7450' to 9000'. The associated planktonic foraminiferal species in this biozone include *Pseudohastegrina micra, Cassigerinella chipolensis, Globigerina ciperoensis ciperoensis Globigerina opima nana, Globigerina venezuelana, Globigerina tripartita, Globigerina angiporoides, Globigerina linaperta, Globigerina eocaena Globigerina cf. taburiensis, Globigerina cryptomphala, Globigerina euapertura* and *Catapsydrax dissimlis* (Fig. 3.3).

Geographical Correlation:

This biozone is equivalent to *Pseudohastegrina spp.* Biozone recorded by Ouda., (1998) from the lower part of the Dabaa Formation at the subsurface sections north of Qattarah depression in the northern part of the western desert of Egypt.

However, in Tunisia this biozone is equivalent to *Pseudohastigerina naguewichiensis* Biozone (O1) recorded by Yaakoub *et al*., (2017) from the upper part of Souar Formation at Menzel Bou Zelfa and Jhaff sections in northeastern Tunisia.

3.3 Chronostratigraphy

3.3.1 The Oligocene/Miocene (O/ M) Boundary:

The Oligocene/Miocene (O/ M) boundary is a good example of an interval that has not undergone any significant environmental changes, also the biotic turnover is very low (extension and organization) within all microfossils, especially in planktonic foraminifera (Spezzaferri, 1994). The Oligocene/Miocene boundary is worldwide lacks widely applicable correlation tools in the Chattian stratotype itself. The Aquitaninan startotype contains planktonic foraminiferal assemblage suggesting foraminiferal biozone N4 and lower portion of N5 of Blow (1969). The boundary can be recognized within the top portion of the foraminiferal Zone P22 of Cushman and Stainforth (1945) and Berggren *et al*. (1995). Many planktonic foraminiferal biostratigraphers place the Oligocene/Miocene boundary at the base of Aquitanian stage, or at the first occurrence datum of *Globorotalia kugleri* interval zone in tropical areas (Bizon and Bizon, 1972; Bizon, 1979; Cita and Premoli Silva, 1968), and informally on the basis of the first occurrence datum of early Miocene *Globoquadrian dehiscens dehiscens* in Mediterranean region (Jenkins, 1966, 1971; Berggren and Andurer, 1973; Keller, 1980; Kennett and Srinivasan, 1981, 1983; Iaccarino and Salvatorini, 1982; Iaccarino, 1985 and Di Stefano *et al.*, 2008). However, a different point of view placed this boundary with the top of *Globorotalia kugleri* zone of Bolli (1957) at the first occurrence (FO) of *Globigerinoides primordius* has been presented by Bolli and Saunders, (1985). Furthermore, the diversification of genus *Globigerinoides* is an additional event to recognize the Oligocene- Miocene boundary (Spezzaferri, 1994). The Oligocene–Miocene (O/M) boundary in the present study are placed at the top of the *Globorotalia kugleri* Biozone (P22) of Bolli and Saunders (1985); as defined by Last occurrence (LO) of *Globorotalia kugleri* with decreasing in number of *Globigerinoides primordius* and its related Miocene planktonic foraminifera. This led to suggest that the sedimentation in Well A1-89 is continuous with no break, marking a conformable contact. However, across this boundary, a remarkable changes in diversity, abundance and preservation of foraminiferal assemblage are observed. It is obvious to mention that the Miocene foraminiferal assemblage, which typified with the occurrence of *Globigerinoides* spp. (Speezaferri, 1994) at this level displayed more diverse and abundance with excellent preservation than the Oligocene foraminiferal suit. These changes are also reported at the Oligocene–Miocene boundary in Egypt by Hewaidy *et al*., (2013 and 2014).

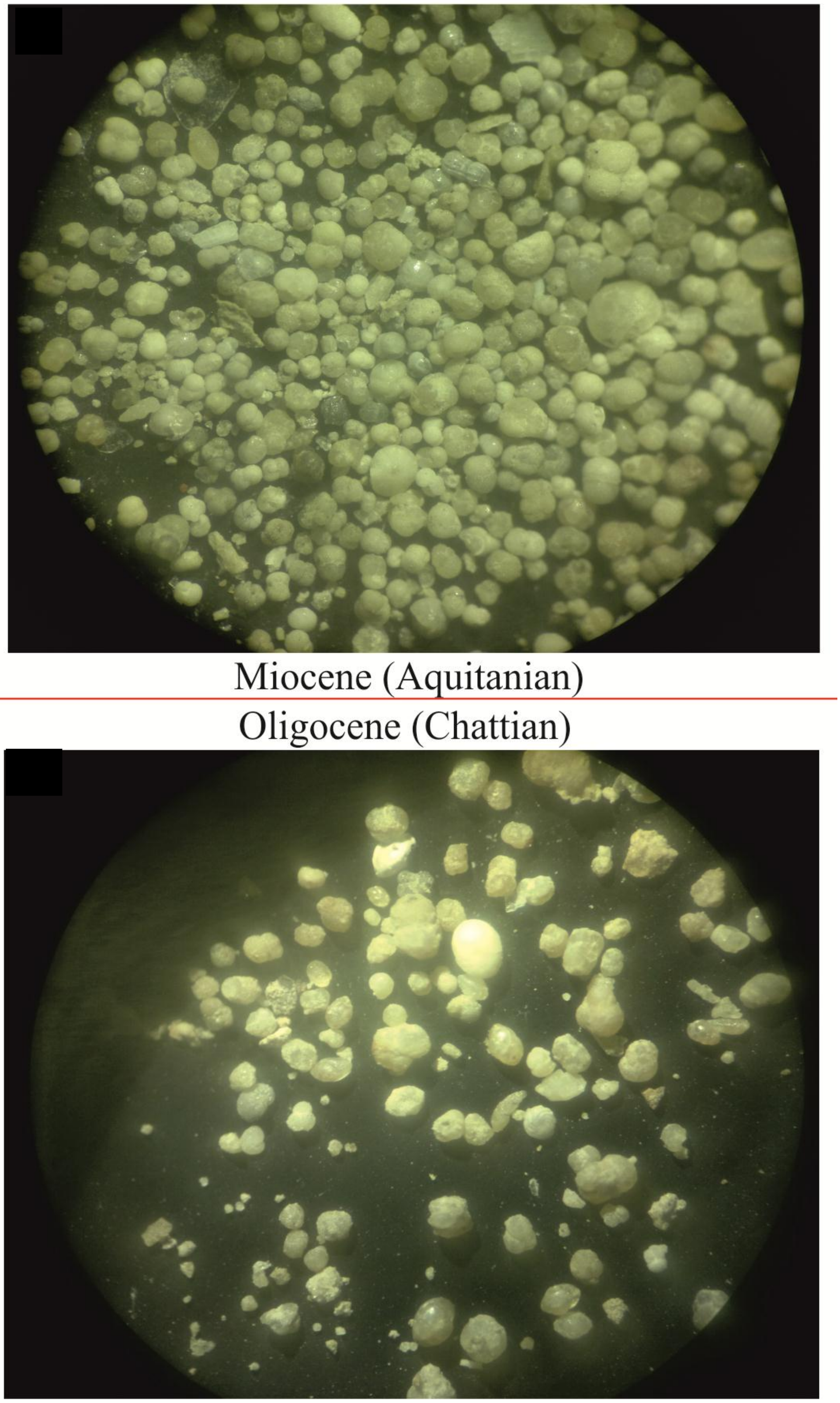

Fig. 3.4 Microscopic views shows the changes in the foraminiferal percentages at the Oligocene-Miocene boundary.

3.3.2 The Miocene/Pliocene (M/P) Boundary:

The Miocene/Pliocene (M/P) boundary according to Cita (1975) corresponds to the first appearance of permanent open marine condition in the Mediterranean after the Messinian salinity crisis. Accordingly, the M/P boundary (coincides with the Zanclean GSSP) is formally defined at the base of the deep marine Trubi marls overlying the continental-type Arenazzolo Formation at the Eraclea Minoa section in Sicily (van Couvering *et al*., 2000). Biostratigraphically, the boundary in the tropical areas can be recognized within the top portion of the *Neogloboquadrina duetertiri* biozone at the first occurrence of *Globorotalia margaritae* (Bolli, 1957a, 1966, 1970 and Bolli and Premoli-Silva, 1973), also the boundary is placed at the top part of *Globorotalia tumida-Sphirodinella subdehiscens paenedehiscens* biozone at the first occurrence of *Sphaerodinella dehiscens* (Blow and Banner, 1966 and Blow, 1969). In the temperate regions the boundary is defined at the top of *Globorotalia conomiozea* biozone at the first evolutionary occurrence of *Globorotalia puncticulata* (Kennett, 1973 and Kennett and Srinivasan, 1981). During the 1960's and 1970's many foraminiferal biozonation for the Mediterranean Pliocene have been proposed (Cita *et al*., 1968; Cita and Premoli-Silva,1971-1973; Bizon and Bizon, 1972; Cita, 1975a; Bizon, 1979; Borsetti *et al*., 1979; Colalongo *et al*., 1982 and Iaccarino and Salvatorini, 1982), most of them were summarized by Iaccarino (1985). The Miocene/Pliocene (M/P) boundary in the present study are placed at the top of *Praeorbulina glomerosa* biozone of Bizon and Bizon, (1972), as defined by the last occuerence (LO) of *Praeorbulina glomerosa* with co-members *Praeorbulina transitoria, Praeorbulina sicana* and *Globigerinoides bisphiricus* and the bottom of *Sphaerodinellopsis seminulina* biozone of Iaccarino and Salvatorini, (1982), biozone N18 according to Iaccarino, (1985). In the Well-A1-89, the Pliocene strata is unconformable overlain the Middle Miocene strata, with completely absence of the following biozones *Orbulina suturalis-Globorotalia peripheroronda, Globorotalia siakensis, Globorotalia menardi, Glborotalia accostaensis, Globigerinoides obliqus extremus and Globorotalia conomiozea* biozones, indicating a long-range unconformity. This hiatus is also reported from the offshore of northwestern Egypt by (Ouda, 1998).

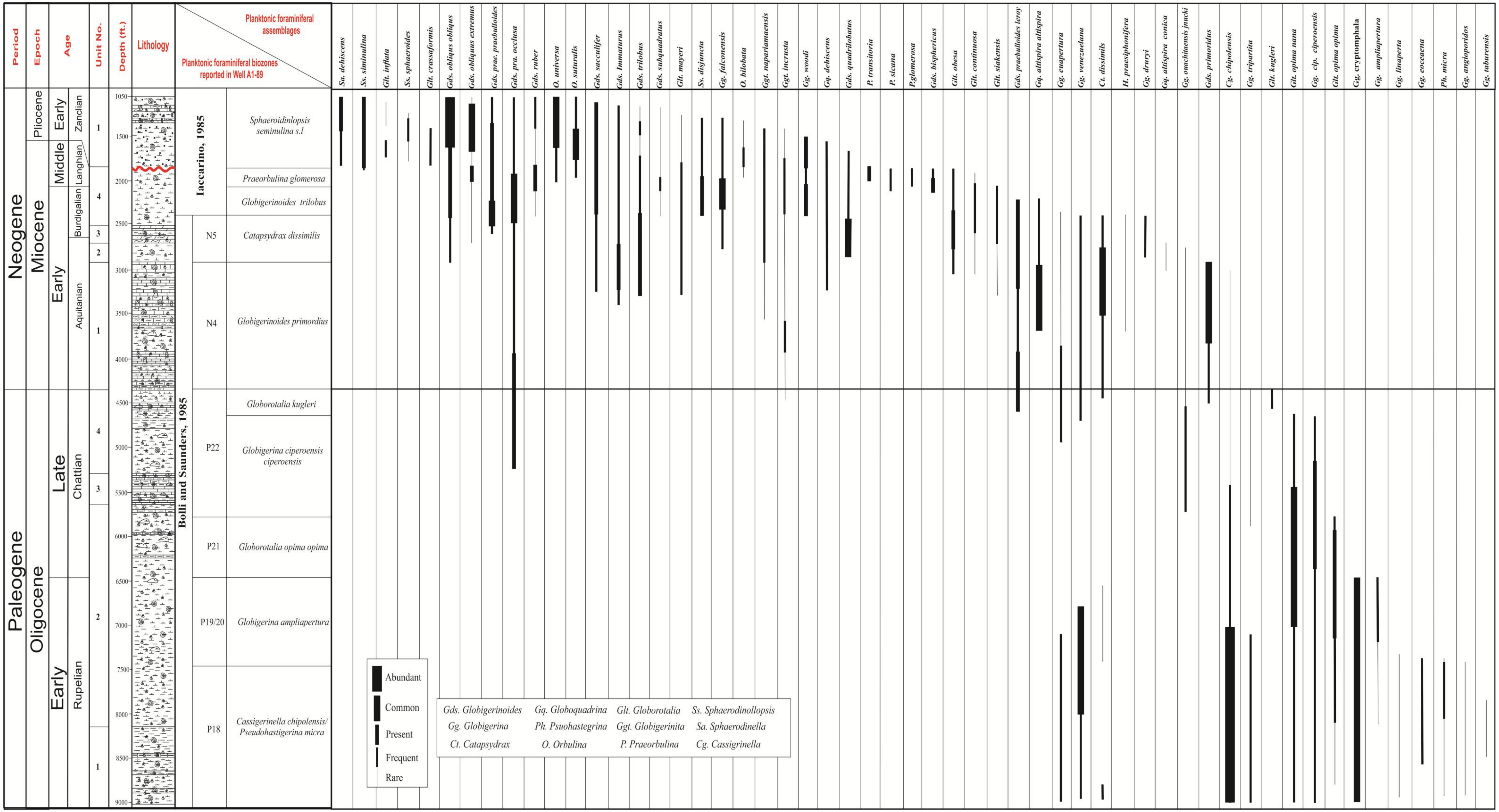

Fig. 3.3 Range chart of Oligocene-Pliocene planktonic foraminiferal assemblages recovered from the studied Well A1-89.

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CHAPTER FOUR

SYSTEMATIC PALEONTOLOGY

4.1 General

Taxonomy of planktonic foraminifera is a fundamental to level up their usefulness to maximum in stratigraphical studies, as precise zonal stratigraphic studies depends upon precise discrimination of genera and species. Therefore, this chapter includes a detailed taxonomic account of all the planktonic foraminifers observed during this study. Since most species are well documented in the literature, this taxonomy section focuses on the most stratigraphically important species. The taxonomy of the Oligocene-Pliocene species has been carried out by considering the descriptive terminology and definitions used for the general morphology as well as generic definitions from the taxonomic literature, such as Postuma (1971), Kennett (1973), Kennett and Srinivasan (1983), Bolli and Saunders (1985), Jenkins (1985), Iaacarino (1985), Loeblich and Tappan (1988), Scott *et al*., (1990), Spezzaferri and Premoli Silva (1991) and Spezzaferri (1994).

For each species, the species name is followed by the original author who proposed the preferred combination. References to original descriptions and illustrations, and consequent changes of the taxonomic position and one or more reference to illustrations that most closely approximate the species concepts used in this study are given. The stratigraphic range of the species are also given. The occurrence is used to give the worldwide distribution as well as the vertical stratigraphic distribution in the studied Well.

The test morphology of the planktonic foraminifera (Fig. 4.1) are the base of their classification where the wall composition descriptive terms such as, wall structure, chamber shape, coiling mode and position of primary aperture designate the family level. The coiling mode, wall ornamentations, shape of champers, sutures characters and primary aperture position and aperture modifications (bulla, lip…etc.), are used in genera descriptions, whereas shape of chambers, degree of trochospire, number of chambers in last whorl, rate of increase of chamber size, diameter of umbilicus, degree of peripheral angle, symmetry of profile, character of umbilical and spiral sutures and inflation of chambers and ornamentations are needed for identification of the species. The (figs. 4.2 - 4.4) illustrates some of descriptive terms mentioned above, which most commonly applied to classification of planktonic foraminifera.

4.2 Systematic taxonomy

In the present study, based on the classification criteria above fifty-one species and eleven subspecies belong to twelve genera have been identified. The species are discussed in the order of genera in alphabetical order and most of the them are photographed and illustrated in the plates (pl. 1–8). The accompanying plate descriptions provide the planktonic foraminiferal species name, with details of age, specimen location, specimen view, sample number and depth (ft.).

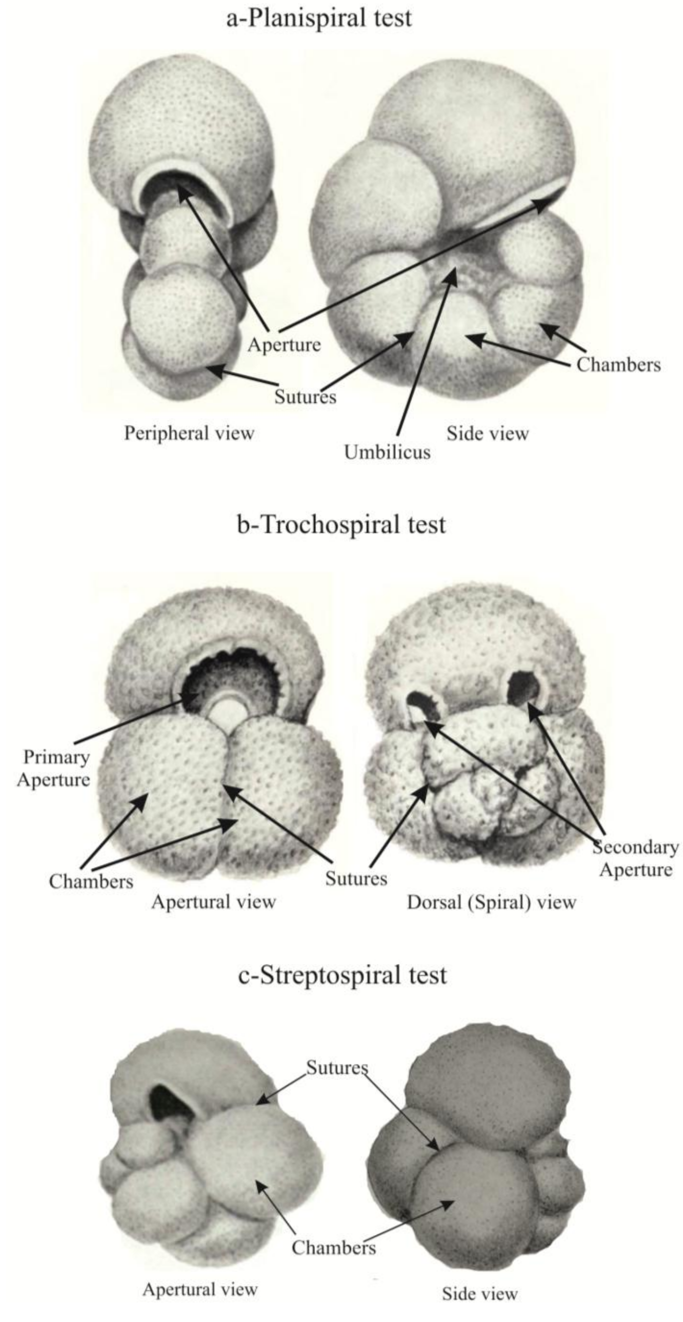
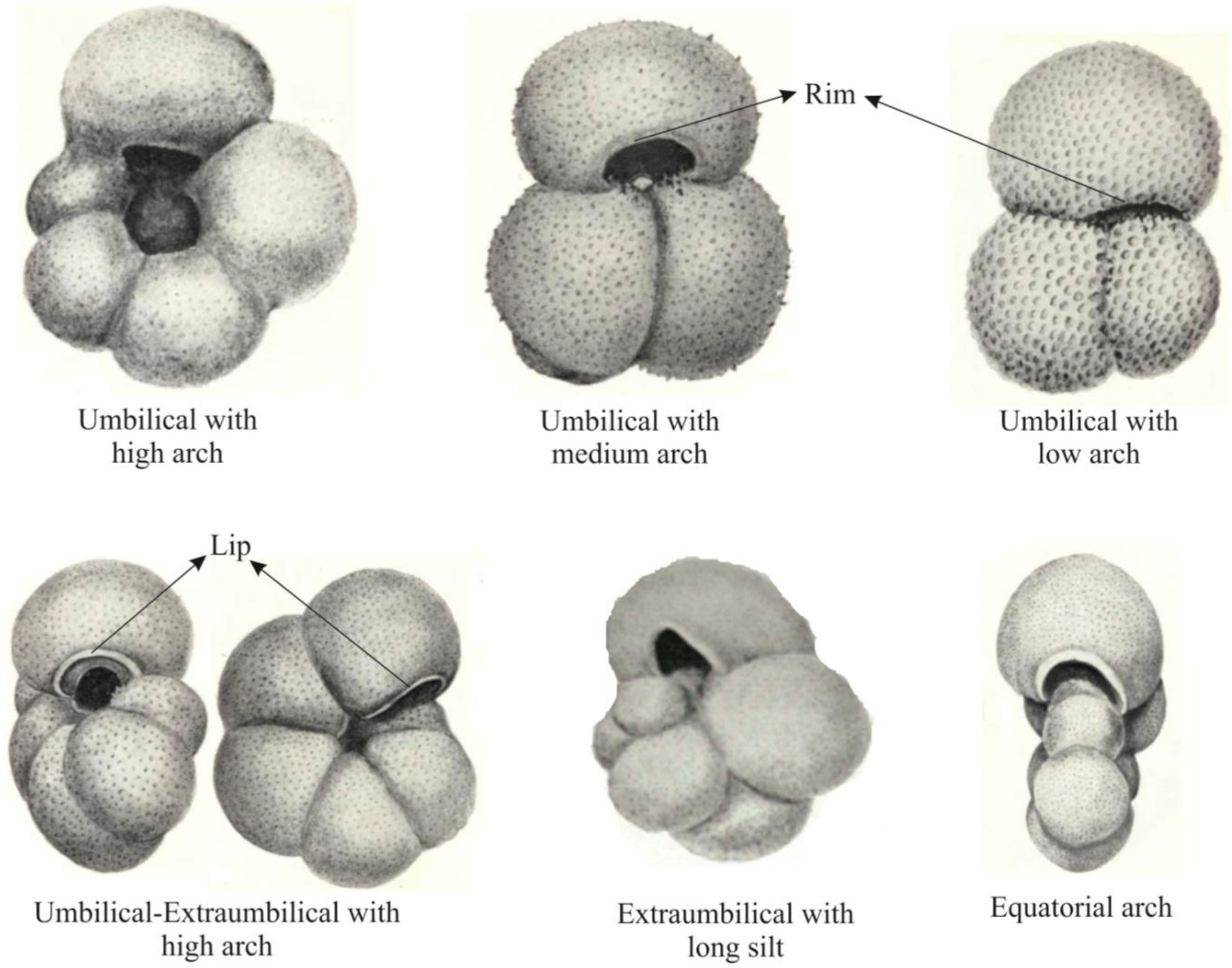


Fig. 4.1 General test morphology of planktonic foraminifera; a) planispiral test; b) trochospiral test and c) streptospiral test (after Postuma, 1971).

Primary Apertures



Sutures

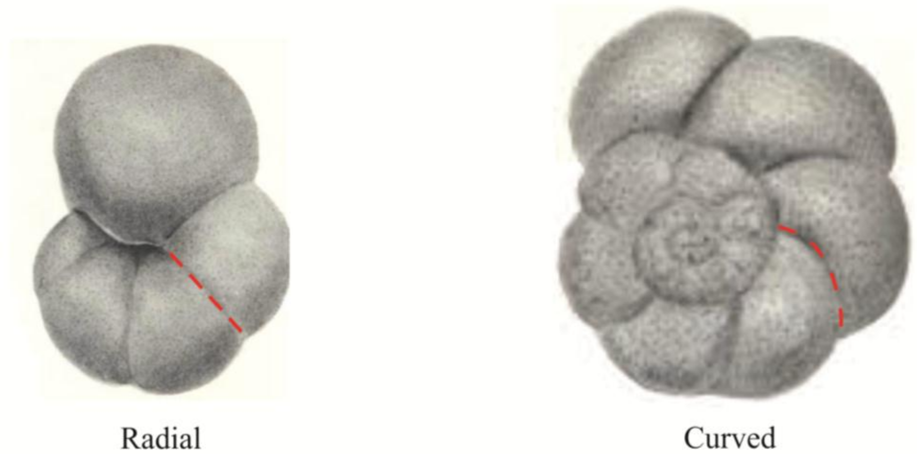


Fig. 4.2 Examples of Primary apertures and sutures positions in planktonic foraminifera (after Postuma, 1971).

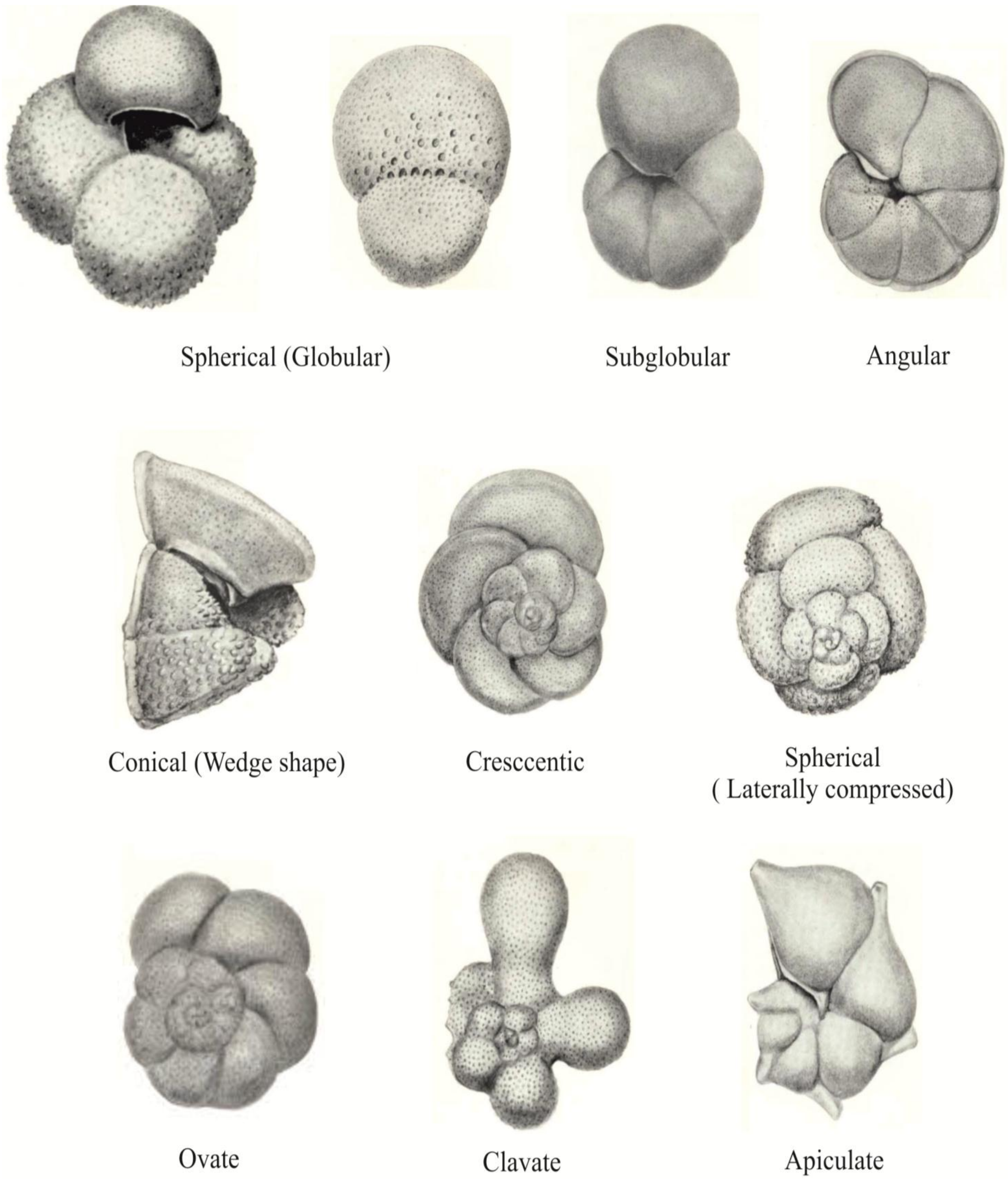


Fig. 4.3 Examples of chambers shapes in planktonic foraminifera (after Postuma, 1971).

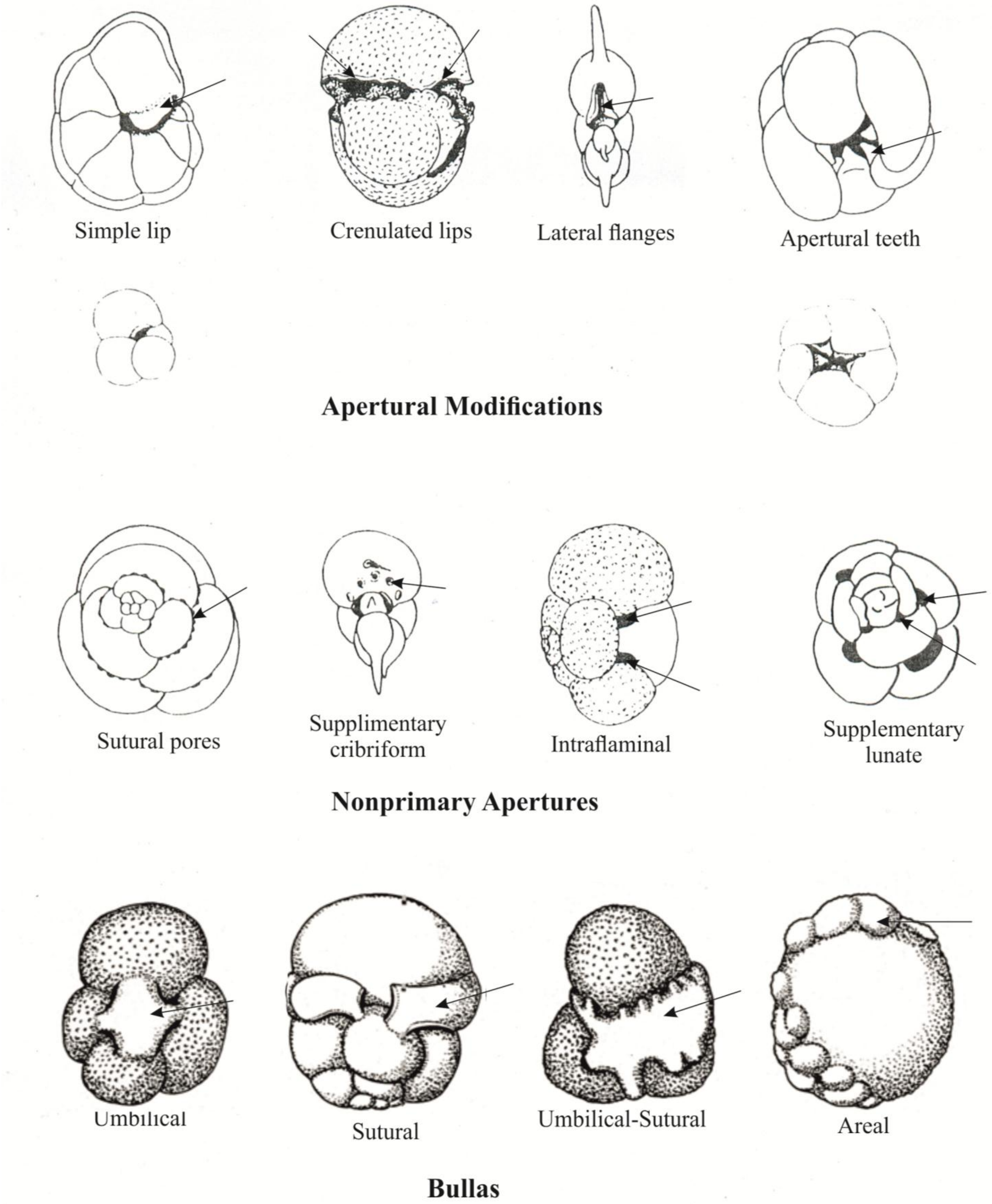


Fig. 4.4 Examples of aperture modifications, nonprimary apertures and bullas in planktonic foraminifera (after Stainforth et al., 1975).

Order FORAMINIFERIDA Eichwald, 1830

Suborder GLOBIGERININA Delage and Herourard, 1896

Superfamily GLOBIGERINACEAE Carpenter, Parker and Jones, 1862

Family GLOBIGERINIDAE Carpenter, Parker and Jones, 1862

Genus *Catapsydrax* Bolli, Loeblich and Tappan, 1957

***Catapsydrax dissimils* Cushman and Bermúdez, 1937**

(Plate 1, Fig. 1)

1957 *Catapsydrax dissimilis* (Cushman and Bermudez) – Bolli, Loeblich and Tappan, p. 36, pl. 7, figs. 6-7.
1971 *Catapsydrax dissimilis* (Cushman and Bermudez) – Postuma, pp. 256-257.

Description: Test generally medium in size, low to medium trochospiral, relatively compact, biconvex. Equatorial periphery lobulate and axial periphery rounded. Chambers spherical, four in the final whorl increase rapidly in size. Sutures depressed and radial. Wall perforate and the surface pitted. Aperture interiomarginal, umbilical covered by a single umbilical bulla with one or more accessory infralaminal apertures.

Occurrence: This species has been reported worldwide, including Egypt from Nukhul Formation (Hamad and El Gammal, 2015); Tunisia from Numidian Formation (Riahi, 2015); Malaysia from Temburong Formation (Asis *et al.*, 2015); Italy from Antognola Formation (Mancini and Pirini, 2001); Spain from de martin de Lagara series (Molina, 1979); Chile from Navidad Formation (Finger, 2013). In addition to the studied Well A1-89, offshore Sirt Basin, interval (9000'-2400'), where present as common to present (Fig. 3.3).

Stratigraphic range: Middle Eocene – Early Miocene (Bolli and Saunders, 1985).

Genus *Globigerina* d'Orbigny, 1826

***Globigerina ampliapertura* Bolli, 1957**

(Plate 1, Fig. 2)

1957 *Globigerina ampliapertura* Bolli, p. 108, pl. 22, figs. 5-7 (no figs. 4a-c).

1971 *Globigerina ampliapertura* Bolli. Postuma, pp. 142-143.

Description: Test medium in size, low trochospiral. Equatorial periphery moderately lobulate and axial periphery rounded. Chambers subspherical and somewhat compressed laterally, with four chambers in the final whorl increase rapidly in size. Sutures on spiral side slightly curved, on umbilical side radial and depressed. Wall perforate and the surface pitted. Umbilicus fairly narrow. Aperture interiomarginal, umbilical with high arch bordered by a rim.

Occurrence: This species has been reported worldwide including Egypt from Dabaa Formation (Ouda, 1998); Tunisia from Numidian Formation (Riahi, 2015); Tanzania from Oligocene sediments in TDP- Sites 11, 12, and 17 (Pearson and Wade, 2015); Syria from Jihar sections. (Kucenjak *et al*., 2006); Italy from Monte piano Formation (Mancini and Pirini, 2001); Spain from De Fuente Caldera series (Molina, 1979); Slovakia from Ciz Formation (Ozdinova and Sotak, 2015). In addition to the studied Well A1-89, offshore Sirt Basin, interval (8150'-6450'), where present as frequent to rare (Fig. 3.3).

Stratigraphic range: Late Eocene – Middle Oligocene (Bolli and Saunders, 1985).

***Globigerina angiporoides* Hornibrook, 1965**

(Plate 1, Fig. 3)

1961 *Globigerina angipora* Stache, Hornibrook, p. 145, fig. 3a-d.

1962 *Globigerina linaperta linaperta* Finlay. Blow and Banner, p. 85, pl. 11, fig. H.

Description: Test generally medium in size, low trochospiral and biconvex. Equatorial periphery lobulate and axial periphery rounded. Chambers subglobular and strongly inflated with three chambers in the final whorl increase rapidly in size. Sutures depressed and radial. Wall thick and perforate and the surface markedly reticulated. Aperture interiomarginal, umbilical covered by a thick lip.

Occurrence: This species has been reported worldwide, including Egypt from Dabaa Formation (Ouda, 1998); Tunisia from Souar Formation (Yaakoub *et al*., 2017); Spain from De Las Pinarejas series (Molina, 1979); Western South Atlantic from Hole DSDP-329 and South Atlantic from Hole DSDP-363 (Spezzaferri,1994); Gulf of Mexico from Hole 538A, DSDP Leg 77 (Spezzaferri and Premoli Silva, 1991);

Australia from Holes 1126A and 1126D (Li *et al*., 2003). In addition to the studied Well A1-89, offshore Sirt Basin, interval (9000'-7300'), where present as rare (Fig. 3.3).

Stratigraphic range: Late Eocene – Early Oligocene (Bolli and Saunders, 1985).

***Globigerina ciperoensis ciperoensis* Bolli, 1957**

(Plate 1, Fig. 4)

1983 *Globigerina* (*Globigerina*) *ciperoensis* Bolli – Kennett and Srinivasan, p. 28-31, pl. 4, figs. 6-8.
1985 *Globigerina ciperoensis ciperoensis* Bolli – Bolli and Saunders p. 178, figs. 1-3.

Description: Test usually small, low trochospiral, consisting of three whorls. Chambers are subspherical to spherical with five chambers in the last whorl increasing consistently in size as added. Umbilicus wide and radial. Sutures depressed and radial on both sides. Wall perforate, fairly pitted and may be slightly rugose near the shoulders of chambers of last whorl. Aperture umbilical, reasonably rounded and large.

Occurrence: This species has been recorded, worldwide, including Egypt from Nukhul Formation (Hewaidey *et al*., 2012); Tunisia from Numidian Formation (Riahi, 2015); Syria from Jihar sections (Kucenjak *et al*., 2006); Italy from Rigisoro Formation (Mancini and Pirini, 2001); Spain from Del Navasuelo series (Molina, 1979); Slovakia from Lucenec Formation (Ozdinova and Sotak, 2015); North Atlantic from Holes DSDP-116 and DSDP-98, South Caribbean from Hole DSDP-153, Equatorial Atlantic from Hole DSDP-354, South Atlantic from Hole DSDP-363 (Spezzaferri, 1994); Gulf of Mexico from Hole 538A (Spezzaferri and Premoli silva, 1991). In addition to the studied Well A1-89, offshore Sirt Basin, interval (9000'-4650'), where present is present to frequent (Fig. 3.3).

Stratigraphic range: Early Oligocene - Early Miocene (Postuma, 1971).

Globigerina cryptomphala **Glaessner, 1937**

(Plate 1, Fig. 5)

1937 *Globigerina bulloides var. cryptomphala* Glaessner Glaessner p.29 pl. 1 fig 1. 1985 *Globigerina cryptomphala* Glaessner- Toumarkine and Luterbacher: p.149 figs..5-6.

Description: Test generally large in size, medium trochospiral and equally bioconvex. Test periphery is lobulate. Chambers globular, with four chambers in the final whorl increase moderately in size. Umbilicus is wide and shallow enclosed by surrounding chambers and often partly to entirely covered by the ultimate chamber. Sutures moderately depressed, straight to slightly curved. Wall cancellate, normal perforate and the surface spinose. Aperture interiomarginal, umbilical and covered by the ultimate chamber (bulla_like), which make them invisible.

Occurrence: This species has been recorded, worldwide, including Tunisia from Numidian Formation (Riahi, 2015); Syria from Jihar sections. (Kucenjak *et al*., 2006); Turkey from Gaziantip Formation (Isik and Hakyemez, 2011); Italy from Scaglia Cinerea Formation (Menichini, 1999). In addition to the studied Well A1-89, offshore Sirt Basin, interval (9000'-6450'), where present is common (Fig. 3.3).

Stratigraphic range: Early Eocene – Early Oligocene (Wade et al., 2018).

Globigerina druryi **Akers, 1955**

1955 *Globigerina druryi* Akers, p. 654, pl.65, fig.1 (fide Ellis and Messina, 1949).
1969 *Globigerina druryi* Akers – Blow, pl. 14, fig. 4.

Description: Test small, low trochospiral and compact consisting of about three whorls. Four subglobular chambers in the last whorl, increasing consistently in size as added. Sutures are radial and slightly depressed on both spiral and umbilical sides. Wall reasonably cancellate and the surface coarsely pitted. Aperture is an umbilical low arch bordered by a rim.

Occurrence: This species has been recorded, worldwide, including Egypt from Sidi Salem Formation (Hewaidy *et al*., 2013); Japan from Kobana Formation (Hayashi and Takahashi, 2002); Austria from Well Spacince-5 in northern Danube Basin (Rybar *et al*., 2015); Trinidad from Brasso Formation (Wilson, 2005); South Caribbean from

Hole DSDP-153, Gulf of Mexico from Hole DSDP-151, North Atlantic from Holes DSDP-116 and DSDP-98; Equatorial Atlantic from Holes DSDP-667A and DSDP-354; Western South Atlantic from Hole DSDP-526A and Equatorial Indian from Hole ODP-709C (Spezzaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (2850'-2450'), where present is frequent (Fig. 3.3).

Stratigraphic range: Early Miocene – Late Miocene (Kennett and Srinivasan, 1983).

***Globigerina eocaena* Gumbel, 1868**

(Plate 1, Fig. 6)

1868 *Globigerina eocaena* Gumbel, p. 662, pl. 2, figs. 109a-b (fide Hagny Lindenberg, 1969).
1985 *Globigerina eocaena* Gumbel. Toumarkine and Luterbacher, p. 149, figs. 1a-c.

Description: Test generally medium in size, medium trochospiral and the spiral side slightly convex. Equatorial periphery lobulate and axial periphery rounded. Chambers subglobular, slightly hugging with four chambers in the final whorl increase rapidly in size. Umbilicus is narrow and deep. Sutures depressed; on the spiral side they vary from radial to radial curves and on the ventral side they are radial. Wall thick and perforate and the surface reticulated. Aperture interiomarginal, umbilical covered by a thin lip.

Occurrence: This species has been recorded, worldwide, including Egypt from subsurface Alam El Buieb Formation (Hassan *et al*., 1984); Tunisia from Numidian Formation (Riahi, 2015); Syria from Jihar sections (Kucenjak *et al*., 2006); Turkey from Bozbel Formation (Hakyemez *et al*., 2016); Tanzania from Oligocene sediments in TDP-Site 12 (Pearson and Wade, 2015); Spain from De Fuente Caldera series (Molina, 1979); Equatorial Pacific from site ODP-1218 (Wade *et al*., 2007). In addition to the studied Well A1-89, offshore Sirt Basin, interval (9000'-7400'), where present is frequent (Fig. 3.3).

Stratigraphic range: Early Eocene – Late Oligocene (Wade et al., 2018).

Globigerina euapertura Jenkins, 1960

(Plate 1, Fig. 7)

1960 *Globigerina euapertura* Jenkins, p.351, pl. 1, figs. 8a-c.
1971 *Globigerina euapertura* Jenkins – Jenkins, p. 147, pl. 15, figs. 457-461; pl. 16, fig. 462.

Description: Test frequently small, low trochospiral, equatorial periphery quadrilobate, axial periphery rounded consisting of three whorls. Chambers are subspherical with four chambers in the last whorl increasing consistently in size as added. Umbilicus fairly small and deep. Sutures incised and fairly radial on both sides. Wall perforate and the surface coarsely pitted. Aperture is an interiomarginal, umbilical and reasonably arched.

Occurrence: This species has been recorded, worldwide, including Egypt from subsurface Alam El Buieb Formation (Hassan *et al*., 1984); Tunisia from Numidian Formation (Riahi, 2015); Syria from Jihar sections (Kucenjak *et al*., 2006); Turkey from Lici Formation (Isik and Hakyemez, 2011); South Caribbean from Hole DSDP-153, Gulf of Mexico from Hole DSDP-151, North Atlantic from Holes DSDP-116 and DSDP-98 and Equatorial Atlantic from Hole DSDP-667A (Spezzaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (9000'-2350'), where present is frequent to rare (Fig. 3.3).

Stratigraphic range: Early Oligocene–Early Miocene (Kennett and Srinivasan, 1983).

Globigerina falconensis Blow, 1959

(Plate 1, Fig. 8)

1959 *Globigerina falconensis* Blow, p. 177, pl. 9, figs. 40a-c, 41.
1973 *Globigerina falconensis* Blow, Kennett, p. 601, pl. 2 figs. 3-4.

Description: Test small to medium in size, low trochospiral, slightly compressed. Chambers are spherical with four chambers in the last whorl increasing slowly in size. Sutures on both sides radial, depressed. Umbilicus small and deep. Surface with small, regularly distributed pores and thin, simple spines. Aperture is an interiomarginal with umbilical arch partly covered by a strongly developed lip of the final chamber.

Occurrence: This species has been recorded, worldwide, including Egypt from Rudies Formation (Hewaidey *et al*., 2014); Japan from Kobana Formation (Hayashi and Takahashi, 2002); Spain from Nijar Formation (Poore and Stone, 1981); Venezuela from Pozon Formation (Blow, 1959); Trinidad from Brasso Formation (Wilson, 2005); Southwest Pacific from DSDP Leg-21, sites 203, 207-207A and 210 (Kennett, 1973). In addition to the studied Well A1-89, offshore Sirt Basin, interval (3200'-1250'), where present is common to frequent (Fig. 3.3).

Stratigraphic range: Early Miocene – Recent (Kennett and Srinivasan, 1983).

***Globigerina linaperta* Finlay, 1939**

(Plate 2, Fig. 1)

1939 *Globigerina linaperta* Finlay, pp. 125, 127, pl. 13, figs. 54-57 - (fide Saito et al., 1969).
1985 *Globigerina linaperta* Finlay, Jenkins, p. 273, figs. 2a-c.

Description: Test medium in size, low trochospiral and spiral side oscillating from flat to slightly convex. Equatorial periphery lobulate and axial periphery rounded. Chambers subglobular, with three chambers in the final whorl increase rapidly in size. Umbilicus is shallow. Sutures depressed and radial. Wall perforate and the surface reticulated. Aperture interiomarginal, umbilical-extraumbilical form a very low arch bordered by a lip.

Occurrence: This species has been recorded, worldwide, including Tunisia from Numidian Formation (Riahi, 2015); Syria from Jihar sections (Kucenjak *et al*., 2006); Jordan from Eocene rocks in Jebel Fedyat-Adhahikiya area (Basha, 2005); New Zealand from Hampden section (Finlay, 1939b); United states of America (USA) from Refugian Gaviota Formation (Lipps, 1967a). In addition to the studied Well A1-89, offshore Sirt Basin, interval (9000'-7300'), where present is rare (Fig. 3.3).

Stratigraphic range: Late Paleocene – Early Oligocene (Wade *et al*., 2018).

Globigerina ouachitaensis gnaucki Blow and Banner, 1962

(Plate 2, Fig. 2)

1985 *Globigerina ouachitaensis gnaucki* Blow and Banner – Bolli and Saunders, p. 182, figs. 16 a-c.
1994 *Globigerina ouachitaensis gnaucki* Blow and Banner – Spezzaferri, p.27, pl. 2, figs.4a-c.

Description: Test small to large in size, high trochospiral, consisting of three and a half whorls. Chambers are subspherical with four chambers in the last whorl increasing consistently in size as added. Sutures incised and moderately radial on both sides. Umbilicus small. Wall finely perforate and surface very finely spinose. Aperture is an interiomarginal, umbilical and fairly arched.

Occurrence: This species has been recorded, worldwide, including Egypt from Mamura Formation (Ouda, 1998); Turkey from Egribucak and Karacaören formations (Hakyemez *et al*., 2016); Italy from Scaglia Cinerea Formation (Menichini, 1999); North Atlantic from Hole DSDP-98, Gulf of Mexico from Hole DSDP-151 South Caribbean from Hole DSDP-153, Eastern South Atlantic from Hole DSDP-516F, Equatorial Indian from Hole DSDP-709C (Spezzaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (5700'-2750'), where present is present to rare (Fig. 3.3).

Stratigraphic range: Late Eocene – Middle Miocene (Spezzaferri, 1994).

Globigerina praebulloides Leroy Blow and Banner, 1962

(Plate 2, Fig. 3)

1962 *Globigerina praebulloides leroyi* Blow and Banner, p. 93, pl. IX, -figs. R-T, text.-fig. 9V.
1985 *Globigerina praebulloides leroyi* Bolli and Saunders p. 178, figs. 13a-c.

Description: Test medium in size, low trochospiral, spiral side slightly convex consisting of about three whorls. Equatorial periphery fairly lobulate and axial periphery widely rounded. Chambers subglobular, clearly inflated and little hugging with four chambers in the last whorl increasing rapidly in size as added. Umbilicus medium wide and deep. Sutures of the spiral and umbilical sides radial and compressed. Wall slightly perforate and the surface finely reticulated and sometimes hispid. Aperture interiomarginal, umbilical, medium high and semi-symmetrical arch, bordered by a well-developed lip.

Occurrence: This species has been recorded, worldwide, including Egypt from Rudies Formation (Hewaidey *et al.*, 2014); Syria from Jihar sections (Kucenjak *et al.*, 2006); Iran from Qom Formation (Nouradini *et al.*, 2015); Turkey from Lici Formation (Isik and Hakyemez, 2011); North Atlantic from Hole DSDP-98, Gulf of Mexico from Hole DSDP-94, Equatorial Atlantic from Hole ODP-667A, South Atlantic from Hole DSDP-363, Eastern South Atlantic from Hole DSDP-17A and Equatorial Indian from Hole ODP-714A (Spezzaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (4600'-2200'), where present is present to frequent (Fig. 3.3).

Stratigraphic range: Late Eocene – Early Miocene (Bolli and Saunders, 1985).

***Globigerina praebulloides occlusa* Blow and Banner, 1962**

(Plate 2, Fig. 4)

1962 *Globigerina praebulloides occlusa* Blow and Banner: p.93 pl.9, figs. U-W.

1985 *Globigerina praebulloides occlusa* Bolli and Saunders p. 178, figs. 12a-c.

Description: Test medium to large in size, low trochospiral, consisting of about three whorls. Equatorial periphery elongate and axial periphery rounded. Chambers are subspherical with four chambers in the last whorl increasing quite rapidly in size as added. Umbilicus small and not deep. Sutures of the spiral and umbilical sides depressed but rather shallow, radial to slightly curved. wall perforate. Aperture , interiomarginal, umbilical, a low to moderate asymmetrical arch.

Occurrence: This species has been recorded, worldwide, including Egypt from Rudies Formation (Hewaidey *et al.*, 2014); Syria from Jihar sections. (Kucenjak *et al.*, 2006); Iran from Qom Formation (Nouradini *et al.*, 2015); Turkey from Lici Formation (Isik and Hakyemez, 2011); North Atlantic from Hole DSDP-98, Gulf of Mexico from Hole DSDP-94, Equatorial Atlantic from Hole ODP-667A, South Atlantic from Hole DSDP-363, Eastern South Atlantic from Hole DSDP-17A and Equatorial Indian from Hole ODP-714A (Spezzaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (5200'-1050'), where present is common to frequent (Fig. 3.3).

Stratigraphic range: Late Eocene – Middle Miocene (Bolli and Saunders, 1985).

Globigerina praebulloides praebulloides **Blow, 1959**

(Plate 2, Fig. 5)

1959 *Globigerina praebulloides* Blow, p. 180, pl. 8, figs. 47a-c, pl. 9, fig. 48.
1985 *Globigerina praebulloides praebulloides* Blow. Bolli and Saunders p. 178, figs. 14a-c.

Description: Test medium to large in size, low trochospiral, consisting of about three whorls. Equatorial periphery lobulate and axial periphery widely rounded. Chambers subglobular, inflated and little hugging with four chambers in the last whorl increasing rapidly in size as added. Umbilicus wide and deep. Sutures of the spiral and umbilical sides radial and very depressed. Wall perforate and the surface finely reticulated. Aperture interiomarginal, umbilical, high and asymmetrical arch, bordered by a rather thin lip.

Occurrence: This species has been recorded, worldwide, including Egypt from RudiesFormation (Hewaidey *et al*., 2014); Iran from Qom Formation (Nouradini *et al*., 2015); Turkey from Lici Formation (Isik and Hakyemez, 2011); Malaysia from Temburong Formation (Asis *et al*., 2015); Slovakia from Lucenec Formation (Ozdinova and Sotak, 2015) North Atlantic from Hole DSDP-98, Gulf of Mexico from Hole DSDP-94, Equatorial Atlantic from Hole ODP-667A, South Atlantic from Hole DSDP-363, Eastern South Atlantic from Hole DSDP-17A and Equatorial Indian from Hole ODP-714A (Spezzaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (2600'-1050'), where present is common to frequent (Fig. 3.3).

Stratigraphic range: Late Eocene – Middle Miocene (Bolli and Saunders, 1985).

Globigerina cf. tapuriensis **Blow and Banner, 1962**

(Plate 3, Fig. 1)

1962 *Globigerina tripartita tapuriensis* Blow and Banner, pp. 97-98, pl. X, figs. H-K.

1966 *Globigerina tripartita tapuriensis* Blow and Banner. Reiss and Gvritzmann, pl. 88, figs. 16a-c.

Description: Test medium to large, low trochospiral, spiral side moderate convex and spiral side convex, consisting of three and a half whorls. Equatorial periphery lobulated and axial periphery subovoidial. Chambers inflated, globular to reniform with three chambers in the last whorl increasing rapidly in size with compressed final chamber. Umbilicus is fairly narrow to fairly wide with a triangular shape. Sutures on both sides radial to slightly curved. Wall thick and perforate and surface reticulated. Aperture is an interiomarginal, umbilical and bordered by a narrow lip. The first whorls of this species is shifted a little to the left, and this is different from *Globigerina tapuriensis* where the first whorls is centered.

Occurrence: This species has been recorded, worldwide, including Egypt from Dabaa Formation (Ouda, 1998); Tunisia from Numidian Formation (Riahi, 2015); Tanzania from Oligocene-Miocene boundary in Drilling Project Sites 11, 12, and 17 (Pearson and Wade, 2015); Syria from Jihar sections (Kucenjak *et al*., 2006); Spain from De Las Pinarejas series (Molina, 1979); Western South Atlantic from Hole DSD-526A and Equatorial Indian from Hole ODP-709C (Spezzaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (8850'-7950'), where present is rare (Fig. 3.3).

Stratigraphic range: Late Eocene – Early Oligocene (Postuma, 1971).

***Globigerina tripartita* Koch, 1926**

(Plate 3, Fig. 2)

1926 *Globigerina bulloides* D'Orbigny *var. tripartita* Koch, p. 746, text fig. 21 (fide Ellis et al., 1969).
1971 *Globigerina tripartita* Koch, Postuma, pp. 276-277.

Description: Test medium in size, low to medium trochospiral, consisting of three and a half whorls. Chambers are spherical with three laterally compressed chambers in the last whorl increasing very rapidly in size. Umbilicus is fairly narrow to fairly wide with a triangular shape. Sutures on spiral side curved, depressed; on umbilical side radial, depressed. Wall perforate and surface smooth, the umbilical edge has a rugosites or short thick spines. Aperture is an interiomarginal, umbilical.

Occurrence: This species has been recorded, worldwide, including Egypt from Dabaa Formation (Ouda, 1998); Tunisia from Numidian Formation (Riahi, 2015); Syria from Jihar sections (Kucenjak *et al*., 2006); Turkey from Gazianteb Formation (Isik and Hakyemez, 2011); Gulf of Mexico from Hole 538A (Spezzaferri and Premoli Silva, 1991); Australia from Hole 1126 A (Li *et al*.,2003). In addition to the studied Well A1-89, offshore Sirt Basin, interval (9000'-4350'), where present is frequent to rare (Fig. 3.3).

Stratigraphic range: Late Eocene – Early Miocene (Postuma, 1971).

***Globigerina venezuelana* Hedberg, 1937**

(Plate 3, Fig. 3)

1937 *Globigerina venezuelana* Hedberg, p. 681, pl. 92, figs. 7a–b.
1971 *Globigerina venezuelana* Hedberg. Postuma, pp. 278-279.

Description: Test medium in size, low to medium trochospiral, consisting of three and a half whorls. Chambers are spherical to ovate with four laterally compressed chambers in the last whorl increasing rapidly in size. Umbiilicus is fairly narrow to fairly wide. Sutures on spiral side slightly curved, depressed; on umbilical side radial, depressed. Wall perforate and surface smooth, the umbilical edge has a rugosites or short thick spines. Aperture is an interiomarginal with umbilical arch.

Occurrence: This species has been recorded, worldwide, including Egypt from Nukhul Formation (Hewaidey *et al*., 2012); Tunisia from Numidian Formation (Riahi, 2015); Syria from Jihar sections (Kucenjak *et al*., 2006); Italy from Rigisoro Formation (Mancini and Pirini, 2001); Slovakia from Lucenec Formation (Ozdinova and Sotak, 2014); Gulf of Mexico from Hole 538A (Spezzaferri and Premoli silva, 1991); Chile from Navidad Formation (Finger, 2013). In addition to the studied Well A1-89, offshore Sirt Basin, interval (8950'-2400'), where present is common to frequent (Fig. 3.3).

Stratigraphic range: Late Oligocene – Early Pliocene (Postuma, 1971).

Globigerina woodi woodi Jenkins, 1960

(Plate 3, Fig. 4)

1960 *Globigerina woodi* Jenkins, p. 352, pl. 2, figs. 2a-c.

1985 *Globigerina woodi woodi* Jenkins, p.273 figs. 21a-c.

Description: Test medium in size, low trochospiral, consisting of about three whorls. Equatorial periphery quadrilobate. Chambers globular to subglobular, with four chambers in the last whorl increasing regularly in size as added. Umbilicus open. Sutures radial and depressed on both spiral and umbilical sides. Wall cancellate and the surface coarsely pitted. Aperture interiomarginal, umbilical and high arched, bordered by a thick rim.

Occurrence: This species has been recorded, worldwide, including Egypt from Karaem Formation (Cherif *et al*., 1993); Slovakia from Lucenec Formation (Ozdinova and Sotak, 2014);); Italy from Tufiti di Tusa Formation (de Capoa, 2002); Chile from Navidad Formation (Finger, 2013); Gulf of Mexico from Hole DSDP-94, Equatorial Atlantic from Hole DSDP-354, Eastern South Atlantic from Hole DSDP-17A, Equatorial Indian from Hole ODP-709C and South Pacific from Hole DSDP-588C (Speezaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (2400'-1500'), where present is present to frequent (Fig. 3.3).

Stratigraphic range: Late Oligocene – Late Pliocene (Kennett and Srinivasan, 1983).

Genus *Globigerinoides* Cushman, 1927

Globigerinoides bisphericus, Todd 1954

(Plate 3, Fig. 5)

1954 *Globigerinoides bispherica* Todd. - Todd et al. : p.681 pl. 1, figs. 1a-c.

1985 *Globigerinoides bisphericus* Todd. - Bolli and Saunders : p.200 figs. 24.8; 7,9,12.

Description: The test medium to large, low trochospiral, consisting of about three and a half whorls. Primary aperture a low slit-like arch bordered by a rim. A small sutural supplementary aperture is situated opposite to the primary one.

Occurrence: This species has been recorded, worldwide, including Egypt from Rudies Formation (Hewaidey *et al*., 2014); Turkey from Lice Formation (Isik and Hakyemez, 2011); Trinidad from Cipero Formation (Bolli, 1957); Eastern South Atlantic from Holes DSDP-360 and DSDP-17A, South Pacific from Hole DSDP-588C (Spezzaferri, 1994); Southwest Caribbean from oil wells northern Columbia (Rincon et al., 2007). In addition to the studied Well A1-89, offshore Sirt Basin, interval (2150'-1850'), where present is present to frequent (Fig. 3.3).

Stratigraphic range: Late Early Miocene – Early Middle Miocene (Bolli and Saunders, 1985).

***Globigerinoides immaturus* LeRoy, 1939**

(Plate 3, Fig. 6)

1983 *Globigerinoides immaturus* LeRoy – Kennett and Srinivasan, p.64, pl.10, fig. 3; pl.13, figs.7-9.
1985 *Globigerinoides trilobus immaturus* LeRoy – Bolli and Saunders, p. 196, fig. 20(14a-c).

Description: Test medium to large, low trochospiral, and consists of three whorls. Three spherical chambers in the last whorl increasing moderately in size as added surface exhibiting cancellate to spinose sculpturing. Sutures are radial and depressed. Aperture interiomarginal, umbilical with few secondary apertures dorsally.

Occurrence: This species has been recorded, worldwide, including Egypt from Nukhul Formation (Hewaidey *et al*., 2012); Iran from Qom Formation (Nouradini *et al*., 2015); Spain from Canada De Jean series (Molina, 1979); Trinidad from Brasso Formation (Wilson, 2005); Equatorial Atlantic from Hole ODP-667A, Equatorial Pacific from Hole DSDP-354 and South Atlantic from Hole DSDP-363 (Spezzaferri, 1994); Southwest pacific from Leg 21 sites (Kennett, 1973). In addition to the studied Well A1-89, offshore Sirt Basin, interval (3400'-1150'), where present is present to frequent (Fig. 3.3).

Stratigraphic range: Early Miocene – Recent (Postuma, 1971).

Globigerinoides obliquus obliquus Bolli, 1957

(Plate 3, Fig. 7)

1957 *Globigerinoides obliquus obliquus* Bolli. - Bolli : p.113 pl. 25, figs. 10a-c.

1985 *Globigerinoides obliquus obliquus* Bolli.-Bolli and Saunders : p.193 figs. 20.12; 7,9,12.

Description: The test trochospiral, chambers spherical except the final one, which is compressed in a lateral oblique manner, three to four in the final whorl increasing rapidly in size as added. Sutures on both sides radial to slightly curved and depressed. surface distinctly pitted and perforated. Aperture large interiomarginal umbilical with arch. Secondary apertures dorsally.

Occurrence: This species has been recorded, worldwide, including Egypt from Rudeis Formation (Hewaidey *et al*., 2014); Nigeria from Agbada Formation (Obaje and Okosun, 2013); Spain from Nijar Formation (Poore and Stone, 1981); Italy from Argille Azzurre Formation (Violanti, 1996); Trinidad from Brasso Formation (Wilson, 2005); Australia from Holes 1126B, 1126C and 1126D (Li et al., 2003). In addition to the studied Well A1-89, offshore Sirt Basin, interval (2900'-1050'), where present is abundant to frequent (Fig. 3.3).

Stratigraphic range: Early Miocene –Early Pliocene (Bolli and Saunders, 1985).

Globigerinoides obliquus extremus Bolli and Bermudez, 1965

(Plate 4, Fig. 1)

1965 *Globigerinoides obliquus extremus* Bolli and Bermudez-Bolli and Bermudez: p.139 pl.1, figs. 10-12.

1985 *Globigerinoides obliquus extremus* Bolli and Bermudez-Bolli and Saunders: p.193 figs. 20.11: 7,10,11.

Description: Test high trochospiral, nearly similar to obliquus subspecies except last chamber somewhat reduced and distinctly flattened; sutures on both sides radial to slightly curved and depressed; surface distinctly pitted, Aperture interiomarginal umbilical, with distinct medium height arch; yielded single secondary aperture dorsally.

Occurrence: This species has been recorded, worldwide, including Egypt from Pliocene sediments at Northern western desert (Ouda, 1998), Nigeria from Agbada Formation (Obaje and Okosun, 2013); China from Hanjiang, yuehai and Wanshan formations (Chunlian *et al*., 2012); Spain from Nijar Formation (Poore and Stone, 1981); Australia from Holes 1126B, 1126C and 1126D (Li *et al*., 2003). In addition to the studied Well A1-89, offshore Sirt Basin, interval (2900'-1050'). where present is common to rare (Fig. 3.3).

Stratigraphic range: Late Miocene – Middle Pliocene (Bolli and Saunders, 1985).

Globigerinoides primordius Blow and Banner, 1962

(Plate 4, Fig. 2)

1962 *Globigerinoides quadrilobatus* (d'Orbigny) *primordius* Blow and Banner, p.115, pl. IX Dd-Ff; Fig. 14 (III- VIII).
1971 *Globigerinoides primordius* Blow and Banner – Postuma, pp. 298-299.

Description: Test medium to large in size, trochospiral, unequally biconvex, equatorial periphery lobulate and axial periphery rounded. Chambers inflated subglobular, four in the final whorl increasing fairly rapidly in size. Sutures on both umbilical and spiral side are radial and depressed. Wall perforate and the surface pitted. Umbilicus small. Aperture interiomarginal, umbilical, low to medium arch bordered by a faint rim. One secondary aperture is present behind the primary one.

Occurrence: This species has been recorded, worldwide, including Egypt from Nukhul Formation (Hewaidey *et al*., 2012); Tunisia from Numidian Formation (Riahi, 2015), Slovakia from Lucenec Formation (Ozdinova and Sotak, 2015); Italy from Antognola Formation (Mancini and Pirini, 2001); Spain from Del Navasuelo series (Molina, 1979); Chile from Navidad Formation (Finger, 2013). In addition to the studied Well A1-89, offshore Sirt Basin, interval (4450'-2900'), where present is common to frequent (Fig. 3.3).

Stratigraphic range: Latest Oligocene – Early Miocene (Bolli and Saunders, 1985).

Globigerinoides quadrilobatus d'Orbigny, 1846

(Plate 4, Fig. 3)

1846 *Globigerina quadrilobata* d'Orbigny, p.164, pl. 9, figs. 7-10 (fide Ellis and Messina, 1949).
1983 *Globigerinoides quadrilobatus* d'Orbigny – Kennett and Srinivasan, p. 66, pl.14, figs.1-3.

Description: Test medium to large, low trochospiral, chambers spherical with three to four chambers in last whorl increasing moderately in size as added. subcircular in outline. Sutures curved and depressed on both sides. Surface is cancellated and spinose. Umbilicus narrow. Aperture interiomarginal umbilical yielded an arch with supplementary apertures dorsally.

Occurrence: This species has been recorded, worldwide, including Egypt from Rudies Formation (Hewaidey *et al*., 2014); Iran from Qom Formation (Nouradini *et al*., 2015); Turkey from Lice Formation (Isik and Hakyemez, 2011); North Atlantic from Hole DSDP-548A, South Atlantic from Hole DSDP-363 and Equatorial Indian from Hole ODP-714A (Spezzaferri 1994); Southwest Pacific from DSDP Leg-21, sites 206, 208 and 209 (Kennet,1973). In addition to the studied Well A1-89, offshore Sirt Basin, interval (2850'-1650'), where present is common to frequent (Fig. 3.3).

Stratigraphic range: Early Miocene – Recent (Bolli and Saunders, 1985).

Globigerinoides ruber d'Orbigny, 1839

(Plate 4, Fig. 4)

1971 *Globigerinoides ruber* (d'Orbigny) – Postuma, p. 300, all figs on p. 301.

1983 *Globigerinoides ruber* (d'Orbigny) – Kennett and Srinivasan, p. 78, pl. 17, figs. 1-3.

Description: Test medium to large, low to high trochospirally coiled with three highly inflated spherical chambers in the last whorl, narrow umbilicus and rounded periphery. Wall cancellate and spinose; sutures subradial to radial, depressed. Aperture interiomarginal umbilical with medium arched opening bordered by a rim. Two secondary apertures dorsally.

Occurrence: This species has been recorded, worldwide, including Egypt from Rudies Formation (Hewaidey *et al*., 2014); Japan from Nobori Formation (Takayanagi and Saito, 1962); Italy from Argille Azzurre Formation (Violanti, 1996); Trinidad from Brasso Formation (Wilson, 2005); Southwest Pacific from DSDP Leg-21, sites 203 and 206 (Kennett,1973); Australia from Holes 1126B, 1126C and 1126D (Li *et al*., 2003). In addition to the studied Well A1-89, offshore Sirt Basin, interval (2400'-1050'), where present is present to rare (Fig. 3.3).

Stratigraphic range: Early Miocene – Recent (Bolli and Saunders, 1985).

Globigerinoides sacculifer Brady, 1877

(Plate 4, Fig. 5)

1877 *Globigerina sacculifera* Brady, p. 535 (no fig.).
1971*Globigerinoides sacculiferus* (Brady) – Postuma, pp. 302- 303.

Description: Test medium to large, low trochospiral with three to four spherical chambers in the last whorl increase slowly in size as added., final chamber being elongated radially, subangular and sack-like; equatorial periphery lobulate with narrow umbilicus. Sutures on both sides slightly curved and depressed; Surface cancellate and spinose. Aperture interiomarginal umbilical, rimmed with small secondary apertures dorsally.

Occurrence: This species has been recorded, worldwide, including Egypt from Mamura Formation (Ouda., 1998); Iran from Qom Formation (Nouradini *et al*., 2015); Turkey from Çağlayancerit and Lici formations (Isik and Hakyemez, 2011); Spain from Nijar Formation (Poore and Stone, 1981); Equatorial Indian Ocean from hole 714A (Spezzeaferri, 1994); Southwest pacific from Leg 21 sites (Kennett, 1973). In addition to the studied Well A1-89, offshore Sirt Basin, interval (3250'-1100'), where present is present to frequent (Fig. 3.3).

Stratigraphic range: Early Miocene – Recent (Bolli and Saunders, 1985).

Globigerinoides subquadratus Brönnimann, 1954

(Plate 4, Fig. 6)

1954 *Globigerinoides subquadrata* Brönnimann, p.680, pl.1, figs. 8a-c.

1971 *Globigerinoides subquadratus* Brönnimann – Postuma, pp.306-307

Description: Test medium to large, low trochospiral, consisting of three and half to four whorls. Three spherical chambers in the last whorl with subquadrate outline. Sutures radial and depressed ventrally but slightly curved and depressed dorsally. Surface cancellate and spinose. Aperture interiomarginal umbilical, arched and rimmed, with two secondary apertures dorsally.

Occurrence: This species has been recorded, worldwide, including Egypt from Rudies Formation (Hewaidey *et al*., 2014); Nigeria from Agbada Formation (Obaje and Okosun, 2013); Iran from Qom Formation (Nouradini *et al*., 2015); Turkey from Lice Formation (Isik and Hakyemez, 2011); South Pacific from Hole DSDP-593; South Atlantic from Hole DSDP-363 and South Caribbean from Hole DSDP-153 (Spezzaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (2400'-2150'), where present is frequent to rare (Fig. 3.3).

Stratigraphic range: Early Miocene – Middle Miocene (Postuma, 1971).

***Globigerinoides trilobus* Reuss, 1850**

(Plate 5, Fig. 1)

1985 *Globigerinoides trilobus trilobus* Reuss – Bolli and Saunders, p. 196, fig. 20 15a- c.

1994 *Globigerinoides trilobus* Reuss – Spezzaferri, p.37, pl. 13, figs. 1a-2c; pl. 15, figs. 6a-c.

Description: The test medium to large, low trochospiral, consisting of about three and a half whorls with three spherical chambers in the last whorl increase rabidly in size as added. Sutures on both sides gently curved and depressed. Surface distinctly cancellate. Primary aperture interiomarginal, umbilical with a low slit-like arch bordered by a rim. A small sutural supplementary aperture is situated opposite to the primary one.

Occurrence: This species has been recorded, worldwide, including Egypt from Nukhul Formation (Hewaidey *et al*., 2012); Tunisia from Numidian Formation (Riahi, 2015); Iran from Qom Formation (Nouradini *et al*., 2015); Malaysia from Temburong Formation (Asis *et al*., 2015); Spain from Del Navasuelo series (Molina, 1979)

Trinidad from Cipero Formation (Bolli, 1957); Chile from Navidad Formation (Finger, 2013). In addition to the studied Well A1-89, offshore Sirt Basin, interval (3300'-1150'), where present is present to rare (Fig. 3.3).

Stratigraphic range: Early Miocene – Recent (Bolli and Saunders, 1985).

Superfamily GLOBIGERINITOIDEA Bermúdez, 1961

Family GLOBIGERINITIDAE Bermúdez, 1961

Genus *Globigerinita* Brönnimann, 1951

Globigerinita naparimaensis Bronnimann, 1951

1951 *Globigerinita naparimaensis* Brönnimann-Brönnimann : p.18 figs. 1-2.

1985 *Globigerinita naparimaensis* Brönnimann.-Bolli and Saunders : p.187 figs. 17.7; 7,9,12.

Description: Test small in size, low to medium trochospiral, consisting of three and a half whorls. Equatorial periphery lobulate and axial periphery rounded. Chambers are spherical to subglobular with three to four chambers in the last whorl increasing rapidly in size. Sutures radial to slightly curved, depressed. Wall perforate and surface smooth to finely pitted. Aperture is an interiomarginal, umbilical covered by an irregular bulla.

Occurrence: This species has been recorded, worldwide, including Egypt from Rudies Formation (Ouda *et al*., 2000); Nigeria from Agbada Formation (Obaje and Okosun, 2013); Italy from Tufiti di Tusa Formation (de Capoa, *et al*., 2002); Trinidad from Cipero and Lengua formations (Bolli, 1957); Southern Indian from Hole-747A (Li, *et al*., 1992). In addition to the studied Well A1-89, offshore Sirt Basin, interval (2850'-1650'), where present is frequent to rare (Fig. 3.3).

Stratigraphic range: Early Miocene – Recent (Postuma, 1971).

Globigerinita incrusta Akers, 1955

(Plate 5, Fig. 2)

1955 *Globigerinita incrusta* Akers, p. 655, pl. 65, figs. 2a-d.

1957 *Globigerinita juv enilis* Bolli, p. 110, pl. 24, figs. 5a-c.

Description: Test very small in size, low to medium trochospiral, consisting of three and a half whorls. Equatorial periphery slightly lobulate and axial periphery rounded. Chambers are subglobular with four chambers in the last whorl increasing gradually in size. Sutures radial and depressed. Wall perforate and the surface smooth or hispid. Aperture is an interiomarginal, umbilical covered by an irregular bulla with branches that extend through the suture grooves with small opening at the end of each branch.

Occurrence: This species has been recorded, worldwide, including Egypt from Sidi Salem Formation (Hewaidy *et al*., 2013); Italy from Scaglia Cinerea Formation (Menichini, 1999); North Atlantic from Hole DSDP-116, Gulf of Mexico from Hole DSDP-94, South Caribbean from Hole DSD-153, Equatorial Atlantic from Hole DSDPP-354, South Atlantic from Hole DSDP-363 and South Pacific from Hole DSDP-588C (Spezzaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (4450'-1400'), where present is frequent to rare (Fig. 3.3).

Stratigraphic range: Late Oligocene – Middle Miocene (Molina, 1979).

Family GLOBOQUADRINIDAE Blow, 1979

Genus *Globoquadrina* Finlay, 1947

***Globoquadrina altispira altispira* Cushman and Jarvis, 1936**

(Plate 5, Fig. 3)

1936 *Globoquadrina altispira* Cushman and Garves, p. 5, pl. 1, figs. 13, 14.

1957 *Globoquadrina altispira altispira* Bolli, p. 111.

Description: Test medium to high trochospiral, equatorial periphery distinctly lobulated; axial periphery broadly rounded. Chambers of early part spherical and those of last whorl strongly compressed arranged in three and a half to four whorls, the four to five chambers in the last chambers increase moderately in size. Umbilicus wide to fairly wide and deep. Sutures on spiral side slightly curved, depressed and on umbilical side radial depressed. Wall distinctly perforate and the surface slightly pitted. Aperture interiomarginal, umbilical with high arch, covered by an elongate tooth-like flap.

Occurrence: This species has been recorded, worldwide, including Egypt from Rudies Formation (Hewaidey *et al*., 2014); China from Hanjiang, yuehai and

Wanshan formations (Chunlian *et al*., 2012); Turkey from and Lici Formation (Isik and Hakyemez, 2011); Trinidad from Cipero Formation (Bolli, 1957); Gulf of Mexico from Hole DSDP-94, Equatorial Atlantic from Hole DSDP-667A, Eastern South Atlantic from Hole DSDP-17A, Equatorial Indian from Hole ODP-714A and South Pacific from Hole DSDP-588C (Speezaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (3700'-2150'), where present is common to frequent (Fig. 3.3).

Stratigraphic range: Early Miocene – Early Pliocene (Bolli and Saunders, 1985).

***Globoquadrina dehiscens* Chapman, Parr and Collins, 1934**

(Plate 5, Fig. 4)

1934 *Globorotalia dehiscens* Chapman, Parr and Collins, p. 569, pl. II, figs. 36a-c.

1939 *Globorotalia quadraria* Cushman and Ellisor, p. 11, pl. 2, figs. 5a-c.

Description: Test low trochospiral, subquadrate, three to four compressed chambers in the last whorl increasing rapidly in size and height, spiral side almost flat, umbilical side strongly convex. Umbilicus fairly narrow to fairly wide and deep. Sutures on both sides radial to slightly curved and depressed. Wall cancellate, rugose near shoulders of chambers. Aperture low arch, interiomarginal, umbilical, covered by an elongate tooth.

Occurrence: This species has been reported worldwide, including Egypt from Mamura Formation (Ouda, 1998); Tunisia from Numidian Formation (Riahi, 2015); Turkey from Çağlayancerit and Lici formations (Isik and Hakyemez, 2011); Italy from Antognola Formation (Mancini and Pirini, 2001); Southwest pacific from Leg 21 sites (Kennet, 1973); Chile from Navidad Formation (Finger, 2013). In addition to the studied Well A1-89, offshore Sirt Basin, interval (3250'-1550'), where present is frequent (Fig. 3.3).

Stratigraphic range: Early Miocene – Early Pliocene (Bolli and Saunders, 1985).

Family GLOBOROTALIOIDEA Cushman, 1927

Genus *Globorotalia* Cushman, 1927

***Globorotalia continuosa* Blow, 1959**

(Plate 5, Fig. 5)

1959 *Globorotalia opima continuosa* Blow. - Blow : p.218 pl.19, figs.125a-c.

1985 *Globorotalia continuosa* Blow-Bolli and Saunders : p.204 figs. 26.8-14; 6,9,12.

Description: Test small, very low trochospiral; equatorial periphery lobulated and the axial periphery rounded. Chambers inflated, subglobular arranged in about three and a half whorls with four champers in last whorl increase regularly in size. Umbilicus fairly wide and deep. Sutures on spiral side slightly to moderatly curved, depressed and on umbilical side radial. Wall coarsely perforate and surface smooth. Aperture interiomarginal, extraumbilical-umbilical with a large high comma-shaped arch bordered by a lip.

Occurrence: This species has been recorded, worldwide, including Egypt from Rudies Formation (Hewaidey *et al.*, 2014); Tunisia from Numidian Formation (Riahi, 2015); Turkey from Lici Formation (Isik and Hakyemez, 2011); Japan from Kobana Formation (Hayashi and Takahashi, 2002); South Caribbean from Hole DSDP-153, Equatorial Atlantic from Hole ODP-667A, Eastern South Atlantic from Hole DSDP-17A, Equatorial Indian from hole ODP-709C and South Pacific from hole DSDP-588C (Speezaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (3050'-1900'), where present is frequent to rare (Fig. 3.3).

Stratigraphic range: Early Miocene – Middle Miocene (Bolli and Saunders, 1985).

***Globorotalia crassaformis* Galloway and Wissler, 1927**

(Plate 6, Fig. 1)

1927 *Globorotalia crassaformis* Galloway and Wissler, p. 41, pl. 7, fig. 12.

1985 *Globorotalia crassaformis crassaformis* (Galloway and Wissler) – Bolli and Saunders, p. 233, fig. 36.6-7.

Description: Test low trochospiral, equatorial periphery lobulate; axial periphery subacuate to subrounded.. Chambers are compressed, arranged in about four whorls; the chambers of last whorl increase rabidly in size. Umbilicus fairly narrow to fairly wide and deep. Sutures on spiral side distinctly curved, depressed and on umbilical side almost radial. Wall finely perforate and surface of early chambers slightly rugose. Aperture interiomarginal, extraumbilical-umbilical, bordered above by a lip.

Occurrence: This species has been recorded, worldwide, including Egypt from Pliocene sediments at Northern western desert (Ouda, 1998); Tiwan from Erhchungcchi and Gutingkeng formations (Huang, 1967); Cyprus from Nicosia formation (Triantaphyllou *et al*., 2010); Spain from Veleri antenna section (Aguirre *et al*., 2005); United states of America (USA) from Quinault Formation (Rau, 1970); Australia from Holes 1126B, 1126C and 1126D (Li *et al*., 2003). In addition to the studied Well A1-89, offshore Sirt Basin, interval (1850'-1400'), where present is frequent (Fig. 3.3).

Stratigraphic range: Early Pliocene – Recent (Bolli and Saunders, 1985).

Globorotalia inflata d'Orbigny, 1839

(Plate 2, Fig. 6)

1839 *Globorotalia inflata* d'Orbigny. - d'Orbigny : p.134 pl. 2, figs. 7-9.

1983 *Globorotalia inflata* d'Orbigny - Kennet and Srinivasan. p. 117, pl. 27, figs. 7-9.

Description: Test low trochospiral, periphery broadly rounded. Chambers are subglobular, more inflated on umbilical side than on spiral side, increasing uniformly in size as added. Umbilicus narrow. Sutures on spiral side distinctly curved, depressed and on umbilical side almost radial, depressed. Surface covered with low, rounded tubercles and smooth, thick cortex. Aperture wide, high arch, interiomarginal, umbilical-extraumbilical with an indistinct rim.

Occurrence: This species has been recorded, worldwide, including Nigeria from Agbada Formation (Ajayi and Okosun, 2014); Jaban from Pleistocene sediments at Kumano basin (Hayashi, *et al*., 2016); Italy from Pliocene sediments at the Tafone and Marta Rivers (Carboni and Palaci, 1998); Norway from Late Weichselian sediments (Hald and Vorren, 1987); Southwest pacific from Leg 21 sites (Kennett, 1973). In addition to the studied Well A1-89, offshore Sirt Basin, interval (1700'-1100'), where present is frequent to rare (Fig. 3.3).

Stratigraphic range: Late Pliocene – Recent (Kennet and Srinivasan, 1983).

Globorotalia Kugleri **Bolli, 1957**

(Plate 6, Fig. 2)

1957 *Globorotalia kugleri* Bolli, p. 118, pl. 28, figs. 5a - 6, (no figs. 7a-c).
1964 *Globorotalia (Turborotalia) kugleri* Bolli. Reiss and Gvirtzmann, pl. 94, figs. 13, 14 y 15a-c.

Description: Test very low trochospiral, equatorial periphery slightly lobulate; axial periphery rounded with tendency to become subangular. Chambers, ovate arranged in about three whorls; six to eight champers of last whorl increase slowly in size. Umbilicus fairly narrow. Sutures on spiral side curved radial and o umbilical side radial, depressed. Wall perforate and the surface smooth. Aperture interiomarginal, extraumbilical-umbilical, with arch bordered by a lip.

Occurrence: This species has been recorded, worldwide, including Tunisia from Numidian Formation (Riahi, 2015); Iran from Qom Formation (Nouradini *et al*., 2015); Italy from Castagnola Formation (Mancini and Pirini, 2001); North Atlantic from Hole DSDP-116, Gulf of Mexico from Hole DSDP-94, South Carribean from Hole DSDP-153, Equatorial Atlantic from Hole ODP-667A, South Pacific from Holes DSDP-588C and 593, Equatorial Indian from Hole 709C (Speezaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (4400'-4350), where present is frequent (Fig. 3.3).

Stratigraphic range: Late Oligocene- Early Miocene (Bolli and Saunders, 1985)**.**

Globorotalia mayeri **Cushman and Ellisior, 1939**

(Plate 6, Fig. 3)

1939 *Globorotalima mayeri* Cushman and Ellisor, Cushman Lab. Foram. Research Contr., vol. 15, p. 11, pl. 2, fig. 4a-c.
1971 Globorotalia mayeri Cushman and Ellisor. Postuma, pp. 332-333.

Description: Test very low trochospiral, equatorial periphery lobulate; axial periphery broadly rounded. Chambers inflated, subglobular arranged in about three and a half whorls with five to sex champers in last whorl increase regularly in size. Umbilicus fairly wide and deep. Sutures on spiral side slightly to moderatly curved, depressed and on umbilical side radial. Wall coarsely perforate and surface smooth. Aperture interiomarginal, extraumbilical-umbilical with a large high arch bordered by a lip or rim.

Occurrence: This species has been recorded, worldwide, including Egypt from Rudies and Belayim formations (Hewaidey *et al*., 2014); Tunisia from Numidian Formation (Riahi, 2015); Iran from Qom Formation (Nouradini *et al*., 2015); Japan from Arakawa group (Hayashi and Takahashi, 2002); Gulf of Mexico from hole DSDP-94, South Caribbean from Hole DSDP-153, Equatorial Atlantic from Hole ODP-667A and Equatorial Indian from Hole ODP-714A (Spezzaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (3300'-1250'), where present is frequent to rare (Fig. 3.3).

Stratigraphic range: Late Oligocene – Middle Miocene (Bolli and Saunders, 1985).

***Globorotalia obesa* Bolli, 1957**

(Plate 6, Fig. 4)

1957 *Globorotalia obesa* Bolli. - Bolli : pl. 29, figs. 2a-3 new species.

1985 *Globorotalia obesa* Bolli. - Bolli and Saunders : p.204 figs. 26.44; 6,9,12.

Description: Test very low trochospiral; equatorial periphery strongly lobulate; axial periphery rounded. Chambers strongly inflated, spherical; chambers of the last whorl increase very rapidly in size. Umbilicus fairly wide and deep. Sutures on both spiral side and umbilical side radial and depressed. Wall coarsely perforate, surface finely pitted, in well preserved specimens with fine, short spines. Aperture interiomarginal, umbilical extraumbilical with a medium to high arch bordered by a slight rim or lip.

Occurrence: This species has been recorded, worldwide, including Egypt from Rudies and Belayim formations (Hewaidey *et al*., 2014); Tunisia from Numidian Formation (Riahi, 2015); Turkey from Çağlayancerit Formation (Isik and Hakyemez, 2011); Spain from Canada De Jean series (Molina, 1979); Italy from Scaglia Cinerea Formation (Menichini, 1999); South Atlantic from hole DSDP-363 and Gulf of Mexico from hole DSDP-94 (Spezzaferri 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (3050'-1850'), where present is present to frequent (Fig. 3.3).

Stratigraphic range: Early Miocene – Middle Miocene (Bolli and Saunders, 1985).

***Globorotalia opima nana* Bolli, 1957**

(Plate 6, Fig. 5)

1957 *Globorotalia opima nana* Bolli, p. 118, pl. 28, figs. 3a-c.

1971 *Globorotalia nana* Bolli. Postuma, pp. 340-341.

Description: Test very low trochospiral, equatorial periphery lobulate; axial periphery rounded. Chambers spherical, arranged in about three whorls; four to five champers of last whorl increase fairly rapidly in size. Umbilicus narrow and deep. Sutures on both sides radial and depressed. Wall coarsely perforate and the surface pitted. Aperture interiomarginal, extraumbilical-umbilical, a low arch bordered above by a thick lip or rim.

Occurrence: This species has been recorded, worldwide, including Egypt from Nukhul Formation (Hewaidey *et al*., 2012); Tunisia from Numidian Formation (Riahi, 2015); Syria from Jihar sections. (Kucenjak *et al*., 2006); Slovakia from Ciz Formation (Ozdinova and Sotak, 2015); Italy from Scaglia Cinerea Formation (Menichini, 1999); Eastern South Atlantic from Hole DSDP-360, Equatorial Atlantic from Hole DSDP-354 and South Pacific from Hole DSDP-588C (Spezzaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (9000'-4700'), where present is common to frequent (Fig. 3.3).

Stratigraphic range: Early Oligocene- Late Oligocene (Bolli and Saunders, 1985).

***Globorotalia opima opima* Bolli, 1957**

(Plate 7, Fig. 1)

1957 *Globorotalia opima opima* Bolli, p. 117, pl. 28, figs. 1-2.

1971 *Globorotalia opima* Bolli. Postuma, pp. 344-345.

Description: Test very low trochospiral, equatorial periphery lobulate; axial periphery rounded. Chambers spherical, arranged in about three whorls; four to five champers of last whorl increase fairly rapidly in size. Umbilicus narrow and deep. Sutures on both sides radial and depressed. Wall coarsely perforate and the surface of early champers slightly rugoseites. Aperture interiomarginal, extraumbilical-umbilical, a low arch bordered above by a slight lip or rim.

Occurrence: This species has been recorded, worldwide, including Egypt from Dabaa Formation (Ouda, 1998); Tunisia from Numidian Formation (Riahi, 2015); Syria from Jihar sections (Kucenjak *et al*., 2006); Slovakia from Ciz Formation (Ozdinova and Sotak, 2015); Italy from Scaglia Cinerea Formation (Menichini, 1999); Eastern South Atlantic from Hole DSDP-360, Equatorial Atlantic from Hole DSDP-354 and South Pacific from Hole DSDP-588C (Spezzaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (8700'-5750'), where present is present to rare (Fig. 3.3).

Stratigraphic range: Middle Oligocene (Bolli and Saunders, 1985)**.**

Globorotalia siakensis Leroy, 1939

1939 *Globigerina siakensis* Roy. - LeRoy : p.262 pl. 4; fig. 20-22.
1975 *Globorotalia siakensis* Le Roy. - Srinivasan : p.149 pl. 4; fig. 1-3.

Description: Test very low trochospiral, equatorial periphery lobulate; axial periphery rounded. Chambers inflated, subglobular arranged in about three whorls; five to six champers of last whorl increase regulary in size. Umbilicus fairly wide to fairly narrow, deep. Sutures on both sides radial and depressed. Wall coarsely perforate and the surface smooth. Aperture interiomarginal, extraumbilical-umbilical, a low arch bordered above by a faint lip or rim.

Occurrence: This species has been recorded, worldwide, including Egypt from Dabaa Formation (Ouda, 1998); Tunisia from Numidian Formation (Riahi, 2015); Spain from Canada De Jean series (Molina, 1979); Italy from Scaglia Cinerea Formation (Menichini, 1999); North Atlantic from Hole DSDP-116, Gulf of Mexico from Hole DSDP-94, South Carribean from Hole DSDP-153, Equatorial Atlantic from Hole ODP-667A, South Atlantic from Hole DSDP-363, Equatorial Indian from Hole ODP-714A and South Pacific from Hole DSDP-593 (Spezzaferri, 1994) .In addition to the studied Well A1-89, offshore Sirt Basin, interval (3250'-2050'), where present is frequent to rare (Fig. 3.3).

Stratigraphic range: Late Oligocene – Middle Miocene (Postuma, 1971).

Genus *Hastigrina* Thomson, 1876

Hastigrina praesiphonifera d'Orbigny, 1839

(Plate 7, Fig. 3)

1969 *Hastigerina (Hastegerina) siphonifera praesiphonifera* Blow, p. 408, pl. 54, figs. 7-9.

1985 *Hastigerina praesiphonifera* Blow – Bolli and Saunders, p. 253, fig. 42(5a-c).

Description: Test medium to large in size, low trochospiral, consisting of about three whorls. Equatorial periphery lobulated and axial periphery generally rounded. Chambers inflated, subglobular with five chambers in the final whorl. Umbilicus fairly. Sutures of chambers of the last whorl deeply incised and curved on both sides. Wall finely perforate, surface pitted. Aperture umbilical to extraumbilical and quite arched.

Occurrence: This species has been recorded, worldwide, including Egypt from Nukhul Formation (Hewaidy *et al*., 2014), Turkey from Lici Formation (Isik and Hakyemez, 2011); Trinidad from Brasso Formation (Wilson, 2005); North Atlantic from Hole DSDP-98, Gulf of Mexico from Hole DSDP-94, Equatorial Atlantic from Hole DSDP-354, South Atlantic from Hole DSDP-363 and Equatorial Indian from Hole ODP-709C (Spezzaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (3700'-2350'), where present is rare (Fig. 3.3).

Stratigraphic range: Middle Oligocene – Middle Miocene (Spezzaferri, 1994).

Pseudohastegrina micra Cole, 1927

(Plate 7, Fig. 2)

1927 *Nonion micrus* Cole. - Cole : p.22 pl. 5 fig. 12.

1985 *Pseudohastegrina micra* Cole – Toumarkine and Luterbacher: p.119 figs 2a-b.

Description: Test small, planispiral early stage may be slightly trochospiral, biumbilicate. Equatorial periphery lobulate and axial periphery rounded. Chambers inflated globular to subglobuar with six chambers in the last whorl, sometimes the final champers of the last whor increase very rapidly in size. Sutures curved and depressed. Wall finely perforate and the surface smooth. Aperture interiomarginal, bordered by a lip.

Occurrence: This species has been recorded, worldwide, including Egypt from Nukhul Formation (Hewaidey *et al*., 2012); Tunisia from Souar Formation (Yaakoub *et al*., 2017); Syria from Jihar sections (Kucenjak *et al*., 2006); Italy from Ranzano Formation (Mancini and Pirini, 2001); Spain from De las Pinarejas series (Molina, 1979); Equatorial Atlantic from Hole DSDP-354 (Spezzaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, interval (9000'-7450'), where present is frequent to rare (Fig. 3.3).

Stratigraphic range: Early Eocene – Early Oligocene (Postuma, 1971).

Genus *Orbulina* d'Orbigny, 1839

***Orbulina bilobata* d'Orbigny, 1846**

(Plate 7, Fig. 4)

1846 *Globigerina bilobata* (d'Orbigny), p. 164, pl. 9, figs. 11-14.
1971 *Orbulina bilobata* (d'Orbigny) – Postuma , p. 370, all figs. on p. 371.

Description: Test consists of two half spherical chambers, the penultimate one partly-completely enveloping the initial globigerine stage. Bilobate in outline. Surface perforate and pitted. Aperture is areal with several small openings scattered over the wall of the final chamber, with distinct small sutural secondary apertures along the sutures.

Occurrence: This species has been recorded, worldwide, including Egypt from Belayiem Formation (Hewaidey *et al*., 2014); South China Sea from 1143 site (Nathan and Leckie, 2003); Trinidad from Cipero and Lengua formations (Bolli, 1957); Gulf of Mexico from Hole DSDP-94 and South Pacific from hole DSDP-588C (Speezaferri, 1994); Southwest Caribbean from oil wells northern Columbia (Rincon *et al*., 2007). In addition to the studied Well A1-89, offshore Sirt Basin, interval (1950'-1300'), where present is frequent to rare (Fig. 3.3).

Stratigraphic range: Middle Miocene – Recent (Bolli and Saunders, 1985).

Orbulina suturalis Brönnimann, 1951

(Plate 7, Fig. 5)

1951 *Orbulina suturalis* Brönnimann, p. 135, text fig. II, figs. 2-4; text fig. IV, figs. 2-4, 15,16, 20.

1971 *Orbulina suturalis* Brönnimann – Postuma, p. 372, all figs. on p. 373.

Description: Test is spherical with early globigerine stage trochospiral and not completely enveloped by the penultimate chamber. Transitional forms of partly enveloped initial globigerine stage to an almost completely enveloped one characterizes this species. Wall exhibits cancellate to spinose sculptures. Aperture is areal in the adult stage with a characteristic small secondary apertures along sutures separating the final and earlier chambers.

Occurrence: This species has been recorded, worldwide, including Egypt from Pliocene sediments (Ouda, 1998); Japan from Kobana Formation (Hayashi and Takahashi, 2002); Indonesia from Ngaryong Formation (Sharaf *et al*., 2005); Italy from Torino hell section (Mancin *et al*., 2010); Trinidad from Cipero and Lengua formations (Bolli, 1957); Southwest Pacific from DSDP LEG 21 (Kennett, 1973); Southwest Caribbean from oil wells northern Columbia (Rincon et al., 2007). In addition to the studied Well A1-89, offshore Sirt Basin, interval (1950'-1050'), where present is common to present (Fig. 3.3).

Stratigraphic range: Middle Miocene – Recent (Bolli and Saunders, 1985).

Orbulina universa d'Orbigny, 1839

(Plate 7, Fig. 6)

1839 *Orbulina universa*, d' Orbigny. De la Sagra, vol.8, p.3, pl. 1, fig.1.

1974 *Orbulina universa*, d' Orbigny. Reiss et al., p.78, pl. 1, pl.8, figs.5-6.

Description: The test is large and spherical, comprising of one chamber, the apertures are multiple and found as the large rounded openings scattered all over the test. However the smaller are pores.

Occurrence: This species has been recorded, worldwide, including Egypt from Belayiem Formation (Hewaidey *et al*., 2014); Japan from Kobana Formation (Hayashi and Takahashi, 2002); Spain from Nijar Formation (Poore and Stone, 1981); Chile from Navidad Formation (Finger, 2013); Trinidad from Cipero and Lengua formations (Bolli, 1957); South Atlantic from hole DSDP-363 (Speezaferri, 1994); Southwest Pacific from DSDP LEG 21 (Kennett, 1973); Australia from Leg 182, Hole 1130 A (Li *et al*.,2003). In addition to the studied Well A1-89, offshore Sirt Basin, Interval (2000'-1050'), where present is common to frequent (Fig. 3.3).

Stratigraphic range: Middle Miocene – Recent (Bolli and Saunders, 1985).

Genus *Praeorbulina* Olsson, 1964

***Praeorbulina glomerosa* Blow, 1956**

(Plate 7, Fig. 7)

1956 *Globigerinoides glomerosa* Blow, p. 65, text.-fig. 1, - nos. 9-19, tex.-fig. 2, nos. 1-4.
1971 *Praeorbulina glomerosa* Blow. Postuma, pp. 376-377.

Description: Test subglobular, ovoid to nearly spherical early portion trochospiral. Periphery almost circular. Chambers spherical, arranged in about four whorls ad the last chambers increase rapidly in size the last whorl. Sutures slightly curved to radial and depressed. Wall distinctly perforate and the surface is slightly pitted. Aperture interiomarginal, umbilical, covered by the final embracing chamber with secondary sutural apertures dorsally.

Occurrence: This species has been recorded, worldwide, including Egypt from Rudeis Formation (Hewaidey *et al*., 2014); Japan from Kobana Formation (Hayashi and Takahashi, 2002); Spain from Del Delgadillo series (Molina, 1979); Trinidad from Cipero Formation (Bolli, 1957); Chile from Navidad Formation (Finger, 2013); South Caribbean from Hole DSDP-153, Gulf of Mexico from Hole DSDP-151 and South Pacific from Hole DSDP-588C (Spezzaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, Interval (2050'-1850'), where present is frequent (Fig. 3.3).

Stratigraphic range: Late Early Miocene – Early Middle Miocene (Bolli and Saunders, 1985).

Praeorbulina transitoria Blow, 1956

(Plate 7, Fig. 8)

1956 *Globigerinoides transitoria* Blow, p. 65, text-fig. 2, nos. 12-13.

1971 *Praeorbulina transitoria* (Blow) – Postuma, pp. 378- 379.

Description: Test consists of two parts the low trochospiral early chambers with the spherical ultimate chamber, in addition to the penultimate chamber which embraces the earlier chambers. surface cancellate and spinose. Test consists of three or more narrow, elongated apertures at the base of the last chamber, with small secondary apertures dorsally.

Occurrence: This species has been recorded, worldwide, including Egypt from Belayiem and Rudies formations (Hewaidey *et al*., 2014); Turkey from Lice Formation (Isik and Hakyemez, 2011); Spain from De Laborcillas series (Molina, 1979); Trinidad from Cipero Formation (Bolli, 1957); South Pacific from hole DSDP-588C, South Caribbean from hole DSDP-153 and Eastern South Atlantic from Holes DSDP-360 and DSDP-17A (Speezaferri, 1994). In addition to the studied Well A1-89, offshore Sirt Basin, Interval (2000'-1850'), where present is present (Fig. 3.3).

Stratigraphic range: Late Early Miocene – Early Middle Miocene (Bolli and Saunders, 1985).

Genus *Sphaeroidinella* Cushman, 1927

Sphaeroidinella dehiscens Parker and Jones, 1865

(Plate 8, Fig. 1)

1865 *Sphaeroidinella dehiscens* Parker and Jones, var. immaturus Cushman, 1919, p. 40, pl. 14, fig. 2.

1973 *Sphaeroidinella dehiscens* Parker and Jones, Postuma, pp. 386- 387.

Description: Test large, trochospiral compact, equatorial periphery broadly ovoid or spherical. Chambers subglobular, three in the last whorl, strongly inflated, increasing rapidly in size. Sutures indistinct, radial and slightly depressed. Primary wall coarsely perforate covered by secondary layers of shell material greatly reducing the external openings of the pores of the primary wall. surface smooth and glassy in appearance.

Primary aperture interiomarginal, umbilical, one or two sutural supplementary apertures present; apertures bordered by crenulated lip, which are extensions of the cortex.

Occurrence: This species has been recorded, worldwide, including India from Trubi Formation (Srinivasan and Srivastava, 1974); Japan from Pleistocene sediments at Kumano basin (Hayashi *et. al*, 2016); Italy from Pliocene sediments at the Tafone and Marta Rivers (Carboni and Palaci, 1998); Southwest pacific from Leg 21 sites (Kennett, 1973). In addition to the studied Well A1-89, offshore Sirt Basin, interval (1850'-1050'), where present is present to frequent (Fig. 3.3).

Stratigraphic range: Early Pliocene – Recent (Bolli and Saunders, 1985).

Genus *Sphaeroidinellopsis* Banner and Blow, 1959

***Sphaeroidinellopsis disjuncta* Finaly, 1940**

(Plate 8, Fig. 2)

1940 *Sphaeroidinellopsis disjuncta* Finaly, p. 469, fig. 226.

1985 *Sphaeroidinellopsis disjuncta,* Bolli and Saunders : p.242 figs. 18-22.

Description: Test low trochospiral, equatorial periphery trilobite to quadrilobat. surface thick, and glassy in appearance Chambers spherical to ovate, four in final whorl. Umbilicus small and deep. Sutures on both spiral and umbilical sides distinct, radial and depressed. Surface cancellate, interpore areas thickened but not gloosy. primary aperture interiomarginal, umbilical bordered by a thick rim.

Occurrence: This species has been recorded, worldwide, including Egypt from Sidi Salem Formation (Hewaidy *et al*., 2013); Nigeria from Agbada Formation (Obaje and Okosun, 2013); Japan from Kobana Formation (Hayashi and Takahashi, 2002); Equatorial Atlantic from Hole DSDP-354, Eastern South Atlantic from Hole DSDP-17A, South Pacific from Hole DSDP-593 (Speezaferri, 1994); Equatorial Pacific from Hole DSDP-77 (Keller, 1981). In addition to the studied Well A1-89, offshore Sirt Basin, interval (2400'-1250'), where present is present to frequent (Fig. 3.3).

Stratigraphic range: Middle Miocene – Late Miocene (Bolli and Saunders, 1985).

Sphaeroidinellopsis seminulina Shwager, 1866

(Plate 8, Fig. 3)

1866 *Globigerina* seminulina (Shwager) p. 256. pl. 7, fig.112.

1971 *Globigerina* seminulina (Shwager} Postuma pp. 274-275.

Description: Test medium to large in size, low trochospiral, consisting of about three whorls. Equatorial periphery lobulate and axial periphery rounded to subangular in the last chamber. Chambers are spherical, the last one often elongate with three to five chambers in the last whorl. Umbilicus small to fairly ide and slightly deep. Sutures of the spiral side slightly curved and depressed on umbilical side radial and depressed. wall perforated and the surface pitted except the last chamber with smooth surface . Aperture is an elongate silt or low arch, interiomarginal, umbilical bordered by a rim.

Occurrence: This species has been recorded, worldwide, including Egypt from Pliocene sediments at Northern western desert (Ouda, 1998); China from Hanjiang, yuehai and Wanshan formations (Chunlian *et al*., 2012); Japan from Kobana Formation (Hayashi and Takahashi, 2002); Italy from Argille Azzurre Formation (Violanti, 2005); Trinidad from Brasso Formation (Wilson, 2005); Southwest Pacific from DSDP Leg-21, sites 203, 206, 207-207A, 208, 209 and 210 (Kennett,1973). In addition to the studied Well A1-89, offshore Sirt Basin, interval (2050'-1150'), where present is present (Fig. 3.3).

Stratigraphic range: Latest Miocene - Early Pliocene (Postuma, 1971).

Sphaeroidinellopsis sphaeroides Lamb 1969

(Plate 8, Fig. 4)

1969 *Sphaeroidinellopsis sphaeroides* Lamb, p.571. 578, pl. 1, fig. 1.

1985 *Sphaeroidinellopsis sphaeroides* Lamb.-Bolli and Saunders : p.242 figs. 38.4-5.

Description: Test large, low trochospiral compact, equatorial periphery broadly ovoid to smoothly rounded . Chambers sphericcal, embracing and inflated, three in the last whorl, increasing rapidly in size. Sutures largely obscured by the secondary test thickening. Primary wall coarsely perforate and the surface smooth and glassy in appearance. Aperture an elongate umbilical opening following the line of suture between the last and first chamber of the final whorl, bordered by a crenulated lip, which are extensions of the cortex.

Occurrence: This species has been recorded, worldwide, including Egypt from Pliocene sediments at Northern western desert (Ouda, 1998); Tiwan from Erhchungccchi, Gutingkeng and Chutouchi formations (Huang, 1967); Cyprus from Nicosia formation (Triantaphyllou *et al*., 2010); Spain from Veleri antenna section (Aguirre *et al*., 2005); United states of America (USA) from Quinault Formation (Rau, 1970); Australia from Holes 1126B, 1126C and 1126D (Li *et al*., 2003). In addition to the studied Well A1-89, offshore Sirt Basin, interval (1800'-1250'), where present is frequent to rare (Fig. 3.3).

Stratigraphic range: Late Miocene – late Pliocene (Bolli and Saunders, 1985).

Superfamily HANTKENINACEA Cushman, 1927

Family CASSIGERINELLIDAE Bolli, Loeblich and Tappan, 1957

Genus *Cassigerinella* Pokorný, 1955, emended Li, 1986

***Cassigerinella chipolensis* Cushman and Ponton, 1932**

(Plate 8, Fig. 5)

1932 *Cassidulina chipolensis* Cushman and Ponton, p.98 pl. 15, figs. 2a-c.

1971 *Cassigerinella chipolensis* Cushman and Ponton – Postuma, pp. 254-255.

Description: Test very small to small, biserially arranged coiled into trochospire with eight to nine globular to subglobular chambers. Equatorial periphery lobulate; axial periphery broadly rounded. Wall perforate and the surface smooth. Sutures are curved and depressed. Primary aperture is an interiomarginal, extraumbilical characterized by an elongate loop-shaped slit with a narrow rim.

Occurrence: This species has been recorded, worldwide, including Egypt from Nukhul Formation (Hewaidey *et al*., 2012); Syria from Jihar sections (Kucenjak *et al*., 2006); Italy from Ranzano Formation (Mancini and Pirini, 2001); Spain from De Fuente Caldera series (Molina, 1979); Gulf of Mexico from Hole 538A (Spezzaferri and Premoli-silva, 1991). In addition to the studied Well A1-89, offshore Sirt Basin, interval (9000'-3000'), where present is abundant to rare (Fig. 3.3).

Stratigraphic range: Early Oligocene – Middle Miocene (Bolli and Saunders, 1985).

CONCLUSIONS

The Oligocene-Pliocene succession in the Well-A1-89 in the offshore of Sirt Basin has been subjected to planktonic foraminiferal biostratigraphy during this work. One hundred and forty one ditch cutting samples have been prepared for their planktonic foraminiferal content. Fifty-one species and eleven subspecies belong to twelve genera have been described systemically, with illustration whenever possible.

Ten planktonic foraminiferal biozones have been established within the studied succession following Bolli and Saunders (1985) and Iaccarino (1985) zonal schemes, in descending order as follows:

1-*Sphaeroidinellopsis seminulina s.l* Biozone (Early Pliocene, Zanclean).

2-*Praeorbulina glomerosa* Biozone (Middle Miocene, Langhian).

3-*Globigerinoides trilobus* Biozone (Early Miocene, Burdigalian).

4-*Catapsydrax dissimlis* Biozone (Early Miocene, Aquitanian-Burdigalian).

5-*Globigerinoides primordius* Biozone (Early Miocene, Aquitanian).

6-*Globorotalia kugleri* Biozone (Late Oligocene, Chattian).

7-*Globigerina ciperoensis ciperoensis* Biozone (Late Oligocene, Chattian).

8-*Globorotalia opima opima* Biozone (Late Oligocene, Chattian).

9-*Globigerina ampliapertura* Biozone (Early Oligocene, Rupelian).

10-*Cassigerinella chipolensis/ Pseudohastegrina micra* Biozone (Early Oligocene, Rupelian).

The biozones boundaries are mostly defined by the last occurrence (LO) of the marker species, which is more reliable than the first occurrence (FO) of ditch cutting samples. The established biozones are correlated with the equivalent biozones introduced by (Hooyberghs, 1973 and 1977; Riahi *et al*., 2010; Ben Ismail-Lattrache, 2000 and Yaakoub *et. al*. 2017;), which includes *Pseudohastigerina naguewichiensis* Biozone, *Globigerina ampliapertura* Biozone, *Globigerina opima opima* Biozone, *Globigerina ciperoensis* Biozone, *Globigerinoides primordius* Biozone, *Catpsydrax dissimilis*

Biozone,) and *Globigerinoides sicanus / Praeorbulina glomerosa* Biozone in the Tunisian sections. However in Egypt are correlated with the equivalent biozones introduced by (Cherif *et al*. 1993; Ouda., 1998; Hewaidy *et al*. 2014 and Hamad and El Gamal, 2015), which includes *Pseudohastegrina spp.* Biozone, *Globigerina ampliaperture* Biozone, *Globorotalia opima opima* Biozone, *Globigerina ciperoensis* Biozone, *Globorotalia kugleri* Biozone, *Globigerinoides primordius* Biozone, *Catpsydrax dissimilis* Biozone, *Globigerinoides trilobus* Biozone, *Praeorbulina glomerosa* Biozone and *Sphaeroidinellopsis spp*. Biozone

The Oligocene–Miocene (O/M) boundary in the present study are placed at the top of the *Globorotalia kugleri* Biozone (P22) of Bolli and Saunders (1985); as defined by Last occurrence (LO) of *Globorotalia kugleri* with decreasing in number of *Globigerinoides primordius* and its related Miocene planktonic foraminifera. This led to suggest that the sedimentation in Well A1-89 is continuous with no break, marking a conformable contact. However, across this boundary, a remarkable changes in diversity, abundance and preservation of foraminiferal assemblage are observed. It is obvious to mention that the Miocene foraminiferal assemblage, which typified with the occurrence of *Globigerinoides* spp. (Speezzaferri, 1994) at this level displayed more diverse and abundance with excellent preservation than the Oligocene foraminiferal suit.

The Miocene/Pliocene (M/P) boundary in the present study are placed at the top of *Praeorbulina glomerosa* biozone of Bizon and Bizon, (1972), as defined by the last occuerence (LO) of *Praeorbulina glomerosa* with co-members *Praeorbulina transitoria*, *Praeorbulina sicana* and *Globigerinoides bisphiricus* and the bottom of *Sphaerodinellopsis seminulina* biozone of Iaccarino and Salvatorini, (1982), biozone N18 according to Iaccarino, (1985). In the Well-A1-89, the Pliocene strata is unconformable overlain the Middle Miocene strata, with completely absence of the following biozones *Orbulina suturalis-Globorotalia peripheroronda*, *Globorotalia siakensis*, *Globorotalia menardi*, *Glborotalia accostaensis*, *Globigerinoides obliqus extremus and Globorotalia conomiozea* biozones, indicating a long-range unconformity. This hiatus is also reported from the offshore of northwestern Egypt by (Ouda, 1998).

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APPENDICES

APPENDIX A

Plates

Explanation of Plate 1

Scale bar equals 100 µm for all figures

Fig. 1: *Catapsydrax dissimilis* (Cushman and Bermudez) Early Miocene, umbilical view, Well A1-89, Sirt Basin, Sample No. 28, Depth 2400'.

Fig. 2: *Globigerina ampliapertura* (Bolli), Early Oligocene, **a**-umbilical view, **b**-peripheral view, Well A1-89, Sirt Basin, Sample No. 91, Depth 6450'.

Fig. 3: *Globigerina angiporoides* (Hornibrook), Early Oligocene, umbilical view, Well A1-89, Sirt Basin, Sample No. 108, Depth 7300'.

Fig. 4: *Globigerina ciperoensis ciperoensis* (Bolli), Late Oligocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 57, Depth 4650'.

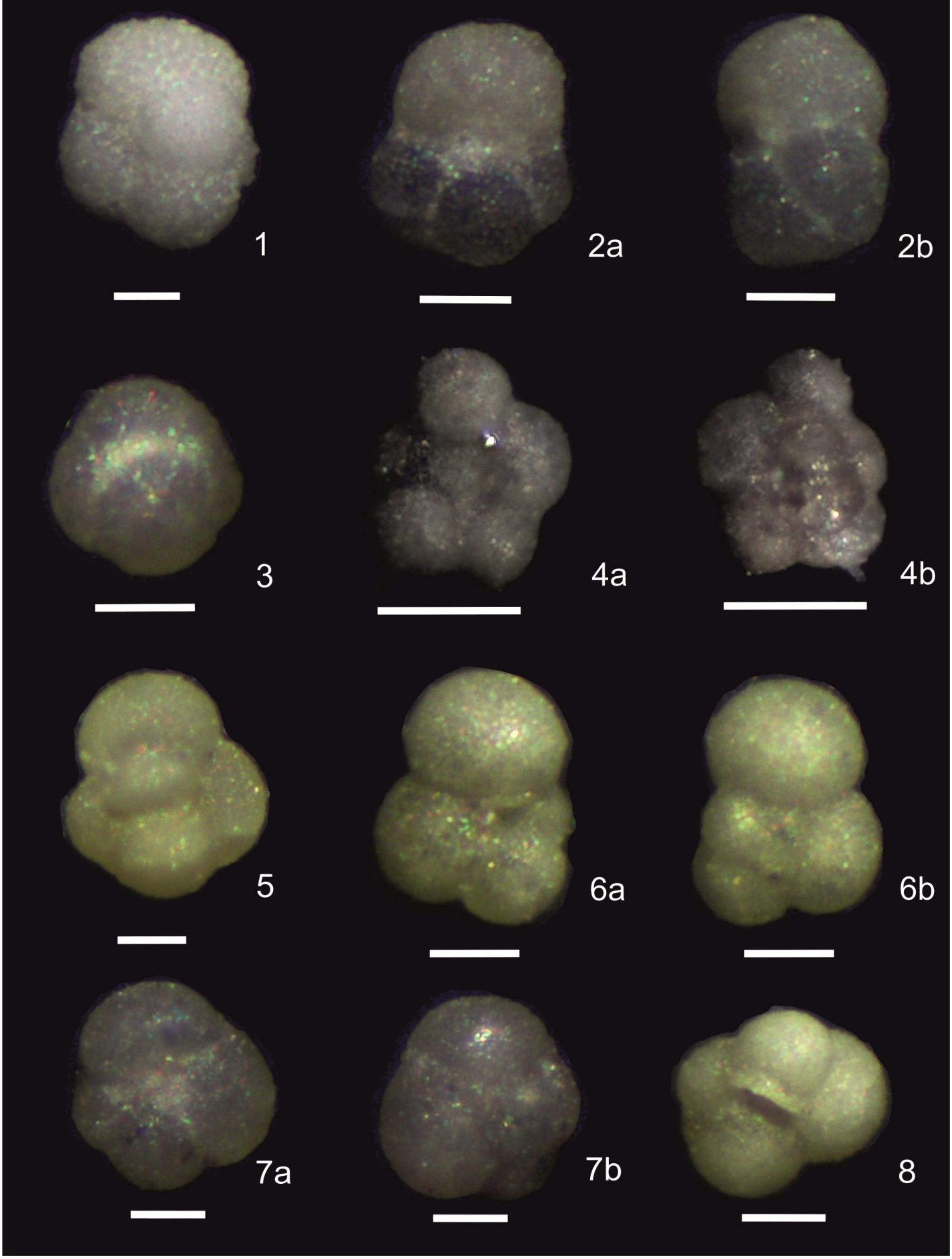
Fig. 5: *Globigerina cryptomphala* (Glaessner), Early Oligocene, umbilical view, Well A1-89, Sirt Basin, Sample No. 91, Depth 6450'.

Fig. 6: *Globigerina eocaena* (Gumbel), Early Oligocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 111, Depth 7450'.

Fig. 7: *Globigerina euapertura* (Jenkins), Early Miocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 31, Depth 2600'.

Fig. 8: *Globigerina falconensis* (Blow), Early Miocene, umbilical view, Well A1-89, Sirt Basin, Sample No. 26, Depth 2300'.

Plate 1



Explanation of Plate 2

Scale bar equals 100 µm for all figures

Fig. 1: *Globigerina linaperta* (Finlay), Early Oligocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 123, Depth 8050'.

Fig. 2: *Globigerina ouachitaensis gnaucki* (Blow and Banner), Early Miocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 37, Depth 2900'.

Fig. 3: *Globigerina praebulloides Leroy* (Blow and Banner), Early Miocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 24, Depth 2200'.

Fig. 4: *Globigerina praebulloides occlusa* (Blow and Banner), Early Pliocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 1, Depth 1050'.

Fig. 5: *Globigerina praebulloides praebulloides* (Blow), Early Miocene **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 25, Depth 2250'.

Fig. 6: *Globorotalia inflata* (d'Orbigny), Early Pliocene, **a**-umbilical view, **b**-peripheral view, Well A1-89, Sirt Basin, Sample No. 4, Depth 1200'.

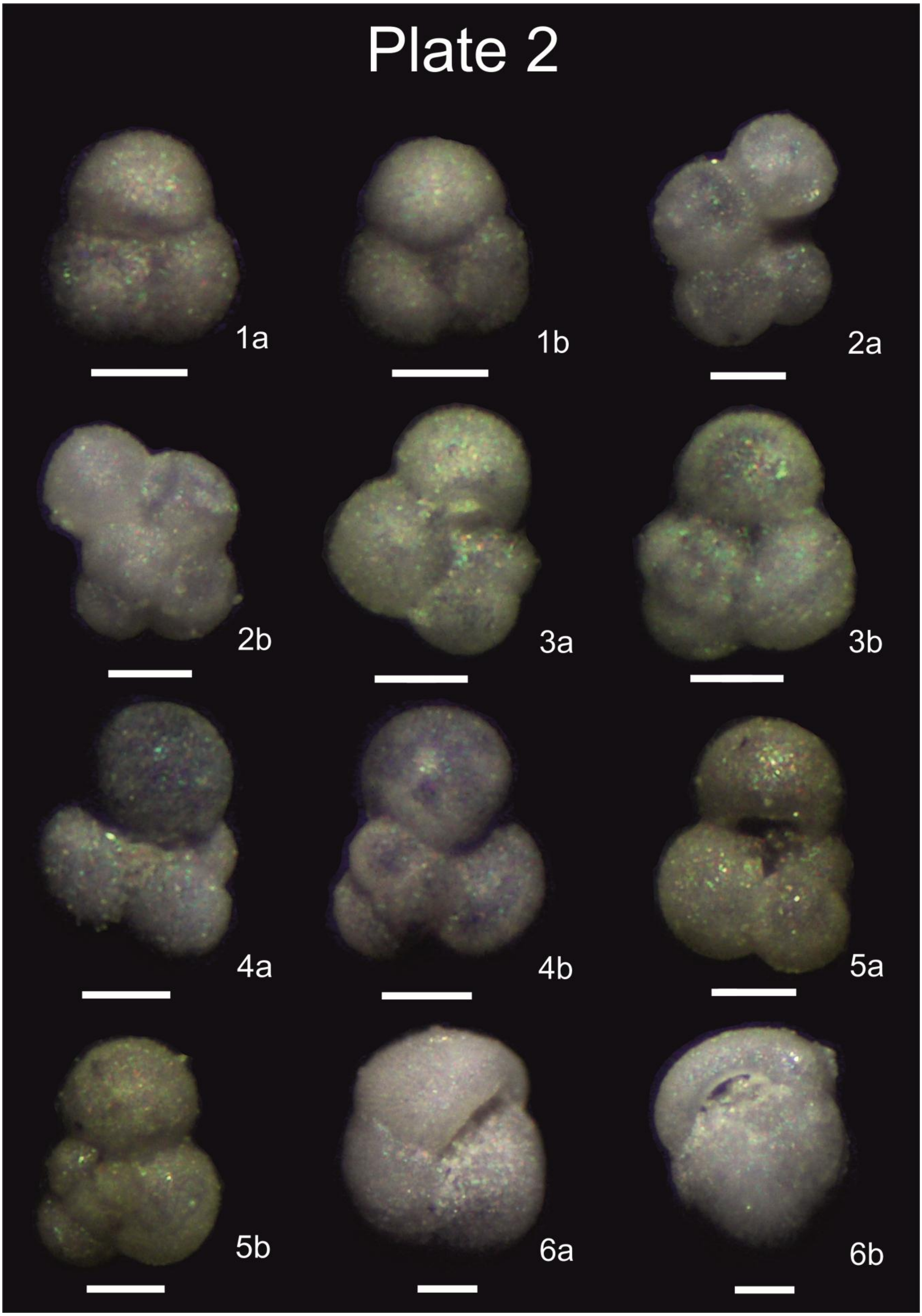


Plate 2
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1b
2a
2b
3a
3b
4a
4b
5a
5b
6a
6b

Explanation of Plate 3

Scale bar equals 100 µm for all figures

Fig. 1: *Globigerina cf. tapuriensis* (Blow and Banner), Early Oligocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 121, Depth 7950'.

Fig. 2: *Globigerina tripartita* (Koch), Early Oligocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 104, Depth 7100'.

Fig. 3: *Globigerina venezuelana* (Hedberg), Early Oligocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 106, Depth 7200'.

Fig. 4: *Globigerina woodi woodi* (Jenkins), Early Pliocene, umbilical view, Well A1-89, Sirt Basin, Sample No. 10, Depth 1500'.

Fig. 5: *Globigerinoides bisphericus* (Todd), Middle Miocene, **a**-umbilical view, **b**-peripheral view, Well A1-89, Sirt Basin, Sample No. 17, Depth 1850'.

Fig. 6: *Globigerinoides immaturus* (LeRoy), Early Miocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 42, Depth 3150'.

Fig. 7: *Globigerinoides obliquus obliquus* (Bolli), Early Pliocene, umbilical view, Well A1-89, Sirt Basin, Sample No. 1, Depth 1050'.

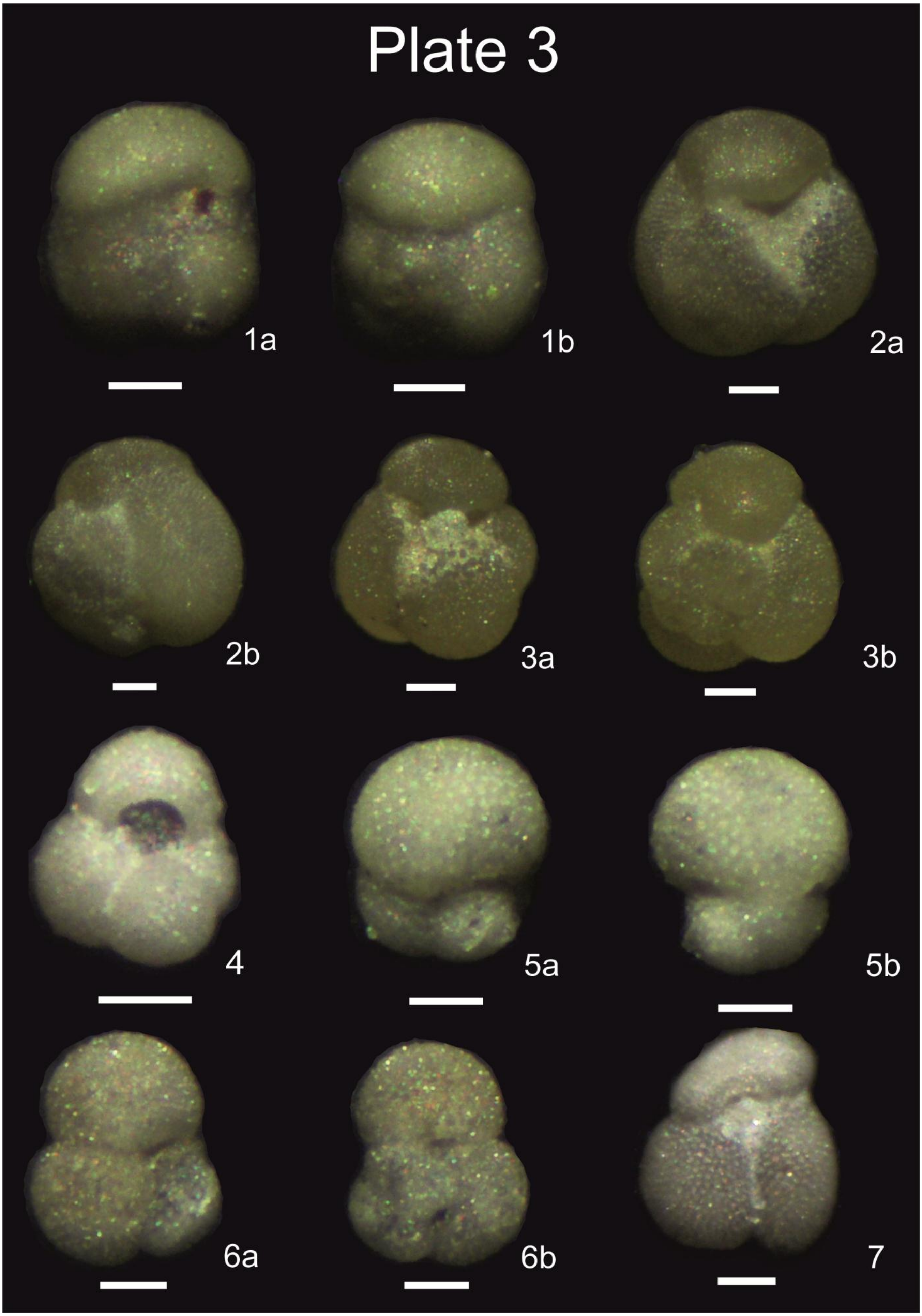
Plate 3
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5a
5b
6a
6b
7

Explanation of Plate 4

Scale bar equals 100 µm for all figures

Fig. 1: *Globigerinoides obliquus extremus* (Bolli and Bermudez), Early Pliocene, **a**-umbilical view, **b**-peripheral view, **c**-spiral view, Well A1-89, Sirt Basin, Sample No. 4, Depth 1200'.

Fig. 2: *Globigerinoides primordius* (Blow and Banner), Early Miocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 37, Depth 2900'.

Fig. 3: *Globigerinoides quadrilobatus* (d'Orbigny), Early Miocene, **a**-umbilical view, **b**-peripheral view, Well A1-89, Sirt Basin, Sample No. 25, Depth 2250'.

Fig. 4: *Globigerinoides ruber* (d'Orbigny), Early Pliocene, umbilical view, Well A1-89, Sirt Basin, Sample No. 16, Depth 1800'.

Fig. 5: *Globigerinoides sacculifer* (Brady), Early Pliocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 2, Depth 1100'.

Fig. 6: *Globigerinoides subquadratus* (Brönnimann), Early Pliocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 3, Depth 1150'.

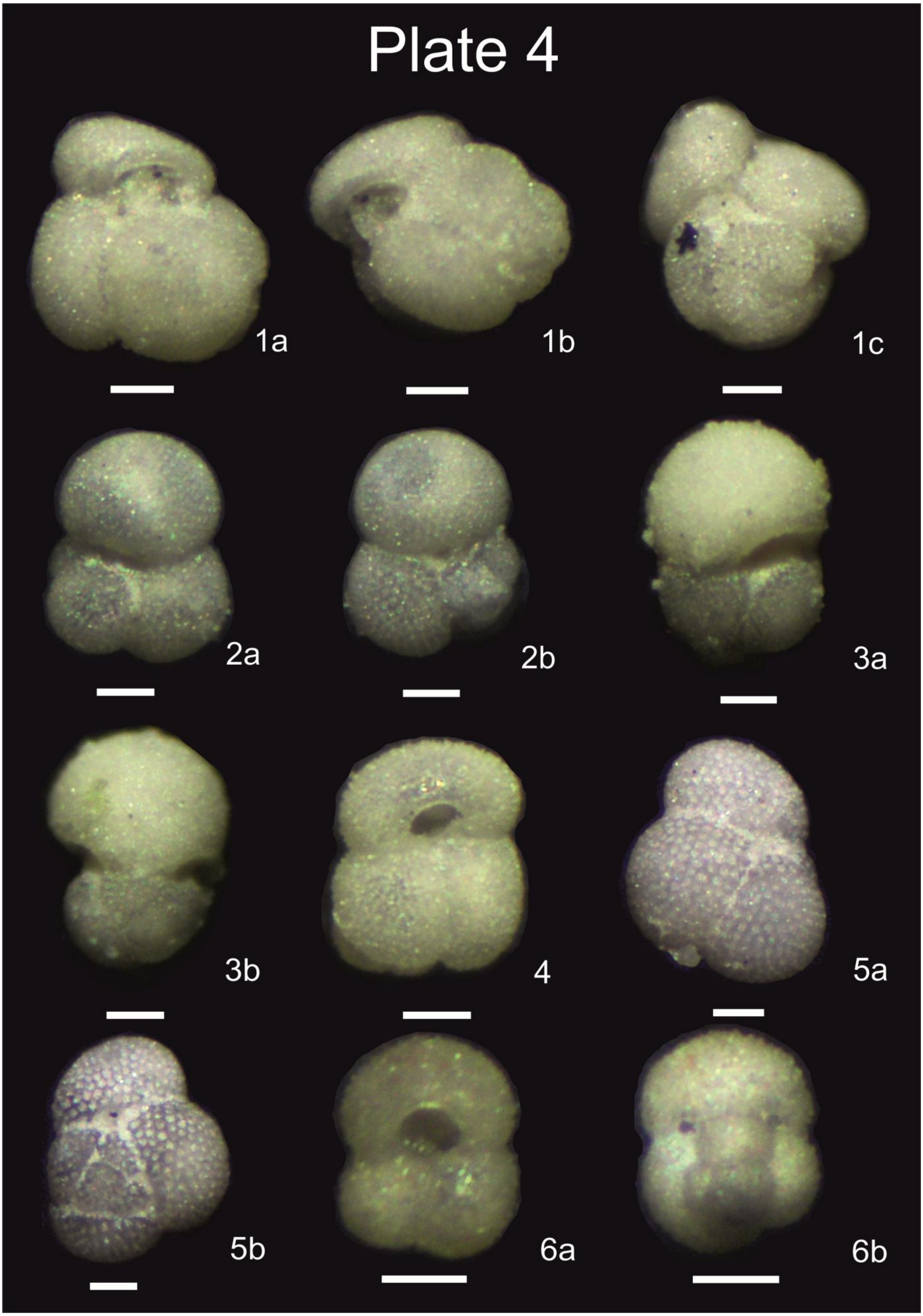
Plate 4
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5b
6a
6b

Explanation of Plate 5

Scale bar equals 100 µm for all figures

Fig. 1: *Globigerinoides trilobus* (Reuss), Early Miocene, **a**-umbilical view, **b**-peripheral view, **c**- spiral view, Well A1-89, Sirt Basin, Sample No. 24, Depth 2200'.

Fig. 2: *Globigerinita incrusta* (Akers), Early Pliocene, umbilical view, Well A1-89, Sirt Basin, Sample No. 8, Depth 1800'.

Fig. 3: *Globoquadrina altispira altispira* (Cushman and Jarvis), Early Miocene, **a**-umbilical view, **b**- peripheral view, **c**-spiral view, Well A1-89, Sirt Basin, Sample No. 38, Depth 2950'.

Fig. 4: *Globoquadrina dehiscens* (Chapman, Parr and Collins), Middle Miocene, **a**-umbilical view, **b**- peripheral view, **c**- spiral view, Well A1-89, Sirt Basin, Sample No. 19, Depth 1950'.

Fig. 5: *Globorotalia continuosa* (Blow), Middle Miocene, **a**-umbilical view, **b**-peripheral view, Well A1-89, Sirt Basin, Sample No. 20, Depth 2000'.

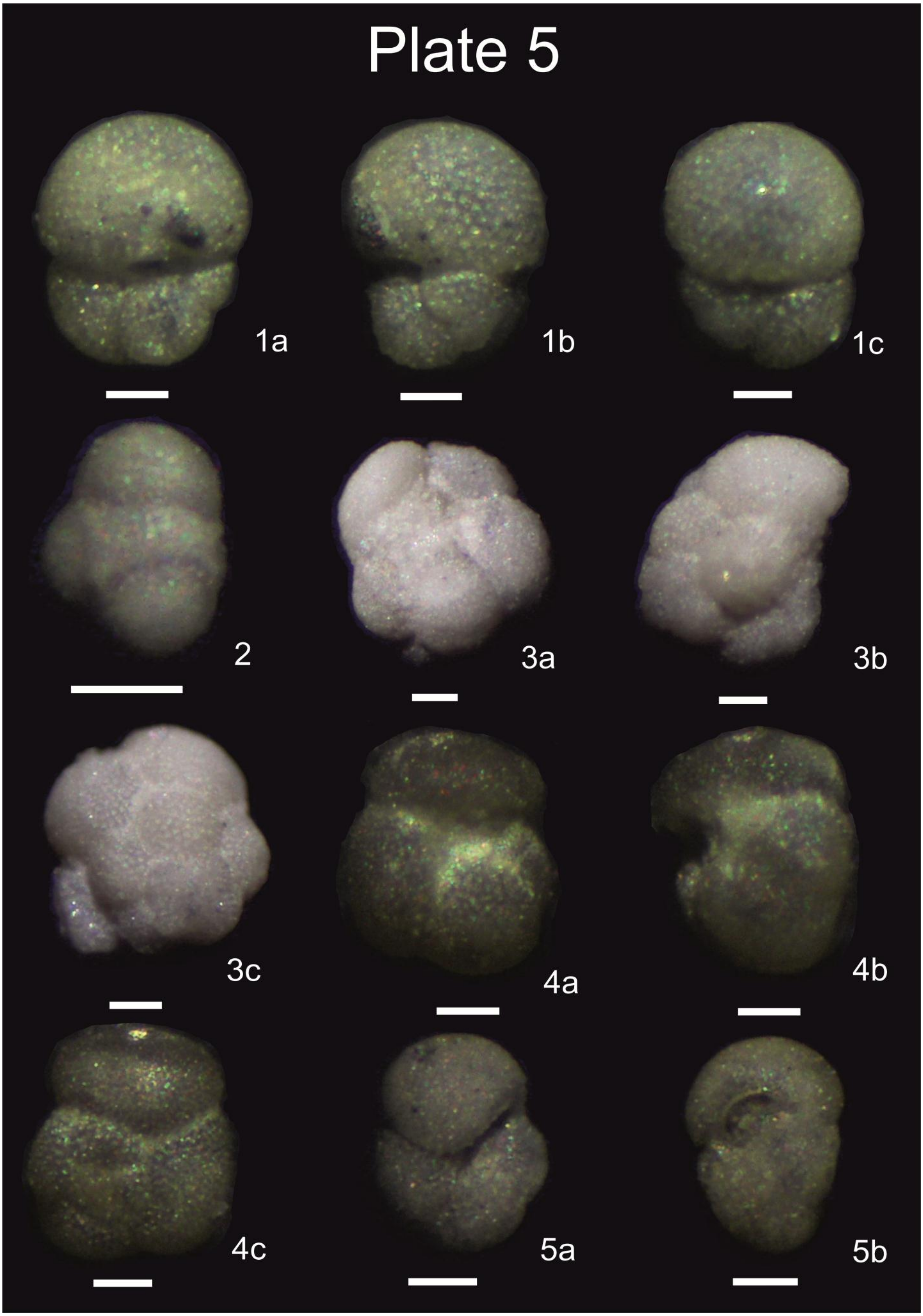
Plate 5
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5b

Explanation of Plate 6

Scale bar equals 100 µm for all figures

Fig. 1: *Globorotalia crassaformis* (Galloway and Wissler), Early Pliocene, **a**-umbilical view, **b**- peripheral view, **c**-spiral view, Well A1-89, Sirt Basin, Sample No. 11, Depth 1550'.

Fig. 2: *Globorotalia Kugleri* (Bolli), Early Miocene, **a**-umbilical view, **b**- spiral view, Well A1-89, Sirt Basin, Sample No. 51, Depth 4350'.

Fig. 3: *Globorotalia mayeri* (Cushman and Ellisior), Early Miocene, **a**-umbilical view, **b**-peripheral view, **c**- spiral view, Well A1-89, Sirt Basin, Sample No. 39, Depth 3000'.

Fig. 4: *Globorotalia obesa* (Bolli), Middle Miocene, **a**-umbilical view, **b**- spiral view, Well A1-89, Sirt Basin, Sample No. 17, Depth 1850'.

Fig. 5: *Globorotalia opima nana* (Bolli), Late Oligocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 58, Depth 4700'.

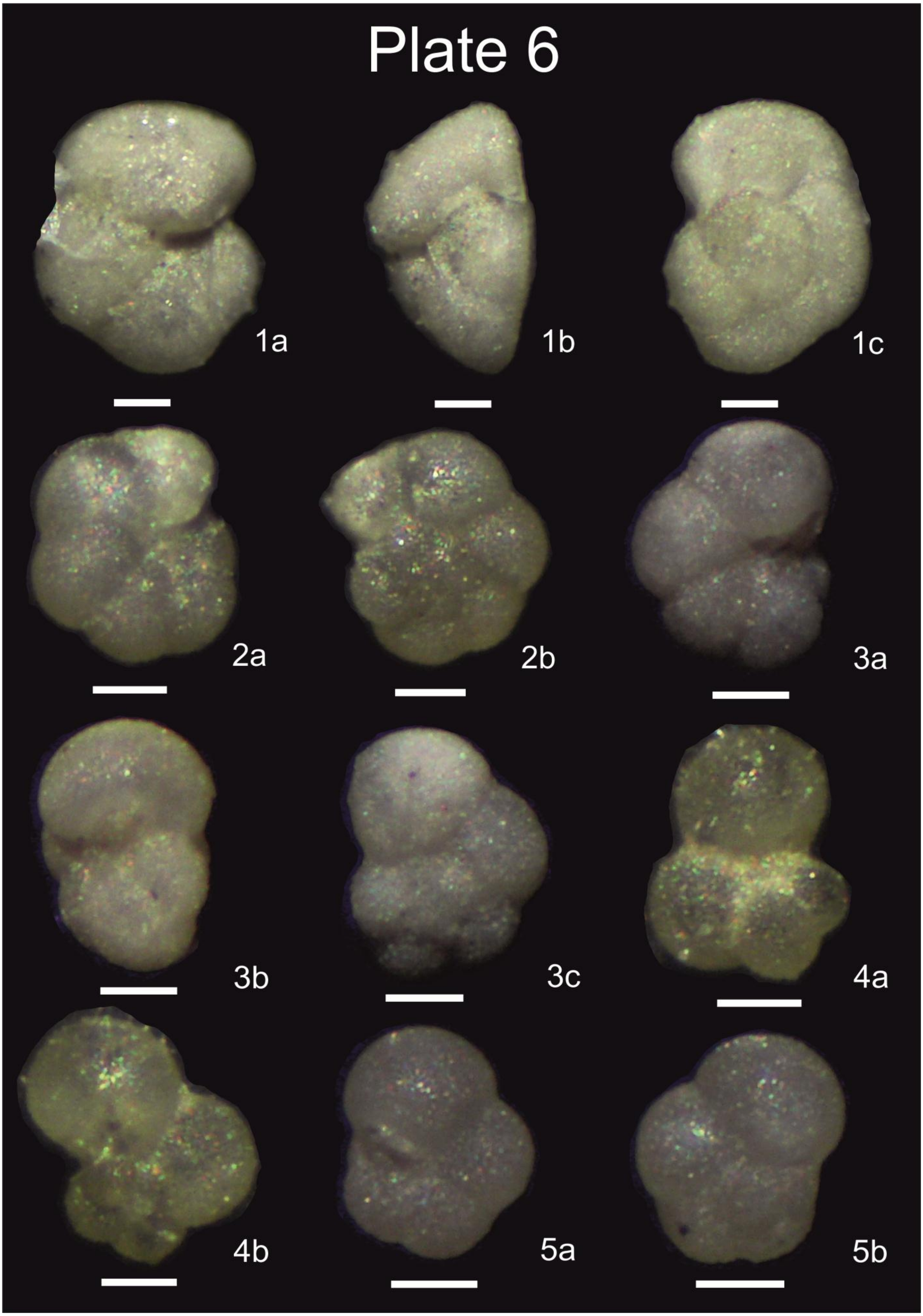
Plate 6
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Explanation of Plate 7

Scale bar equals 100 µm for all figures

Fig. 1: *Globorotalia opima opima* (Bolli), Late Oligocene, **a**-umbilical view, **b-** peripheral view, **c-** spiral view, Well A1-89, Sirt Basin, Sample No. 77, Depth 5750'.

Fig. 2: *Pseudohastigrina micra* (Cole), Early Oligocene **a** and **b-** side views, Well A1-89, Sirt Basin, Sample No. 111, Depth 7450'.

Fig. 3: *Hastigrina praesiphonifera* (d'Orbigny), Early Miocene, spiral view, Well A1-89, Sirt Basin, Sample No. 27, Depth 2350'.

Fig. 4: *Orbulina bilobata* (d'Orbigny), Early Pliocene, Well A1-89, Sirt Basin, Sample No. 6, Depth 1300'.

Fig. 5: *Orbulina suturalis* (Brönnimann), Early Pliocene, lateral view, Well A1-89, Sirt Basin, Sample No. 8, Depth 1400'.

Fig. 6: *Orbulina uiversa* (d'Orbigny), Early Pliocene, Well A1-89, Sirt Basin, Sample No. 1, Depth 1050'.

Fig. 7: *Praeorbulina glomerosa* (Blow), Middle Miocene, umbilical view, Well A1-89, Sirt Basin, Sample No. 17, Depth 1850'.

Fig. 8: *Praeorbulina transitoria* (Blow), Middle Miocene, **a** and **b-** peripheral views, Well A1-89, Sirt Basin, Sample No. 18, Depth 1900'.

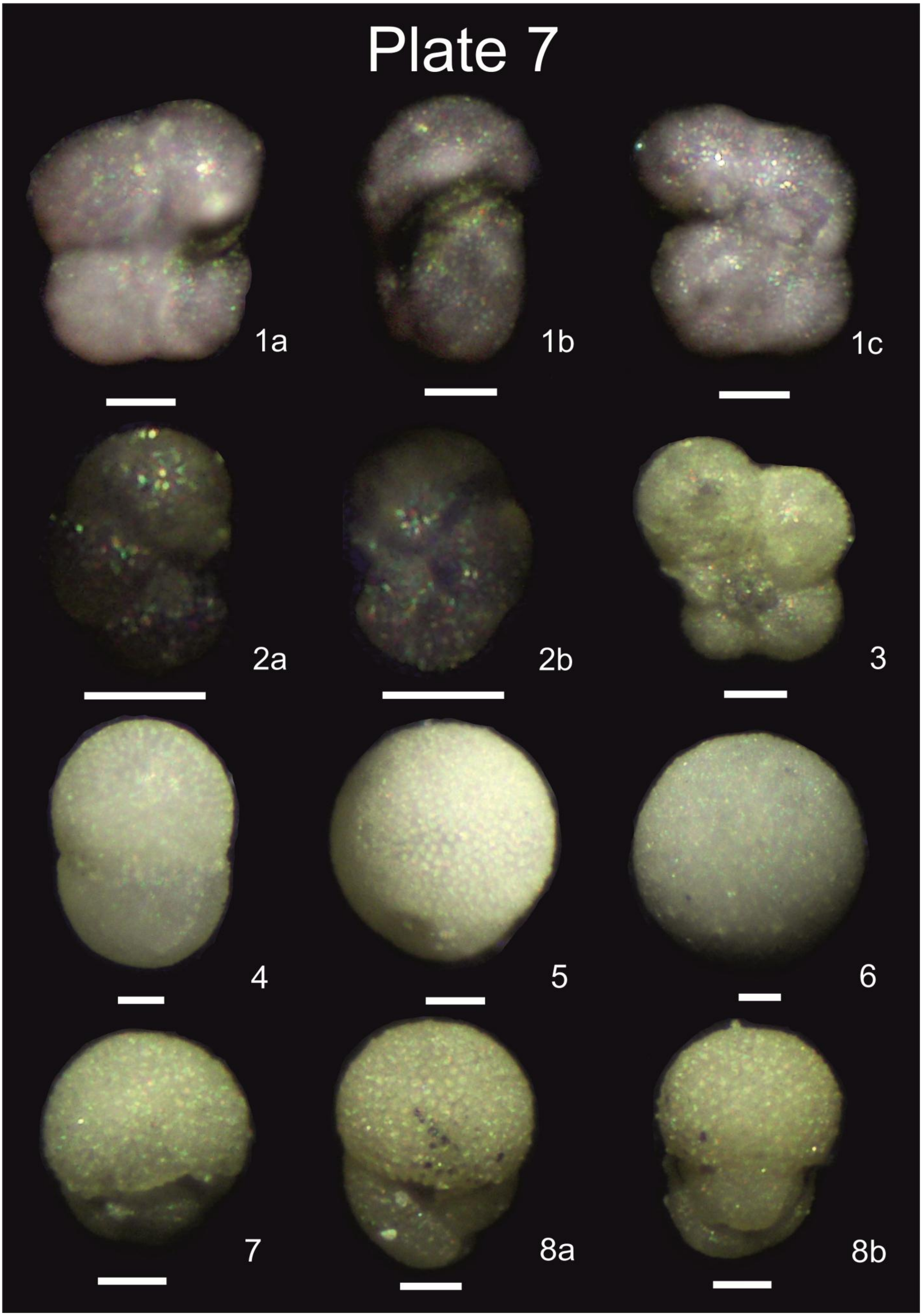

Plate 7
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Explanation of Plate 8

Scale bar equals 100 µm for all figures

Fig. 1: *Sphaeroidinella dehiscens* (Parker and Jones), Early Pliocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 1, Depth 1050'.

Fig. 2: *Sphaeroidinellopsis disjuncta* (Finaly), Early Pliocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 5, Depth 1250'.

Fig. 3: *Sphaeroidinellopsis seminulina* (Shwager), Early Pliocene, **a**-umbilical view, **b**-spiral view, Well A1-89, Sirt Basin, Sample No. 6, Depth 1300'.

Fig. 4: *Sphaeroidinellopsis sphaeroides* (Lamb), Early Pliocene, **a** and **b**- side views, Well A1-89, Sirt Basin,Sample No. 7, Depth 1350'.

Fig. 5:*Cassigerinella chipolensis* (Cushman and Ponton), Early Oligocene, **a** and **c**-side views, **b**–apertural view, Well A1-89, Sirt Basin, Sample No. 128, Depth 8300'.

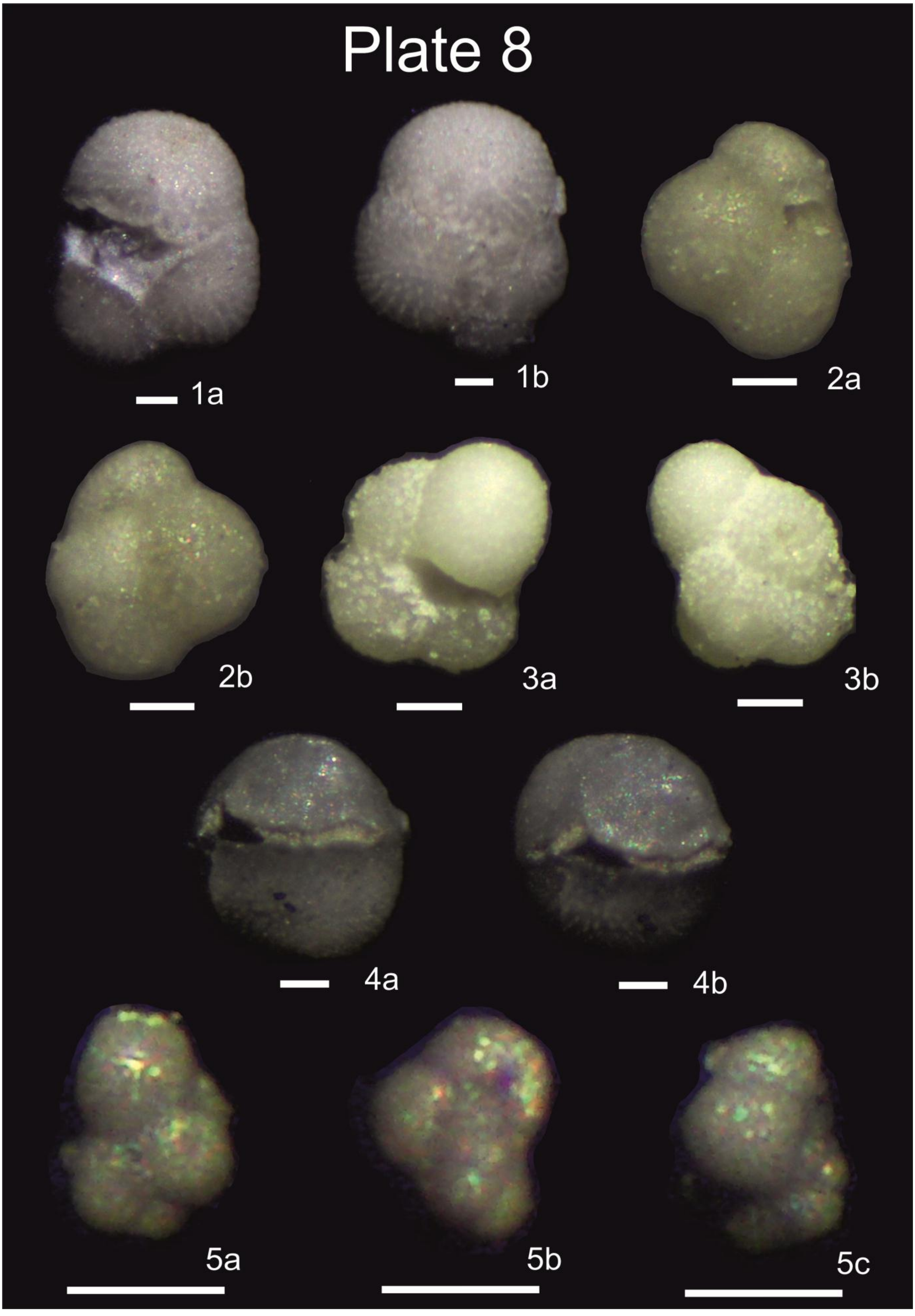
Plate 8
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APPENDIX B

Table 1.1. Shows the depth, age and lithology of prepared ditch cutting samples in Well A1-89.

Sample Number	Depth (ft.)	Age	Lithology (rock type)
1	1050	Early Pliocene	Calcaereous claystone
2	1100	Early Pliocene	Calcaereous claystone
3	1150	Early Pliocene	Marly liemstone
4	1200	Early Pliocene	Marly liemstone
5	1250	Early Pliocene	Marly liemstone
6	1300	Early Pliocene	Marly liemstone
7	1350	Early Pliocene	Calcaereous claystone
8	1400	Early Pliocene	Calcaereous claystone
9	1450	Early Pliocene	Calcaereous claystone
10	1500	Early Pliocene	Calcaereous claystone
11	1550	Early Pliocene	Calcaereous claystone
12	1600	Early Pliocene	Calcaereous claystone
13	1650	Early Pliocene	Calcaereous claystone
14	1700	Early Pliocene	Calcaereous claystone
15	1750	Early Pliocene	Calcaereous claystone
16	1800	Early Pliocene	Calcaereous claystone
17	1850	Middle Miocene	Calcaereous claystone
18	1900	Middle Miocene	Calcaereous claystone
19	1950	Middle Miocene	Calcaereous claystone
20	2000	Middle Miocene	Calcaereous claystone
21	2050	Middle Miocene	Calcaereous claystone
22	2100	Early Miocene	Calcaereous claystone
23	2150	Early Miocene	Calcaereous claystone
24	2200	Early Miocene	Calcaereous claystone
25	2250	Early Miocene	Calcaereous claystone
26	2300	Early Miocene	Calcaereous claystone
27	2350	Early Miocene	Calcaereous claystone
28	2400	Early Miocene	Calcaereous claystone
29	2450	Early Miocene	Calcaereous claystone
30	2550	Early Miocene	Mary dolostone
31	2600	Early Miocene	Mary dolostone
32	2650	Early Miocene	Mary dolostone
33	2700	Early Miocene	Mary dolostone
34	2750	Early Miocene	Calcaereous claystone
35	2800	Early Miocene	Calcaereous claystone
36	2850	Early Miocene	Calcaereous claystone
37	2900	Early Miocene	Calcaereous claystone

Table 1.1. Continued

Sample Number	Depth (ft.)	Age	Lithology (rock type)
38	2950	Early Miocene	Limestone
39	3000	Early Miocene	Limestone
40	3050	Early Miocene	Limestone
41	3100	Early Miocene	Limestone
42	3150	Early Miocene	Limestone
43	3200	Early Miocene	Limestone
44	3250	Early Miocene	Limestone
45	3300	Early Miocene	Limestone
46	3350	Early Miocene	Limestone
47	3400	Early Miocene	Limestone
48	3450	Early Miocene	Limestone
49	3700	Early Miocene	Shale
50	3750	Early Miocene	Calcaereous claystone
51	4350	Early Miocene	Calcaereous claystone
52	4400	Late Oligocene	Argilaceous limestone
53	4450	Late Oligocene	Argilaceous limestone
54	4500	Late Oligocene	Calcaereous claystone
55	4550	Late Oligocene	Calcaereous claystone
56	4600	Late Oligocene	Calcaereous claystone
57	4650	Late Oligocene	Calcaereous claystone
58	4700	Late Oligocene	Calcaereous claystone
59	4750	Late Oligocene	Calcaereous claystone
60	4800	Late Oligocene	Calcaereous claystone
61	4850	Late Oligocene	Calcaereous claystone
62	4900	Late Oligocene	Calcaereous claystone
63	4950	Late Oligocene	Calcaereous claystone
64	5000	Late Oligocene	Calcaereous claystone
65	5050	Late Oligocene	Calcaereous claystone
66	5100	Late Oligocene	Calcaereous claystone
67	5150	Late Oligocene	Calcaereous claystone
68	5200	Late Oligocene	Calcaereous claystone
69	5250	Late Oligocene	Calcaereous claystone
70	5300	Late Oligocene	Calcaereous claystone
71	5350	Late Oligocene	Argilaceous limestone
72	5400	Late Oligocene	Argilaceous limestone
73	5450	Late Oligocene	Argilaceous limestone

Table 1.1. Continued

Sample Number	Depth (ft.)	Age	Lithology (rock type)
74	5600	Late Oligocene	Argilaceous limestone
75	5650	Late Oligocene	Calcaereous claystone
76	5700	Late Oligocene	Calcaereous claystone
77	5750	Late Oligocene	Calcaereous claystone
78	5800	Late Oligocene	Calcaereous claystone
79	5850	Late Oligocene	Calcaereous claystone
80	5900	Late Oligocene	Calcaereous claystone
81	5950	Late Oligocene	Calcaereous claystone
82	6000	Late Oligocene	Calcaereous claystone
83	6050	Late Oligocene	Calcaereous claystone
84	6100	Late Oligocene	Calcaereous claystone
85	6150	Late Oligocene	Calcaereous claystone
86	6200	Late Oligocene	Calcaereous claystone
87	6250	Late Oligocene	Calcaereous claystone
88	6300	Late Oligocene	Calcaereous claystone
89	6350	Late Oligocene	Calcaereous claystone
90	6400	Late Oligocene	Calcaereous claystone
91	6450	Early Oligoccene	Calcaereous claystone
92	6500	Early Oligoccene	Calcaereous claystone
93	6550	Early Oligoccene	Calcaereous claystone
94	6600	Early Oligoccene	Calcaereous claystone
95	6650	Early Oligoccene	Calcaereous claystone
96	6700	Early Oligoccene	Calcaereous claystone
97	6750	Early Oligoccene	Calcaereous claystone
98	6800	Early Oligoccene	Calcaereous claystone
99	6850	Early Oligoccene	Calcaereous claystone
100	6900	Early Oligoccene	Calcaereous claystone
101	6950	Early Oligoccene	Calcaereous claystone
102	7000	Early Oligoccene	Calcaereous claystone
103	7050	Early Oligoccene	Calcaereous claystone
104	7100	Early Oligoccene	Calcaereous claystone
105	7150	Early Oligoccene	Calcaereous claystone
106	7200	Early Oligoccene	Calcaereous claystone
107	7250	Early Oligoccene	Calcaereous claystone
108	7300	Early Oligoccene	Calcaereous claystone
109	7350	Early Oligoccene	Calcaereous claystone

Table 1.1. Continued

Sample Number	Depth (ft.)	Age	Lithology (rock type)
110	7400	Early Oligoccene	Calcaereous claystone
111	7450	Early Oligoccene	Calcaereous claystone
112	7500	Early Oligoccene	Calcaereous claystone
113	7550	Early Oligoccene	Calcaereous claystone
114	7600	Early Oligoccene	Calcaereous claystone
115	7650	Early Oligoccene	Calcaereous claystone
116	7700	Early Oligoccene	Calcaereous claystone
117	7750	Early Oligoccene	Calcaereous claystone
118	7800	Early Oligoccene	Calcaereous claystone
119	7850	Early Oligoccene	Calcaereous claystone
120	7900	Early Oligoccene	Calcaereous claystone
121	7950	Early Oligoccene	Calcaereous claystone
122	8000	Early Oligoccene	Calcaereous claystone
123	8050	Early Oligoccene	Calcaereous claystone
124	8100	Early Oligoccene	Calcaereous claystone
125	8150	Early Oligoccene	Shale
126	8200	Early Oligoccene	Shale
127	8250	Early Oligoccene	Shale
128	8300	Early Oligoccene	Shale
129	8350	Early Oligoccene	Shale
130	8400	Early Oligoccene	Shale
131	8450	Early Oligoccene	Chalky limestone
132	8500	Early Oligoccene	Calcaereous claystone
133	8550	Early Oligoccene	Calcaereous claystone
134	8650	Early Oligoccene	Shale
135	8700	Early Oligoccene	Calcaereous claystone
136	8750	Early Oligoccene	Calcaereous claystone
137	8800	Early Oligoccene	Calcaereous claystone
138	8850	Early Oligoccene	Shale
139	8900	Early Oligoccene	Shale
140	8950	Early Oligoccene	Calcaereous claystone
141	9000	Early Oligoccene	Calcaereous claystone

APPENDIX C

Abbreviations of terms used in the text:

LO: Last occuerence

FO: First occuerence

O/M: Oligocene/Miocene boundary

M/P: Miocene/Pliocene boundary

GSSP: Global Boundary Stratotype Section and Point

Gds: Globigerinoides

Gq: Globoquadrina

Glt: Globorotalia

Ss: Sphaerodinollopsis

Ph: Psuohastegrina

Gg: Globigerina

Ct: Catapsydrax

O: Orbulina

Ggt: Globigerinita

P: Praeorbulina

Cg: Cassigrinella

Sa: Sphaerodinella

الطبقيه الحيوية للمنخربات الهائمة لتتابع الأليغوسين-البلايوسين في البئر المغمور رقم (أ1-89) بحوض سرت ليبيا

قدمت من قبل :

محمد فرج محمد

تحت إشراف :

د. عصام عمر عبدالصمد

د. أحمد محمد مفتاح

الخلاصة

الدراسة الحالية تناولت دراسة الطبقية الحياتية للمُنَخْرَبات الهائمة لتتابع العصرين الأليغوسيني والبلايوسيني في البئر أ1-89 في الجزء المغمور بالبحر من حوض سرت. اعتمدت هذه الدراسة على مئة وأربعين عينة فتات صخري من هذا البئر والتي غطت الاعماق من 1050 الي 9000 قدم. تم تحديد واحد وخمسون نوعاً واحد عشر نوعاً فرعيا منتمية إلى اثنى عشر جنساً. بناءً على التوزيع الطبقي الرأسي للأنواع المنخربات الهائمة مع إيلاء اهتمام خاص للحدث الأخير للأنواع الدالة من المنخربات الهائمة بهذا البئر تم تحديد عشر نطاقات حياتية استنادا لمرجع Bolli & Saunders (1985) وكذلك Iaccarino (1985) وهي في ترتيب تنازلي على النحو التالي:

Sphaeroidinellopsis seminulina s.l (Zanclean)

Praeorbulina glomerosa (Langhian)

Globigerinoides trilobus (Burdigalian)

Catapsydrax dissimlis (Aquitanian-Burdigalian)

Globigerinoides primordius (Aquitanian)

Globorotalia kugleri (Chattian)

Globigerina ciperoensis ciperoensis (Chattian)

Globorotalia opima opima (Chattian)

Globigerina ampliapertura (Rupelian)

Cassigerinella chipolensis/ Pseudohastegrina micra (Rupelian)

الحد الأليغوسيني/المايوسيني وجد متوافقا ووضع في الجزء العلوي من النطاق الحيوي *Globorotalia kugleri*. علي أي حال، الحد المايوسيني/ البلايوسيني وجد غير متوافقا ووضع في الجزء العلوي من النطاق الحيوي *Praeorbulina glomerosa*. بالإضافة إلى ذلك، تم مضاهاة النطاقات الحيوية بهذه الدراسة مع نظيراتها في كل من تونس ومصر.

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قدمت هذه الرسالة استكمالا لمتطلبات الحصول على درجة الماجستير في علوم الارض

جامعة بنغازي

كلية العلوم

يونيو 2019