Late Eocene- Pleistocene planktonic foraminiferal biostratigraphy of the Kuripan-1 well, North Central Java, Indonesia

Darwin Kadar[1], Ricky Adi Wibowo[2], Hansen Wijaya[1], Leonardo Sebayang[1] and Emma Yan Patriani[3]
[1]*Geologist/Paleontologist LAPI-ITB, assigned to Pertamina UTC*
[2]*Pertamina Upstream Technology Center, Jakarta*
[3]*Center for Geological Survey, Bandung*

ABSTRACT

Planktonic foraminifera of the Kuripan-1 well, North Central Java, Indonesia were studied in detail, using side wall cores collected from the marine Ngimbang, Kujung, Tuban, Selorejo and Lidah Formations. The age interpretation, using first and last appearance datum planes,. concludes that the well section ranges in age from Late Eocene to Pleistocene (upper Zone P17- Zone N22 of Blow, 1969). The main datum planes, from old to young, are *Globigerina gortanii(B), Globigerina sellii(B), Globigerina angulisuturalis(B), Globigerinoides primordius(B), Globorotalia kugleri(T), Praeorbulina sicana(B), Orbulina suturalis(B), Globorotalia peripheroronda/ G.praefohsi(T)* and *Globorotalia tosaensis(B).*

The Ngimbang Formation is likely Late Eocene in age and the Kujung Formation ranges from latest Eocene(?) to earliest Miocene (upper Zone P17- lower N4). The Selorejo and Lidah Formatons are likely Late Pliocene to Pleistocene in age. The zonation also shows the presence of a late Middle Miocene- Early Pliocene hiatus between the Tuban and the overlying Selorejo Formation, spanning zones N13- N19, which reflects a Late Miocene uplift event in the Rembang zone.

A chronostratigraphic correlation between the Kuripan-1 and the Purwodadi-1 wells is attempted using some of the above datum planes, as well as other bioevents occurring in both wells. The correlation of the two wells indicates that the Late Miocene hiatus in Kuripan-1 is correlatable with the top of the Tuban Formation in Purwodadi-1. The Prupuh limestone, above the *Globigerina sellii* top datum in Purwodadi 1, is not developed in Kuripan-1. Here, the carbonate facies changes to a mudstone of shallow marine environment. The upper Ngimbang and Kujung Formations in Kuripan-1, bounded at the top by the Top *Globigerina sellii* datum and at the base by the Top *Globorotalia centralis* datum, is well correlated with the upper Ngimbang and Kujung Formations in the Purwodadi-1 well.

INTRODUCTION

While working on a regional bio-chronostratigraphic correlation project of the Northeast Java Basin, we found the Kuripan-1 well of the Purwodadi area, North Central Java possesses a set of 102 side wall cores which are important for understanding the biostratigraphy of the Northeast Java basin. The samples range in depth from 570 down to 5116'. These were collected systematically covering a time span from Late Eocene to Pleistocene. The side wall cores are mostly mudstone, limestone, and few sandstone/siltstones. The mudstones generally contain frequent to moderate well preserved planktonic foraminifera while the limestone is barren of it. The planktonics therefore merit analysis for zonation and correlation.

Unlike Neogene planktonic foraminifera, there are only a few studies on Paleogene planktonic foraminifera of the Indonesian region. The few papers published are by Hartono (1960), who reported the occurrence of the genus *Hantkenina* Cushman from the bridge construction drill cores about 6 km north of Nanggulan village, Yogyakarta, Central Java. In 1969, Hartono described the genus and proposed a new species *Hantkenina nanggulanensis,* which is very important for the Eocene age. Later, beside documenting additional important species in the Eocene-Oligocene Nanggulan Formation, Purnamaningsih and Pringgoprawiro (1981) proposed a new Seputih Member for the formation and subdivided it into four Interval Zones based on first and last occurrences of planktonic foraminifera. Prior to this paper, Paltrinieri et al. (1976) studied the Middle Eocene to Early Oligocene sequence of the Luk Ulo area,

Central Java and applied Blow (1969) numerical zonation to subdivide the sections, but did not publish any details of biostratigraphy. Jamas and Marks (1978) recorded some Oligocene planktonic foraminifera from the Southern Tanjung Mangkalihat area, Kalimantan, and used some top and base datum of the species for correlation.

As known, planktonic foraminifera live floating in sea water and are distributed worldwide geographically. The widespread distribution and short life span makes this group of fossils a good tool for regional correlation. The first and last occurrences of planktonic foraminifera are commonly used as the datum for correlation. It is why the side wall cores from Kuripan-1 deserve analysis and investigation for understanding the stratigraphy of the northeast Java basin. The present paper is aimed to subdivide the Kuripan-1 well biostratigraphically. The chronostratigraphic correlation of the Kuripan-1 with the Purwodadi-1 well, which is located about 25.5 km away, is attempted using some base and top datum planes established herein. Images of some important diagnostic species are also given.

STRATIGRAPHY OF KURIPAN 1 WELL

The Kuripan-1 well is located about 13.78 km southwest of the town of Purwodadi and about 25.5 km southwest of the Purwodadi-1 well, north Central Java (Figure 1). The well coordinates are 110º 50'13.4" East and 7º 6'31.3" South. It was drilled in 1991 by the former Pertamina-Stanvac Joint Operating Company and reached a total depth at 5116'. Physiotectono-stratigraphically, the well is in the Randublatung zone, a synclinal valley or a depression between the Rembang anticlinorium in the north and the Late Pliocene and younger Kendeng fold-thrust zone in the south. It extends eastward to Madura Strait (van Bemmelen, 1949) and is characterized by zero to 20 mgal gravity anomaly (Untung, 1978). The zone had been gently deformed and today is structurally lower than the Kendeng and Rembang zones (Musliki, 1991).

The stratigraphy of the Kuripan-1 well is shown in Figure 2. Depths are in feet, measured from the derrick floor. Formations are, from old to young:

Ngimbang Formation (4270'-5116'). The interval penetrated probably belongs to the upper part of the formation. It is predominantly massive limestone with mudstone in the upper part, and mudstone in the lower part. The limestone is barren of planktonic foraminifera, but contains *Nummulites spp.* at several depths.

Kujung Formation (2010'-4270'). Conformably overlies the Ngimbang Formation. It consists predominantly of mudstone with thin limestone and sandstone intercalations. A limestone bed, ranges from 2089 up to 2010', occurred at the uppermost part of the unit. It is a chalky marl rich in well preserved planktonic foraminifera probably of deep marine environment, as indicated by the presence of benthic foraminifera *Bulimina sp., Eggerella sp., Karreriella sp., Laticarinina pauperata, Pleurostomella sp., Siphonina sp.* and *Sphaeroidina sp.*

Tuban Formation (750'-2010'). This unit is predominantly mudstone with thin sandstone and siltstone intercalations.

Selorejo Formation (692'-750'). This 58' thick probably unconformably covers the Tuban Formation. It is composed predominantly of sandy marl/calcarenite with many reworked planktonic foraminifera, as is indicated by a slightly darker color and abrasion of the shell surfaces. The presence of a hiatus between the Tuban and Selorejo Formations was reported by Kadar and Sudiyono (1994) from the Rembang quadrangle of north Central Java.

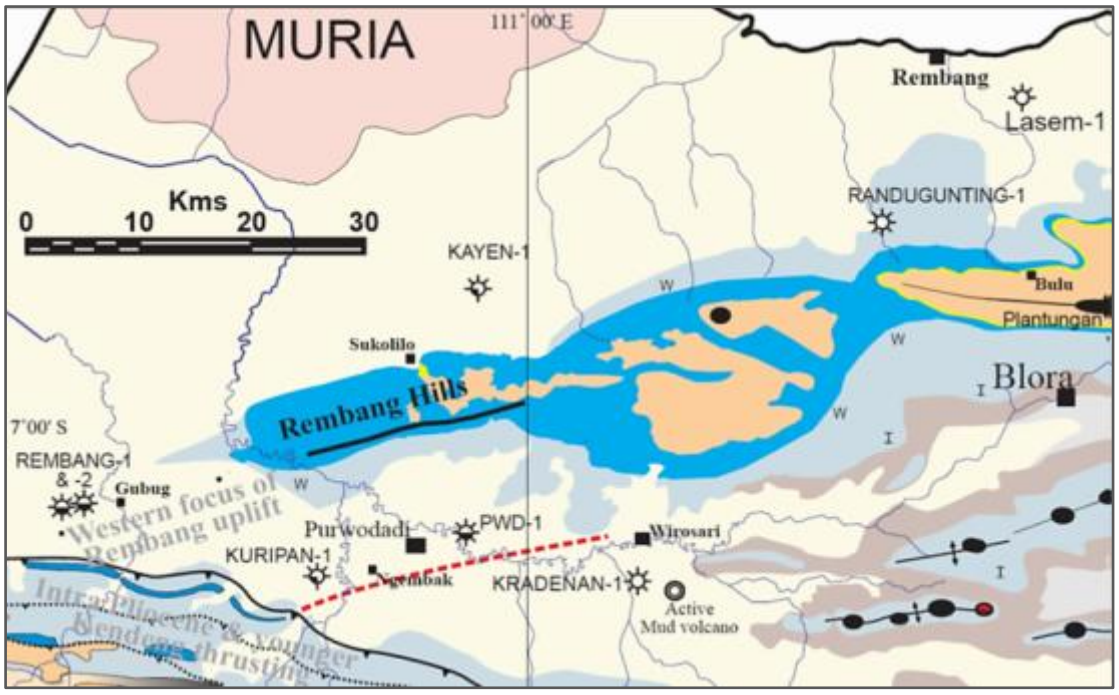


***Figure 1**. Locality map of Kuripan-1 and Purwodadi-1 wells between Rembang Hills and Kendeng zone in North Central Java (from Lunt 2013, Fig, 117)*

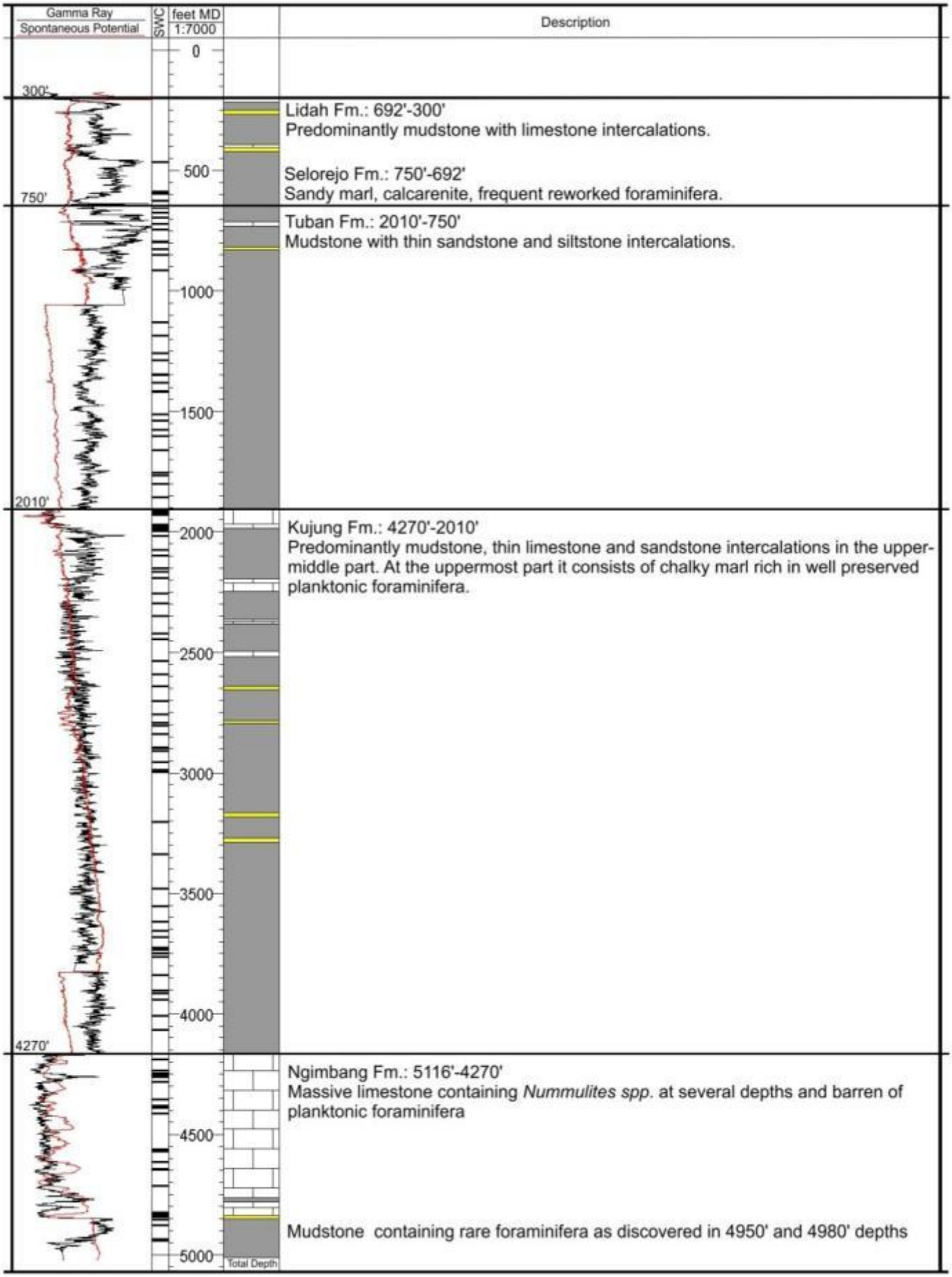


Figure 2. *Stratigraphy of Kuripan-1 well. Gamma Ray (GR) and Spontaneous Potential (SP) logs on left.*

Lidah Formation (300'-690'). This unit is conformable above the Selorejo Formation' and is predominantly mudstone with limestone intercalations. The age is likely Pliocene to Pleistocene.

BIOSTRATIGRAPHY

The stratigraphic distribution of planktonic foraminifera in the Kuripan-1 well is shown in Figure 3, with indication of their relative abundance. Categories used for the species abundance are: vr (very rare) used for 1 specimen, r (rare) for 2-5, f (frequent) for 6 -10, c (common) for 11-20 and a (abundant) for 21-50 specimens. The occurrence of frequent to moderate planktonic foraminifera and the presence of important species have allowed the recognition of nine interval zones. The zonation was based on first and last appearance datum planes of diagnostic species as also used by Blow (1969). These datum planes from old to young are: *Globigerina gortanii(B), Globigerina sellii(B), Globigerina angulisuturalis(B), Globigerinoides primordius(B), Globorotalia kugleri(T), Praeorbulina sicana(B), Orbulina suturalis(B), Globorotalia peripheroronda(T)/ Globorotalia praefohsi(T)* and *Globorotalia tosaensis(B).* The abbreviation of B is for base or first appearance datum and T for top or last occurrence datum.

Planktonic foraminifera zones recognized in the Kuripan-1 well based on the above mentioned datum planes are:

Upper Zone P17, interval 5116'– 4980'

The top of the zone is marked by first appearance of *Globigerina gortanii,*while its base is not defined in this well due to lack of samples. Besides, the two samples representing the unit also barren of planktonic foraminifera. The absence of *G. gortanii praeturritilina* in the sample of 4980' might support the conclusion that this unit is late Eocene, Upper Zone P17.

Zone P18, interval 4980' – 3584'

Base of the zone is defined by first appearance of *G.gortanii* at 4980' while its top boundary is marked by the first appearance of *Globigerina sellii* at 3584'. The assemblage persistently present in the unit includes *G. tripartita, G. praesaepis, G. yeguaensis, G. gortanii* and *Globorotalia nana. Globorotalia increbescens* and *Globigerina ampliapertura* made their first appearance in the lower part of the zone, while *Catapsydrax pera* and *C. primitiva* first appear in its upper portion. The first appearance of *Globigerina tapuriensis* at 3866' is probably not its real first appearance. A single specimen of *Globorotalia centralis* is present at 4930' and it probably corresponds with its last appearance datum. Blow (1969) considered that this species extinct in upper Zone P.17. The massive limestone in this unit belongs to the upper Ngimbang Formation and is Early Oligocene in age.

Zones P19 –P20, interval 3584' – 2550'

The zone is marked at the base by the first appearance of *Globigerina sellii* at 3584' while its top boundary is defined by the first occurrence of *Globigerina angulisuturalis* at 2550'. The species consistently occurring in this zone are *G. tripartita, G. praesaepis, G. gortanii, G. sellii, Globorotalia opima, G. nana* and *Catapsydrax unicava,* while *G. oligocaenica, G. ciperoensis* and *Catapsydrax dissimilis* first appear in its lower part. *Globorotalia increbescens* made its last occurrence in the uppermost part of the unit.

Zones P21 –P22, interval 2550' – 2121'

The base of the unit is characterized by the first occurrence of *G.angulisuturalis* and its upper boundary is marked by the first occurrence of *Globigerinoides primordius.* Other important species occurring in the unit are *C. dissimilis, C. unicava, G. gortani, G. ciperoensis, G. praesaepis, G. tripartita* and *G. kugleri. Globorotalia nana* made its last occurrence in the lower part of the zone.

Zone N4, interval 2121' – 1870'

The base of the zone is marked by first occurrence of *Globigerinoides primordius* while its upper limit is defined by the extinction of *Globorotalia kugleri.* The planktonic foraminiferal association in this unit includes *G. primordius, G. kugleri,* and *G. pseudokugleri. Globigerinoides subquadratus* first appears in the lower part of the zone, while *G. altiapertura* occurs first in its upper part. The extinction of *Globigerina sellii, G. gortanii, G. oligocaenica, G. praesaepis,* and *G. tripartita* is in the lower part of the zone. The zonation suggests that the Kujung Formation ranges in age from Early Oligocene to earliest Miocene, Zone P18 to lower Zone N4.

Zones N5 - N7, interval 1870' – 1020'

The zone is bounded in the lower part by the last occurrence of *Globorotalia kugleri,* while its upper boundary is marked by the first occurrence of *Praeorbulina sicana. Globigerinoides primordius* made its last occurrence in the lowermost part of the unit, while *Globigerinoides altiapertura* disappeared in its upper part. The zonation indicates that the age of the Tuban Formation is Early to Middle Miocene, ranging from upper Zone N4 to Zone N12. The boundary between the Kujung and Tuban Formations lies in the lower part of the unit.

Zone N8, interval 1020' – 900'

The unit is defined at the base by first occurrence of *P sicana* and at the top by the first occurrence of *Orbulina suturalis.* The *Praeorbulina* group characterizes the zone while *Globigerinatella insueta* disappeared in its uppermost part. Other species in the unit are *Globigerinoides subquadratus, G. diminutus, Globorotalia siakensis, G. peripheroronda,* and *Globigerinatella insueta.*

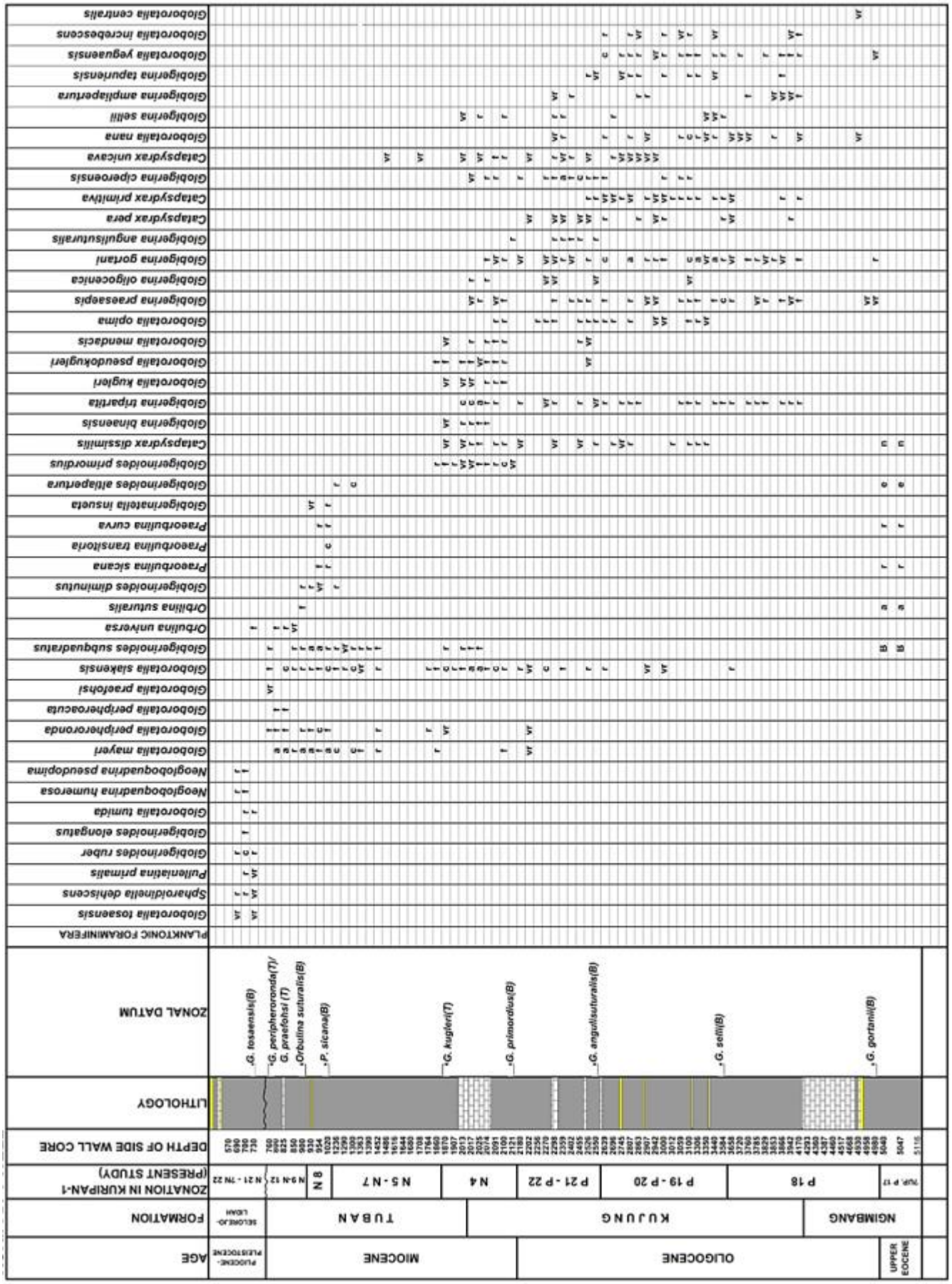


Figure 3. *Distribution of planktonic foraminifera in Kuripan-1 well*

Zones N9 –N12, interval 900' – 760'

The zone is defined at the base by first occurrence of *Orbulina suturalis* and at the top by the last occurrence of *Globorotalia peripheroronda/G. praefohsi.* Other species in the unit are *Globigerinoides subquadratus* and *Globorotalia siakensis. Globigerinoides diminutus* made its last occurrence in the lowermost part of the zone. The first occurrence of *Globorotalia peripheroacuta,* which can be used to mark the base of Zone N10, occurs at 825', in the middle part of this unit. The top of the Tuban Formation, represented by sample depth 760', contains abundant small-size planktonic foraminifera. The species in the sample, among others, are *G. subquadratus, G. siakensis,* and *G. peripheroronda.* The interval between 900' up to 825' may belong to Zone N9 and the interval between 825' and 760' is concluded to be Zone N10-N12 of Blow (1969).

Zones N20/N21 –?N22, interval 760'- 300'

The base of the unit is defined by the first appearance of *Globorotalia tosaensis* at 730' while its upper limit is not defined. The real first appearance of *G.tosaensis* is not exactly known due to lack of samples. However, its lowest occurrence is probably somewhere between 760' and 730'. The interval between 760' and 300' is likely coeval with Zone N20/N 21- ?N22. The zone lies directly on top of Zone N9-N12.. A hiatus is therefore concluded between the Selorejo-Lidah and the Tuban Formations; sediments representing Zone N13 to Zone N19 are not present due to erosion or non-deposition. The Selorejo Formation in Kuripan-1 (750'- 692') contains abundant reworked planktonic foraminifera as is indicated by darker color and slightly abraded foraminiferal shells. The in situ species occurring in the unit are *Pulleniatina primalis, Globigerinoides ruber, G. elongatus, Globorotalia tumida,* and *G. tosaensis.* The Lidah Formation (692'- 300') contains abundant benthonic foraminifera such as *Pseudorotalia spp., Robulus spp., Eponides praecintus* and *Bolivina spp.* The in situ planktonics are *Globorotalia crassaformis, G. tosaensis, Globigerinoides elongatus and G. ruber.* The unit is included in Zone N20/N21- ?Zone N22 of the Blow (1969) zonation.

AGE AND CORRELATION WITH PURWODADI 1 WELL

The biostratigraphic analysis of Kuripan-1 well concludes that the well section ranges in age from Late Eocene to Pleistocene, upper Zone P17 to Zone N20/N21- ?N22. The basal shale member of the Ngimbang Formation, the lowest unit in the section, is of Late Eocene to earliest Oligocene age, upper Zone P17- lowermost Zone P18. The age of the limestone at the top of the Ngimbang Formation is likely Early Oligocene, Zone P18. The Kujung Formation spans the Early Oligocene to basal Miocene (uppermost Zone P17- lower Zone N4). The Tuban Formation is concluded as an Early to Middle Miocene age, upper Zone N4- Zone N12. The Selorejo and Lidah Formations may be included in the Late Pliocene- Pleistocene, although reworked older planktonic foraminifera are common.

Our data suggests a significant hiatus between the Tuban Formation and the overlying Selorejo Formation, spanning late Middle Miocene to Pliocene Zones N13- N20, which represents a time from about 12 Ma to 3.3 Ma, or longer. This is the result of the Late Miocene uplift of the Rembang- Madura zone, estimated to have taken place around 8 Ma by Lunt (2013).

To get an overview regarding subsurface correlation between wells a chronostratigraphic correlation between the Kuripan-1 and Purwodadi-1 is attempted by using some of the above mentioned datum planes (Figure 4). The Purwodadi 1 well was drilled on the 'Purwodadi High', which has a relatively thin Eocene- Miocene stratigraphic section, which is possibly also in a somewhat shallower marine facies. Biostratigraphic data used in Purwodadi-1 was from the 1981 analysis by the former Pertamina Paleontology- Stratigraphy Laboratory. The analyzed samples are mainly ditch cuttings, although some side wall cores were also used in the Kujung Formation. In case of ditch cuttings, the evaluation and separation of the in-situ species from the caved, contaminated assemblages were strictly done. Besides, the reworked taxa were also taken into consideration. The in-situ species were chosen by taking the oldest species top datum among the assemblages occurring in each sample's depths. Ten first and last appearance datum planes in the two wells are chosen for correlation, from old to young (see Figure 4): *Globorotalia centralis(T), Globigerina ampliapertura(B), G. sellii(B), G. opima(B), G. increbescens(T), G. opima(T), G.sellii(T), G. kugleri(T), P sicana(B)* and *Globigerinoides altiapertura(T).*

The correlation between the two wells shows that the upper part of the Tuban Formation and the Selorejo, and Lidah Formations are absent in Purwodadi-1, probably due to erosion or non-deposition. The Prupuh limestone in Purwodadi-1 shows a shallowing-upward sequence above the *G.sellii* top datum. In Kuripan-1, similar phenomena are also observed above the *G.sellii* top datum as represented by a dark-grey mudstone that was probably deposited in a shallow marine environment, as indicated by the occurrence of rare and tiny planktonics as well as benthonic foraminifera such as *Ammonia sp.* and *Bolivina sp*. It means that the Prupuh carbonate in Purwodadi-1 did not develop in the Kuripan-1 well above the *G.sellii* top datum. Very likely this top datum acts as a Sequence Boundary in Early Miocene time. The upper Ngimbang and Kujung Formations in Kuripan-1, bounded at the base and at top by last appearance datum planes of *Globorotalia centralis* and *Globigerina sellii,* are well correlated with the upper Ngimbang and Kujung Formations in the Purwodadi-1 well.

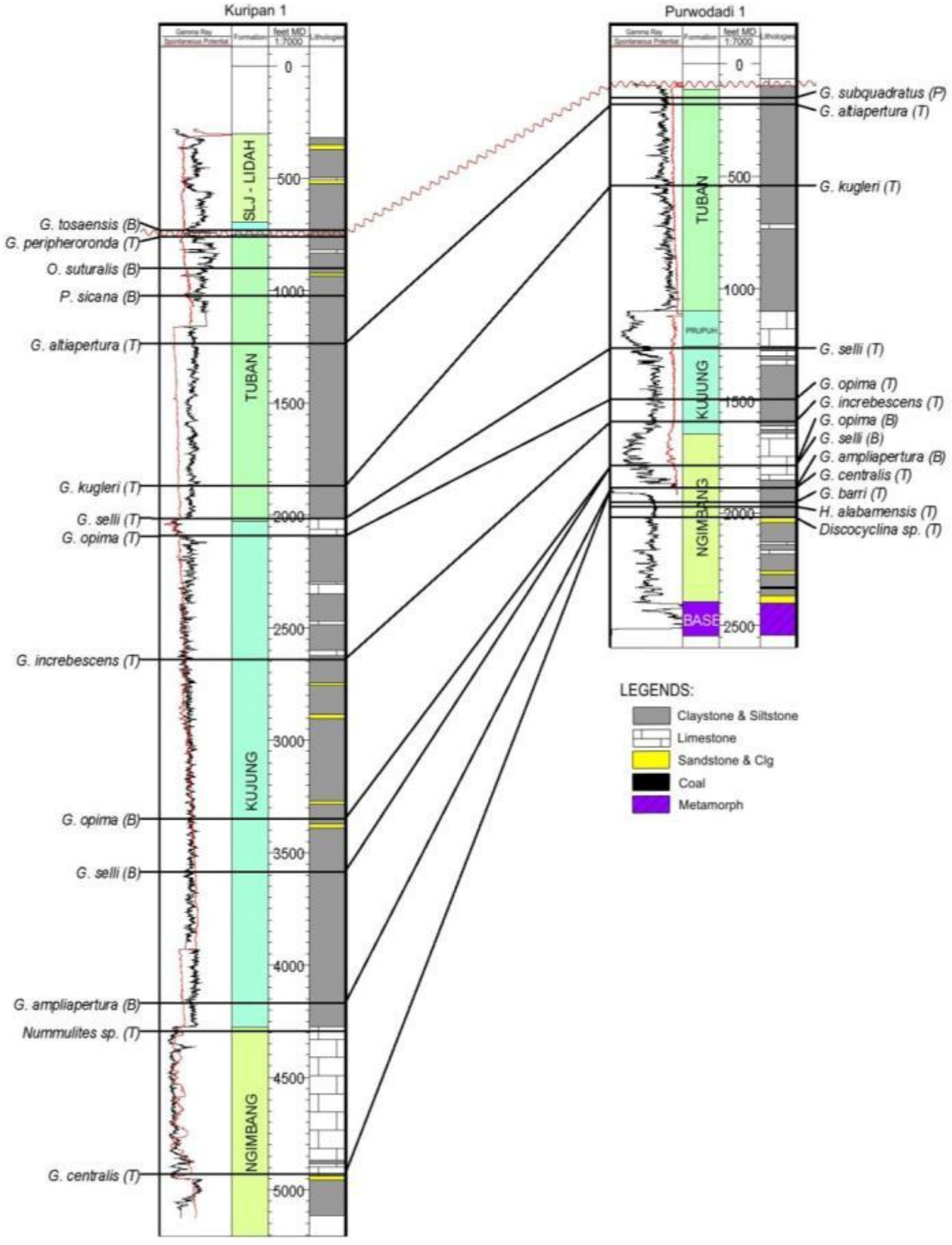


***Figure 4**. Biostratigraphic correlation of Kuripan-1 and Purwodadi-1 wells*

SYSTEMATIC PALEONTOLOGY

Order Foraminiferidae

Genus *Globigerina* d'Orbigny, 1926

***Globigerina tripartita* (Koch)**
Pl. 2, Figs. 4-5
Globigerina bulloides d'Orbigny var. *tripartita* Koch, 1926, p. 746, figs. 21 a-b
Globigerina tripartita tripartita (Koch), Eames, Banner, Blow and Clarke, 1962, p. 96-97, pl. XA-C, fig.18
Globigerina tripartita Koch, Postuma, 1971,p. 276-277.
Description/remarks: Test moderately large, low trochospiral, equatorial periphery subquadrate to lobulate, axial periphery rounded. Ventral side more convex than the dorsal side. Chambers spherical, arranged in about three whorls. The three chambers of the last whorl increase gradually in size except the ultimate one which slightly reduced or about the same size with the penultimate one. Sutures on spiral and ventral sides radial and incised. Umbilicus fairly wide, deep, triangular in outline. Aperture is a low arch, deep in the umbilicus.
Stratigraphic distribution: Blow (1969) recorded this species from Late Eocene to Late Oligocene, upper Zone P14 to upper Zone P22. Purnamaningsih and Harsono (1981) also reported the species to range from Late Eocene to Late Oligocene.
Figured species: from 2015'.

***Globigerina tapuriensis* (Blow and Banner)**
Pl. 2, Fig. 3
Globigerina rohri Bolli, 1957, p. 109, pl. 23, figs. 1-4
Globigerina tripartita tapuriensis Blow and Banner 1962, Eames, Banner, Blow and Clarke, P97-98, pl.XH-K
Globigerina tripartita rohri Bolli, Raju, 1971, p. 27, pl. III, figs. 2 and 4.
Description/remarks: Test moderately large, low trochospiral, coiled in about three whorls. Equatorial periphery subcircular to subquadrate, axial periphery broadly rounded. The last whorl is having three chambers, subspherical increase fairly rapidly in size. At the earlier stage it is about four. Wall coarsely perforate, surface pitted around the umbilicus. Dorsal side is slightly convex while the ventral side is strongly convex. Dorsal sutures of the last whorl slightly depressed and radial. Sutures on umbilical side deeply incised. Umbilicus fairly wide, elongate and deep. Aperture a medium arch opening, intra-umbilical. The species differs from *G.tripartita* in having much less depressed chambers, more convex dorsal surface and more open aperture.
Stratigraphic distribution: Blow (1969) noted the species in Oligocene, ranges from Zone P18 to Zone P19.
Figured species: from 3000'.

***Globigerina sellii* (Borsetti)**
Pl. 1, Fig. 4
Globoquadrina sellii Borsetti, 1959, p. 209, pl. XIII, figs. 3a-d
Globigerina sellii (Borsetti), Postuma 1971, p. 272-273.
Description/remarks: Test low trochospiral, dorsal side slightly convex. Equatorial periphery subcircular to subquadrate. Axial periphery rounded. Three chambers of the last whorl subspherical to ovoid increase rapidly in size, compressed laterally. Ventral side is much more convex. Wall distinctly and coarsely perforate, surface slightly pitted around the umbilicus. Sutures weakly incised dorsally, radial, and slightly depressed ventrally. Umbilicus fairly wide, opened and deep, triangular in outline. Apertural face of the ultimate chamber broad and flat. Aperture a low arch, umbilical with a distinct lip and tooth-like rim.
Stratigraphic distribution: In Yogyakarta area, Purnamaningsih and Pringgoprawiro(1981) recorded the species in Early to Late Oligocene, while Blow(1969) noted the species in Oligocene, Zone P19 to lower Zone P22.
Figured species: 4a-b from 2100'; 4c from 2100'.

***Globigerina oligocaenica* Blow and Banner**
Pl. 2, Fig. 5
Globigerina oligocaenica Blow and Banner, 1962, Eames, Banner, Blow and Clarke, 1962, p. 88-90, pl. XG, L-N.
Description/remarks: Test low trochospiral, chambers coiled in about three whorls. The last whorl consisted of three chambers, increase rapidly in size. The chambers compressed laterally. Equatorial periphery lobate to subquadrate. Axial periphery broadly rounded. Wall distinctly perforate, in places pitted and hispid. Sutures slightly curved and radial dorsally. Umbilicus fairly wide and deep with slightly flattened and slightly concave apertural face. Aperture a low arch, intra- umbilical with a tooth like rim.
Stratigraphic distribution: Blow and Banner (1962) considered age of the species Lower or Middle Oligocene.
Figured species:from 2017'.

***Globigerina binaiensis* Koch**
Pl. 2, Fig. 2
Globigerina binaensis Koch, 1935, v. 26, p. 558, Blow, 1969, p. 316, pl. 13, figs. 1-2.
Description/remarks: Test low trochospiral, equatorial peryphery lobate to subcircular, axial periphery rounded. The test is coiled in about three whorls. Three chambers of the last whorl increase rapidly in size especially the ultimate one. Wall distinctly perforate, surface pitted. Dorsal side slightly convex, ventral side convex, sutures weakly depressed. Umbilicus wide, open and deeply depressed. Apertural face broad and flattened with a low arch aperture at its base, extends from umbilicus the periphery.
Stratigraphic distribution: Blow (1969) noted the species from Late Oligocene to Early Miocene, upper Zone P22 to lower Zone N5. Djamas and Marks (1978) noted the occurrence of the species in the Tanjung Mangkalihat area, Kalimantan in Late Oligocene–Early Miocene Zone P22 to top of Zone N5.

PLATE 1

Scale line = 100 microns

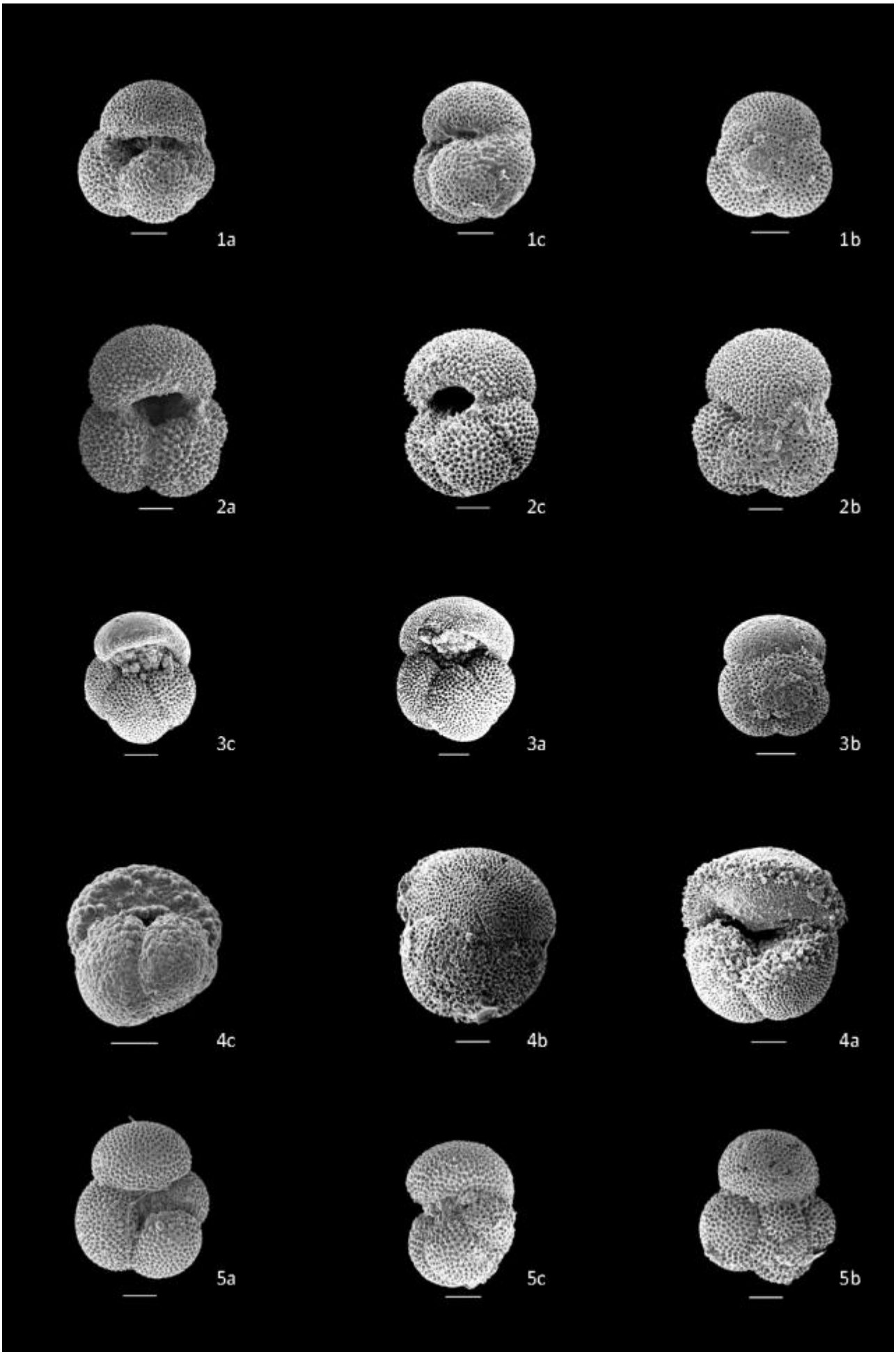


PLATE 1

Scale line = 100 microns

1. *Globigerina prasaepis* Blow and Banner
   a and c ventral and side views from 2100', b dorsal view from 2298'

2. *Globigerina ampliapertura* Bolli
   a-c ventral, side and dorsal views from 2402'

3. *Globigerina ampliapertura* Bolli
   a-c ventral, dorsal, and side views from 4170'

4. *Globigerina sellii* (Borsetti)
   a-b ventral and dorsal views from 2205', side view from 2100'

5. *Globigerina yeguaensis* Weinzierl and Applin
   a-c ventral, side, and dorsal views from 2639'

PLATE 2

Scale line = 100 microns

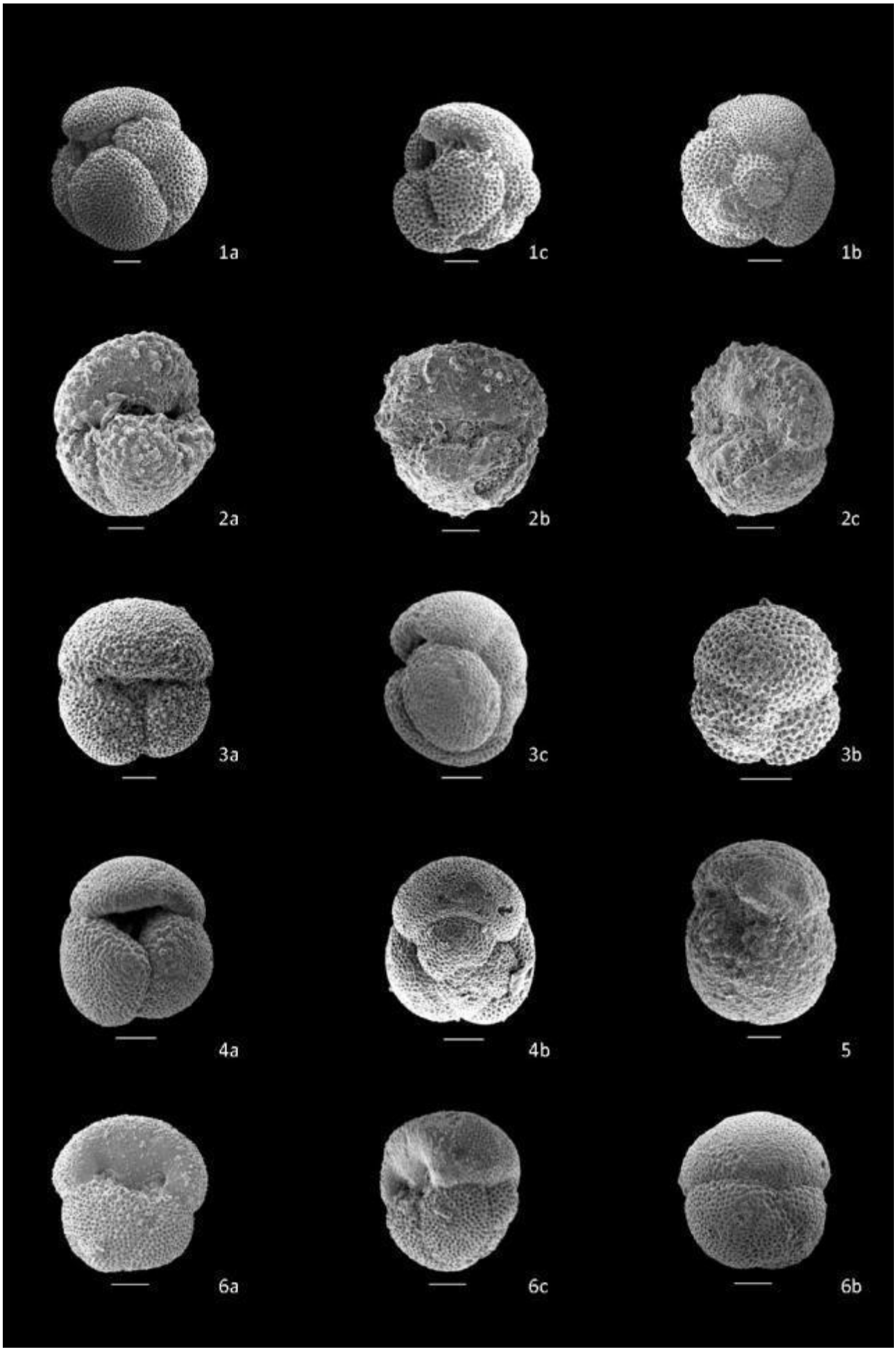


PLATE 2

Scale line = 100 microns

1. *Globigerina gortanii* (Borsetti)
   a-c ventral, side, and dorsal views from 4170'

2. *Globigerina binaensis* Koch
   a-c ventral, apertural, and side views from 2013'

3. *Globigerina tapuriensis* (Blow and Banner)
   a-c ventral, side, and dorsal views from 3000'

4. *Globigerina tripartita* (Koch)
   a-b ventral and dorsal views from 2015'

5. *Globigerina tripartita* (Koch)
   c ventral views from 2015'

6. *Globigerina oligocaenica* Blow and Banner
   a-c ventral, side, and dorsal views from 2017'

Djamas and Marks (1978) noted the occurrence of the species in the Tanjung Mangkalihat area, Kalimantan in Late Oligocene- Early Miocene Zone P22 to top of Zone N5. In Kuripan-1 it occurs in Early Miocene, Zone N4.
Figured species: from 2013'.

***Globigerina prasaepis* Blow and Banner**
Pl. 1, Fig. 1
Globigerina ampliapertura Bolli, 1957, p. 108, pl. 22, figs. 4a-b
Globigerina ampliapertura euapertura (Jenkins), Blow and Banner, 1962, p. 84, pl.11, figs.E-G
Globigerina praesaepis Blow, 1969, p. 382-383.
Description/remarks: Test low trochospiral, about 4 chambers in the last whorl, inflated, subspherical and slightly depressed especially the ultimate one. Wall coarsely perforate. Dorsal side slightly convex. Sutures slightly depressed both ventral and dorsal. Umbilicus narrow and deep, slightly rectangular in outline. Aperture a low arch bordered by a fine lip, intra-umbilical extending between two earlier opposing chambers.
Stratigraphic distribution: Blow (1969) noted the species in late Eocene- Oligocene, upper part of Zone P17 to Zone P21. In Kuripan-1, it ranges from upper Zone P17 to lower Zone N4.
Figured species: 1a and c from 2100'; 1b from 2298'.

***Globigerina ampliapertura* Bolli**
Pl. 1, Figs. 2-3
Globigerina apertura Cushman, Bronnimann, 1950, pt.3-4, p.80
Globigerina ampliapertura Bolli, 1957, p. 108, pl. 22, figs. 4a-7b, Postuma, 1971, p. 142-143.
Description/remarks: Test trochospiral, dorsal side slightly convex. Ventral side is convex. Equatorial periphery lobate to subquadrate, axial periphery rounded. Chambers in the last whorl are four, subspherical to ovoid, compressed laterally especially the ultimate one, increase fairly rapidly in size. Wall distinctly peforate, surface finely pitted. Sutures on ventral side radial and depressed. On the spiral side these are radial, slightly depressed. Umbilicus fairly wide and deep. Aperture a high, distinct semi-circular arch arch facing the umbilicus. Specimens of the younger age possessing subglobular to globular chambers with strongly pitted surface.
Stratigraphic distribution: Blow (1969) noted the species in Late Eocene to Oligocene, ranges from Zone P17 to lowermost Zone P21. Purnamaningsih and Pringgoprawiro(1981) recorded the species in the Late Eocene-Oligocene Nanggulan Formation of the Yogyakarta area. In Kuripan-1 the species ranges from middle Zone P18 to lower Zone P21-P22.
Figured species: 2a-c from 2402'; 3a-c from 4170'.

***Globigerina ciperoensis* Bolli**
Pl. 4, Fig. 5
Globigerina ciperoensis Bolli, 1957, p. 109, pl. 22, fig.1, Postuma 1971, p. 264-265, Kadar, D., 2008 p. 16, pl. 2, fig.8.
Description/remarks: Test low to medium trochospiral, equatorial periphery lobate to nearly circular, axial periphery rounded. Test coiled in about three whorls. Five chambers in the last whorl, subglobular to globular in shape, increase gradually in size. Wall coarsely perforate, surface sligtly hispid. Sutures radial, both dorsal and ventral, distinct and deeply depressed. Umbilicus slightly wide and deep. Aperture a high arch, with opening facing the umbilicus.
Stratigraphic distribution: Blow(1969) recorded the species in Oligocene to Early Miocene from middle part of Zone P19 – lower Zone N4. In Central Sumatera, Kadar et al. (2008) reported the species from Late Oligocene to Early Miocene, Zone P19-Zone N5. In Kuripan-1 the species ranges from Zone P19 - P20 to upper part of Zone N4.
Figured species:from 2359'.

***Globigerina angulisuturalis* Bolli**
Pl. 4, Fig. 6
Globigerina ciperoensis angulisuturalis Bolli, 1957, p. 109, pl. 22, figs. 11a-c
Globigerina angulisuturalis Bolli, Postuma, 1971, p. 260-261.
Description/remarks: Test low to medium trochospiral, biconvex. Equatorial periphery lobate to nearly circular. Axial periphery rounded. Chambers inflated, subglobular, arranged in about three whorls. Five chambers of the last whorl increase gradually in size. Wall distinctly perforate, surface slightly hispid. Sutures both ventral and dorsal are radial, broadly depressed. Umbilicus wide and fairly deep. Aperture a semicircular arch facing the umbilicus. The species differs from *G. ciperoensis* in having broadly depressed, angular U shape sutures.
Stratigraphic distribution: Blow (1969) recorded the species in Late Oligocene to Early Miocene, Zone P21 to lower part of Zone N5. In Kuripan-1 it ranges from Zone P21 to lower most part of Zone N4.
Figured species: from 2402'.

***Globigerina yeguaensis* Weinzierl and Applin**
Pl. 1, Fig. 5
Globigerina yeguaensis Weinzierl and Applin, 1929, p. 408, pl. 43, figs. 1a-b, Bolli 1957, p. 163, pl. 35, figs.14a-15c, Postuma, 1971, p. 162-163.
Globigerina yeguaensis yeguaensis Weinzierl and Applin, Eames, Banner, Blow and Clarke, 1962, p. 99-100, pl. XIIIH-M.
Description/remarks: Test low trochospiral with slightly convex dorsal side, ventral side is convex. Equatorial periphery lobate to subquadrate and axial periphery broadly rounded. Wall coarsely perforate, surface pitted near the umbilicus.Test is coiled in about three whorls. Four chambers of the last whorl are subspherical to ovoid, compressed laterally, increase gradually in size. Sutures radial and deeply depressed both ventral and dorsal. Umbilicus wide, deep and rectangular in outline. Aperture a low arch with a fine lip facing the umbilicus.
Stratigraphic distribution: Blow (1969) considered *Globigerina galavisi* Bermudez a synonym of *G. yeguaensis*. According to Blow, *G. galavisi* ranges from Middle Eocene to Oligocene, older than Zone

P13 to Zone P21. In Kuripan-1, the species ranges from Early Oligocene to Late Oligocene, upper Zone P18 to uppermost Zone P19-P20.
Figured species:from 2639'.

***Globigerina gortanii* Borsetti**
Pl. 2, Fig. 1
Globigerina gortanii gortanii Borsetti,1959
Globigerina turritilina turritilina Blow and Banner, Eames, Banner, Blow and Clarke, 1962, p. 98, pl. XIIID, E-G.
Description/remarks: Test large, high trochospiral, consists of about three whorls. Four chambers of the final whorl inflated, compressed laterally, increase rapidly in size. Equatorial periphery subcircular to subquadrate, axial periphery broadly rounded. Wall coarsely perforate, surface weakly pitted. Sutures depressed on ventral and slightly incised dorsally. Umbilicus narrow to moderately wide, deep and quadrate in outline. Apertural face slightly flattened. Aperture a low arch, facing the umbilicus.
Stratigraphic distribution: Blow(1969) recorded the species in Oligocene, ranging from Zone P18 to lower P22. In Kuripan-1 it ranges from upper Zone P17 to lower N4.
Figured species: from 4170'.

Globorotalia Cushman, 1927

***Globorotalia increbescens* Bandy**
Pl. 4, Fig. 1
Globorotalia increbescens Bandy, 1948, n. 131, p. 120, Postuma, 1971, p. 194-195.
Globorotalia (Turborotalia) increbescens (Bandy), Eames, Banner, Blow and Clarke, 1962, p. 118-119, pl. XIIIT–V, XVIID,K.
Description/remarks: Test low trochospiral, slightly convex dorsally, ventral side convex. Equatorial periphery lobate and axial periphery broadly rounded. Chambers are coiled in about three whorls. The final whorl consists of four chambers, increase fairly rapidly in size, inflated, compressed laterally. Wall distinctly perforate, in places surface finely pitted. Surface of the last chamber finer than the earlier ones. Sutures on ventral side radial and incised, slightly curved dorsally. Umbilicus narrow, deeply depressed. Aperture is a semi-circular arch, extending from umbilicus almost to the periphery. Some of the specimens agree with description and figures of Postuma (1971). Others resemble much the original figures of Bandy (1949).
Stratigraphic distribution: Blow (1969) noted the occurrence of the species in Late Eocene to Oligocene, Zone P15 to lower Zone P19. Purnamaningsih and Pringgoprawiro (1981) reported the species in Late Eocene- Oligocene of the Nanggulan Formation, Central Java. In Kuripan-1 it ranges from middle Zone P18 to top of Zone P19-P20.
Figured species: from 4170'.

***Globorotalia opima* Bolli**
Pl. 3, Fig. 7
Globorotalia opima opima Bolli, 1957, p. 117, pl. 28, figs.1a-c, 3
Globorotalia opima Bolli, Postuma, 1971, p. 34-35.
Description/remarks: Test low trochospiral, dorsal side almost flat. equatorial periphery fairly circular, axial periphery broadly rounded. Ventral side convex. Wall distinctly perforate, slightly pitted near the umbilicus. Chambers four to five in the last whorl inflated, ovoid, increase rapidly in size. Wall distinctly perforate, surface pitted in places. Sutures radial both ventral and dorsal, deeply depressed ventrally Umbilicus narrow and deep. Aperture is a low arch bordered by a fine lip extending from umbilicus to periphery.
Stratigraphic distribution: Blow (1969) recorded the species within the Oligocene, from upper Zone P19 to P21. From Nanggulan in Central Java Purnamaningsih and Harsono (1981) noted it in Late Oligocene. In Kuripan-1, it ranges from lower Zone P19-P20 to upper Zone P21-P22.
Figured species: from 2017'.

***Globorotalia nana* Bolli**
Pl. 3, Fig. 6
Globorotalia opima nana Bolli, 1957, p. 118, pl. 28, figs. 3a-c.
Globorotalia (Turborotalia) opima nana Bolli, Eames, Banner, Blow and Clarke, 1962, p. 119-120, pl. XIII Q-S.
Globorotalia nana (Bolli), Postuma 1971, p. 340-341.
Description/remarks: Test very low trochospiral, dorsal side slightly convex to nearly flat and ventral side is convex. Equatorial periphery lobate, slightly elongate, axial periphery rounded. Wall coarsely perforate, surface pitted in places. Sutures radial both on ventral and dorsal side, incised. Four chambers in the final whorl, subspherical to ovoid, increase rapidly in size. Umbilicus narrow. Aperture a low arch, extending from umbilicus to periphery.
Stratigraphic distribution: Blow (1969) recorded the species in Late Eocene to Oligocene, ranging from upper Zone P15 to lower Zone P19. Djamas and Marks (1978) in Kalimantan noted the species to range up to Late Oligocene, lowermost Zone P22. In Kuripan-1, it ranges from lowermost Zone P18 to upper P21- P22.
Figured species: from 2526' and 2807'.

***Globorotalia (Fohsella) kugleri* Bolli**
Pl. 4, Fig. 2
Globorotalia kugleri Bolli, 1957, p. 118, pl. 28, figs. 5a-6, Postuma, 1971, p. 324-325.
Globorotalia (Fohsella) kugleri Bolli, Kadar 2008, p. 18, pl. 5, figs. 4-5.
Description/remarks: Test low trochospiral, equatorial periphery lobate to subcircular, axial periphery rounded. Six to seven chambers in the last whorl, inflated, increase gradually in size. Wall calcareous perforate, slightly pitted near the umbilicus. Dorsal side flat with radial, strongly curved and weakly incised sutures. Ventral sutures radial and slightly curved. Umbilicus narrow and depressed. Aperture a semi arch opening, umbilical-extra umbilical bordered by a fine lip.

PLATE 3

Scale line = 100 microns

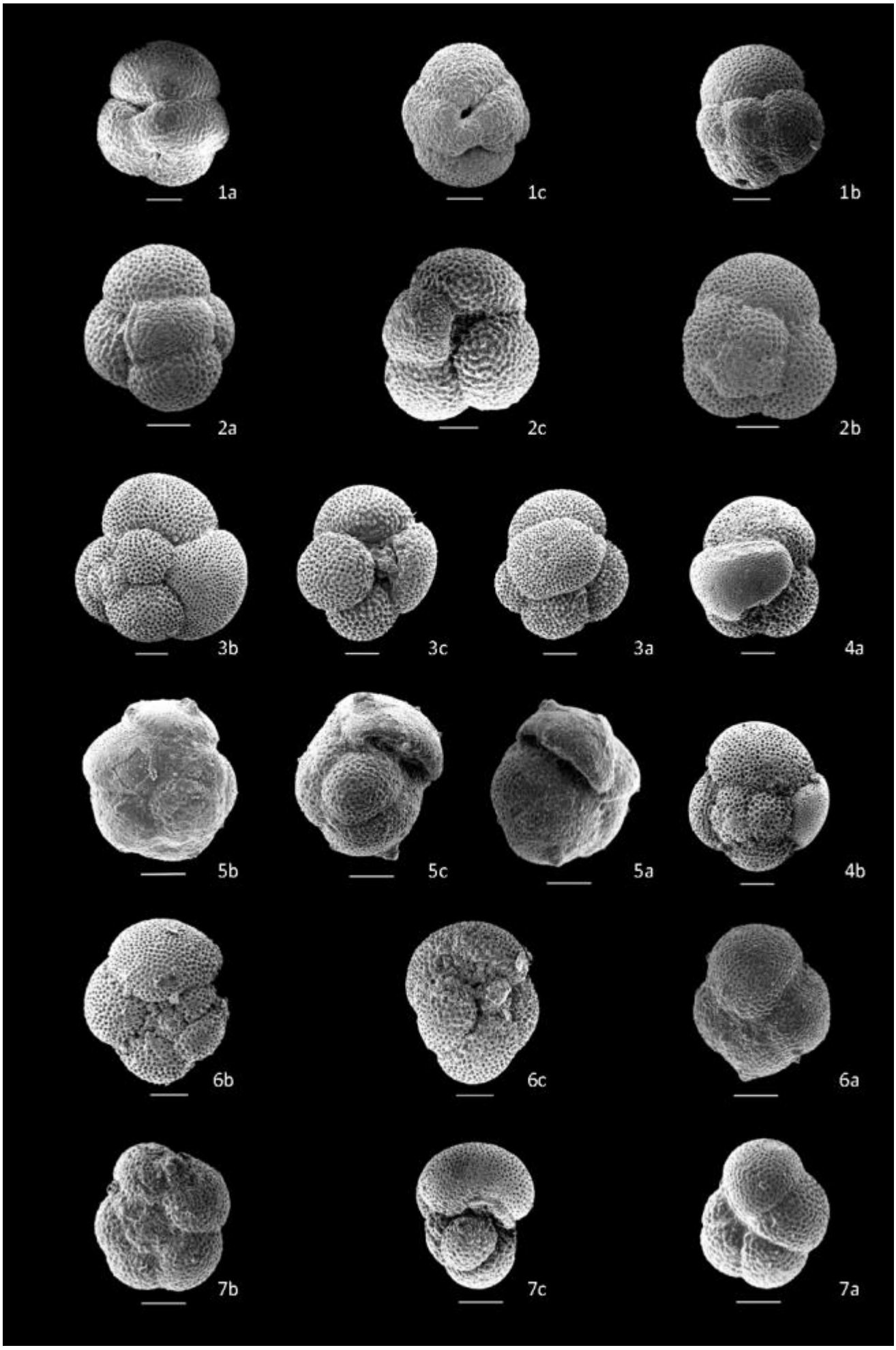


PLATE 3

Scale line = 100 micron

1. *Catapsydrax dissimilis* (Cushman and Bermudez)
   a-c ventral, side, and dorsal views from 2025'

2. *Catapsydrax unicava* Bolli, Loeblich and Tappan
   a-c ventral, side, and dorsal views from 3760'

3. *Catapsydrax pera* Todd
   a-c ventral, dorsal, side views from 3000'

4. *Catapsydrax primitiva* (Blow and Banner)
   a-b ventral and dorsal from 3866'

5. *Globorotalia* cf. *centralis* Cushman and Bermudez
   a-c ventral, dorsal, and side views from 4930'

6. *Globorotalia nana* Bolli
   a-b ventral and dorsal views from 2526', c side view from 2807'

7. *Globorotalia opima* Bolli
   a-c ventral, dorsal, and side views from 2017'

PLATE 4

Scale line = 100 microns

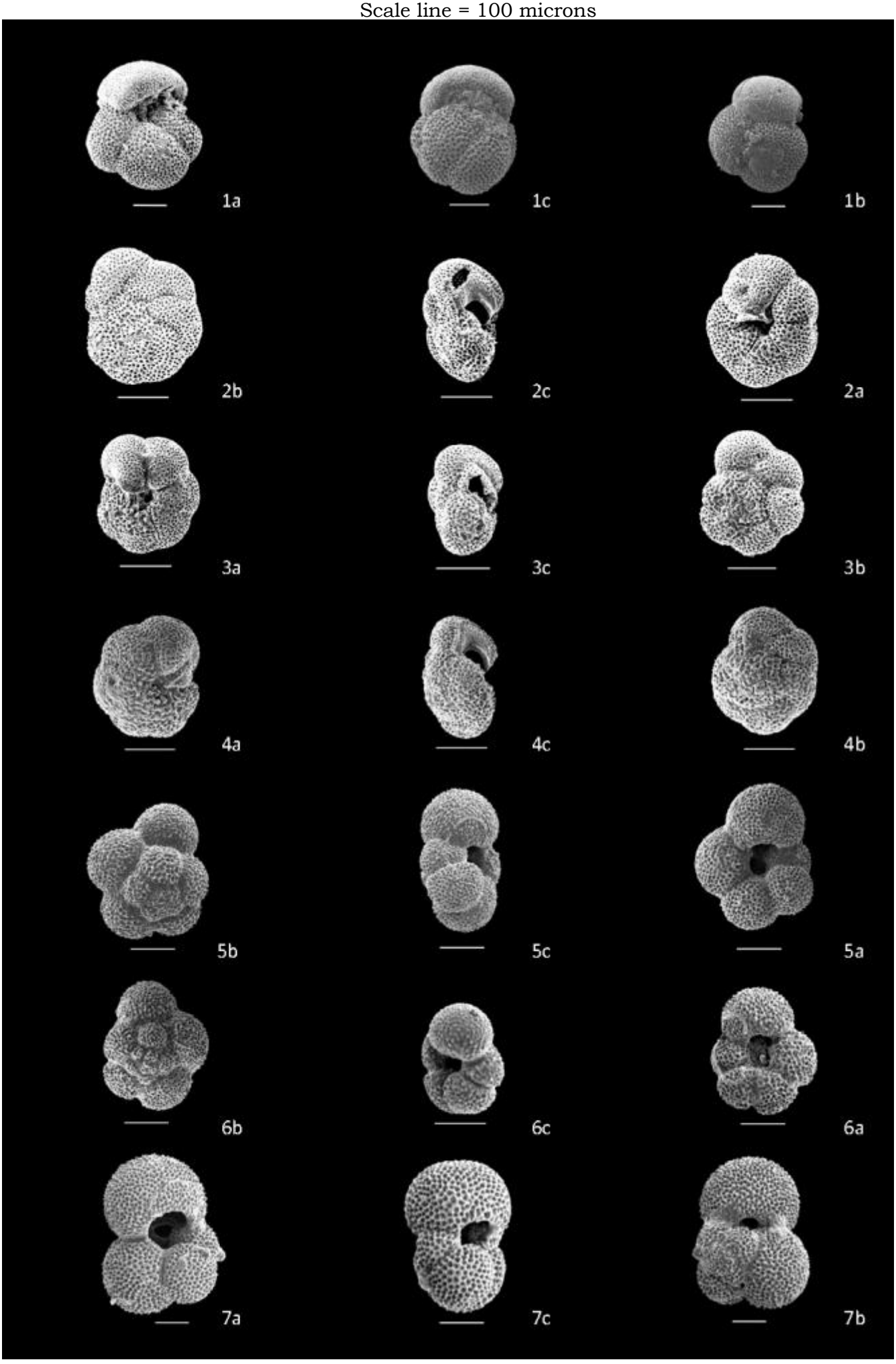


PLATE 4

Scale line = 100 micron

1. *Globorotalia increbescens* Bandy
   a-c ventral, dorsal, and side views from 4170'

2. *Globorotalia (Fohsella) kugleri* Bolli
   a-c ventral, dorsal, and side views from 2091'

3. *Globorotalia (Fohsella) pseudokugleri* (Blow)
   a-c ventral, dorsal, and side views from 2091'

4. *Globorotalia (Fohsella) mendacis* Blow
   a-c ventral, dorsal, and side views from 2091'

5. *Globigerina ciperoensis* Bolli
   a-c ventral, dorsal, and side views from 2359'

6. *Globigerina angulisuturalis* Bolli
   a-c ventral, dorsal, and side views from 2402'

7. *Globigerinoides primordius* (Blow and Banner)
   a-c ventral, dorsal, and side views from 2091'

Stratigraphic distribution: Blow (1969) and Djamas and Marks (1978) recorded the species in Late Oligocene to Miocene, upper Zone P22 to top N4. In Central Sumatra, Kadar (2008) reported the species in Late Oligocene- Early Miocene Zone P22 to top of N4. In Kuripan-1 it ranges from lowermost Zone N4 to top of N4.
Figured species: from 2091'.

***Globorotalia(Fohsella) mendacis* Blow**
Pl. 4, Fig. 4
Globorotalia (Turborotalia) mendacis Blow, 1969, p. 390-391, pl. 38, figs. 5-9
Description/remarks: Test low trochospiral, biconvex, equatorial periphery lobate, axial periphery rounded. Wall distinctly perforate, slightly pitted and hispids near the umbilicus. Chambers about 6 to 7 in the last whorl, inflated. Sutures on ventral side radial, slightly curved. Dorsally the sutures are curved and indistinctly incised. Umbilicus small, almost closed. Aperture a low arch opening, umbilical-extraumbilical bordered by a fine lip. The species is distinguished from *G. kugleri* in having convex spiral side, less curved dorsal sutures and less distinct intercameral sutures.
Stratigraphic distribution: Blow (1969) recorded the species in Late Oligocene to Early Miocene, upper Zone P21 to lower N4.
Figured species: from 2091'.

***Globorotalia(Fohsella) pseudokugleri* Blow**
Pl. 4, Fig. 3
Globorotalia (Turborotalia) pseudokugleri Blow, 1969, p. 391, pl. 10, figs. 4-6, pl. 39, figs. 5-6.
Globorotalia cf. *kugleri* Bolli, 1957, pl. 28, figs.7a-c.
Description/remarks: Test low trochospiral with 6 to 7 chambers in the final whorl, inflated. Equatorial periphery lobate to circular, axial periphery rounded. Dorsal side slightly convex. Wall calcareous perforate, surface partly pitted near the umbilicus. Sutures radial on ventral and slightly curved and incised dorsally. Umbilicus narrow, deeply depressed. Aperture a low to medium arch opening, extending from umbilicus to periphery. The species differs from *G. kugleri* in having a convex dorsal side instead of flat, and more curved dorsal sutures. The species can be distinguished from *G. mendacis* in having a wider umbilical depression and rounded peripheral margin.
Stratigraphic distribution: The species ranges from late Oligocene to early Miocene, upper Zone P22 to lower N4 (Blow, 1969). In Kuripan-1 it ranges from lowermost Zone P21 to lower N5.
Figured species: from 2091'.

***Globorotalia (Turborotalia) centralis* Cushman and Bermudez**
Pl. 3, Fig. 5
Globorotalia centralis Cushman and Bermudez, Bolli, 1957, p. 169, pl. 39, fig. 1-4; Eames, Banner, Blow and Clarke, 1962, p. 117, pl. XII, figs. K-M; Postuma, 1971, p. 182-183.
Description/remarks: Test low trochospiral, dorsal side slightly convex, ventral side distinctly convex. Equatorial periphery nearly circular, axial periphery rounded. Wall finely perforate, surface smooth. Five chambers in the last whorl, subspherical to ovoid, increase fairly rapidly in size, compressed laterally. Sutures on spiral side radial and curved slightly. Ventrally the sutures are radial, and depressed. Umbilicus narrow and closed. Aperture is a low and elongated arch, extending from umbilicus to the periphery. The specimen figured on Plate 3 is the only one discovered in the Ngimbang mudstone of the Kuripan-1 well.
Stratigraphic distribution: Blow(1969) recorded the species in Middle to Late Eocene, Zone P11- P17. In the Yogyakarta area Purnamaningsih and Pringgoprawiro (1981) also reported it from Middle to Late Eocene. In Kuripan-1 it occurs in the basal Oligocene, lowermost zone P18.
Figured species: from 4930'.

Catapsydrax Bolli, Loeblich and Tappan, 1957

***Catapsydrax dissimilis* Cushman and Bermudez**
Pl. 3, Fig. 1
Globigerina dissimilis Cushman and Bermudez, 1937, pt. 1, pl. 25, pl. 3, figs. 4-6
Catapsydrax dissimilis (Cushman and Bermudez), Bolli et al. 1957, p. 36, pl. 7, figs. 6-8, Kadar D., 2008, p. 16, pl. 3, fig. 3.
Description/remarks: Test low trochospiral, slightly convex dorsally. Equatorial periphery lobate to subquadrate, axial periphery broadly rounded. Wall finely perforate, surface pitted in places. Sutures on ventral side are radial and incised. Dorsally the sutures are weakly depressed. Umbilicus wide, elongated, covered by a bulla. Aperture is covered by a single umbilical bulla with two to four small supplementary apertures at the intersection between bulla and sutures.
Stratigraphic distribution: Blow (1969) recorded the species in Late Eocene to Early Miocene, upper Zone P13 – Zone N6. In Central Sumatra, Kadar (2008) reported the highest occurrence of the species at the top of Zone N6. In Kuripan-1, it ranges from lower Zone P19 - P20 to upper N4.
Figured species: from 2025'.

***Catapsydrax unicava* Bolli, Loeblich and Tappan**
Pl. 3, Fig. 2
Catapsydrax unicava Bolli, Loeblich and Tappan, 1957, p. 37, pl .7, fig. 9.
Globigerinita unicava unicava Bolli, Loeblich and Tappan, Blow and Banner, 1962, p. 113, pl. XIV, figs. M-N.
Catapsydrax unicava Bolli, Loeblich and Tappan, Kadar, 2008, p. 16, pl. 3, fig. 2.
Description/remarks: Test low trochospiral, equatorial periphery subcircular to subquadrate, axial periphery broadly rounded. Dorsal side slightly convex, ventral strongly convex. Wall coarsely perforate, surface pitted in places. Chambers coiled in about three whorls. The final whorl consists of four chambers, ovoid, increase gradually in size. Sutures radial both ventral and dorsal, deeply incised ventrally. Umbilicus wide, covered by a bulla which is subquadrate in outline.The bulla posseses a

single slit like aperture, facing the penultimate chamber. The species differs from *C. dissimilis* Cushman and Bermudez in having a single aperture between bulla and umbilicus.
Stratigraphic distribution: Blow (1969) recorded the species in Middle Oligocene to Early Miocene, Zone P20 to top of N6. In Kuripan-1, the species ranges from Oligocene to Early Miocene, middle part of Zone P19 - P20 to middle N5-N7.
Figured species: from 3760'.

***Catapsydrax pera* (Todd)**
Pl. 3, Fig. 3
Globigerina inflata d'Orbigny, Subbotina, 1953, p. 72, pl. 15, figs. 6a-c.
Globigerina pera Todd, 1957, p. 301, pl. 70, figs. 10, 11.
Globigerinita pera (Todd), Eames, Banner, Blow and Clarke, 1962, p. 99-100, pl. XIVE-H.
Description/remarks: Test low trochospiral, biconvex, equatorial periphery subcircular to subquadrate, axial periphery broadly rounded. Chambers subspherical to ovoid, arranged in about three whorls. The four chambers of the last whorl increase rapidly in size. Wall coarsely perforate, in places surface pitted and hispid. Sutures deeply depressed. Umbilicus wide, deep, covered by an inflated almost quadrate bulla. Primary aperture is covered by a bulla, while a single accessory aperture is present between the margin of the bulla and the surface of the penultimate chamber. Surface of the bulla is less coarsely perforate.
Stratigraphic distribution: Blow (1969) recorded the species in Late Eocene to Oligocene, upper Zone P14 to middle P20. In Kuripan-1 it ranges from Early Oligocene, upper Zone P18 to upper part of zone P21- P22.
Figured species: from 3000'.

***Catapsydrax primitiva* (Blow and Banner)**
Pl. 3, Fig. 4
Catapsydrax unicavus Bolli, Loeblich and Tappan, 1957, p. 166, pl. 37, figs. 7a-b
Globigerinita unicava primitiva Blow and Banner, Eames, Banner, Blow and Clarke, 1962, p. 114, pl. XIVJ-L.
Description/remarks: Test low trochospiral, dorsal slightly convex, ventral side strongly convex. Equatorial periphery subcircular to subquadrate, axial periphery rounded. Chambers subspherical to ovoid, arranged in about three whorls. Four chambers of the last whorl increase rapidly in size. Wall coarsely perforate. Sutures on ventral side radial, deeply depressed. Umbilicus wide, covered by a finely perforate bulla, subtriangular in outline. The primary aperture is not seen, concealed in the umbilicus. A single low arch accessory is present between umbilicus and penultimate chamber. The species differs from *Catapsydrax pera* in having more restricted subtriangular bulla which incompletely covers the umbilicus.
Stratigraphic distribution: Blow (1969) recorded the species from Late Eocene to Oligocene, Zone P14 to upper Zone P20. In Kuripan-1, it ranges from upper Zone P18 to lowermost P21- P22.
Figured species: from 3866'.

Genus ***Globigerinoides*** Cushman, 1927

***Globigerinoides primordius* (Blow and Banner)**
Pl. 4, Fig. 7
Globigerinoides quadrilobatus primordius Blow and Banner, 1962, p. 115, pl. IX, Dd-Ff, Stainforth et al., 1975, p. 305-307, fig. 136.
Globigerinoides primordius (Blow and Banner), Postuma, 1971, p. 298-299, Kadar, 2008, p. 15, pl. 1, figs. 8a-9b.
Description/remarks: Test low trochospiral, equatorial periphery lobate. Three and half chambers of the last whorl are subglobular, increase rapidly in size. The ultimate chamber is bigger or about the same size with the earlier chambers combined. Wall coarsely perforate, surface slightly pitted and hispid. Umbilicus narrow, deeply depressed. Sutures deeply depressed both on ventral and dorsal. Main aperture a moderate arch opening, interio-marginal facing the umbilicus. There is only one single supplementary aperture present on the dorsal side. It distinguishes the species from its immediate ancestor *Globigerina bulloides occlusa*, *w*hich does not have any supplementary aperture, which also distinguishes it from *Globigerinoides quadrilobatus*. The latter is having more than one single supplementary apertures on the spiral side.
Stratigraphic distribution: The species ranges from N4 to middle N5 (Blow, 1969). In Central Sumatra, Kadar (2008) recorded the species to range from Zone N4 to upper N5. In Kuripan-1, it ranges from base of Zone 4 to lowermost N5.
Figured species: from 2091'.

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