THE MIOCENE/PLIOCENE BOUNDARY* IN THE NORTH EAST JAVA BASIN, INDONESIA

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Editor's note :

This article has to appear for the second time, since in the first one, there have been so many typographic errors for which we have to apologize. It's published again due to its importance.

Abstract. *Late Miocene to Early Pliocene marine sediments of the North East Java Basin are represented by the Kerek and Kalibeng formations in the Kendeng zone and by the Ledok and Mundu members of the upper part of Kawengan Formation in the Rembang zone. Generally, Miocene sediments are characterized by the alternation of calcareous clay, marl, sandy limestone or calcareous sandstone; whereas the Pliocene sediments are characterized by unbedded marl or calcareous clay. Based on these phenomena, the Miocene sediments were deposited at shallower environment in comparison with the Pliocene one. A regressive phase took place during the end of Miocene, followed by a trangressive phase in the Early Pliocene.*

In the Kendeng zone, **Globorotalia tumida** *(Brady) appears for the first time at the uppermost part of the Kerek Formation, whereas in the Rembang zone this species made its first appearance at the uppermost part of the Ledok Member, upper part of Kawengan Formation. This* **Globorotalia tumida** *(base) datum can be used as a Miocene/Pliocene Boundary in the North East Java Basin, Indonesia.*

INTRODUCTION

As a part of the LEMIGAS Research Programme on Neogene Epoch Boundaries in the Indonesian Tertiary Basins, in 1981 fiscal year is selected North East Java Basin as an object for research. In this paper we will stress our work on the Miocene/ Pliocene Boundary of the basin based on planktonic Foraminifera.

More recently a lot of paleontologists have been working on the Miocene/Pliocene Boundary problem. Bandy (1963) used the first appearance of *Sphaeroidinella dihescens* as a boundary in the Phillipine, whereas Bolli (1966, revision in 19/0) put this stage boundary based on the initial apppearance of *Globoratalia margaritae.* In 1969, Blow carried out an examination of samples from the Trubi Marl of the Zanclean Sicily and came to the conclusion approximately with middle N18 of this zonal scheme.

Berggren (1973) proposed the limit of this stage boundary based on the last occurrence of *Globoquadrina dehiscens.* Kaneps (1974) based on this observation on planktonic Foraminifera of the DSDP cores from the Eastern Equatorial Pacific Ocean came to the conclusion that the Miocene/Pliocene Boundary lies at the base of *Globoratalia tumida* zone. The base of this zone was placed at the horizon of the initial appearance of *Globoratalia tumida* while the upper boundary was placed at the horizon of reversal in coiling direction of *Pulleniatina primalis* from left below to right above. Pringgoprawiro and Baharuddin (1979) on the other hand proposed the initial appearance of *Sphaeroidinella immatura* as a boundary between these two periods.

The purpose of this paper is to study the ranges of some selected important species, and to detect how far these species can be used as a tool for Miocene/Pliocene Boundary in the North East Java Basin. No radiometric age dating has been done in the area.

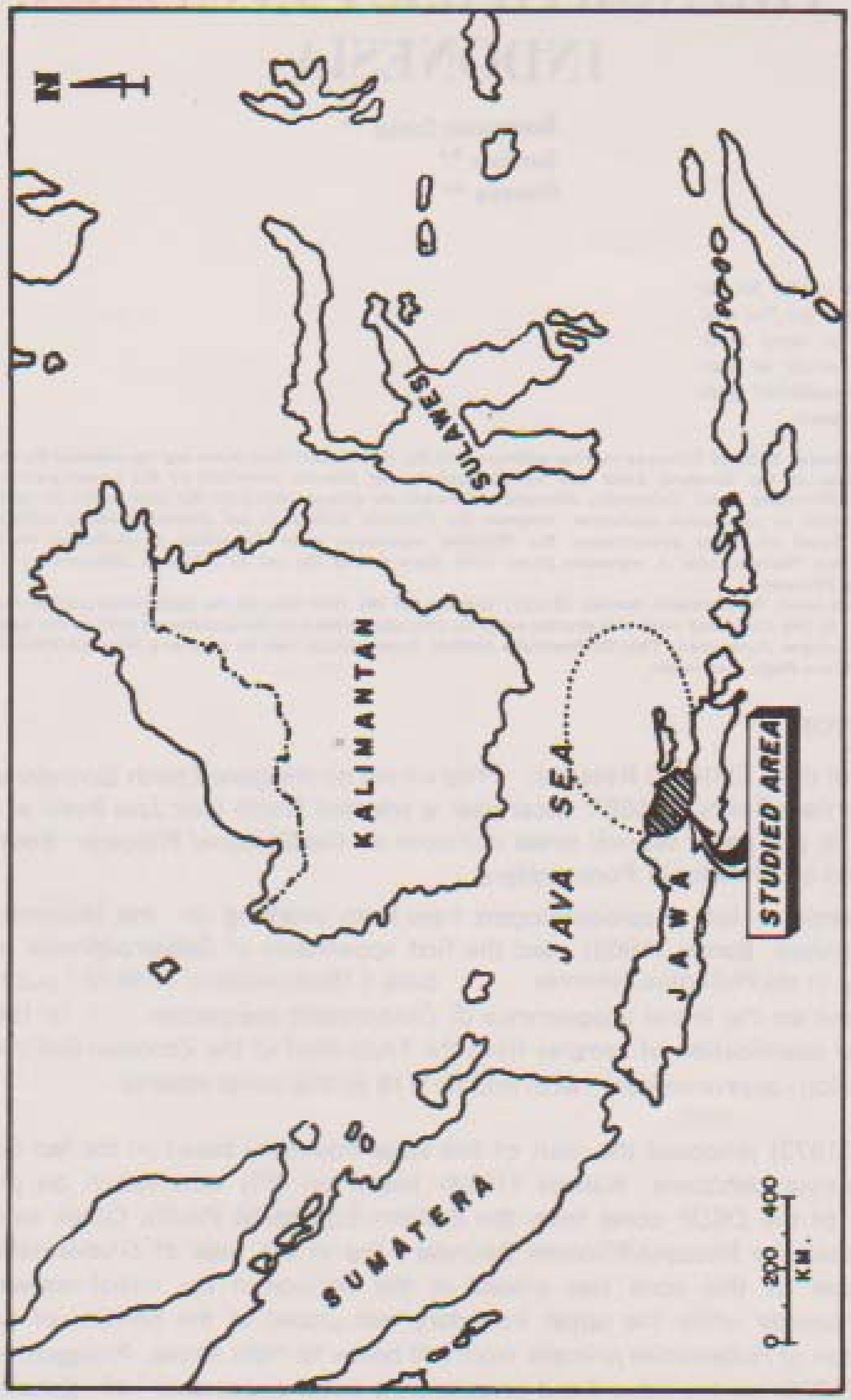

Fig. 1 Index map of studied area.

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GEOLOGY

GENERAL

The configuration of North East Java Basin is East-West oriented parallel to the volcanic range (Fig. 2). This basin is generally divided into two major structural units :

1. The Northern Java Hinge Belt consists of physiographic subdivision known as the alluvial plains of Northern Java, the Rembang-Madura hills and the Randublatung depression.
2. The Southern Axial Java Trough, also consists of two physiographic subdivisions : the Kendeng hills and the Central plain of East Java (Sutarso and Suyitno, 1976).

Rembang zone

It is bordered by a stable platform to the North and it plunges westward toward the Semarang Trough. This zone is continued by northern half part of Madura hill to the East, and is bordered by Randublatung depression to the South. Tectonically this area intensively folded with long narrow assymetrical anticilines.

Kendeng zone

The structural pattern is very tight, assymetrical fold with fault complication at depth. The Northernboundary limits with the Randublatung depression, through most of its length, which implies fault control. The southern part is defined by the Central plain of East Java.

To the East, the boundary become arbitrary perhaps continuing under the Madura Strait, while the western boundary is not known.

STRATIGRAPHY

The sedimentary rock of the North East Java Basin was deposited from the Eocene to Pleistocene with morethan 5.000 m thick. The sediment consists predominantly of marl and clay, interbedded with sandstone and limestone (Sutarso and Suyitno, 1976).

The regional stratigraphic units (Fig. 4) are as follows :

1, Lidah Formation	- Late Pliocene to Pleistocene
2, Kawengan Formation	- Middle Miocene to Pliocene
3, Tuban Formation	- Early to Middle Miocene
4, Kujung Formation	- Oligocene to Early Miocene
5, Pre Kujung Formation	- Eocene to Oligocene

Pre Kujung Formation

This is the oldest sedimentary rocks (Eocene to Oligocene) of the North East Java Basin, which has deposited unconformably over the Pre Tertiary basement. The lithology of this formation consists of shale, clay, sandstone intercalation with coal and limestone.

Kujung Formation

This formation conformably overlain the Pre Kujung Formation. The deposition took place during the Oligocene to Early Miocene. The lower part of the formation consists of shale, marl with limestone intercalation whereas the upper part consists of chalky limestone alternating with marl.

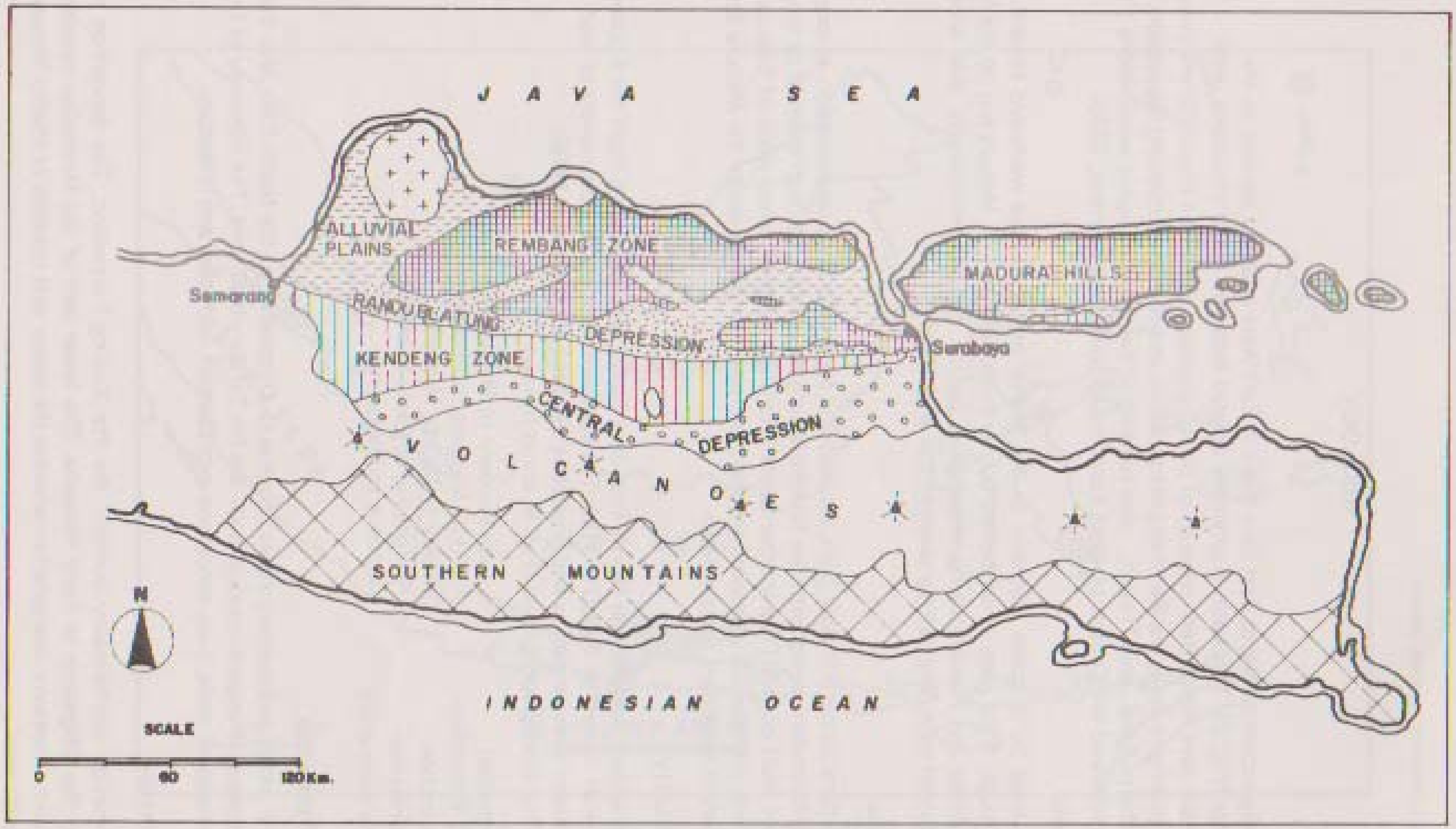

Fig. 2 PHYSIOGRAPHIC AND STRUCTURAL SKETCH MAP-NORTH EAST JAVA BASIN

(Sutarso & Suyitno , 1976)

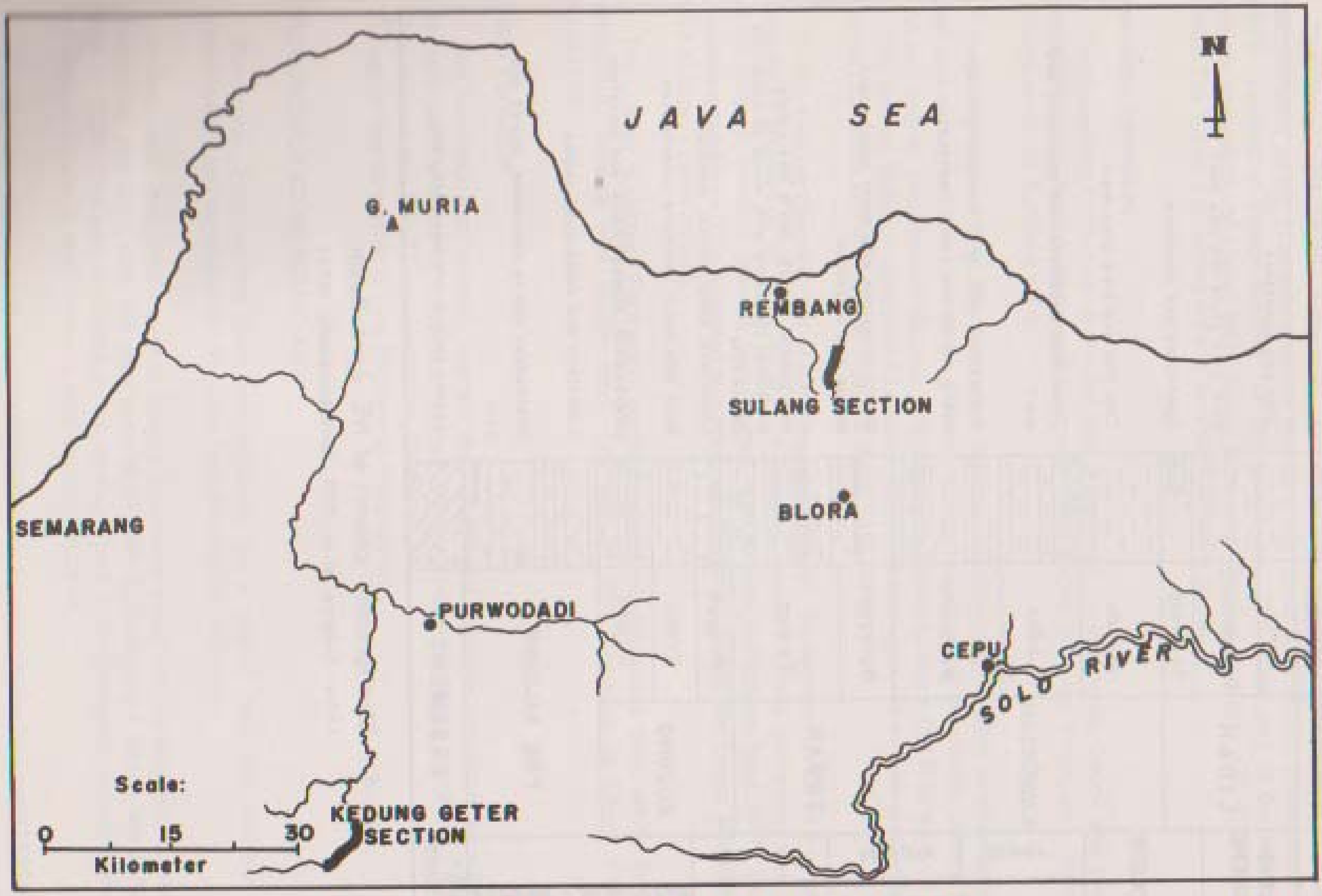

Fig. 3 Location map of measured sections.

Hd._

AGE		STRATIGRAPHIC UNITS: FORMATION	STRATIGRAPHIC UNITS: MEMBER	REMARKS
PLEIS-TOCENE		LIDAH	Turi	Clay and sandstone
PLEIS-TOCENE		LIDAH	Tambakromo	Blue grey shale and clay marl.
PLIOCENE		LIDAH	Selorejo	Sandstone and limestone
PLIOCENE		KAWENGAN	Mundu	Calc. clay and blue grey marl.
MIOCECE	Upper	KAWENGAN	Ledok	Calcareous sandstone rich glauconite and marl.
MIOCECE	Upper / Middle	KAWENGAN	Wonocolo	Interbedded calc, quartz sandstones and sandy marls and sandy limestone.
MIOCECE	Middle	TUBAN	Ngrayong	Quartz sandstone with minor interbedded shales and limestone
MIOCECE	Lower	TUBAN	Tawun	Interbedded shales, marls and sandy orbitoidal limestone with minor of sandstone, glauconitic.
MIOCECE	Lower	KUJUNG	Prupuh	Limestone, coral, foram, massive
EOCENE – OLIGOCENE		KUJUNG	Kranji	Marl with minor limestone interbedded.
EOCENE – OLIGOCENE		KUJUNG	Kujung	Interbedded shales/marls and limestone
EOCENE – OLIGOCENE		PRE KUJUNG		Limestone and calcareous shales. Interbedded coarse sandstone, shales and coal.
PRE-TERTIARY		BASEMENT		Igneous rock or metamorphic rock.

Hd.

Fig. 4 : Stratigraphic column of NE Java Basin
(After Sutarso, et. al, 1976, Koesoemadinata, 1978)

Tuban Formation

The lower part of the formation consists of shale and marl with Orbitoid limestone intercalation ; which in previous report known as "Orbitoid Kalk" (OK). Koesoemadinata (1978) regarded as Tawun Member for this lower unit. The upper part of the formation consists dominantly of a sand body called Ngrayong Member or Upper OK (Soeka et al. 1980). The Tuban Formation is Early to Middle Miocene in age.

Kawengan Formation.

The Kawengan Formation is divided into 3 members i.e. Wonocolo, Ledok and Mundu members in the Rembang zone, and it was correlatable with the Kerek and Kalibeng formations of the Kendeng zone.

In Sulang section (Fig. 5), the Ledok Member lithologically consists of alternation of marl and dark grey, fine to medium grained, well sorted rounded, glauconite, clayey, hard and well bedded calcareous sandstone. This member is Upper Miocene (N17) in age.

The Mundu Member consists of calcareous clay and marl, grey to blueish grey, massive and soft to brittle and is of Lower Pliocene (N18-N19) in age

In the Kedung Geter section of Kendeng zone (Fig. 6), the topmost of Kerek Formation consists of alternation of white to grey, tuffaceous, massive, brittle calcareous clay ; and white to grey, medium grained, fairly sorted, subrounded, tuffaceous, hard, fairly bedded calcareous sandstone. This sediment sequence was deposited during the Upper Miocene or N17 of Blow's zonal scheme.

The Lower Kalibeng Formation consists mainly of calcareous clay, white to grey, tuffaceous, massive and brittle marl. The age of this formation is Lower Pliocene (N18-N19).

Lidah Formation

This formation conformably overlain the Kawengan Formation consists of blueish grey clay with sand and marl alternation. This unit can be divided into three members : Selorejo, Tambakromo and Turi (Koesoemadinata, 1969).
The age of this formation is Late Pliocene to Pleistocene.

MIOCENE/PLIOCENE BOUNDARY

Planktonic Foraminifera have been regarded as a useful tool for relative age determination and correlation of the Late Neogene marine sediments.

In Indonesia, Bolli (1966) tried to make a bizonation based on this plaktonic forms. His observation was done over the core samples of well Bodjonegoro-1 which was drilled by BPM in 1934. This well is located at the northern part of Bodjonegoro, approximately 90 km west of Surabaya, and reached a total depth of 2025 m.

The Miocene and Pliocene were introduced as stratigraphic terms by Lyell (1833) in the first edition of his "PRINCIPLES OF GEOLOGY". Whereas the Websters International

Dictionary defines boundary as "that which indicates or fixes a limit or extent......a bounding or separating line". Saito and Burckle (1975) came to the conclusion that, in geology, it means a time boundaries or limit.

In the Capo Rossello section of Sicily, this stage boundary was lying at the base of the Trubi Marl. This lithologic unit overlain the evaporitic sequence. The *Sphaeroidinella immatura* appears for the first time at the lower part of Trubi Marl, approximately 40 feet above the contact between evaporitic sequence and Trubi Marl.

In different area, for example in the DSDP Core 132-21-2, beneath the floor of Tyrrhenian Sea, this boundary lies at the limit between calcitic-dolomitic-pyritic marl and the younger overlying foraminiferal ooze.

The Miocene/Pliocene boundary, suggested by Berggren (1969c, 1972a) is 5,0 my BP in age; and recent investigation have added support to this estimation (Berggren, 1973;Cita, 1973, 1974; Gill and Mc. Dougall, 973; Saito, et al., 1974).

Berggren (1973) reported that *Globorotalia tumida* appears fo the first time at 4,9 my BP whereas *Sphaeroidinella immatura* at 4,8 my BP. The last occurrence of *Globoquadrina dehiscens* was still below the initial appearance *of Globorotalia tumida*. It was extinct at, 5,9 my BP. Based on these data, Berggren (1973) put the Miocene/Pliocene Boundary at the last occurrence of *Globoquadrina dehiscens*.

Ikebe and Chiji (1978) based on their observation of the Pacific Neogene samples reported that *Globorotalia tumida* appears for the first time between 5,0-5,5 my BP, whereas *Sphaeroidinella immatura* between 4,5-4,8 my BP. Taylor and Deighton (1978) proposed an age of 4,8 my BP for the first appearance of *Sphaeroidinella immatura* in South West Pacific. This age assignment is similar to those proposed by Berggren (1973).

In the Kedung Geter section (Fig.6) of the Kendeng zone of North East Java Basin,*Globorotalia tumida* appears for the first time at the topmost part of Kerek Formation, 6 m below the contact between Kerek and the overying Kalibeng Formation. It is associated with *Globorotalia plesitotumida, Globoquadrina dehiscens, Sphaeroidinellopsis seminulina. Ss. subdehiscens, Ss. sphaeroides*, and other tropical fauna. The N18 of Blow's zonal scheme *(Globorotalia tumida* to *Sphaeroinella immatura* Interval-zone) snatches at 351m thick. In this section *Globoquadrina dehiscens* still exists until N 19 of Blow's zonal scheme.

In the Sulang section (Fig.5) of Rembang zone of North East Java Basin, the initial appearance of *Globorotalia tumida* is found in the sample MP 154 taken from Ledok Member, 3 m below the contact between the Ledok and Mundu Member.
The lithology comprise of sandy calcareous clay, grey, brittle ad massive. This species is associated with *Globorotalia plesiotumida, Gt. menardii, Globigerinoides trilobus, ,Gs. sacculiferus, Globoquadrina altispira and Pulleniatina primalis.*

Zone N18 *(Globorotalia tumida to Sphaeroidinella immatura* Interval-zone) snatches at 208 m thick (Fig. 5). The thickness seems to be nearly same as in the Cubagua-1 well, Venezuela which snatches at 200 m thick.

Baumann (1975) regarded this zone as equivalent with *Globorotalia margaritae* zone of Bolli (1966b).

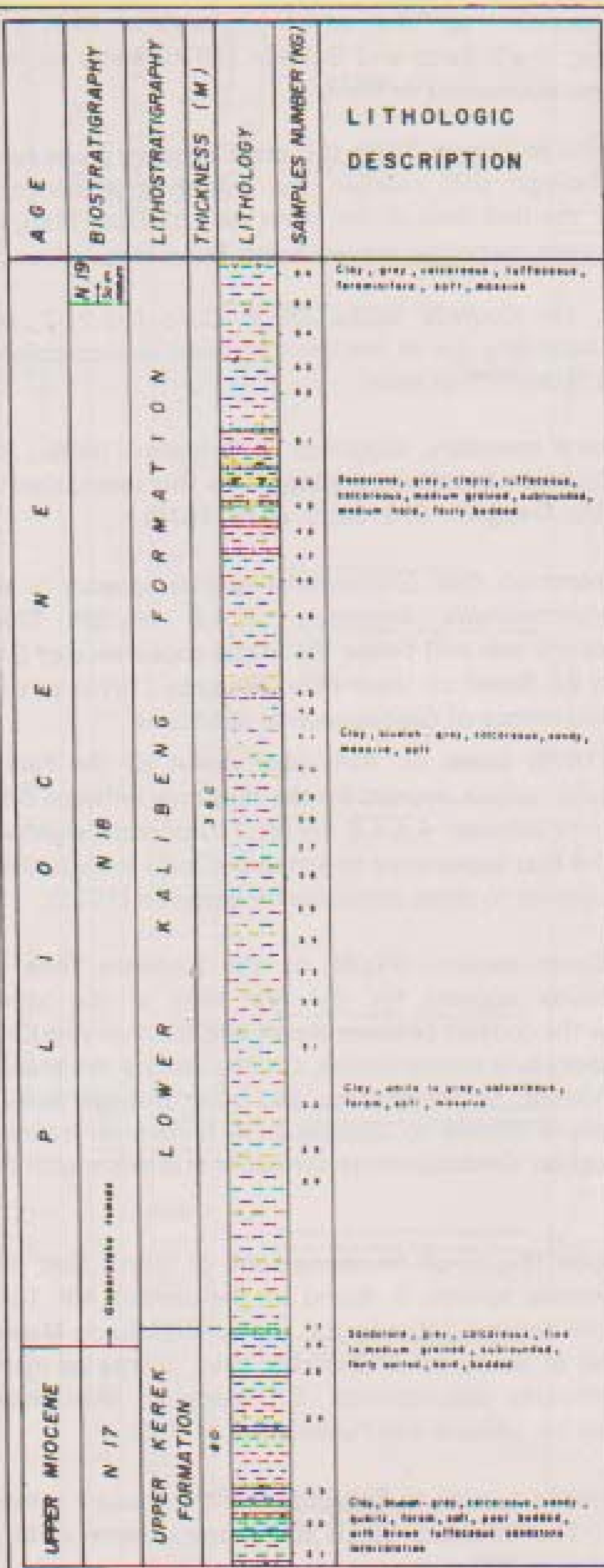

Fig.6 BIOSTRATIGRAPHY OF THE KEDUNG GETER SECTION CENTRAL JAVA

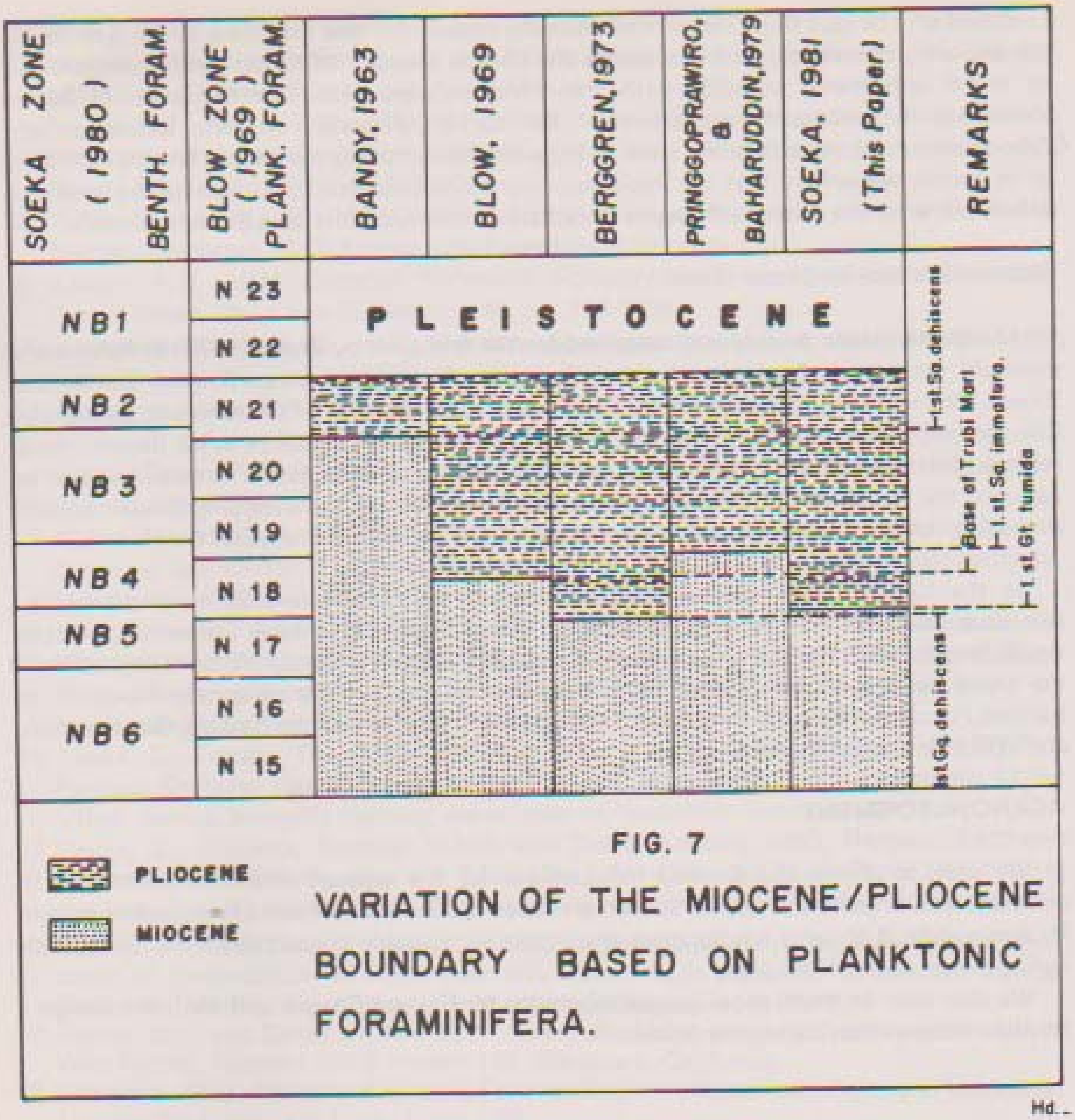

FIG. 7

VARIATION OF THE MIOCENE/PLIOCENE BOUNDARY BASED ON PLANKTONIC FORAMINIFERA.

Like in the Kedung Geter section, in the Sulang section, *Globoquadrina dehiscens does* still exist up to zone N19 associated with *Sphaeroidinella immatura.*

In the equatorial Pacific section (including DSDP Site 62.1 and Piston Core RC 12-66) a conspicuous carbonate minimum is present in the Latest Miocene or Earliest Pliocene. Ryan et al. (1974) and Van Andel et al. (1975) attributed this minimum to increased dissolution during a rise of the Carbonate Compensation Depth, triggred by Antartic Glaciation (in Van Gorsel and Troelstra, 1981).

Our data from the Sulang section show a minimum Calcium Carbonate content in the samples of the Ledok Member (Latest Miocene), and then followed by an increased of Calcium Carbonate in the samples of Lower Mundu Member (Earliest Pliocene). These phenomena suggest a regression phase during the Latest Miocene, and then followed by a transgression during the Earliest Pliocene due to the temperature fluctuation

Based on the fact that *Globorotalia tumida* appears for the first time at the 6 m below the Kalibeng Formation, and 3 m below the Mundu Member of Kawengan Formation; and its initial appearance coincide with the trend between carbonate minimum of Latest Miocene to the carbonate maximum of the Earliest Pliocene; and the extinction of *Globoquadrina dehiscens* is in the zone N 19; while *Globorotalia margaritae* is rather difficult to be found, we believe that the initial appearance of *Globorotalia tumida* can be used as a datum-plane for the Miocene/Pliocene Boundary in the Nort East Java Basin, Indonesia .

Globorotalia tumida Datum-plane

The Globorotalia tumida was described for the first time by Brady (1877) as *Pulvinulina menardii* var *tumida* from New Ireland, Bismarck Archipelago. According to Banner and Blow (1965a) this species appears to be the direct descendent of *Globorotalia plesitumida.* The first appearance of this *Globorotalia tumida* signed the base of N18 Blow's zonal scheme. Natori (1976) reported that this *Globorotalia tumida* datum is considered to be between the underlying *Pulleniatina primalis* datum plane and the overlying *Sphaeroidinella immatura* datum-plane in the lower part of Yonabaru formation of Ryusei Well No. 1.

In the Kedung Geter section, Kendeng zone of North East Java Basin, *Globorotalia tumida* appears for the first time at the 6 m below the baseof Kalibeng Formation, while in the Sulang section, Rembang zone it appears at 3 m below the Mundu Member coincide with the trend between carbonate minimum of Latest Miocene to the carbonate maximum of Earliest Pliocene. The total thickness of the zone N18 is 351 m in the Kedung Geter section, and 208 m in the Sulang section.

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