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THE PALEOCENE-EOCENE SUCCESSION IN THE GUIANA BASIN

by

Theo E. WONG[1]

ABSTRACT

The Paleocene-Eocene boundary in the southern part of the Guiana Basin is a well-defined biostratigraphical and lithostratigraphical event. It is an unconformable contact which forms a sequence boundary between a Late Paleocene (TA 2.1 ?) and an Early Eocene (TA 2.4 ?) sequence. This boundary cannot be correlated toward the deeper part of the basin. More conspicuous hiatuses occur at the Cretaceous-Tertiary boundary, at the beginning of the Late Eocene (the bauxite hiatus) and near the base of the Miocene. Since the area is located on a stable craton it seems likely that eustatic sea level movements rather than major tectonic factors controlled these periods of non-deposition.

KEY WORDS

Paleocene-Eocene boundary, Guiana Basin, Suriname, sequence stratigraphy.

1. GEOLOGICAL SETTING

The Guiana Basin is a coastal sedimentary basin along the northeastern edge of South America, lying to the north of the Precambrian Guiana Shield. The coastal plains of Suriname, French Guiana and Guyana constitute the onshore part of the basin (fig.1). In the offshore part of the basin two morphological units can be discerned (fig.2); the continental shelf (water depths up to 100 m) and the Guiana Marginal Plateau or Demerara Rise (water depths up to 3000 m).

The Guiana Marginal Plateau has been formed during successive stages of plate tectonism (with wrench faulting) in connection with the separation of both North America and Africa from South America. Although active rifting of the Precambrian Guiana Shield occurred during the Jurassic and Early Cretaceous, the tectono-stratigraphic development of the Guiana Basin follows a simple passive, trailing margin model. In this cratonic realm there were no major tectonic events as is evidenced by the horizontal to sub-horizontal bedding of the sedimentary section. Moreover, large scale faulting and deformation features do not occur in the Paleogene section.

As is shown by stratigraphical and seismic data, progressively younger sediments onlap the basement in a southerly direction. The oldest strata overlying the basement in the coastal area have a Late Cretaceous age, whereas offshore the deepest drilling encountered Lower Cretaceous sediments. The entire section consists of Cenozoic and Mesozoic clastic sediments unconformably overlying basement rocks, which dip gently northwards.

In the Tertiary section, several regressions and transgressions as well as major periods of non-deposition, can be recognized (fig. 3). These hiatuses occur at the Cretaceous-Tertiary boundary (RM 10) and near the base of the Miocene (RM 8). Near the edge of the basin the so-called bauxite hiatus was effective from the beginning of the Late Eocene through the Oligocene. In previous studies dealing with this area however, the Paleocene-Eocene boundary has never been regarded as an unconformable contact.

[1] Geological Survey of the Netherlands, P.O. Box 157 - NL-2000 AD Haarlem. Nederland.

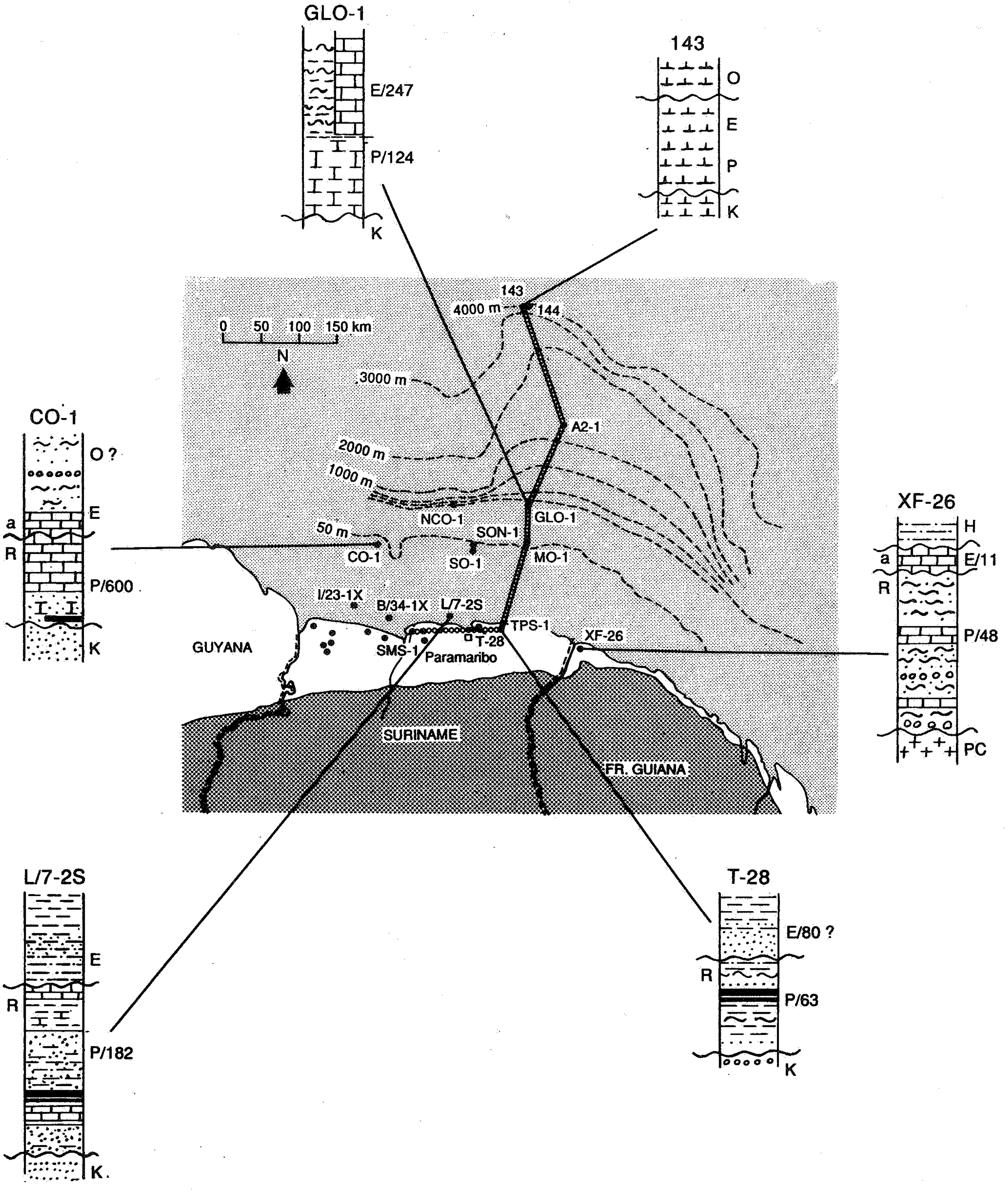

Figure 1. Outline of the Guiana Basin, showing locations of relevant wells and sections. Paleocene-Eocene sections (not to scale) of some key wells are also given (PC = Precambrian, K = Cretaceous, P = Paleocene, E = Eocene, O = Oligocene, R = highest occurrence of *Ranikothalia*, A = algae and 124 thickness in metres of that particular interval).

2. DESCRIPTION OF VARIOUS LOWER TERTIARY SECTIONS

2.1. The coastal plain

2.1.1. General

The Tertiary section in the coastal plain begins with Paleocene sediments which unconformably overlie the weathered Precambrian basement and/or Late Cretaceous sediments. The latter belong to the Nickerie Formation which is characterized by a regular alternation of predominantly consolidated quartz sands with multicoloured claystones, siltstones and minor shales. The top of this formation is strongly weathered. The sediments have been deposited under continental (mostly fluvial) conditions. The Cretaceous - Tertiary unconformity is of regional significance and can be traced all the way to DSDP sites 143 and 144 on the northern edge of the Guiana Marginal Plateau. Within the Paleocene section of the coastal plain of Suriname, Wong (1989) has recognized three different facies. From south to north, these reflect the paleogeographical trend : a continental basin edge facies, a coastal-fluvial facies and a restricted, lagoonal facies (fig. 4). The continental basin edge facies comprises kaolinized and bauxitized sediments of the Onverdacht Formation, the occurrence of which is restricted to the so-called Bauxite Belt in Suriname and Guyana. The next lithological unit northwards (Saramacca Formation in Suriname) consists of alternating sands and clays with occasional lignites. The lagoonal facies is represented by fossiliferous marls, limestones, calcareous sands and lignites, which are grouped in the Alliance Formation. In most of the sections in the coastal plain the transition from Paleocene to Eocene strata is characterized by a biostratigraphical and lithostratigraphical break of which the latter can be recognized on wire line logs and seismic sections. Hence, an hiatus at this level can be inferred of which the duration cannot be established because adequate biostratigraphical data is lacking.

2.1.2. Description of relevant sections

In the Onverdacht bauxite area the traditional two-fold division of the Onverdacht Formation (Montagne, 1964) represents Eocene sediments overlying Paleocene strata. The Paleocene section, covering weathered Precambrian rocks, reaches a thickness of approximately 10 m. The ages were based on palynological studies by Van der Hammen *et al.* (1964) and Wijmstra & Van der Hammen (1964). According to Wijmstra (1971) the main bauxitization period was from the Late Eocene through the Oligocene. Virtually all the commercial bauxite deposits of Suriname and Guyana were formed during this period.

In the western and central parts of the Surinam coastal plain, the Paleocene section of the Saramacca Formation consists of alternating sands and clays with occasional lignite beds. This section has been deposited in a fluvial to deltaic realm. The total thickness ranges up to 100 m. The base of the overlying Eocene section comprises a relatively thick clay unit, which may have been deposited during a major transgression over the Paleocene sands. On the various well logs from this area this transition is very distinct and it can be successfully correlated from well to well (fig. 5). Since no marine fossils occur in this section the age determinations are solely based on palynological data (e.g. Wijmstra, 1971 ; Amstelveen, 1971). It appears that from a palynological point of view the transition from Paleocene to Eocene strata is well marked by the sudden disappearance of various Paleocene species at the boundary level. This event was so distinct that a Late Paleocene (B2) and an Eocene pollen zone (C) can be recognized (see fig. 3).

In the eastern coastal plain the calcareous Alliance Formation (Paleocene) with its characteristic benthonic foraminiferal fauna is overlain by clays and sands of the Saramacca Formation (e.g. fig. 6). Again the Paleocene-Eocene boundary is well defined based on palynological data from the T-28 well (Wijmstra, 1969). The Paleocene foraminifera in the section (63 m thick) belong exclusively to the benthonic type, dominated by *Boldia carinata*, *Anomalinoides midwayensis*, *Siphonina prima*, *Anomalinoides danicus*, *Ranikothalia catenula* and several representatives of the Rotalidae (Van Voorthuysen, 1969 ; Wong 1976). Other faunal elements which occur frequently throughout the section are ostracods, bryozoans and oyster fragments. Glauconite is also met with in this interval. There is no continuation of this faunal association into the overlying Eocene strata.
A similar calcareous Paleocene section and microfauna as in T-28 were described from the subsurface sediments of northwestern French Guiana near the village of Mana (Drooger, 1960a, b ; Wong, 1976). In well XF-26 this section (unit 1 in fig.7) is 46 m thick. Wong (1976) stressed the similarity of the Paleocene microfauna with the «Tethyan carbonate fauna» (TCF) as defined by Berggren (1974). The TCF represents a shallow, inner shelf to middle shelf fauna, characteristic of carbonate environments along the margins of the Tethyan area. Wong (1976) suggested that the Paleocene sediments of XF-26 were deposited in a vegetated coastal lagoonal environment with fluctuating salinities. The distribution chart of well XF-26 (fig.7) shows that the faunal diversity tends to increase slightly from the base upwards, reaching a maximum between 75 and 59 m, and then to decrease again towards the top of the Paleocene interval. The overlying carbonate section (unit 2) is characterized by algae and echinids, and is devoid of terrigenous

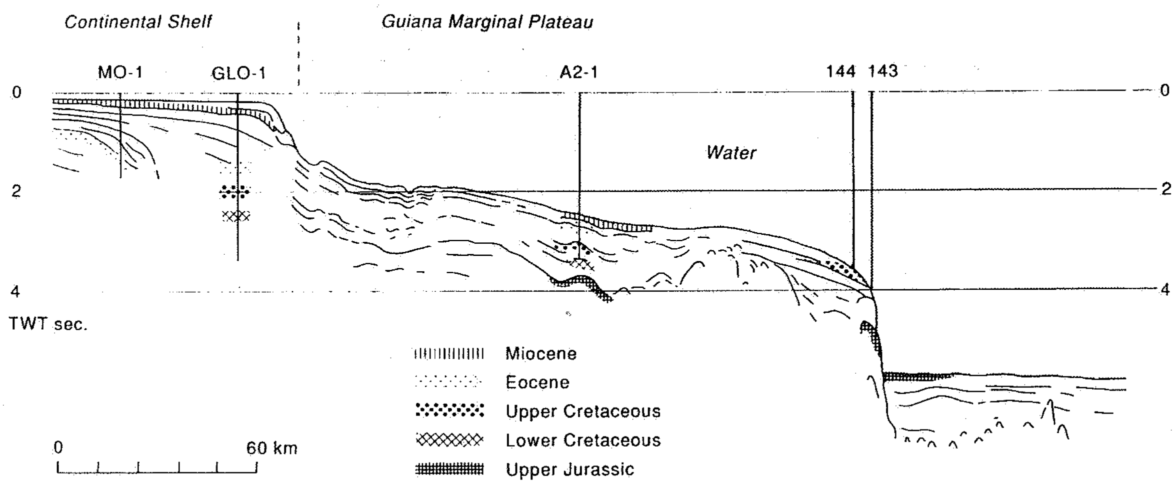

Figure 2. N-S section through the Guiana Basin, showing the continental shelf and Guiana Marginal Plateau or Demerara Rise. (modified after Collette *et al.*, 1971).

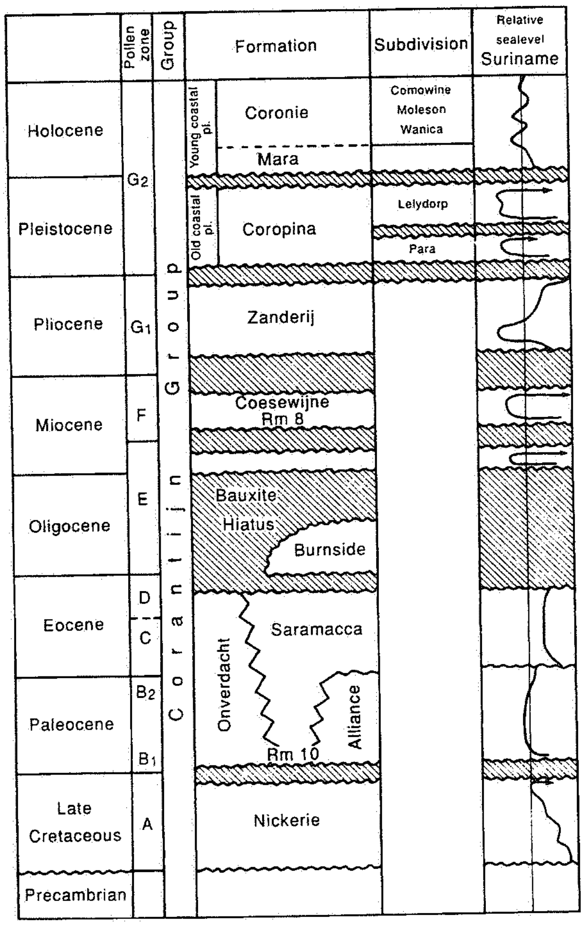

Figure 3. Stratigraphical framework of the coastal plain of Suriname, showing various sea level movements.

sediments. The entire unit has a thickness of 11 m. The scarce foraminifera are a strongly reduced continuation of the underlying fauna. The stratigraphic position of this section is still uncertain. Wong (1976) tentatively assigned it to the Eocene since it is above the highest occurrence of *Ranikothalia* which was thought to coincide with the top of the Paleocene. This Eocene section probably can be correlated with the transgressive clay unit of the Saramacca Formation but hard stratigraphical evidence to support this assumption is lacking.

2.2. The offshore area

2.2.1. General

From the presence of similar lagoonal conditions at sites CO 1 and XF-26/T-28, Wong (1976) concluded that the Paleocene coastline of Suriname ran in NW-SE direction (see also fig. 4). Toward the north these conditions were replaced by outer shelf to upper bathyal environments, reflecting the deepening of the basin in that direction. The Eocene sediments show the same trend with the exception that in the Eocene the calcareous lagoonal conditions became even more restricted than in the Paleocene.

2.2.2. Description of relevant sections

In the offshore area near the coast of Suriname the Paleocene section consists of alternating sands, clays and siltstones with intercalations of thin limestone beds and a few lignites (e.g. well L/7-2S, fig.8). The topmost part of this section is fairly calcareous and contains abundant *Ranikothalia* specimens and shell fragments. The thickness of the Paleocene section is 182 m. The Paleocene-Eocene boundary is also well defined by the palynological record. The Eocene consists of a

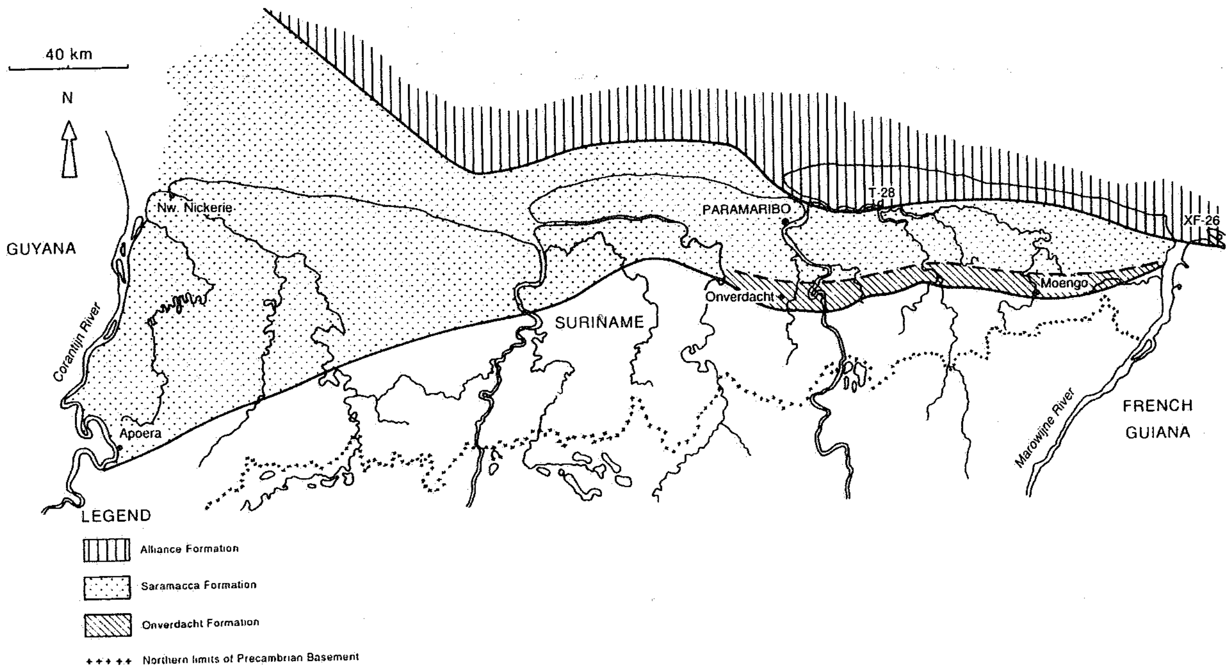

Figure 4. Subsurface distribution of the Paleocene-Eocene Onverdacht, Saramacca and Alliance Formations (after Wong, 1989).

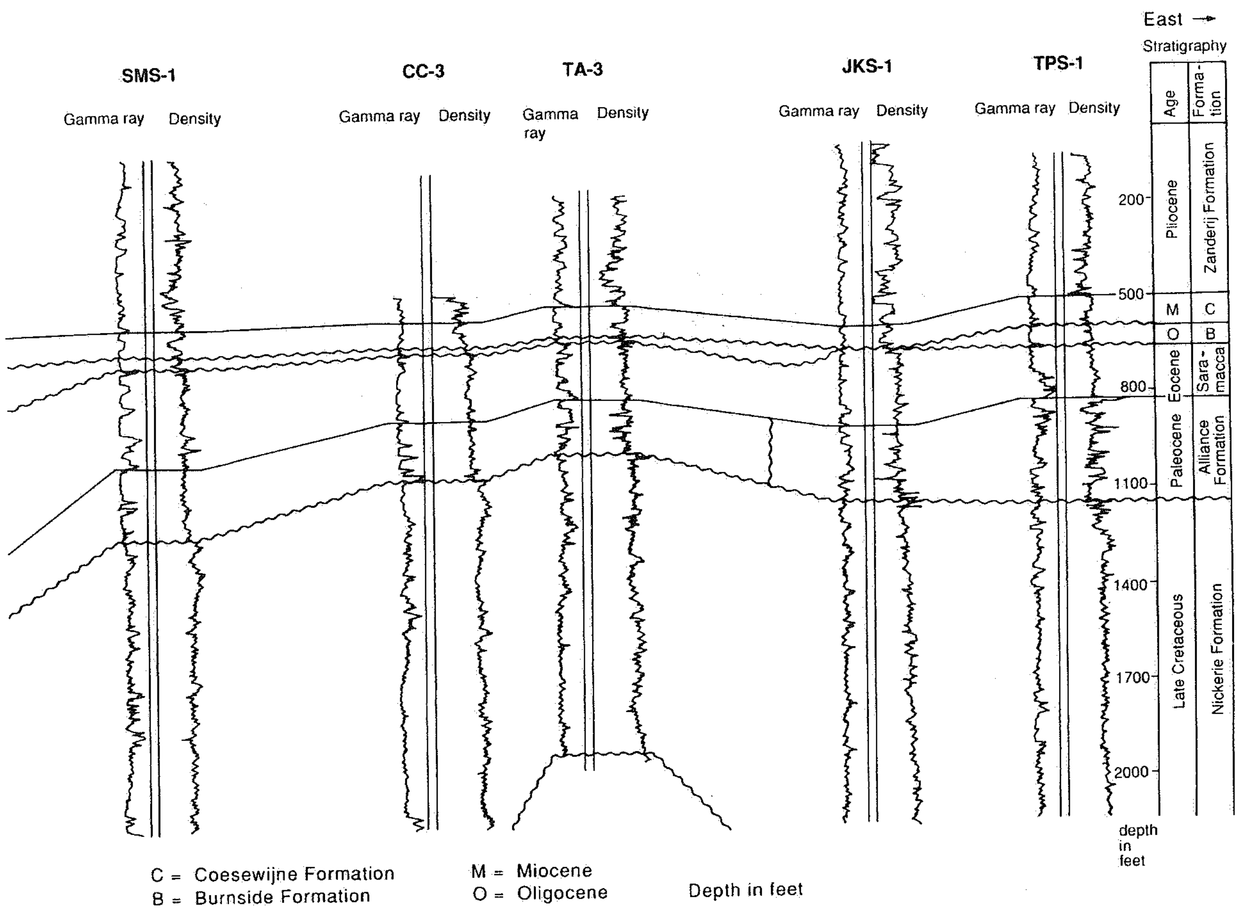

Figure 5. E-W log correlation through the coastal plain of Suriname, showing well-defined boundary between Paleocene and Eocene strata (after Wong, 1989).

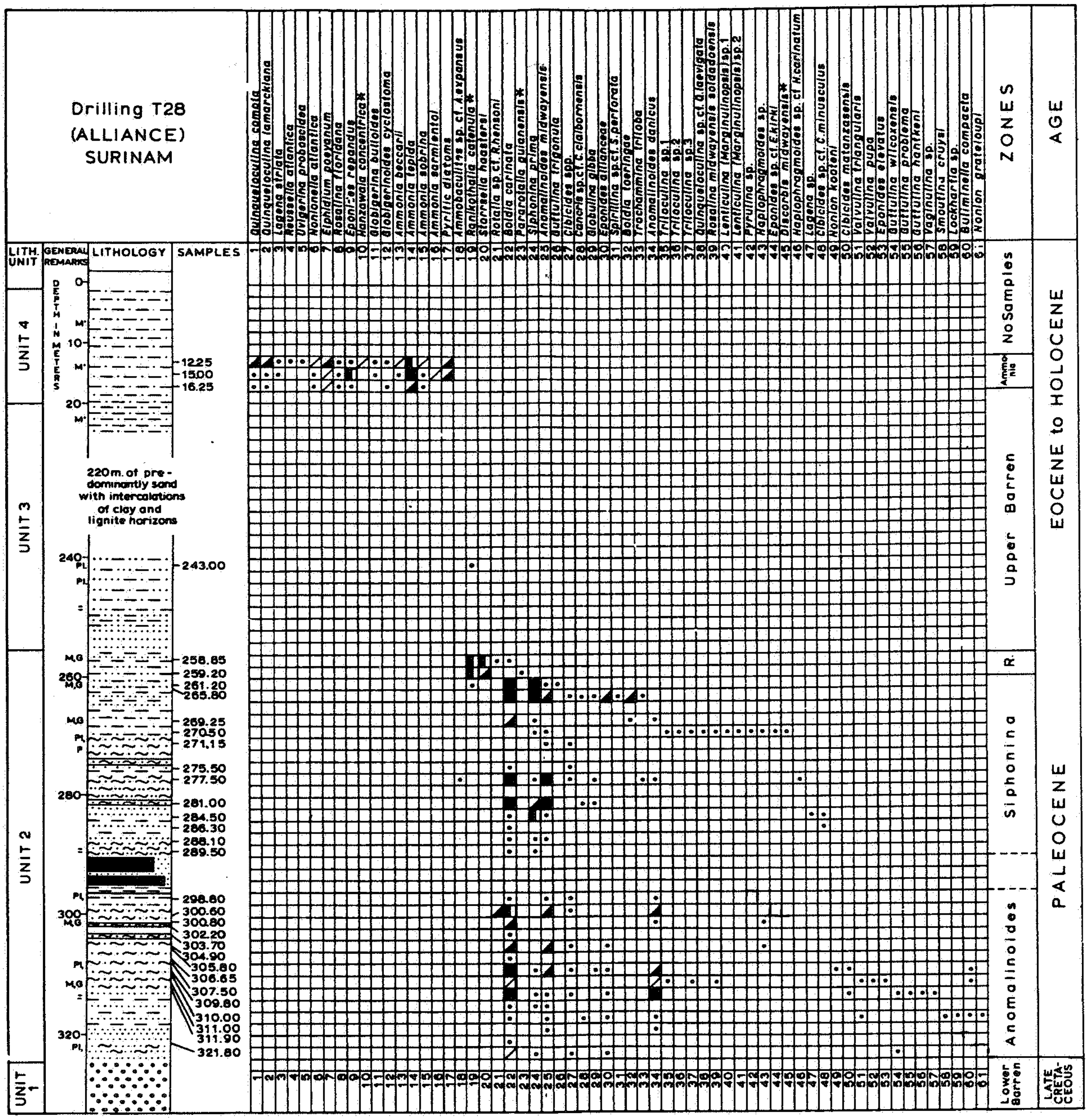

Figure 6. Paleocene-Eocene section of well T-28, Alliance, Suriname (after Wong, 1976). See fig. 10 for explanation of symbols.

regular alternation of sands, siltstones and clays. The basal part of this section is characterized by relatively thick, orange-brown, or grey to light green siltstone units. No microfauna have been recorded in the Eocene sediments from this location.

On the western continental shelf (well CO-1) the upper part of the Paleocene interval is represented by a predominantly calcareous section (fig.9). The lower part of the Paleocene section is rather arenaceous with a few coal beds at the base. The entire interval is 600 m thick. The microfauna mainly consist of *Ranikothalia* specimens but these are not found in the overlying calcareous Eocene section. Here, abundant green algae of the genus *Ovulites* are characteristic.

The Eocene-Oligocene boundary is located somewhere in the 655 m thick section, which comprises unconsolidated sands with some thin layers of marls and marly limestones.

Farther away from the present coast (wells GLO-1 and NCO-1) the Paleocene sections (about 100 m thick), consist of limestones and claystones and contain a rich, well-diversified benthonic and planktonic microfauna. The Eocene is represented by marls, claystones and limestones, which also contain rich, well-diversified benthonic and planktonic microfaunas. The planktonic zonation from the Late Paleocene into the Eocene (Zone P5 to P6) seems to be fairly continuous in well GLO-1 (Belsky *et al.*, 1972 ; Wong, 1976) so that a

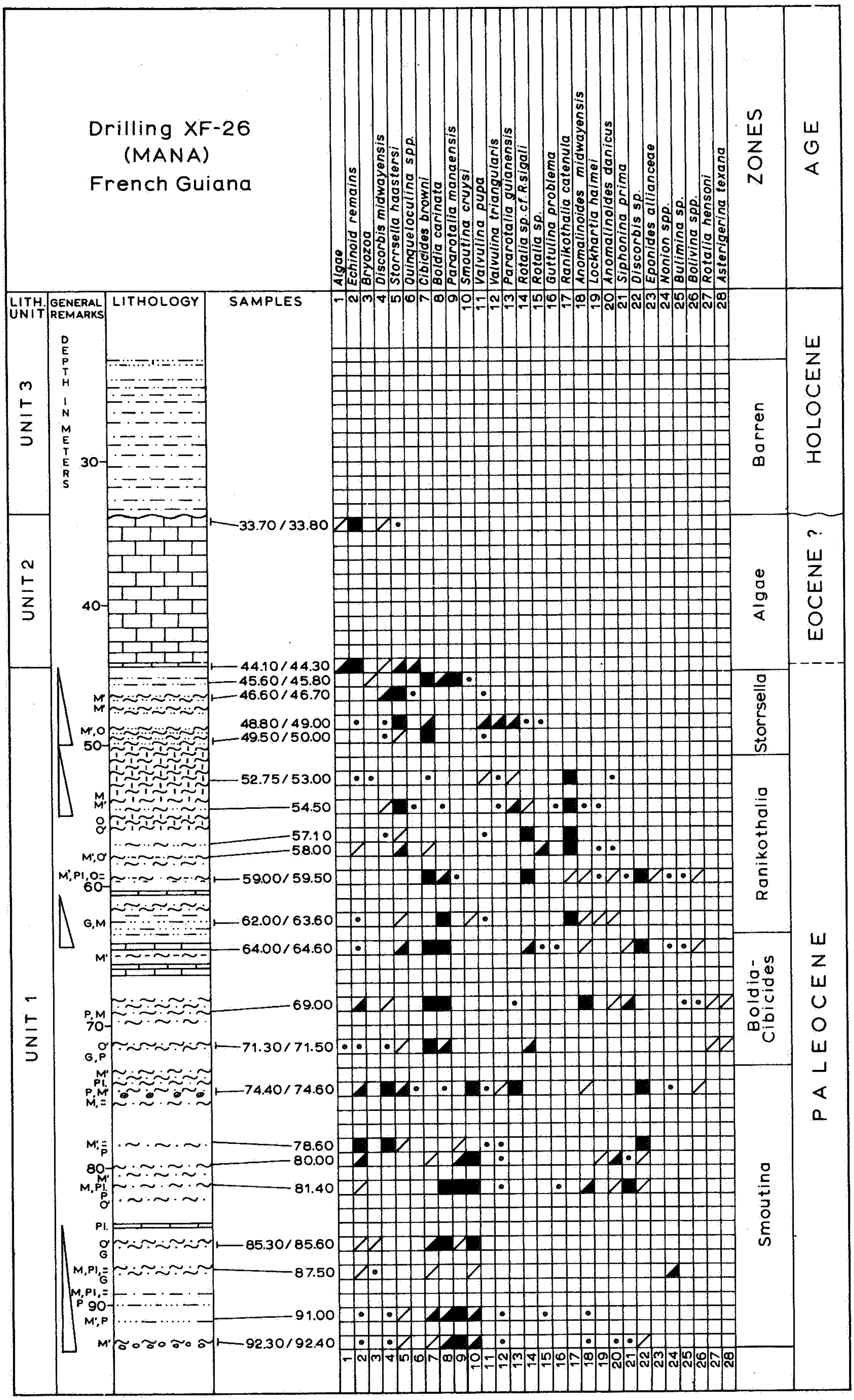

Figure 7. Paleocene-Eocene section of well XF-26, Mana, French Guiana (after Wong, 1976). See fig. 10 for explanation of symbols.

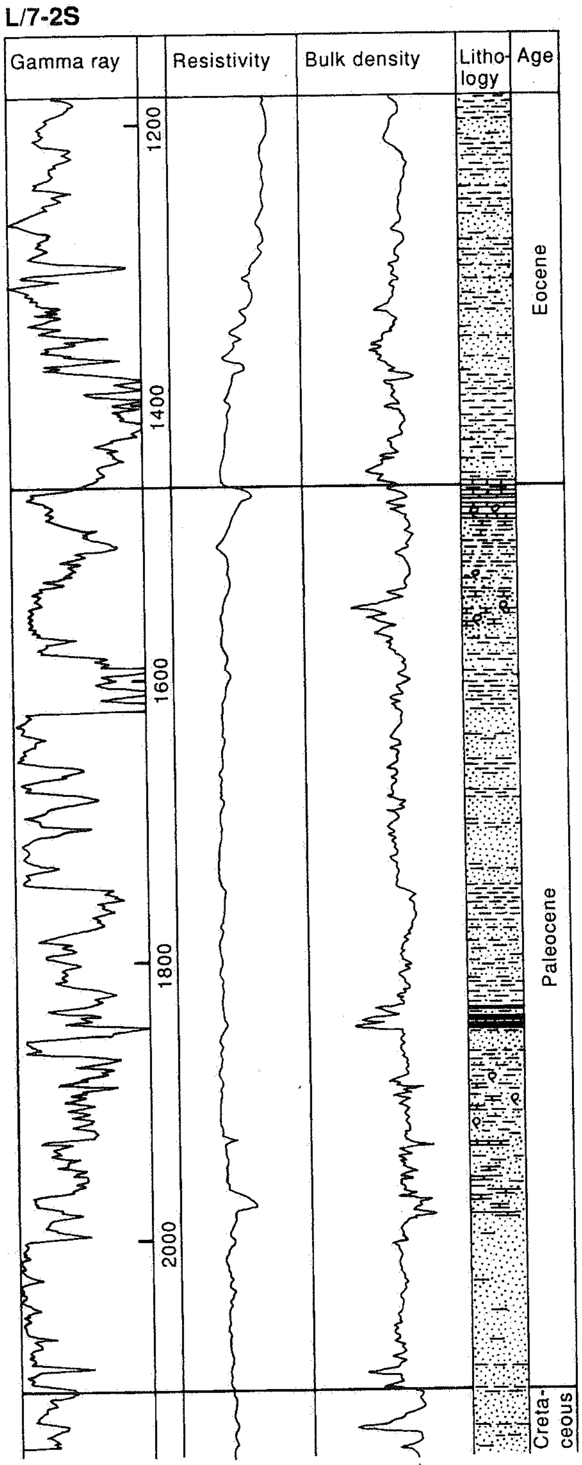

Figure 8. Paleocene-Eocene section of well L/7-2S in the near shore part of the continental shelf of Suriname (depth in metres).

major hiatus at the Paleocene-Eocene boundary is less likely here.

At DSDP sites 143 and 144, two hiatuses have been recorded in the Tertiary section. These are in the Upper Eocene and at the Cretaceous-Tertiary boundary. However, no cores have been recovered from the interval with the Paleocene-Eocene succession. The

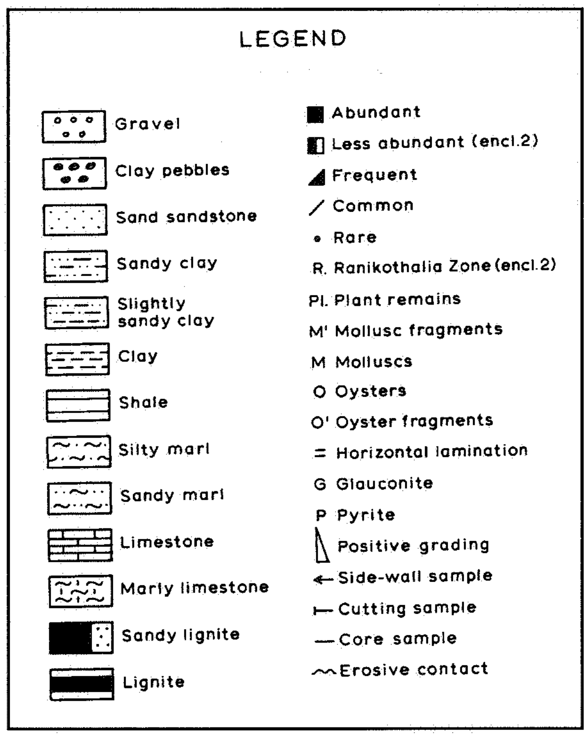

Figure 10. Explanation of symbols used in figs. 6, 7 and 9.

Late Paleocene sediments are represented by oozes and marls which were deposited under bathyal conditions. The higher recovered cores contain chalk oozes of middle Eocene age (Hayes *et al.*, 1972).

3. CONCLUSIONS

When considering how the unconformities in the coastal area originated, we should remember that due to the extremely low relief of the area even the gentlest change in the sea level would have resulted in the emergence or inundation of large areas. The Guiana Shield is a typical cratonic area which was not subjected to active deformation or transformation for a long period of time. The latest major tectonic activity that affected this shield was the large-scale rifting during the Late Jurassic-Early Cretaceous that created various grabens in northern Brazil and Guyana in conjunction with the opening of the Atlantic. During the Late Cretaceous and Tertiary only relatively small faults, probably related to reactivation of existing major faults in the Precambrian basement, affected the overlying sediments. Hence, major tectonic movements did not take place in this area and eustatic sea-level movements must have been the principal mechanism, controlling sedimentation.

The contact between the Paleocene and Eocene sediments in the coastal area and southern continental shelf is distinctly unconformable as is shown by the well-marked lithological and biostratigraphical chan-

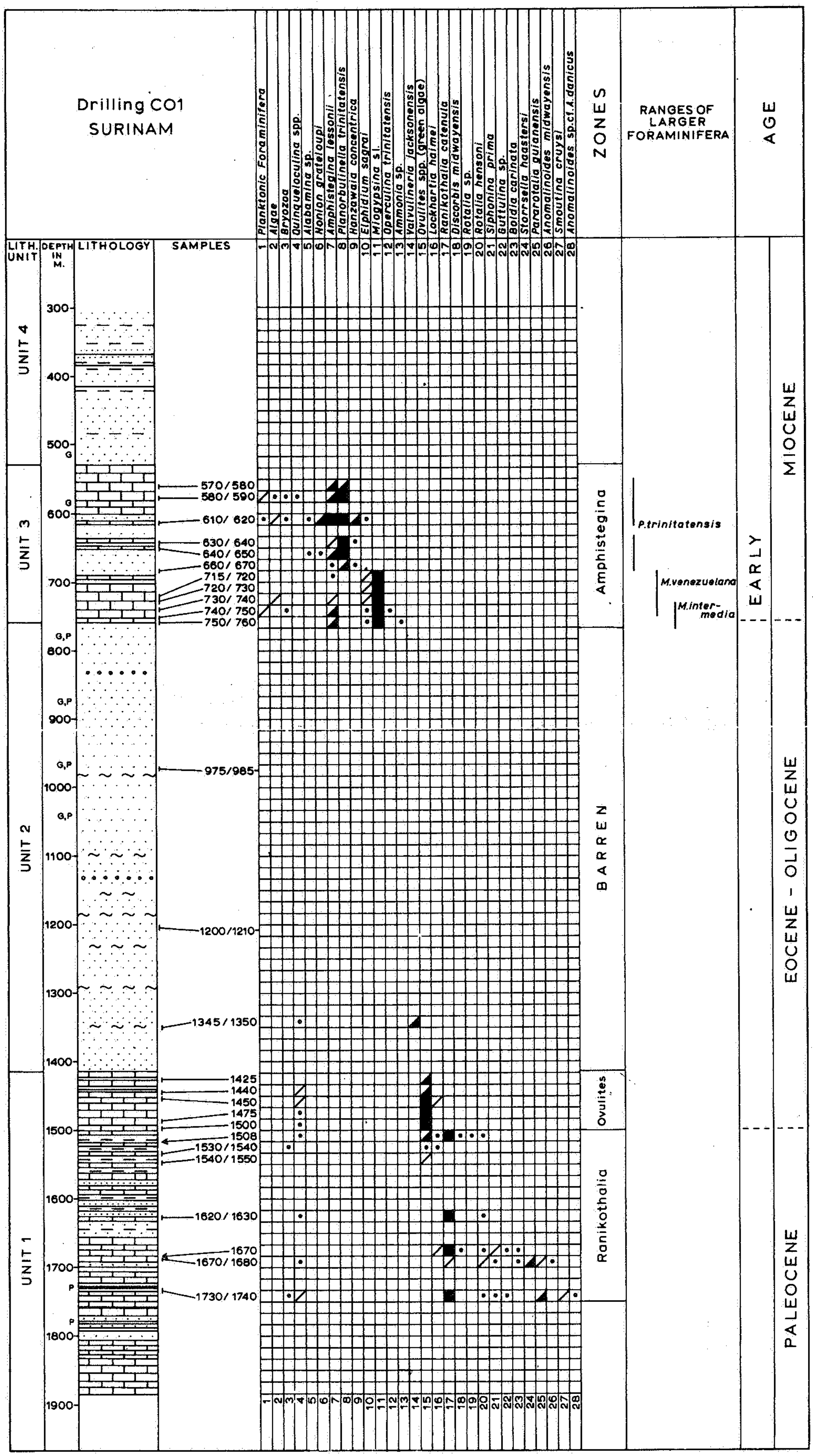

Figure 9. Paleocene-Eocene section of well CO-1 on the continental shelf of Suriname (after Wong, 1976). Lower part of Paleocene section has not been pictured (see fig. 1). See fig. 10 for explanation of symbols.

ges. In general, this unconformity is less conspicuous than those at the Cretaceous-Tertiary boundary, at the base of the Late Eocene and at the base of the Miocene. Although biostratigraphical studies dealing with this Paleocene- Eocene interval may lack detailed control, the data suggest that the magnitude of the hiatus may have varied from place to place (e.g. the Late Paleocene algal limestone in XF-26 and CO-1 is not present in T-28). It seems logical that the breaks in the relatively thin, coastal sections are more pronounced than in the deeper part of the basin (wells GLO-1 and NCO-1). The hiatus in Upper Eocene bathyal sediments at DSDP sites 143 and 144 seems to correspond with part of the bauxite hiatus in the coastal plain.

One could argue about the location of the Paleocene-Eocene boundary in the calcareous sections in the coastal area. Two options are possible : the first one is the major lithological change from calcareous to non-calcareous sediments (e.g. figs. 6-9). The second option is the biostratigraphical break emphasized by the highest occurrence of *Ranikothalia* and the introduction of green algae; moreover, there is also a lithological change caused by the reduction of clastic material in the overlying section. This reduced clastic appòrt could be due to a higher sealevel which flooded the former sources of clastic material. In this paper the second option, also favoured by Wong (1976), is followed. In sequence-stratigraphical concepts the Paleocene sediments of, for instance, unit 1 in XF-26 (fig. 7) were deposited during one major transgressive sequence (possibly cycle TA 2.1 of Haq *et al.*, 1988). In this respect, the level in the section with the richest fauna (between 55 and 75 m) may correspond to the maximum flooding surface. During the following highstand the shelf prograded toward the south and at site XF-26 a more diverse sedimentation started to prevail, leading to a decrease in water depth and further restriction of the area. Eventually, continental conditions were established and erosion occurred. During the next transgression (possibly cycle TA 2.4 of Haq *et al.*, 1988) the sediments of unit 2 were deposited on the eroded surface. Hence, the Paleocene-Eocene boundary is unconformable here and forms a sequence boundary, which can be traced over large areas in the coastal area of Suriname. It should be clear that since we lack biostratigraphical control in the coastal sections, the correlations with the above mentioned regional cycles of Haq *et al.* (1988) is highly speculative.

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