# Establishing Evidence for Paleocene-Eocene Boundary using Biostratigraphy of Larger Foraminifera on Kakinada Terrace, Krishna Godavari Basin, India*

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## Introduction

The Paleocene-Eocene boundary is one of the difficult and debated levels worldwide. The Paleocene Epoch, characterized by equable climate, exhibits increased faunal diversity and productivity in both the marine as well as terrestrial biota (Berggren et al., 1998). The Eocene Epoch was the warmest interval, with significant changes in global climate and considerably affected both marine and terrestrial faunal/floral populations and their extinctions. The Paleogene Period is characterized by gradual climatic transition between the warm, ice-free Cretaceous and the much colder Neogene (Zachos et al., 1993). Paleocene-Eocene Thermal Maxima (PETM ) (Thomas et al., 2000) is widely considered as the first major Paleogene climatic event of sudden global warming. This episode is also referred by other authors as the Late Paleocene Thermal Maxima (LPTM) (Zachos et al., 1993) and the Initial Eocene Thermal Maxima (IETM) (Thomas et al., 2006). The Paleocene/Eocene boundary is marked in the GSSP (Dababiya section, Luxor, Egypt) at the LO biochron of *A. sibaiyaensis* (≡ Chron C 24r, ca. 2 Myr) in the planktic foraminiferal scale. The P/E boundary is also considered at the onset of a pronounced negative carbon isotope excursion (CIE) (Stott et al., 1996). Planktic foraminiferal 'excursion' taxa such as *A. sibaiyaensis, A. africana* and *M. allisonensis* that appeared in response to the Initial Eocene thermal maximum (IETM) in the carbon isotope excursion (CIE) interval are reported to occur globally. These short lived planktic foraminiferal 'excursion' taxa (PFET) are proxy indicators for the CIE and may be used in identifying the Paleocene/Eocene boundary (Kelly et al., 1998).

In India, the Paleocene Epoch is characterized both by marine and non-marine sediments along with occasional volcanic rocks. Rich foraminiferal occurrences (planktic as well as larger benthic) have been noticed in the Pondicherry Formation (Cauvery Basin), Modi Formation (Krishna Godavari Basin) and foraminiferal limestone (Meghalaya) on the eastern Indian shelf during the Paleocene. Marine Paleocene and younger sequences have also been widely reported under various formation names, in several parts of the

western Indian shelf stretching from the Kerala-Konkan in the south through Mumbai offshore to the Barmar Basin in the north. Among the planktic foraminifera, besides short lived planktic foraminiferal 'excursion' taxa (PFET) such as *A. sibaiyaensis*, *A. africana* and *M. allisonensis* which have also been reported from Rajasthan, India (Kalia et al, 2008), usually *Globorotalia (Morozovella) velascoensis* Zone was widely recognized as the youngest zone in the Paleocene, also corresponding to the ostracoda zone: *Anommatocythere indica* Range Zone (Bhandari, 2008). However, in the case of larger foraminifera, an assemblage represented by *Discocyclina ramaraoi* and other associated larger foraminifers is believed to correspond to the top of the Paleocene in India and underlies the *Miscellanea miscella* Zone roughly equivalent to P5. In view of this, an attempt was made to evolve biostratigraphic criteria for defining the Paleocene-Eocene boundary by larger benthic foraminifera and index larger foraminifers for Paleocene and Eocene were restudied from selected intervals in wells KG-T (interval 1251 m-3400 m) and KG-B (interval 1060 m to 2759 m), over Kakinada terrace, Krishna Godavari (K.G.) Basin (Figure 1).

## Material and Methods

Standard methods of sample processing and examination were followed. About 126 samples from wells KG-T (1251-3725 m) and KG-B (1060-2759 m) referable to Pallakollu, Pasarlapudi and Bhimanapalli formations were studied with special reference to important larger benthic foraminifera. A number of oriented sections were prepared for the important larger foraminifers. The concept of normal order of stratigraphic superposition was followed for studied well sections to know various species of larger foraminifers, successively falling in an evolutionary sequence with their entry (FAD) and exits (LAD) being important events. The ranges of selected larger foraminifers and other fossils are shown in Figure 2 and Figure 3. Biostratigraphic subdivision of the two wells showing the position of the Paleocene-Eocene boundary against the foraminiferal zones is provided. The main objective of this study has been to evolve biostratigraphic criteria for defining the Paleocene-Eocene boundary by larger foraminifera. In view of this, index larger foraminifers for the Paleocene have been marked and compared, and possible criteria for the Paleocene-Eocene boundary by planktic microfossils are also discussed.

## Previous Studies

Some of the more important works over the Paleocene-Eocene boundary problem are summarized below:

Davies and Pinfold (1937) recorded *Nummulites nuttalli, N. thalicus, N. sindensis, N. globulus, N. sp. cf. N. mamilla, Assilina dandotica, Miscellanea stampi, M. miscella, L. haimei, Lepidocyclina (Polylepidina) punjabensis, Discocyclina ranikoti, Alveolina vredenburgi* and others from the Ranikot beds of Punjab Salt Range, Pakistan. These strata are commonly referred to the Late Paleocene.

Adams (1970, 1987) regarded *Actinosiphon punjabensis, Assilina dandotica, Discocyclina ranikotensis, Fasciolites (including F. vredenburgi), F. glomalveolina), Lockhartia spp., Miscellanea miscella, Nummulites nutalli (= Ranikothalia nuttalli), N. spp., Operculina sindensis, O. canalifera* and *Saudia labyrinthica* as the diagnostic fauna for Late Paleocene in Indian areas. Adams (1970), while reconsidering the East Indian letter classification of the Tertiary, stated that no continuous carbonate succession across the Ta1/Ta2 (=Paleocene-Eocene) boundary has been described and there exists a faunal break between the youngest Ta1 and oldest Ta2 larger foraminiferal assemblages everywhere in the southeast Asian region. In west Pakistan where strata of Ta2 age rest over Ta1 beds, e.g. Dungan Hill and Mehrab Tangi, Baluchistan and at Thal, N.W.F.P., still the faunal sequences are either undescribed or need detailing. Later, Adams (1987) described important Paleocene genera *Actinosiphon* and *Orbitosiphon* and suggested that additional data on the morphology, variation and stratigraphic levels of these taxa will be needed to establish their true relationships to the other groups. Commenting on the evolutionary history of the Tertiary orbitoidal foraminifera, he believed that the Cretaceous orbitoids became extinct at the end of Maastrichtian times and were replaced by new larger foraminiferal faunas in the Tertiary. The earliest Paleocene larger benthic foraminifers are still not fully known and in places where both Maastrichtian and Paleocene larger foraminiferal faunas occur (e.g. the Middle East and Pakistan) the Cretaceous-Tertiary boundary (KTB) is marked by pronounced facies changes. In the later part of the Middle Paleocene, a low diversity of larger foraminiferal fauna occurred, e.g. primitive Tertiary alveolinids such as *A. (Glomalveolina) primaeva* Reichel, simple nummulitids and rotaliids such as *Lockhartia.* Few orbitoidal foraminifera occur before the Late Paleocene when *Actinosiphon* and *Orbitosiphon* are found with discocyclinids in the circum-tropical region. Discussing the evolution of lepidocyclinids and related genera, Adams regarded *Actinosiphon* to be a less likely ancestor of *Lepidocyclina.* The occurrence of *Miscellanea* and/or *Ranikothalia* has never been proved to be confined to the Paleocene owing to the absence of any form of control over their extinction levels. Adams considered *Orbitosiphon* and *Actinosiphon* to be restricted only to Paleocene.

Schaub (1968), while discussing some Paleocene and Eocene stages of the Paris Basin, observed that in the Mesogean marine series there are five biozones in the stage “Illerdian” i.e. above the Thanetian and below the zone of *N. planulatus*, whereas the three biozones between the Illerdian and the inferior Lutetian at *N. laevigatus* represent the “Cuisian” stage. Probably the Sparnacian and the Ypressian s.s. are correlated to the upper zone of the Illerdian, but the exact correlation was not possible. Amard and Blondeau (1979) described the appearance of *Ranikohalia bermudezii* in the Upper Paleocene of Sahara in association with *Lockhartia sp., Miscellanea miscella* and other fossils. They traced the limit of the Paleocene-Eocene boundary not only with the appearance of true *Nummulites* but also with the disappearance of *Ranikothalia* and above all by the microfaunal assemblage of upper Paleocene.

Berggren, Kent and Flynn (1986) opined that the exact location of Paleocene-Eocene boundary has been a subject of controversy since Schimper (1874) originally defined the Paleocene. Alternative placements have spanned the extremes of basal Illerdian (= base of

*Nummulites deserti/frassi* Zone) to the base of Cuisian (= base of *Nummulites planulatus* Zone) with intermediate positions including the base and top of the Sparnacian, base of Ypressian, and top of the Landenian stages. Marine micropaleontologists have drawn the Paleocene-Eocene boundary at various levels ranging from the *Planorotaloides pseudomenardii-Morozovella velascoensis* (P4-P5) boundary to the *Morozovella formosa – M. aragoensis* (P7-P8) boundary, with intermediate positions including the P5-P6 boundary, the *Pseudohastigerina* Datum (within zone P6), base of Zone NP9, base of Zone NP10, middle of zone NP10, base of the *Apectodinium hyperacanthum* Zone, base of *W. astra* Zone, etc. Berggren et.al. considered the Paleocene to consist of two stages, the Danian and the Thanetian, and have also suggested a Paleocene time scale. They summarized the data on Paleocene-Eocene boundary and suggested the boundary to lie:

1. Between *A. hyperacanthum* (Sparnacian) – *W. astra* (Ypressian) dinocyst Zones.

2. Between calcareous nannoplankton zones NP9 (Thanetian) and NP10 (Ypressian) or within zone NP10.

3. Between zones P6a and P6b (planktic foraminifera).

4. Within the lower part of chron C 24 R corresponding biostratigraphically within the tuff series of North Sea and NW Europe, near the base of Division A2 of the London Clay Formation, and near the base of Lepar Formation (Belgium) and the Cuisian s.l. (France).

Mohan and Pandey (1971) discussed the Paleocene-Eocene boundary in Indian basins and suggested that the recommendations of the Eocene Colloquium (Paris, 1968) for delineation of Paleocene-Eocene boundary by means of planktic and larger foraminifera are not well applicable in the Indian region. They opined that in the Indian region *Nummulites* and *Assilina* first appear in the lower part of *G. pseudomenardii* Zone. Pandey and Ravindran (1988) discussed the boundaries and subdivisions of the Indian Paleocene based on foraminiferal controls and related aspects and suggested a tie-up of planktic foraminifer zones and benthic assemblages. Shukla (2008) considered the first appearance of *Nummulites, Assilina, Discocyclina, Lockhartia, Daviesina, Miscellanea* and *Alveolina* nearly at the same level in the Indian late Paleocene, in association with initiation of extensive carbonate deposition on the shelf. The top of the *Globorotalia* (*M.) velascoensis* Zone and *Discocyclina ramaraoi (seunesi)* Partial Range Zone coinciding with the P6a/P6b boundary has been regarded as a good choice for the Paleocene-Eocene boundary in the Indian region.

## Case Histories: Faunal Occurrences and Age Assignment

### KG-T Well

The foraminiferal record in well KG-T between intervals 1251-3400 m was studied for faunal controls, occurrence and diversity of index larger benthic taxa (Figure 2). The former level corresponds to Eocene and the later Cretaceous on the basis of occurrence of *Globotruncana spp*. Lithologically, the section comprises mainly the clastic sediments with minor carbonates and is represented by sandstones, siltstones, clays, claystone, minor shale and occasional limestone, however the dominance of clastic over other types of sediments is significant. An almost continuous record/succession of certain larger benthic foraminifers were observed during the Late Paleocene-Eocene coinciding with the gradually changing paleobathymetry. In order to understand faunal succession through geological time, a larger interval was taken and a few observations over the studied interval are as follows:

1. The well section below 3000 m is frequented by planktic foraminifer species referable to the Paleocene. Sporadic/inconsistent occurrence of larger benthic foraminifers is also noted. Important planktonic species in the interval 3000-3400 m include *Globorotalia velascoensis, G. pseudomenardii* and others.

2. The interval 2600-3000 m shows fairly good occurrence of larger foraminifer species but with lesser diversity. Planktic foraminifers are either absent or rare. A significant change in the preservation type, relative abundance, colour and to some extent size of the larger index species is observed below 2560-2565 m. Here the fauna is dark, some times pyritized and relatively smaller and more abundant.

3. The interval 1251-2600 m is represented by a rich and diversified larger foraminifer population and a number of Paleocene and Eocene species range through it.

4. Considering the first down hole appearance (=LAD) of index taxa, the LAD of *Assilina dandotica* was marked at 2000-2005 m. The LAD of *A. pustulosa* was at 1950-1955 m, and could not be recorded in the side wall core sample at 1978.5 m. An almost consistent record of *A. dandotica* has been made further below to 3000 m.

5. Considering the *A. dandotica* top as the Paleocene top, along with other Paleocene index foraminifers, the Paleocene-Eocene boundary in the well is suggested at 2000 m. The faunal occurrences and ranges are shown in Figure 2.

6. Other significant Paleocene larger foraminifers include *Actinosiphon sp., Lockhartia sp. aff. L haimei, Daviesina langhami, Discocyclina seunesi, Nummulites frassi, N. solitarius* and *Assilina sp. aff. A ranikoti. A. aff. Arenensis* and *A. pustulosa* although quite abundant in the Paleocene also range into Eocene.

7. Non-typical occurrence of *Ranikothalia sp.* does not help to mark the Paleocene-Eocene boundary, first because the typical *Ranikothalia* seems to be absent, and secondly the ranikothaline *Nummulites* ranges above the extinction level of definite Paleocene taxa. *Ranikothalia* itself may well range into the basal Eocene (Adams, 1987).

8. Predominant Eocene forms include *A. papillata, A. exponens, N. acutus, N. douvillei, N. anomalous, N. chavannessi, Pellatispira sp., Fasciolites (Alveolina) sp.* and species of *Discocyclina*.

**Well KG-B**

The foraminiferal record in well KG-B between intervals 1060-2759 m was examined for faunal diversity, controls and occurrences of larger foraminifera (Figure 3). The former level corresponds to the Eocene while the later to Paleocene. The interval is characterized by clastic-dominated facies with intermittent carbonates and is represented by sandstones, shale, siltstones, clays (Claystone) and limestone/dolomite. Below 2340 m shale occurs as the dominant lithological constituent. An almost consistent occurrence of important larger benthic taxa was observed in complete section, except for the SWC at 2759 m yielding only smaller benthic fauna. The following are a few observations made over the faunal occurrences:

1. Cuttings interval 1770-2505 m is characterized by fairly consistent occurrence of *A. danotica* along with other prominent Paleocene assemblages. *A. pustulosa* and *A. sp aff. A arenensis* occur only in the upper part and continue into the Eocene section.

2. Development and abundance of *A. pustulosa* seems to be better in the KG-B well as compared to well KG-T, where the *A. pustulosa* is not abundant in the Eocene section, instead a single first down hole occurrence is noticed at 1950-1955 m.

3. The Late Paleocene section in the well KG-B is represented by *A. dandotica, A. sp aff. A ranikoti, A.sp aff. A arenensis, A. pustulosa, Lockhartia sp aff. L. haimei, Actinosiphon sp., Daviesina langhami, N. frassi, N. solitarius, N. sp aff. N precursor* and *D. ramaraoi* etc.

4. Most prominent among the Eocene larger foraminifers are *A. papillata, A. exponens, Nummulites acutus, N. chavannessi, N. douville, N. stamineus, N. laevigatus, N. anomalus, Lockhartia alveolata and Pellatispira sp. Faciolites (Alveolina) sp. Fasciolites (Alveolina)* are fairly common at certain levels and are a highly complex evolutionary group during the Lower Tertiary.

5. *Miscellanea* is not a typically developed genus in these wells and only rare occurrences have been noticed in the Paleocene sections. A comparison made with the typical *Miscellanea miscella* from the western offshore well KD-1 attributes the non-typical nature of K.G. Basin species to the substratum/provenance conditions or the paleobathymetry.

**Establishing Foraminiferal Biostratigraphic Evidence for the Late Paleocene**

Lower Paleogene over the Kakinada terrace is generally characterized by good larger foraminiferal diversity and control. A fairly continuous evolutionary series among the faunal assemblages can be traced in these wells from Upper Cretaceous-Lower Paleocene to Upper Paleocene-Eocene levels. With the gradually changing bathymetry in well KG-T, the older Upper Cretaceous-Lower Paleocene section is dominated by planktonic and smaller benthic faunas indicative of deep water outer shelf to bathyal environments. Occurrence of index planktonic species such as *Globorotalia pusilla, G. velascoensis, G. pseudomenardii* and others at 3205-3210 m is considered equivalent to planktic datum zone P4. The overlying about 200 m section does not indicate very good larger or planktonic foraminiferal controls and is also characterized by less diversity and less abundance of the taxa. Consistent occurrence of important Paleocene and Eocene larger foraminifers in the younger sequence in well KG-T suggests shallow water, inner shelf, stable environments of deposition with gradually increasing larger foraminifer diversity. In well KG-B, however, the larger foraminifera are occurring throughout the studied interval and abundance of certain taxa is much better than in well KG-T.

Taking into account the present status of index larger foraminifera during Late Paleocene and Eocene in K.G. Basin wells, the rich assemblage comprising of *Assilina dandotica, A. ranikoti, A. leymerie, Discocyclina ramaraoi (seunesi), Actinosiphon punjabensis, Actinosiphon sp., Daviesina langhami, Nummulites solitarius, N. indicus, N. sp aff. N precursor, Lockhartia haimei, Ranikothalia sp* and *Miscellanea spp* are indicative of Late Paleocene age on the Kakinada terrace. The extinction level of *Assilina dandotica*, which is seen above the extinction levels of many associated taxa, has been considered as the Paleocene-Eocene boundary in these wells and may correspond to the short lived planktic foraminiferal 'excursion' taxa (PFET) zone comprising *A. sibaiyaensis, A. africana* and *M. allisonensis* in areas of planktic foraminiferal dominance. It has also been observed that among the Paleocene genera *Actinosiphon* and *Orbitosiphon*, the former is well developed in these wells, whereas the later could not be recorded. *Ranikothalia*, although suspected of not being confined only to the Paleocene, is non-typical in studied material and should be regarded as a good Late Paleocene marker species. *Nummulites* as such are rather well developed in the Late Paleocene-Eocene sediments and a number of species such as *N. frassi, N. solitarius, N. praecursor* provide supporting evidence to the Late Paleocene level. The abundance of *N. exilis* (group)

forms is evident in the basal part of the Early Eocene rather than in the Late Paleocene. Genus *Alveolina (Fascoilites)* is non-typical and less abundant in K.G. Basin wells, however several species of *Alveolina* such as *A ellipsoidalis* and *A pasticillata* etc. are excellent markers for the Late Paleocene over the Indian shelf. On the contrary, the Eocene larger foraminifers are very highly diversified and represented by several genera and species such as *Nummulites acutus, N. discorbinus, A. papillata, A. exponens, Nummulites atacicus, N. chavannessi, N. douville, N. stamineus, N. laevigatus, N. anomalus, Lockhartia alveolata and Pellatispira sp. Alveolina (Faciolites) elliptica, Discocyclina spp* and many more. Shukla et al. (2009) had clearly pointed out that Shallow Benthic Zones (SBZ 6 and 7) falling in the Paleocene-Eocene boundary time span and equivalent to basal Illerdian stage (Europe), equivalent to zone P-6a, and also referable to the Khasian stage (India) are the uppermost Paleocene bio-chronozones for Tethyan sedimentary basins in the Indian subcontinent and adjacent areas. This level roughly corresponds to 54.2 Ma on the absolute geological age and lies at the top of the P-E boundary transition spanning about 1.3 Ma.

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## References

Adams, C.G., 1970, A reconsideration of the East Indian letter classification of the Tertiary: British Museum Nat. Hist. (Geology), v. 19/3, p.87-137.

Adams, C.G., 1987, On the classification of the *Lepidocyclinidae* (Foraminiferida) with re-descriptions of unrelated Paleocene genera *Actinosiphon* and *Orbitosiphon*: Micropalaeontolgy, v. 33/4, p.289-317.

Amard, B., and A. Blondeau, 1979, Le Paleocene superior a *Ranikothalia bermudezi* et l'Eocene inferieur (Illerdian basal) a *Nummulites frassi* et. *N. deserti* du Tademait-E et. Tinrhert-W: Geobios, no. 12/5, p.635-651.

Berggren, W.A., D.V. Kent, and J.J. Flynn, 1986, Paleocene geochronology and chronostratigraphy, The Chronology of the Geological Record: N.J. Snelling (ed.), The Geological Society Memoir No. 10, p.141-186.

Berggren, W.A., and M.P. Aubry, 1998, The Paleocene-Eocene Epoch Series boundary: Chronostratigraphic framework and estimated chronology, *in* M.P. Aubry, S. Lucas, and W.A. Berggren, (eds.), Late Paleocene-Early Eocene Climatic and Biotic Events in the Marine and Terrestrial records: Columbia University Press, New York, p. 18-36.

Bhandari, A., 2008, Ostracode biostratigraphy and carbon and oxygen isotopic studies across the Paleocene-Eocene boundary in the subsurface of Jaisalmer Basin, Rajasthan, India: Senckenbergiana lethaea, v. 88/1, p. 67-76.

Davies, L.M., and E.S. Pinfold, 1937, The Eocene beds of the Punjab Salt Range, India: Geol. Survey of India Memoirs, Palaeontologica Indica, Calcutta, India, n.s., v. 24, p. 25.

Kalia, P., 2008, Foraminiferal Biostratigraphy in the Paleocene-Eocene boundary Section in Subsurface of Jaisalmer Basin, Rajasthan: IPE, Unpublished report, Collab. Res. project.

Kelly, D.C., T.J. Bralower, and J.C. Zachos, 1998, Evolutionary consequences of the latest Paleocene thermal maximum for the tropical planktonic foraminifera: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 141, p. 139-161.

Mohan, M., and J. Pandey, 1971, Foraminiferal control in the Tertiary Basins of India: Jour. Palaoent. Soc. India, v. XVI, p. 78-88.

Pandey, J., and C.N. Ravindran, 1986, Foraminiferal controls in the Indian Paleocene. Symposium on Paleocene of India - its limits and subdivisions: IAP, BSIP, Lucknow, India.

Schaub, H., 1968, A propos de quelques etages du Paleocene et de L'Eocene du Bassin de Paris Et leur correlation avec les etages de la Tethys: Mem. Rech. Geol. Min., v. 58, (Colloq. Sur. L, Eocene, Paris), Table 1, p. 643-654.

Shukla, S., 2008, Atlas of Taxonomic and Bio-Chronostratigraphic Studies on Palaeogene larger benthic foraminifera from Indian Sedimentary Basins, Paleontographica Indica (Number 9): K.D. Malaviya Institute of Petroleum Exploration, Oil & Natural Gas Corporation, Dehradun, India, p. 1-148.

Stott, L.D., A. Sinha, M. Thiry, M.P. Aubry, and W.A. Berggren, 1996, Global δ13C changes across the Paleocene-Eocene boundary, Criteria for marine-terrestrial correlations, *in* R.W.O'B. Knox, R. M. Corfield, and R.E. Dunay (eds.), Correlation of the early Paleogene in Northwest Europe: Geological Society Special Publication 101, p. 381-399.

Thomas, E., 2000, Where are we in understanding the PETM/IETM?: Climate and Biota of the Early Paleogene: volume of abstracts, p. 135.

Thomas, E., R. Ulla, M. Simonetta, W. Thomas, B. Barbara, and M. Guia, 2006, An early Eocene hyperthermal event at ~52.5 MA: Climate and Biota of the Early Paleogene, volume of abstracts, p. 136.

Zachos, J.C., K.C. Lohmann, J.G.C. Walker, and S.W. Wise, 1993, Abrupt climate change and transient climates during the Paleogene: A marine perspective: The Journal of Geology, v. 101, p. 191-213.

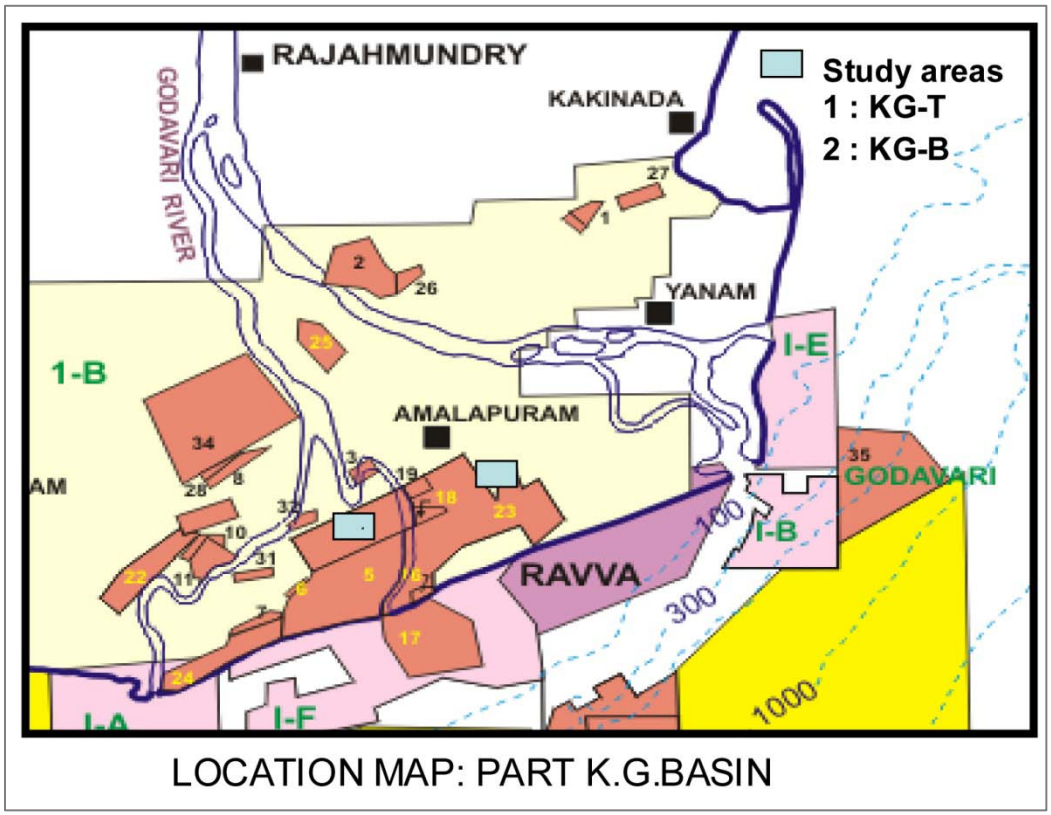


Figure 1. Location map of part of Krishna Godavari Basin.

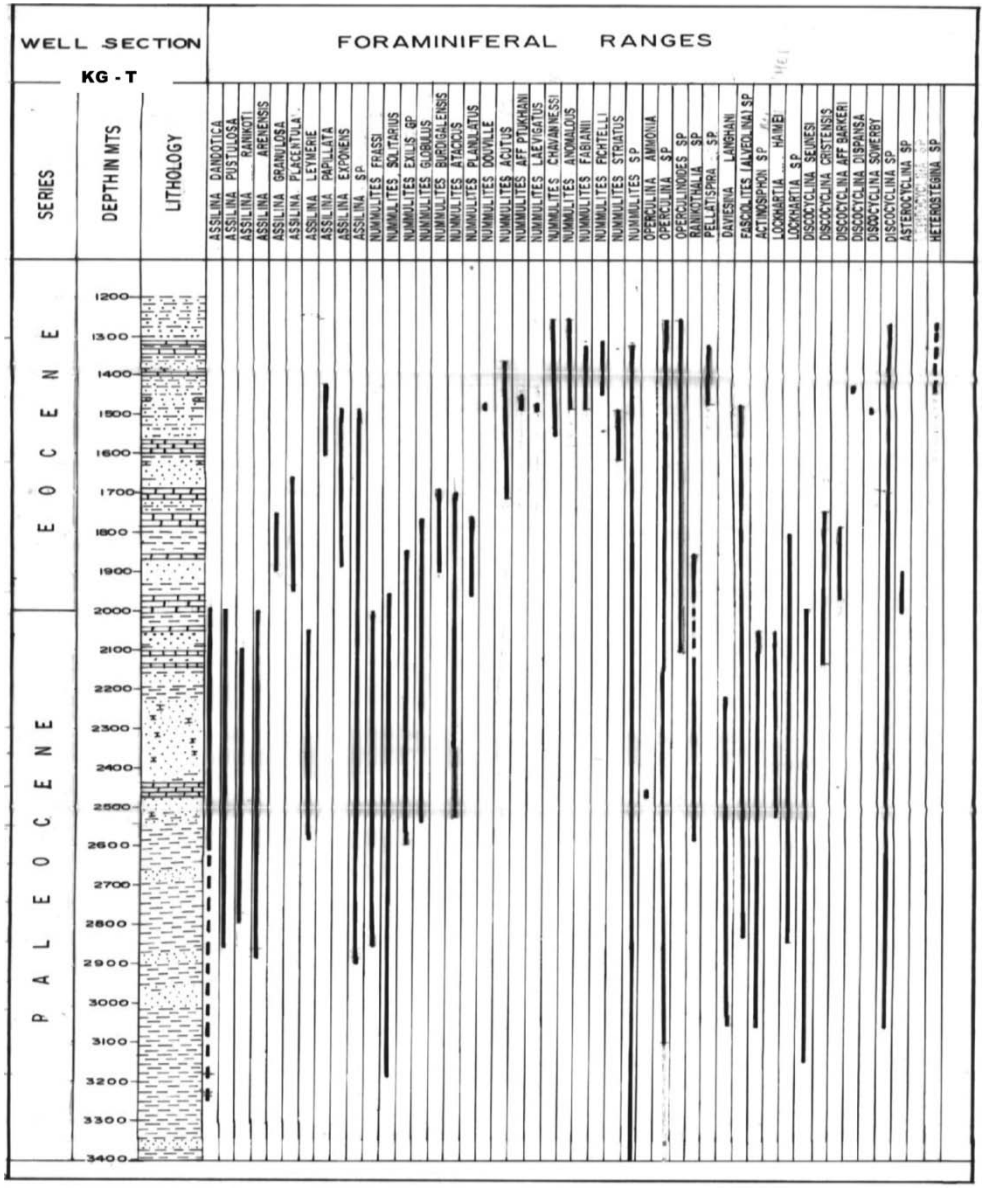


Figure 2. Ranges of Late Paleocene-Eocene key larger foraminifera in well KG-T, Krishna Godavari Basin, India.

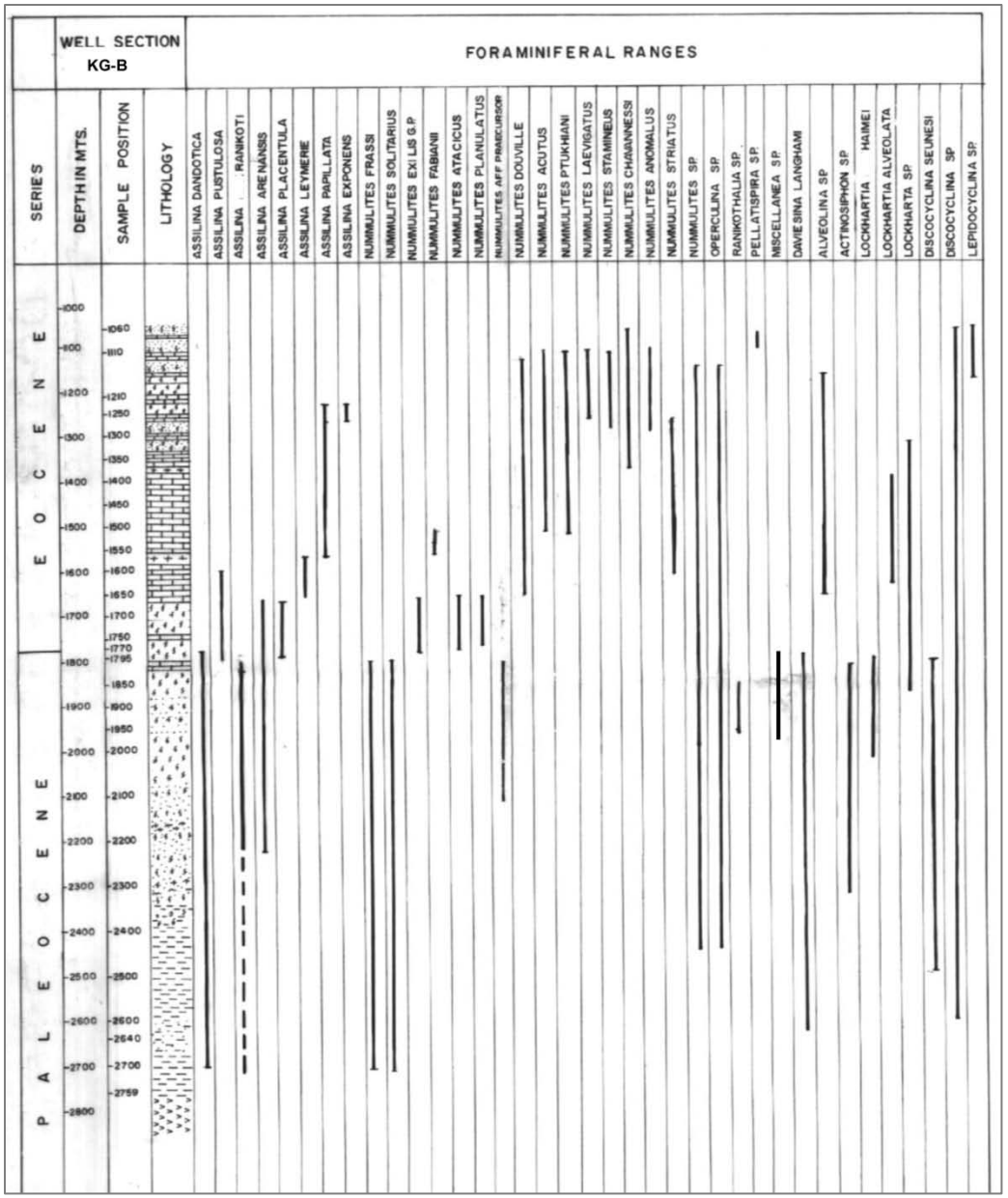


Figure 3. Ranges of Late Paleocene-Eocene key larger foraminifera in well KG-B, Krishna Godavari Basin, India.