



BENTHIC FORAMINIFERA PROXY TO ESTABLISH AGE AND PALEOENVIRONMENT IN THE MID-CRETACEOUS OF KG OFFSHORE

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ABSTRACT

Smaller benthic foraminifera including deep water arenaceous forms and age-significant planktonic forms are recorded from an offshore well A-A in the Krishna-Godavari Basin. These forms are in sediments ranging in age from Aptian to early Cenomanian and are significant to infer the paleoenvironmental conditions of the sediments. In the absence of planktonic forms to fix the top of Albian, the first downhole occurrence of benthic form *Epistomina spinulifera* at 450m is used to mark the top of Albian. This *Epistomina* 'datum' may be of local significance in marking Albian in the absence of planktonic foraminifera at this level in this area. Faunal evidence suggests deep shelf marine conditions prevailed during Aptian-Albian while gradual shallowing to inner-middle shelf is inferred during the earliest Cenomanian.

Keywords: Foraminifera, Aptian-Albian, Paleoenvironment, offshore K-G Basin, India

INTRODUCTION

Krishna-Godavari Basin is a passive margin pericratonic basin formed as a result of fragmentation/rifting of eastern Gondwana land (Powell *et al.*, 1988). The basin consists of about 5 km thick, shallow to deep marine sediments ranging in age from Upper Mesozoic (latest Jurassic-Early Cretaceous) to Holocene. Recent discoveries of commercial oil and gas from this basin have necessitated for detailed geoscientific studies with special reference to biostratigraphy. The well A-A was drilled on Kavali High tectonic block, west of the Pennar Depression with the objective of exploring the lower Cretaceous sequence in KG offshore (Fig.1). The ditch samples collected from the well A-A were studied for foraminifera. The well cuttings yielded fair to moderate occurrence of benthic and planktonic foraminifera. A total of nine species belonging to five genera of planktonic foraminifera, besides 18 genera of benthic foraminifera, were recorded in the sediments ranging in age from Aptian to earliest Cenomanian. The lithology of the studied interval mainly consists of claystone alternated by sandstone with minor limestone and siltstone.

Amongst the benthic foraminifera recorded from the well A-A, the genus *Epistomina* is found to occur commonly. Epistominids are a widely used benthic group of foraminifera for dating shelf sediments of Jurassic and Cretaceous ages in western Europe and North America (Bartenstein, 1977; Bartenstein and Bolli, 1977; Ascoli, 1983; Williamson, 1987; Jenkins and Murray, 1989). In the present work, we use the first downhole occurrence of *Epistomina spinulifera* to demarcate Albian, in the absence of planktonic foraminifera restricted to Albian.

MATERIAL AND METHODS

Standard processing techniques were followed for recovery of foraminifera. A total of 46 samples approx. 20gm each at a sample spread of 20 to 40m interval were processed and studied. Bolli *et al.*, 1985; Loeblich and Tappan, 1988; Jenkins

and Murray, 1989 and other relevant publications were referred for this report. The geological timescale is after Gradstein *et al.* (2004).

PREVIOUS WORK

Extensive foraminiferal studies have been carried out both on the exposed sections and in the subsurface sediments of Krishna-Godavari Basin. Foraminifera from the outcropping and subsurface inter and infra-trappean sediments have been reported by Sastri (1953, 1961), Bhalla (1966), Govindan, (1981a) and others. Foraminiferal studies from the Raghavapuram Shale of this basin include Bhalla, (1965, 1969), Sastri *et al.*, (1961), Bakshi (1966) and others.

FORAMINIFERAL BIOSTRATIGRAPHY

Interval 305-430m

This section is poorly fossiliferous and yielded only very rare benthic foraminifera such as *Lenticulina* sp. along with ostracoda and echinoid spines. In the absence of zonal marker species in this section, a definite age could not be assigned. Based on the stratigraphic position, Cenomanian or younger age is suggested. Sediments are probably deposited in shallow marine environment.

Interval 430-450m

This sequence is also poorly fossiliferous. Rare occurrence of planktonic foraminifera *Rotalipora gandolfi* is recorded in the sample 430-35m along with benthic foraminifera represented by *Lenticulina* spp. The recorded stratigraphic range of *Rotalipora gandolfi* is latest Albian to earliest Cenomanian (Bolli *et al.*, 1985). Further downhole the record of this species at 525m is more likely due to caving as this form is absent in the overlying samples. Early Cenomanian age is assigned for this interval. Some benthic foraminifera such as *Lenticulina* sp. is recorded at this level. The sediments are inferred to be deposited probably in shallow shelf environment.

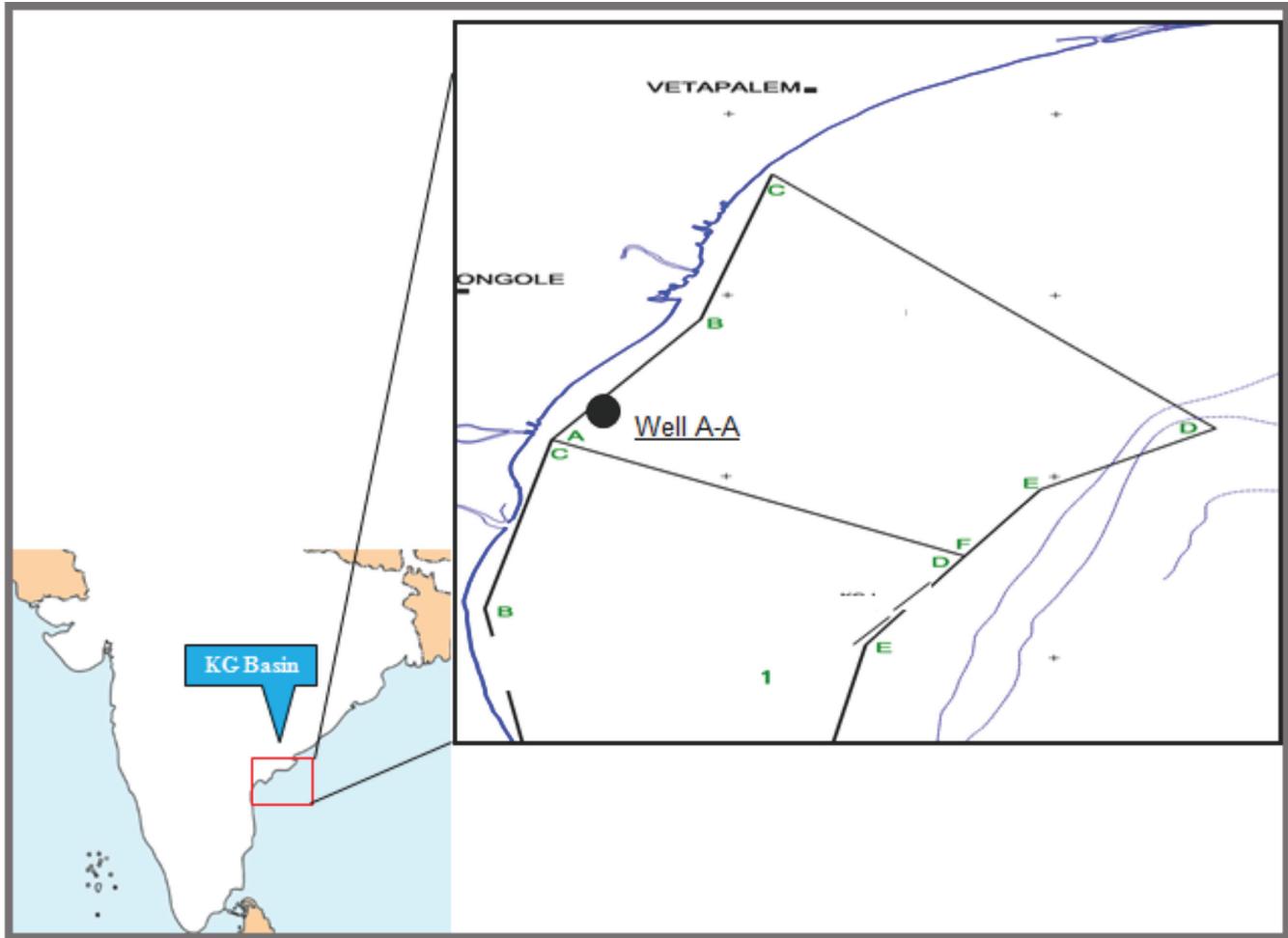


Fig. 1. Location map of the studied well, A-A

Interval 450-750m

This section yielded good to moderate occurrence of planktonic and benthic foraminifera. Diagnostic forms recorded include *Hedbergella planispira*, *H. delrioensis*, *H. trocoidea*, *Rotalipora gandolfi* (probably caved), *Praeglobotruncana delrioensis*, *Whiteinella baltica*, *Epistomina spinulifera*, *Ammodiscus cretacea*, *Bathysiphon* sp., *Cibicides* sp., *Nonion* sp., *Lagena* sp., *Epistomina* sp. and *Lenticulina* sp. Based on foraminiferal record Albian age is inferred to this interval. The sediments in this section seem to be deposited in deep shelf marine conditions.

Interval 750-1055m

Diagnostic fauna recorded in this section include *Hedbergella planispira*, *H. delrioensis*, *H. sigali*, *H. gorbachikae*, *Globigerinelloides* sp., *Ammodiscus cretacea*, *Ammobaculites* sp., *Gavelinella* sp., *Gyroidinoides* sp.,

Glomospira sp., *Haplophragmoides* sp., *Nodosaria* sp., *Nonion* sp., and *Lenticulina* sp. Based on the presence of *Hedbergella sigali*, this section is suggested to be of Aptian age. Presence of open marine deep benthic foraminifera such as *Gyroidinoides* sp., *Gavelinella* sp., *nodosariids* etc. the sediments were deposited under deep shelf marine conditions.

Interval 1055-1200m

This section is poorly fossiliferous and only sporadic occurrence of *Gavelinella* sp., *Haplophragmoides* sp. and *Lenticulina* sp. are recorded. In the absence of any age-diagnostic foraminifera, possible age could not be assigned. The sediments are probably deposited in open marine conditions.

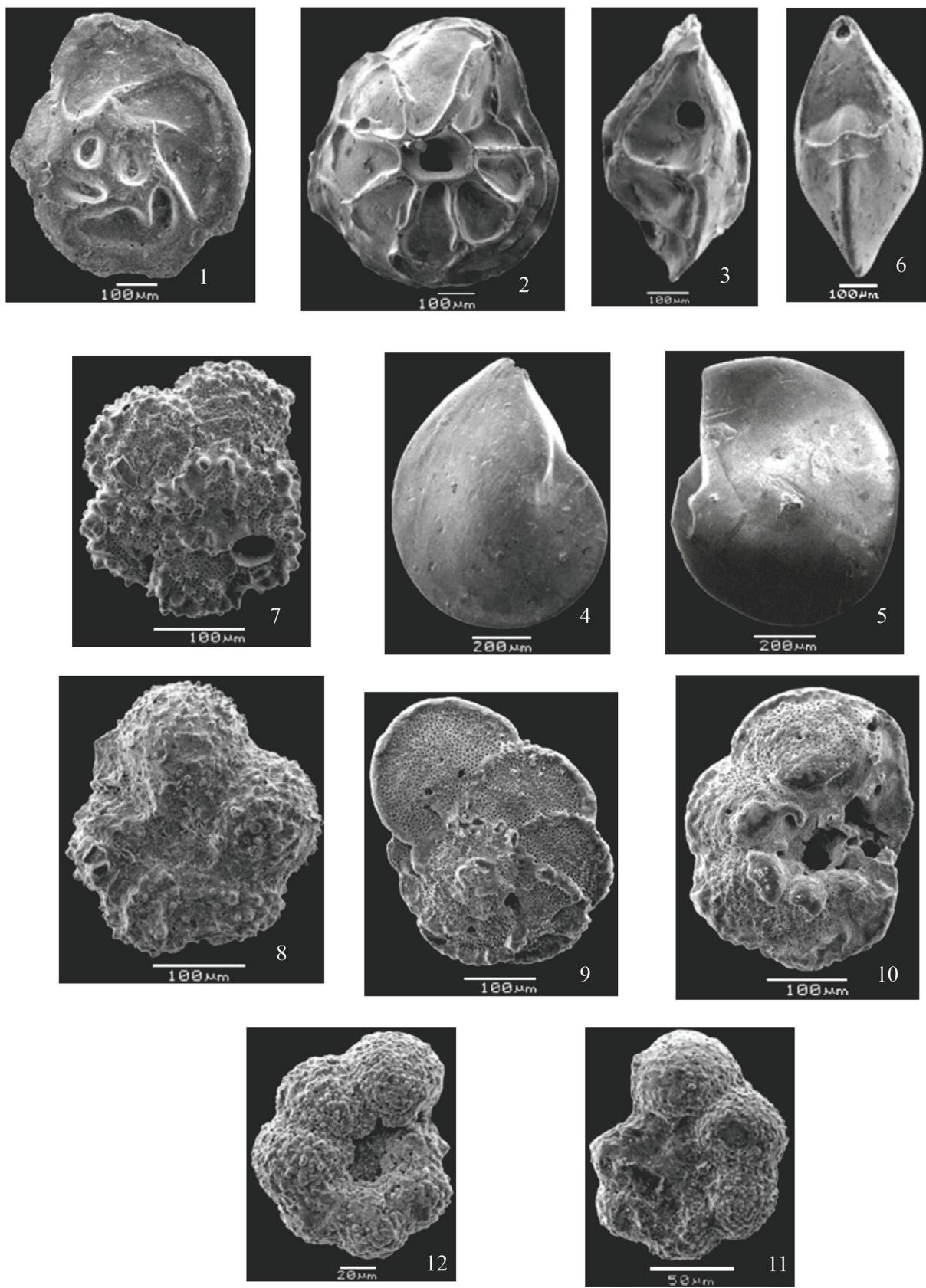
Interval 1200-2155m

This section is devoid of foraminifera.

The distribution of foraminifera depth wise is shown in fig. 2.

EXPLANATION OF PLATE I

1. *Epistomina spinulifera* (Reuss); spiral view (x100); 2. *Epistomina spinulifera* (Reuss); umbilical view (x100); 3. *Epistomina spinulifera* (Reuss); apertural view (x200); 4. *Lenticulina* sp.1; spiral view (x85); 5. *Lenticulina* sp.2; spiral view (x80); 6. *Lenticulina* sp.2; apertural view (x120); 7. *Praeglobotruncana delrioensis* (Plummer); spiral view (x250); 8. *Praeglobotruncana delrioensis* (Plummer); umbilical view (x230); 9. *Rotalipora gandolfi* Luterbacher & Premoli-Silva; spiral view (x200); 10. *Rotalipora gandolfi* Luterbacher and Premoli-Silva; umbilical view (x100); 11. *Hedbergella planispira* Tappan; spiral view (x500); 12. *Hedbergella planispira* Tappan; umbilical view (x550)



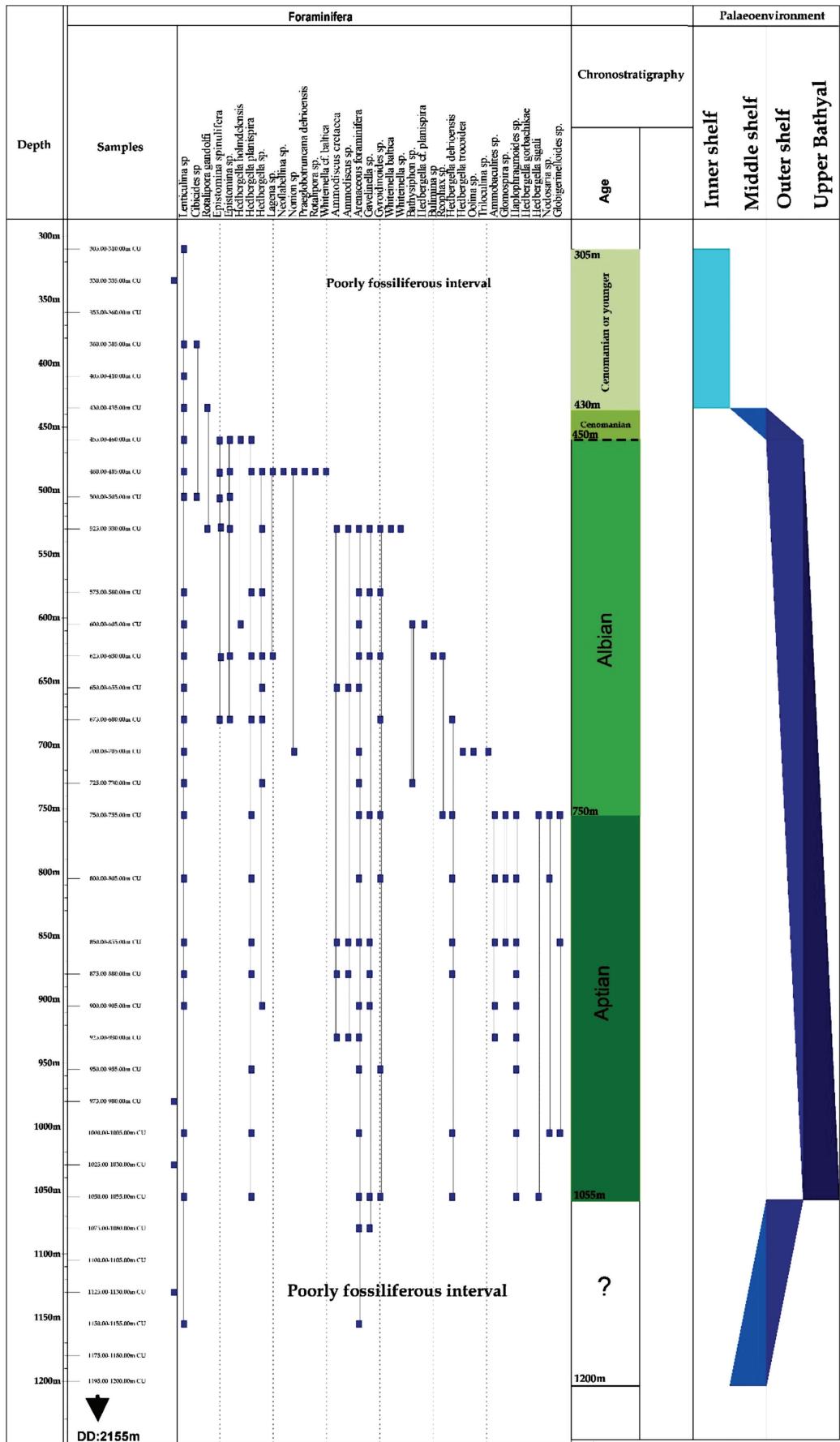


Fig. 2. Distribution of foraminifera in well A-A, KG Basin.

DISCUSSION

Albian to Cenomanian sediments in K-G Basin are represented by the Raghavapuram Formation (Venkatarengan, *et al.*, 1993), which is characterised by shale, clays and minor sandstone. The formation unconformably overlies Golapalli Sandstone / Kanukollu Sandstone and is overlain conformably by Tirupati Sandstone.

In the present study, 24 foraminiferal genera consisting of 11 calcareous benthic genera, 8 arenaceous genera and 5 planktonic foraminifera genera are reported. These are recorded in sediments ranging in age from Aptian to Cenomanian. Foraminiferal assemblages consist age significant forms such as *Rotalipora gandolfi*, *Hedbergella sigali*, *H. planispira*, *H. delrioensis*, *H. trocoidea*, *H. holmdelensis*, *Praeglobotruncana delrioensis*, *Whiteinella baltica*, *Epistomina spinulifera*, and paleoenvironmentally significant forms such as *Ammobaculites* sp., *Ammodiscus cretacea*, *Bathysiphon* sp., *Cibicides* sp., *Nonion* sp., *Lagena* sp., *Epistomina* sp., *Lenticulina* sp., *Gavellinella* sp. and nodosariids.

In this well, Albian is marked on the basis of first downhole occurrence of *E. spinulifera*. This *Epistomina* 'datum' may be of significance in the nearby wells in this area in absence of Albian-restricted planktonic foraminifera. Although *E. spinulifera* is restricted to Albian, it is not evident if latest Albian is present in this well or not. According to Hart (in Govindan, 2000), the species *E. spinulifera* first appears at the base of middle Albian, which corroborates well with our marking of Albian at the FDO of the taxon. As a part of Albian is a hiatus of varying duration at many places in K-G Basin (Aswal *et al.*, 2011 and Shandilya and Kumar, 2013), hence, this needs further biostratigraphic investigation in view of creating smaller benthic foraminiferal proxies for the Albian-Cenomanian transition.

Cenomanian top is tentatively marked at 430m on the basis of *Rotalipora gandolfi*, a form that has its total stratigraphic range from late Albian to early Cenomanian. However, continuous occurrence of this form is not recorded in the well and the record of this species at 525m after its absence in three overlying samples is more likely due to well bore caving rather than a true stratigraphic record. Therefore, instead of relying on the whole stratigraphic range i.e. late Albian to early Cenomanian, the occurrence of this species in this well seems to be existing in the Cenomanian only.

Paleoenvironmentally significant forms recorded include *Ammobaculites* sp., *Ammodiscus cretacea*, *Bathysiphon* sp., *Gavellinella* sp. and nodosariids. Occurrence of significant deep water arenaceous forms indicates an outer shelf to probably upper bathyal (?) paleoenvironment prevailed during Aptian-Albian time in this area. A general shallowing is observed in the uppermost section as evidenced by the poor record of foraminifera.

CONCLUSION

In the present well, the Albian-Cenomanian boundary is marked at 450m based on the appearance of *Epistomina spinulifera* in the absence of age significant planktonic foraminifera at this level. The genus *Epistomina* has a total stratigraphic range from late Jurassic to early Cretaceous. Cenomanian is marked on the basis of planktonic foraminifera *Rotalipora gandolfi*, a form having a restricted range in Cenomanian.

Paleoenvironmentally significant benthic forms are recorded in the well that includes *Ammobaculites* sp., *Ammodiscus cretacea*, *Ammodiscus* sp., *Bathysiphon* sp., *Gavellinella* sp. and nodosariids. Based on these forms it is inferred that deep marine shelf conditions prevailed during Aptian-Albian time in this part while gradual shallowing is inferred during the later part of Albian onwards.

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REFERENCES

- Ascoli, P.** 1983. *Epistomina* biostratigraphy across the Jurassic-Cretaceous boundary in the north western Atlantic Shelf. Proceedings Second International Symposium on Benthic Forams (Pau, 1983), 27-34.
- Aswal, H. S., Singh, K. and Mehrotra, N. C.** 2011. High Resolution Sequence Biochronostigraphic Analysis of Late Jurassic-Cretaceous, Raghavapuram-Golapalli-Tirupati-Razole Petroleum System, Onland Krishna-Godavari basin, India. Search and Discovery Article #50407, extended abstract, GEO-India, New Delhi, 2011.
- Bakshi, S. K.** 1966. On the foraminifera from Raghavapuram mudstone, West Godavari District, Andhra Pradesh, India. *Geological, Mineralogical and Meteorological Society of India, Bulletin*, **37**: 1-19.
- Bartenstein, H. and Bolli, M.** 1977. The foraminifera in the Lower Cretaceous of Trinidad, W.I. pt. 4 Cuche Formation, Upper Parat; *Leupoldina protuberens* zone. *Eclogae Geologicae Helvetiae*, **70** (2): 543-573.
- Bhalla, S. N.** 1965. New species of foraminifera from the Raghavapuram Shales (Lower Cretaceous) Andhra Pradesh, India. *Bulletin of Geological Society of India*, **2**: 39-43.
- Bhalla, S. N.** 1966. Foraminifera from the Infra Trappean beds of the Pangadi area, India. *Journal of Palaeontology*, **40**(2): 243-353.
- Bhalla, S. N.** 1969. Foraminifera from the type Raghavapuram shales, East Coast Gondwanas, India. *Micropaleontology*, **15**(1): 61-84.
- Bolli, H. M., Saunders, J. B. and Perch-Nielsen, K.** 1985. *Plankton Stratigraphy*. Cambridge University Press, Cambridge.
- Govindan, A.** 1981a. Foraminifera from the infra- and intertrappean subsurface sediments of Narsapur Well-1 and age of Deccan Trap flows. In: Khosla and Kachara (Eds.), *Proc. 9th Indian Colloquium of Micropaleontology and Stratigraphy*, 81-93.
- Govindan, A.** 2000. Cretaceous Stage Boundaries: Review of Current Definitions and Relevance to Sections in India. Memoir, *Geological Society of India*, **46**: 39-64.
- Govindan, A. and Sastri, V. V.** 1983. Upper Cretaceous arenaceous foraminifera from the Godavari-Krishna, Andhra Pradesh, India. In: Proceedings First Workshop on arenaceous foraminifera. (Ed) J.G. Verdinis *et al.*, 33-56.
- Gradstein, Felix, Ogg, James, Smith, Alan**, 2004. *A Geologic Time Scale*. Cambridge University Press, Cambridge.
- Jenkins, D. G. and Murray, J. W.** 1989. *Stratigraphical Atlas of Fossil Foraminifera*. Ellis Horwood Limited, Chichester.
- Loeblich, Alfred R., Tappan, Helen Jr.** 1988. *Foraminiferal genera and their classification*. Van Nostrand Reinhold- New York.

- Powell, C. McA., Roots, S. R. and Vevers, J. J.** 1988. Pre-breakup continental extension in East Gondwanaland and the early opening of the eastern Indian Ocean. *Tectonophysics*, **155**: 261-283.
- Raju, D. S. N., Ravindran, C. N., Mishra, P. K. and Singh, Jagmohan,** 1991. Cretaceous and Cenozoic Foraminiferal Zonal framework for east coast sedimentary basins of India. *Geoscience Journal*, **12**(2): 155-175.
- Prabhakar, K. N. and Zutshi, P. L.** 1993. Evolution of southern part of Indian East Coast sedimentary basins. *Journal of Geological Society of India*, **41**(7): 215-250.
- Sastri, V. V.** 1953. A note on the foraminifera and Ostracoda from the Inter-trappean beds near Rajahmundry. *Records of Geological Survey of India*, **92**: 293-310.
- Sastri, V. V.** 1961. Foraminifera and ostracoda from Inter-trappean beds near Rajahmundry. *Indian Minerals*, **15**: 197-198.
- Sastri, V. V., Chandra, A. and Pant, S. C.** 1961. Foraminifera from Raghavapuram Shales near Tirupati, Andhra Pradesh. *Indian Minerals*, **15**: 81.
- Shandilya, Ashutosh and Kumar, Tarun** 2013. Basement Exploration in KG Basin- the Untouched Frontier. *10th Biennial International Conference and Exposition*, Kochi, 2013.
- Williamson, M. A.** 1987. A quantitative Foraminiferal Biozonation of the late Jurassic and Early Cretaceous of the East Newfoundland Basin. *Micropaleontology*, **33**(1): 37-65.

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