

Paleo Water-Depth Determination: Case Studies From Cretaceous-Cenozoic Subsurface Strata of East-Coast Basins of India with a Proposal for a Water-Depth Zones

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Realization of the importance of fossils in reconstructions of paleoenvironment dates back to 6th-5th century B.C. to the times of Pythagoras. But major breakthroughs during the past 120 years in recognition of criteria and determination of paleoenvironment /paleobathymetry were closely linked to progress in hydrocarbon exploration. Research in this direction was in increments. sponsored by oil companies. Research and application of foraminifera in determination of paleoenvironment shifted from marginal marine to shelf to deep/ultra deep waters. In india, some progress was made by universities and National Institute of Oceanography in establishing foraminifera criteria for reconstruction of paleo upper, middle to lower estuary, upper, lower lagoon, littoral, innershelf. Micropaleontologists of ONGC realized the usefulness of Uvigerinids by 1970's following leads published by O. L. Bandy (1960-1964)

Preliminary studies on Uvigerinids of Bay of Bengal were carried out by paleontologists of ONGC and GSI in early 1990's Raju and others have proposed in 1996 ten depth zones for water depths ranging from 20 to 1200m. Later studies on a basin –scale as in case of Krishna-Godaveri and other basins made it clear that the order of successive events of morphotypes of Uvigerinids from innerself to bathyal/abyssal settings during late Paleogene and Neogene are comparable to modern distribution in Bay of Bengal. Only question can be whether Uvigerinids morphotypes had different water depth distribution during geologic history. One limitation is that Uvigerinids and other deep- water forams are rare in some stratigraphic intervals particularly is debris flows deposits. This can be overcome by scanning through larger quantities of processed sediments. A major advantage is that Uvigerinids are preserved in sediments deposited under anoxic conditions. Agglutinated forams play a major role in determination of paleo water-depth of Cretaceous deposits of onshore-offshore-east-coast rifted basins. Sediments deposited below foraminiferal lysocline (FL around 2500m bathymetry) are known in offshore KG basin.

Observations by AN Reddy of ONGC and Rajiv Nigam of NIO and present author in Indian ocean, Arabian Sea and Bay of Bengal suggest that FL and CCD does not exist even up to a depth of 4000m in present day setting. During mid-Cretaceous FL seems to be at shallower depths in KG Basin.

Available data from Bay of Bengal and basin-scale subsurface information permits recognition of criteria for determination of paleoenvironments and paleobathymetry. Voluminous data are available from marginal marine (estuaries, lagoons) setting of India. A review article was published in APG special publication in 2005.

For shelf, slope and abyssal depths the following depth zones will be useful.

1. 0-20m: Foraminiferal criteria for high energy/ low energy zones are well documented.
2. 20-45m.: The upper depth limit (UDL) is set by *Uvigerina proboscidea vadescens*. But it can be transported upward to lagoons.
3. 45- 70/80m The UDL is set at small coastate *Uvigerina*
4. 70/80m-120m.: UDL is set by *U. schenki* and *U.porrcta*. Genera *Orbulina/Praeorbulina* are usually below 70m.
5. 115/120m-190m UDL is set by *U. flinti* and a other morphotypes of *Uvigerina*

6. 190-350m: UDL is set by small hispid – coarctate *Uvigerina*
7. 350-525/550m: UDL is set by stont coarctate *Uvigerina*, eg. *U. schwageri*.
8. 525/550m-850/900m: UDL is set by *U. proboscedia proboscedia*
9. 850/900m-1200/1350m : UDL is set by *U. hispida /U. rugosa*
10. 10. 1200/1350-1900m. UDL may be set by large *U. proboscedia*

Deeper than 1900m.

11. Below FL

Further research is required to establish depth limits of different morphotypes of *Uvigerina*.

Determination of paleo water depths is important in resolving several geological problems like.

i) mixed marginal/shallow marine/shelf foraminifera/playnofossils with deep marine markers which helps in understanding the recycling of sediments from source

ii) Recognition of slumps/ slides from marginal marine/ shelf or slope to deep marine environments.

iii) To some extent the sedimentary process/mode of transportation by observing the state of preservation of foraminifers.

iv) In both dating of sediments and determination of paleowater depth. Species concepts of paleontologists in classification/ taxonomy/nomenclature plays a major role.

Best procedure suggested is: identification/illustration and documentation of different morphotypes of each species /genus. With accelerated exploration in deep/ultra deep water, basic research towards establishing water depth ranges of different marphotypes /species in modern Bay of Bengal/Indian ocean is the need of the day. To fix lower depth limits of morphotypes, core samples(upper 1 cm or so) are required.

Thus study and application of Microfossils in deep water Paleo-environmental reconstruction is of immense help in guiding the exploration programmes and its success.

What the audience will learn and or problems addressed

With exploration extending from paleo marginal marine to deep/ultradeep water settings, it becomes important to understand the paleoenvironments of source, reservoir and seal rocks and paleogeographic settings.

We have carried out some research on modern and Cenozoic *Uvigerinides* to recognize criteria for determination of paleowater-depth zones.

Studies on subsurface strata encountered in basins extending from west coast, east coast, Andaman, NE region (including outcrop sections) convinced the present author that *Uvigerinides* play a major role in determination and recognition of narrow paleowater depth zones essential for exploration. Further research is needed to document precise depth ranges of different morphotypes of *Uvigerinides* and associated benthos.

For the interval of Cretaceous criteria for determination of paleowater-depths based on agglutinated forams and applicable to rift basins of India is the need of the day.

What is new about the information or application presented

The paleowater-depths zones after further refinement will have immediate application in understanding the tectonic evolution of basin and eventually in hydrocarbon exploration.