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A Neogene calcareous nannofossil biozonation scheme for the deep offshore Niger Delta

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ABSTRACT

A detailed calcareous nannofossil analysis was carried out on the deep-water offshore Niger Delta strata penetrated by eight wells in order to erect a basin-wide Neogene biozonation scheme for the region. Four of the wells penetrated Miocene to Early Pliocene strata while the others drilled through Miocene sediments. The recorded rich and diversified nannofossil suites enabled the subdivision of the Neogene sequences into 13 zones [NN1 (CN1a) – Early Miocene to NN13 (CN10c) – Early Pliocene] and 15 subzones. Five (NN1, NN2, NN4, NN5 and NN11) zones are divided into subzones based on First and Last occurrences plus relative abundance of marker species. Dearth of nannofossils in the Middle Miocene NN5–NN8 zones precludes a refined zonation construction for the interval. Several new criteria are suggested for delineating new and previously erected zones. The resulting refined scheme offers an improved stratigraphic framework for correlation of thin reservoir units within and across Niger Delta fields.

1. Introduction

Refined biostratigraphic zonation schemes are crucial to making key contributions to oil exploration tools e.g., sequence stratigraphy (Simmons and Williams, 1992; Armentrout, 1996; and Emery and Myers, 1996). A refined local high-resolution scheme is also vital to meet the rising need for precise correlation of reservoirs within a field/basin and for biosteering in drilling horizontal wells. Consequently, the development of local schemes has taken a central stage in many basins around the world in the recent past. Such high-resolution schemes, of highly localized (field-wide) value (Simmons and Lowe, 1996; Shipp and Marshall, 1995), which eschew classical zonal indices, employ local acme events and slight changes in assemblage characteristics. Besides, some studies show that the stratigraphic ranges of several marker nannofossil taxa in the North Sea area are different from those in the classical zonation schemes of Martini (1971), Okada and Bukry (1980) and Varol (1998). This is probably true for other areas, e.g., the Niger Delta basin. Possible reasons for the disparity include biogeographic variation, local adverse environmental conditions, and poor preservation. Thus, a need arises in many areas for the redefinition of zones. Such redefinition has often been a response to anomalous response occurrences of marker species reflecting the biogeography (Burnett, 1998).

Many zonation schemes have been proposed for different ages and areas depending on the oil industry need. Erection of new local schemes plus refinements of old schemes cuts across ages and basins globally. An example is Bown and Cooper (1998) Jurassic scheme summarized from various calcareous nannofossil studies carried out in NW Europe. Also, Bown et al. (1998) presented the boreal zonation, which represents the refinement of previous zonations particularly those of Jakubowski (1987) and Crux (1989). Others include Burnett (1998) refined scheme for the Upper Cretaceous and those of Perch-Nielsen (1979), Heck and Prins (1987), Varol (1989a) and Gallagher (1990) for the North Sea Paleocene.

Problems linked with Martini (1971) and Okada and Bukry (1980) 'global' Neogene zonation schemes include zones with random duration (0.1–4 Ma) and the use of poor events to the exclusion of some good ones (Young, 1998). This is why the schemes have been modified by various authors: Varol (1989b), Raffi et al. (1995), Kaenel de and Villa (1996) for the North Sea and Theodoridis (1984), Fornaciari and Rio (1996) and Fornaciari et al. (1996) for the Mediterranean area. The stratigraphic ranges of many nannofossil species are truncated toward the higher

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latitudes as many taxa could not inhabit the high latitudes (Wei and Wise, 1992). Similarly, those of some cool-/cold-water forms that could not thrive in warm waters became shorter towards lower latitudes. This species latitudinal diachroneity is most distinctive of the Neogene, when the thermal gradients across the latitudes soared due to long-term Caenozoic global cooling (Young, 1998).

The challenges associated with the use of classical global schemes, the construction of refined schemes in other parts of the world, and the advancement in deepwater exploration in the Niger Delta frontier areas, necessitate the development of high resolution biozonation schemes there (Fig. 1).

This need informed the high resolution nannofossil studies in the deepwater Niger Delta presented in this paper. The work resolves zonal ambiguities due to index forms' stratigraphic ranges and inconsistent occurrences. This should greatly enhance the usage of biostratigraphy in exploration activities in this oil rich region and the entire Gulf of Guinea Coast.

2. Materials and methods

Ditch-cutting samples from eight randomly located offshore deepwater Niger Delta wells (Fig. 1) code-named DPW1–8 for proprietary reasons were studied. Smear slides prepared for each sample with Norland Optical Adhesive mounting medium were examined with an Olympus trinocular polarizing photomicroscope (CX31P) at 1000X and 1500X magnifications under cross-polarized and transmitted light. The forms logged in eight horizontal sweeps (traverses) in each slide were identified (to species level where possible) with relevant literature. The suites' relative abundance and diversity and other relevant information, e.g., taxa appearance under light microscope, preservation state, and dissolution degree, were recorded on an analysis (logging) sheet for each sample.

3. Results

A total of 93 coccolith and nannolith species were identified in the study. The Helicosphaeraceae, Sphenolithaceae, Discoasteraceae, and Prinsiaceae families dominate the nannofossil suites. Other key families are Ceratolithaceae, Coccolithaceae and Triquetrorhabdulaceae. *Coccolithus pelagicus* (Wallich, 1877) is abundant in the Early to Middle Miocene strata of most of the wells. The monospecific genus – *Minylitha* is consistently present in almost all the wells analysed and thus used as a zonal marker. The Pontosphaeraceae family of little stratigraphic significance is well represented and few species of the Braarudospheracea, Lithostromationacea, Rhabdosphaeracea, Syracosphaeracea and Thoracosphaeracea occur rarely.

Some Martini (1971) and Okada and Bukry (1980) schemes' zones were easily delineated but several of their sub-zonal markers are absent or show distributional patterns of no value for Niger Delta zonation. Besides, several of their zonal markers are poorly represented or absent. We incorporated the schemes' events and datums recognized in our study into our local zonation scheme (of zones and subzones) constructed for the Niger Delta deep offshore region.

Figs. 2–9 show the stratigraphic distribution of the key nannofossils we recorded. Fig. 10 shows the stratigraphic ranges of the consistent index taxa employed in erecting our zones. The right side of each well's chart shows a comparison of the delineated Martini (1971) zones with our proposed scheme's zones and subzones.

Plates 1–5 shows the microphotographs of the index nannofossils species employed in the zonation scheme erected in this work.

4. Discussion

Nannofossil occurrence in the DPW1–DPW8 wells' strata shows that these fossils are highly abundant in the Niger Delta deepwater milleu, which is a confirmation of the group's high abundance and diversity in low latitude (tropical) environments. The Martini (1971) and Okada and Bukry (1980) schemes' zones we came across in this study are Early Miocene NN1 (CN1a) to Early Pliocene NN13 (CN10c). Four wells – DPW2, DPW4, DPW5 and DPW6 penetrated Miocene–Pliocene strata while the four other wells only drilled through the Miocene (Fig. 11).

The study shows that despite the abundant Niger Delta deepwater nannofossil occurrences, Martini (1971) and Okada and Bukry (1980) schemes and zonal markers are, for various reasons, inadequate for its required refined biozonation. Several taxa used the schemes' zonal subdivisions are absent or show inconsistent occurrences while some other forms found in the study to have very consistent occurrences do not feature in these earlier schemes.

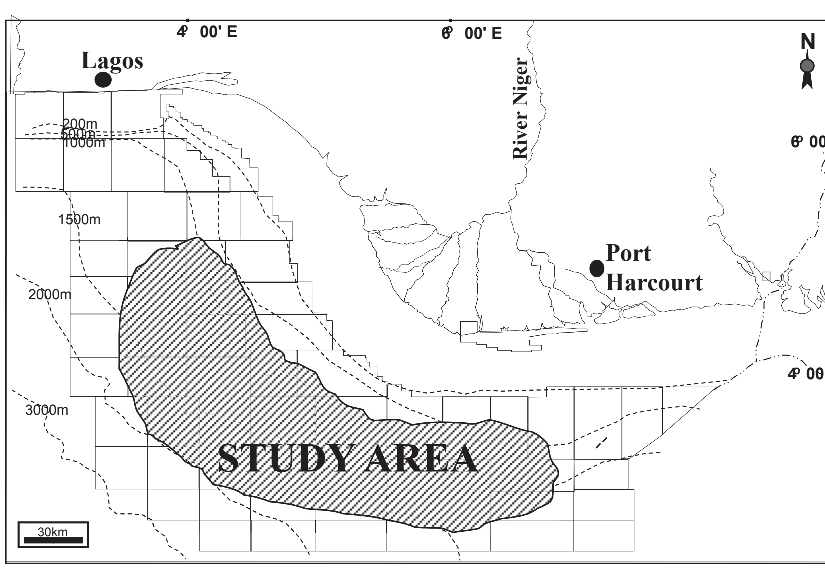

Fig. 1. Niger Delta Map showing the approximate location of the study area.