THE STUDY OF FORAMINIFERAL DISTRIBUTION TRENDS IN THE COASTAL ENVIRONMENTS OF SOUTHWEST NIGERIA SECTOR OF THE GULF OF GUINEA

BY

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DEDICATION

This thesis is dedicated to the Almighty God.

CERTIFICATION

This is to certify that this thesis for the award of Ph.D in Applied Geology (option in Sedimentary and Petroleum Geology) was written by Phillips Olusegun Adebayo (SCP10/11/H/0561) under my supervision.

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ABSTRACT

This study established the distribution trends of foraminiferal assemblages in relation to the parameters influencing the trends in the coastal environments of some parts of southwest Nigeria sector of the Gulf of Guinea. This was with a view to characterizing the surface sediments in the various environments using benthic foraminiferal population.

Two hundred surface-sediment samples were collected from Ikate beach, Tarkwa bay, Lagos harbour, Lagos lagoon, Badagry creek, Yewa river and Badagry beaches in southwest, Nigeria. Bottom water was collected for pH and salinity measurements; and water depths measured where necessary. Sediment samples were used for granulometric, chemical and foraminiferal analyses. Granulometric analysis involved the calculation of grain size percentages and generation of probability cumulative frequency curves from which various textural parameters were calculated. Aqua regia digestion of <75 µm sediment fractions was done for 0.5 g of relevant samples and Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES) was used to measure concentration of trace metals. Also, 30 g was taken from each sample and washed over 63 µm sieve for foraminiferal analyses. The foraminifera were picked, stored in cellules, identified, counted, described and assigned to families, genera and species. The data generated were subjected to various multivariate analyses using the Paleontological Statistics (PAST) software package (including two similarity indices, the "Q" and "R" modes) and abundance variation of the foraminifera.

The identified assemblages in decreasing order of abundance were *Textularia sagittula, Ammonia beccarii, Eponides cribrorepandus, Quinqueloculina padana and Hanzawaia boueana* (Ikate beach assemblage); *Hanzawaia boueana, Textularia sagittula, Florilus atlanticus, and Meloni padana* (Tarkwa bay and Lagos harbour assemblages); *Ammonia beccarii, Florilus*

atlanticus, Hanzawaia boueana, and Textularia sagittula (Lagos lagoon assemblage); *Textularia sagittula, Eponides cribrorepandus, Hanzawaia boueana, Florilus atlanticus, Quinqueloculina padana and Q. vulgaris* (Badagry beach assemblage). *Textularia sagittula,* seemed to register most abundant occurrence throughout the study area but confined to only sand dominated substrates in the microhabitats of Lagos lagoon. The Total Foraminiferal Number (TFN) was highest at Lagos harbour and lowest at Badagry beach based on favourable sediment texture identified in Lagos harbour. The harbour sediment was mainly fine sand whereas the Badagry beach was mostly coarse sand. The trace metal concentrations were below background levels at the Tarkwa bay and Lagos harbour but constituted moderate pollution in Lagos lagoon, Badagry creek and Yewa river. Water depth and pH seemed to have significance on few stations in Lagos harbour and lagoon. Salinity also played prominent role but was masked by the nature of the substrates at the northwestern end of Lagos lagoon where mono-specific assemblage was encountered. The non-saline to extremely low salinity condition imposed as a result of the overwhelming fluvial activities might account for the non-recovery of foraminifera in sediments of Badagry creek and Yewa river. Also, low pH made these environments uninhabitable for foraminifera as tests of calcareous hyaline and porcellaneous were easily decalcified at pH <7.5.

The study concluded that the processes that defined the substrates strongly correlated with the species abundance and variation, and hence determined the pattern of distribution of foraminifera.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

The principal characteristic of coastal environments is that they occur at the transition between continental and marine realms i.e. estuaries, lagoons, marshes, swamps, and are subject to high fresh water input (see Debenay *et al.*, 2000). These environments undergo strong stresses resulting from the drastic changes during each tide cycle. They include full strength penetration of sea water during flood-tide which can be almost entirely replaced by fresh water during ebb tide; immersion of the intertidal area. Consequently, there will be changes in temperature, salinity, pH, and oxygen content of the interstitial waters.

Owing to a poor knowledge of the impact of natural variables, the use of bio-indicators merits many more studies. This need is particularly critical in estuaries and coastal lagoons that are on one hand, subject to tidal and seasonal changes in natural variables and, on the other hand, heavily exposed to a number of chemicals, including industrial pollutants, sewage and agricultural pesticides. These environments have great economic potential, particularly as tourist areas and for fisheries. The choice of bio-indicators depends on the ecosystem (Wilson *et al.*, 1995; Shear, 1996; Yazvenlco and Rapport, 1996). In coastal settings, large numbers of foraminifers can be collected in small sample volumes. Moreover, the abundance of the living forms and tests of the dead specimens which are often preserved in sediments usually allow comparison between anthropogenic and pristine conditions. Also, several forms are widespread in

estuaries and lagoons, allowing comparative studies between these environments. Bio-monitoring, based on foraminifera, will deal with:

a.) species or group of species indicating pollution impact by their absence, presence, abundance or dominance; and

b.) study of individuals with morphological abnormalities due to chemical contamination (Alve, 1991; Yanko *et al*., 1994; Bresler and Yanko, 2000), which is being used to complement the earlier method (a.), because of the controversies arising from it.

The following are examples of the controversies generated:

a.) the high variability of test morphology exhibited by epiphytic species such as *Rosalina globularis, Lobatula lobatula* and *Planorbulina mediterranensis* as a result of irregularity of the substrate (Boltovskoy and Wright, 1976). Hence, abnormal specimens of these species cannot be used to indicate environmental stress;

b.) globular chamber formed by some planktonics (Bé *et al*., 1983)or benthic species (Hottinger *et al*., 1993) are not induced by environmental conditions hence good knowledge of biology is required;

c.) severe abnormalities may also be brought about by mechanical trauma (Bé and Spero, 1981); they are generally easy to distinguish by scanning electron microscope (SEM) investigation because they are often characterized by the presence of scars, irregular contours of crushed or repaired chambers, or by the construction of new chambers in a coiling plane different from the original ones (Boltovskoy, 1957, 1965; Boltovskoy and Wright, 1976). These deformations

result either from strong hydrodynamics or from the action of predators (Akturk, 1976; Vilela and Koutsoukos, 1992).

d.) majority of malformations (protuberance on spiral side near proloculus, abnormal size or shape etc) are observed in natural environments characterized by fluctuations in salinity (Geslin *et al*., 2000).

The study area is a network of creeks, rivers and lagoons which connects to the sea through the Lagos harbour. The harbor and lagoons at the West African coast possesses an unusual combination of physical characteristics of particular interest to the ecologist. Lagos harbour is situated at the centre of a system of marginal lagoons extending 160 miles from Cotonou in Republic of Bénin to the Niger Delta and is the only major outlet for exchange of fresh water from creeks, rivers and lagoons and marine water from the Atlantic Ocean (Hill and Webb, 1958). Besides salinity, many of the physical features of the area are comparatively stable e.g. relatively constant temperature throughout the year; light intensity being of the same order and constant length of the day (approximately 12 hours). Exceptionally, low tidal range i.e. never greater than 4 ft. and usually much less has been recorded for Lagos in the Gulf of Guinea Coast (Hill and Webb, 1958).

Foraminifers are sensitive to subtle changes in ambient environmental conditions and therefore have emerged as potential tools for assessing climatic/environmental changes (Bhala *et al.*, 2007). In the last four decades, investigators (e.g. Asseez *et al.*, 1974; Adegoke *et al*., 1976; Salami, 1982; Dublin-Green, 1999; 2004; Okewole, 2007; Phillips *et al*., 2010; 2012; Olayiwola and Odebode, 2011) have studied Quaternary

benthic foraminiferal species diversity in the southwestern Nigeria sector of the Gulf of Guinea.

Asseez *et al*. (1974), having worked on the ecology of the Ogun river estuary, recovered the assemblages constituted by *Ammobaculites crassus A. dilatatus, Haplophragmoides wilberti, Miliammina earlandi, M. fusca* and *Ammonia beccarii.* The study of pollution indicating foraminifera in Lagos lagoon (Nigeria) undertaken by Okewole (2007) recorded an assemblage of *Ammonia tepida, A. parkinsonia, A. inflata, Cribroelphidium deciphens and Textularia sagittula.* Also, Phillips *et al*. (2012) studied the distribution of benthic foraminifera in Lagos lagoon and reported abundance and common occurrences of *Ammonia beccarii* and *A. tepida*; and rare occurrence of *Eggerella scabra, Cribroelphidium semistriatum, Hastigerina pelagica* and *Marginulina sp.*

Benthic foraminifera have also been used as sediment provenance and transport tracers in Victoria Island beaches in the south-west Nigeria coast (Phillips, 2008). Despite the recent contributions of these workers to the study of foraminifera in the study area, the possible influence of the adjoining environments on the physico-chemical conditions that could produce a change in foraminiferal fauna composition has not been considered. Besides temperature, pH, salinity and depth, parameters such as chemical pollutants, sediment texture and biological interactions which could also affect the distribution of benthic foraminifera, making them useful for ecological and environmental interpretation were not considered in the areas investigated.

Therefore, the main objectives of the present study are to characterize the population of benthic foraminifera in surface sediments, establishing a relationship of