Journal of African Earth Sciences 147 (2018) 220–227

Contents lists available at ScienceDirect

Journal of African Earth Sciences

journal homepage: www.elsevier.com/locate/jafrearsci

Variations in terrigenous input into the eastern Equatorial Atlantic over 120ka: Implications on Atlantic ITCZ migration

Akintoye E. Akinnigbagbe[a,b,c], Xiqiu Han[a,*], Weijia Fan[a], Yong Tang[a], Adedayo O. Adeleye[a,b,c], Rasheed O. Jimoh[a,b,c], Zhanghua Lou[b]

[a] Second Institute of Oceanography, State Oceanic Administration, Hangzhou, 310012, China
[b] Department of Marine Sciences, Ocean College, Zhejiang University, Zhoushan, China
[c] Nigerian Institute for Oceanography and Marine Research, P.M.B.12729, Lagos, Nigeria

ARTICLE INFO

Keywords:
ITCZ
XRF core scanning
XRD
Sedimentation
Kaolinite
Equatorial Atlantic

ABSTRACT

Variation in the location of the Intertropical Convergence Zone (ITCZ) in eastern equatorial Atlantic (EEA) drastically affects rainfall in equatorial Africa and hence sedimentation on the African margin. Sediment core DY26III-Nig-S60-GC2 taken from the slope of the EEA offshore Nigeria (4°28′56″.388′E, 3°33′10″.764′N; water depth: 2946 m) was studied to decode the climatological response to the ITCZ migration in the past 120 ka. Based on oxygen isotope stratigraphy and radiocarbon dating, the sedimentation rates of this core range from 0.64 to 6.90 cm/ka and average of 3.17 cm/ka. The periods MIS 2, MIS 4 and MIS 5b from our studied core are characterized by Minima of Fe/K and maxima of K/Al, Ti/Al and magnetic susceptibility along with more kaolinite. This reflects a period when the region supposedly dominated by less precipitation and strong trade winds which suggest southward position of the ITCZ. Conversely, the periods MIS 1, MIS 3 and MIS 5a exhibit an opposite trend; these wet periods are of weak trade winds and northerly ITCZ excursion.

Fluctuations in Fe/K, K/Al and Ti/Al records reflect changes in the low-latitude insolation cycle (23 kyr) and thus indicate a close coupling between terrigenous input and climate changes. This work thus highlights the importance of the terrigenous input as a prerequisite for the interpretation of ITCZ position in the EEA.

1. Introduction

The Atlantic Intertropical Convergence Zone (ITCZ) zone acts as the major climatic boundary separating arid conditions of the north from humid conditions of the south. Understanding its positions, structure and migration are clearly very fundamental for describing the atmospheric processes and the earth's climate on the global scale (Waliser and Gautier, 1993). It also serves as an important parameter for climatic studies in tropical areas as it is responsible for much of the annual rainfall (Chen et al., 2008).

Equatorial Atlantic is characterized by the contact of meteorological cycles between Northern and Southern Hemispheres at the ITCZ; hence it presents a suitable location for investigations on climate fluctuations and land-ocean interaction (Zabel et al., 2004; Marret et al., 2013). It has been shown that the last glacial ITCZ summer position in equatorial Africa is located between 12°26′ and 13°40′N (Itambi et al., 2009, 2010), however, there is paucity of recent information on the situation in the EEA, and our knowledge of large-scale hydrological changes and their forcing factors is however limited in this region.

The study area is located on the western flank of the Niger Fan and south of the Niger Delta (Fig. 1.), under the influence of West African monsoon. In 2012, a sediment core DY26III-Nig-S60-GC2 was taken from the slope of the EEA offshore Nigeria (4°28′56″.388′E, 3°33′10″.764′N; water depth: 2946 m) during Chinese DY26 cruise, this serves as a material for this study. The main purpose of this work is to infer the ITCZ migration pattern in the past from the variation in terrigenous input as it affects the Niger River watershed in response to climate change over the past 120 ka. To this end, elemental ratios, magnetic susceptibility, clay minerals, stable oxygen isotope and ^{14}C AMS measurements of the core were used for the study.

2. Geographical and oceanographic setting

The study area is within the EEA, off the Niger Delta and the vicinity of the Gulf of Guinea (Fig. 1.), which extends from the west coast of Ivory Coast to the Gabon estuary. Variation in the West African monsoon over the EEA is known to produce significant changes in the atmospheric circulation controlling annual rainfall, moisture,

* Corresponding author. Second Institute of Oceanography, State Oceanic Administration, Hangzhou, 310012, China.
E-mail address: Xqhan@sio.org.cn (X. Han).

https://doi.org/10.1016/j.jafrearsci.2018.06.010
Received 23 August 2017; Received in revised form 7 June 2018; Accepted 9 June 2018
Available online 18 June 2018

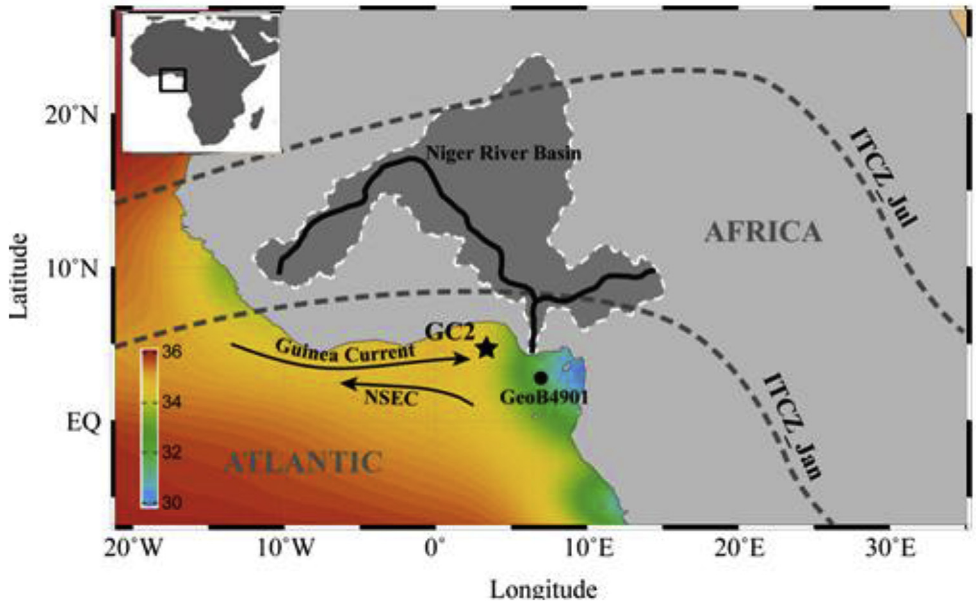

Fig. 1. Location of core studied (black star) and reference location (black circle), the Niger River basin and ocean currents of the Gulf of Guinea (Guinea Current (GC) and Northern South Equatorial current (NSEC)), and also shown is the movement of ITCZ southward and northward in the EEA, adapted from Deptuck et al. (2007).

temperature and wind (Baldi et al., 2004). Strong solar radiation in boreal summer heats the landmass, creating a region of low pressure the ITCZ – where air rich in water vapour flows in from the surrounding ocean, contributing to the monsoon rainfall (Ruddiman, 2001). Strong SE trade winds during boreal summer move the ITCZ to 18–20°N and strong NE trades push the northern limit close to the equator (3–5°N) in winter. Over land the ITCZ extends farther north or south than over the oceans due to the seasonal variation in land temperatures. The strength of the monsoon has been related to periodic orbital changes in summer insolation (Kutzbach, 1981) as well as vegetation cover (Kutzbach, 1996; Brovkin et al., 1998). The hydrographic regime of the Gulf of Guinea is dominated by the westward flowing North and South Equatorial Currents (NEC and SEC, respectively) and the eastward-flowing shallow water mass known as the Guinea Currents. Several rivers such as: Volta, Niger, Sanaga and Congo discharge into the Gulf of Guinea and bring vast amounts of terrigenous sediments into Niger River, the main river drains into EEA, has large watershed (approximately 2.3×10^6 km^2) draining regions of different climatic conditions (Itambi et al., 2010). The Niger is the longest river (4160 km) in West Africa and the third longest in Africa (after the Nile and Congo). It has a high rate of sediment discharge, and is an important source of terrigenous sediment (Milliman and Meade, 1983). The average amount of total suspended material transported by the Niger River is 26 g/m^3 (Konta, 1985). The suspension load consists mainly of highly weathered solids, with the average composition being 51% kaolinite, 32% illite, 8% montmorilonite/smectite, 15% quartz, 2% K-feldspar, 1% acid plagioclase, and 1% chlorite (Konta, 1985). Kaolinite reflects the erosion of the wide-outcropping pedologic formations of the north-equatorial and humid tropical African climatic belts. It originates from well-drained lateritic soils (Millot, 1964), mainly from the upstream parts of river basins, together with goethite and sub-amorphous iron oxides which gave the reddish colour to the clay fractions. Smectite originates from the lower part of rivers and poorly drained soils of the tropical and sub tropical climatic belts (Paquet, 1969); which is responsible for the blackish colour of marine clays. The other minerals occurring in the EEA can be directly linked to the exposed rocks of the Niger drainage basin. This is the case of minerals (illite, quartz, chlorite, and feldspar). Their relative abundances in sediments increase in the dry zones of northwest Africa (Chamley and Diester-Haass, 1979).

3. Material and methods

3.1. Core collection and processing

DY26III-Nig-S60-GC2 is a 350 cm long sediment core collected from the slope of the EEA offshore Nigeria, (4°28′56″.388′E, 3°33′10″.764′N; water depth: 2946 m; Fig. 1) during RV *'Da Yang Yi Hao'* cruise DY26III in August 2012. Prior to the transport of the sediment core to the laboratory of Second Institute of Oceanography, State Oceanic Administration (SIOSOA), sediment core was split into halves. One half was sampled in the spacing of 1 cm for various analyses such as stable isotopes measurements and radiocarbon dating and part was used for X-ray diffraction (XRD) analysis. The other half of the split core was prepared for non-destructive XRF elemental analysis using ITRAX micro-XRF core scanner and sediment's physical properties measurement using multi-sensor core logger.

3.2. X-ray fluorescence scanning

Relative elemental abundances of elements such as Ca, Al, Fe, K, Ti as well as the optical image were acquired at 2 mm resolution with the counting time of 20 s and a 10 kV, 30 KV and 50 kV acceleration intensities using ITRAX micro-XRF core scanner at SIOSOA. This device allows non-destructive extraction of near-continuous records of variations in element concentrations from sediment cores with a minimum of analytical effort. The precision of the measurement is based on correction for varieties of physical and operational factors that may affect count rates, including changes in grain-size, water content and other sample heterogeneities. We prefer ratios over intensity data because the intensities are effectively proportions that are affected by dilution effects (Weltje and Tjallingii, 2008; Govin et al., 2012). A detailed description of the ITRAX instrument is provided by Croudace et al. (2006).

3.3. Stable isotopes measurements and radiocarbon dating

A total of 119 subsamples were yielded for micro-paleontological work. The samples were dried in the oven at 40 °C, weighed, washed and sieved through a mesh size of 63 μm and dried again at 40 °C. Five specimens of epibenthic foraminifera *Uvigerina celtica* with their sizes