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Deep Sea Turbidities from the Abyssal Basin of Eastern Equatorial Atlantic: Implications for Landslide Activity

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Abstract

Over the last decade considerable attention has been given to the occurrence and distribution of mass transport deposits in the world oceans especially turbidites. Deep sea turbidites are sedimentary deposits that form on the ocean floor as a result of underwater landslides, also known as turbidity currents. These currents are triggered by a variety of mechanisms; including earthquakes, submarine volcanic activity, and the destabilization of underwater slopes due to various factors. The study of deep sea turbidites has implications for our understanding of landslides, particularly those that occur in marine environments. By analyzing the sedimentary deposits left behind by these turbidity currents. Lithological and sedimentological data of sediment core DY26III-Nig-S71-GC8 from the abyssal basin of the eastern Equatorial Atlantic (EEA) revealed a 30 cm thick turbidite layer at a depth of 90 cmbsf. The turbidite deposit consists of feldspar and quartz with fining upward sequence. They are characterized by poor sorting, rounded to sub-rounded coarse grain sizes. The source area of the turbidite is inferred to be located at the shelf–edge on the Nigerian continental margin, approximately 340 km east to the sampling site. It is suggested that great earthquakes likely struck the Nigerian continental margin during ca.35 and 40.9 ka ago that triggered the turbidite events leading to the deposition of terrigenous sediment into the deep sea and/or slope failure due to reduced hydrostatic pressure caused by the lowering of sea level. Overall, the study of deep sea turbidites has important implications for our understanding of both the past and present natural hazards, as well as for our broader understanding of earth's history and geology.

Keywords: Sediment core • Grain size • Turbidites • Canyon • Sediment core • Eastern equatorial Atlantic

Introduction

Deep sea turbidites are sedimentary deposits formed by the settling of sediment-laden water that flows turbulently down submarine canyons and channels onto the ocean floor. These deposits are composed of a mixture of sand, silt, and clay that can accumulate to form thick layers of sediment over time. Turbidity currents, which are responsible for the transportation of these sediments, are triggered by various factors such as earthquakes, storms, and underwater landslides. The latter, in particular, can cause massive sediment flows that can travel for hundreds of kilometers along the ocean floor, and ultimately form turbidites. The study of deep sea turbidites has important implications for understanding the geological processes that shape the seafloor and for assessing the potential hazards posed by underwater landslides. By analyzing the characteristics of turbidite deposits, researchers can infer information about the frequency, magnitude, and distribution of past landslides, which can aid in the assessment of future landslide hazards. Additionally, the study of deep sea turbidites can provide insights into the history of climate change, ocean currents, and tectonic activity over geological time scales. Deep sea regions experience more stability and fewer disturbances compared with coastal areas, and have the unique advantage of adequate preservation of records of any depositional event. A number of factors controlling sediment dynamics on marine environment, include paleoclimate and palaeoceanographic parameters such as variations in the state of the sea level and precipitation in response to changes in the climatic conditions in the hinterland [1,2].

During RV 'Da Yang Yi Hao' DY26III cruise in 2012, we collected a 170 cm long sediment core DY26III-Nig-S71-GC8 in the deep sea off the tropical region of West Africa. The site is located at 3°39'49.572'' N, 2°29'25.512'' E, water depth 4066 m, ~340 km off the coast of the Gulf of Guinea (Figure 1). In this core, we found a layer of turbidite deposition in the depth of 90 cm with a thickness of 30 cm. The triggering of turbidity currents and landslides from submarine canyons, shelf edges, and seamount edifices is becoming reasonably well-known [3], Heezen and Ewing [4], demonstrated that offshore earthquakes can trigger turbidity currents or reduced hydrostatic pressure caused by isostatic rebound, thus creating destabilization of gas hydrates Maslin et al. [5].

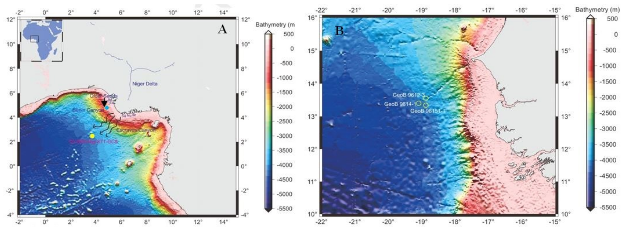

Figure 1. (A) Regional location map showing the tropic equatorial Atlantic and location of the study area (yellow circle) showing the bathymetric contour, distribution of submarine canyons on the Nigerian continental margin, Niger Delta and its estuaries (Be: Benin river; Es: Escravos river; Ra: Sangana river; Nu; Nun river, Br: Brass River) adapted from Allen, [6]; Deptuck, et al. [7]; Olabode and Adekoya [8]. (B) Map of NW-Africa including the locations of the presented cores.

In this study, we established the age frame of core DY26III-Nig-S71-GC8, using stable oxygen isotope stratigraphy and AMS 14C dating, and studied the mineral compositions and the Grain Size Distribution (GSD) of the turbidite layer. We aim to reveal the timing of the turbidite deposition documented by the core and discuss the possible triggering mechanisms.

Material and Methods

Core collection and processing

The sediment core was split into halves in the laboratory of Second Institute of Oceanography, State Oceanic Administration (SIOSOA). One half was sampled in the spacing of 1cm for various analyses such as stable isotopes measurements, radiocarbon dating and grain size analysis. The other half of the split core was prepared for non-destructive XRF elemental analysis using ITRAX micro-XRF core scanner.

X-Ray fluorescence scanning

Relative elemental abundances of elements such as Si, Fe, and K as well as the optical image were acquired at 2 mm resolution with the counting time of 20 sec 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 the correction for varieties of physical and operational factors that may affect count rates, including changes in grain size, water content and other sample heterogeneities. A detailed description of the ITRAX instrument is provided by Croudace, et al. [9].

Stable isotopes measurements and radiocarbon dating

A total of 156 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 planktic foraminifera *Globigerinoides sacculifer* with their sizes ranging from 300 to 360 µm were picked under binocular microscope SMZ 1500 for $\delta^{18}O$ analysis. Species of *Globigerinoides sacculifer* and *Globigerinoides ruber* of planktonic foraminifera size (>250 µm) of ca. 1000 specimens were handpicked for AMS (accelerator mass spectrometry) ^{14}C dating. The $\delta^{18}O$ analysis of *G. sacculifer* was performed on a Finnigan-MAT-252 mass spectrometer at state key laboratory of marine geology, Tongji University, China. The mean external precision is 0.08% for $\delta^{18}O$ values. AMS measurements were provided by Beta Analytic Inc, Miami, U.S.A. Analytical procedures followed the description in Nadeau, et al. [10]. The ^{14}C ages were corrected for reservoir effect of 400 years [11], and converted to calendar years using CALIB 7.0.4 calibration software [12], with the marine calibration based on MARINE 13 data set. The ages are reported here as years before present, abbreviated as yr BP, and "present"=AD 1950 (Table 1).

Table 1. AMS radiocarbon dates (^{14}C) and calendar ages (calendar ages calibrated with CALIB software based on the calibration curve MARINE13; Stuiver, et al.). Ages were corrected for a reservoir effect of 400 years.

Laboratory number	Core depth (cm)	^{14}C age and error (ka BP)	Calendar age and error (ka BP)
Beta-443216	1.5	1.770 ± 0.030	1.235 ± 0.031
Beta-443217	14	8.740 ± 0.040	9.316 ± 0.052
Beta-443218	39.5	16.240 ± 0.060	18.975 ± 0.086
Beta-443219	78.5	26.490 ± 0.120	30.274 ± 0.234
NGGC8L-142	142	41.400 ± 3200	40.929 ± 1700

Grain size analysis

Grain size of carbonate material free terrigenous particles in the range of 0.04 to 2000 µm was analyzed with a Malvern auto sampler 2000 apparatus at SIOSOA. Prior to the analysis, siliciclastic sediment fraction was isolated by dissolving carbonate and organic matter using ca. 0.5 ml HCl on the bulk sediment samples. Samples were then dispersed by soaking for 24 hr in 200 ml of distilled water to which 50 ml of 10% sodium hexametaphosphate (calgon) was added. The grain size distribution of each sample (N=86) was then analyzed on the siliciclastic sediment with the aim of unmixing sediment sub-populations that represent different sources or dispersal processes.

Quartz grains micro textural analysis

Individual quartz grain samples (N=208) from different depths within the turbidite layer of the core were selected for micro texture analysis. 50 grains were selected randomly from the core at depths 101.5 cmbsf, 103.5 cmbsf, 105.5 cmbsf and 58 grains from depth 111.5 cmbsf. Their micro textures were analyzed using Leica M205C stereographic microscope in the laboratory at the SIOSOA, Hangzhou, China. Quartz grain surface microtexture classification methods are based on the studies of Helland and Holmes and Strand, et al. [13].

Results

Lithology, oxygen isotope stratigraphy and radiocarbon dating

The core stratigraphic column is presented in (Figure 2). Macroscopic observation of the core shows three sedimentary units noted I, II and III from top to bottom of the core. Unit I is a 90 cm thick unlaminated mud having homogenous texture, fair compaction with alternations of thin bands and laminae of clean silt. The mud varies from brownish gray to dark gray and brownish gray with dark gray bands. Unit II is 40 cm thick brown silty sand with mud lens, medium grained texture with fining upward sequence which grades into unit I. This layer is hydrodynamically sorted prior to deposition and shows a clean sand facies and having a sharp erosive basal contact with units III. Unit III is a brownish, 40 cm thick, compacted, and poorly sorted sandy silt facies with gray mud clumps containing remains of wood fragments. On the surface of unit III, sand filled burrow penetrating downward is observed.

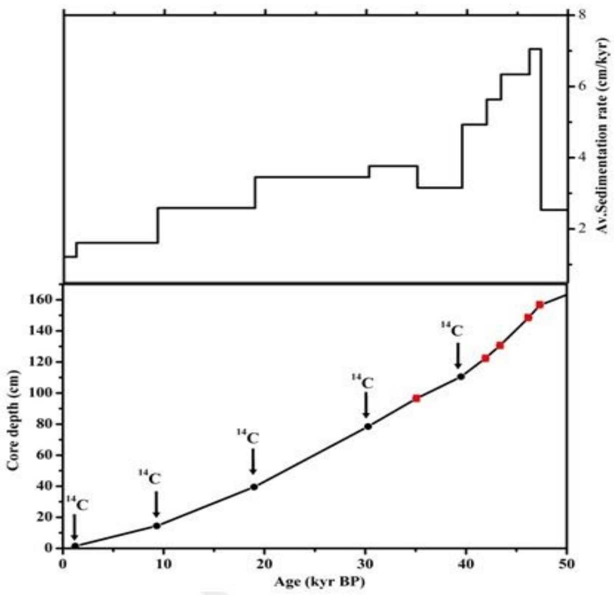

Figure 2. Age-depth model.

Age-depth model linear interpolation plot was based on calendar ages derived from ^{14}C AMS. Age-depth model, linear interpolation plot was based on calendar ages derived from ^{14}C AMS dating (red dot points) and visual matching with DY26II-Nig-S71GC8 $\delta^{18}O$ record (blue dot points) between the stratigraphy age points.

The age model for core DY26III-Nig-S71-GC8 is based on its $\delta^{18}O$ curve of foraminifera with five Accelerator Mass Spectrometry (AMS) radiocarbon dates for the last 40 kyr BP. This age frame based on the $\delta^{18}O$ curve of foraminifera was calibrated by AMS ^{14}C dating of the core at depths 1.5, 14, 39.5, 78.5 and 142 cm which correspond to ages of 1,235 ± 31 yr BP, 9,316 ± 52 yr BP, 18,975 ± 86 yr BP, 30,274 ± 234 yr BP and 40,929 ± 3200 yr BP respectively. Unit I (0-90 cm depth interval) is a homogenous mud layer that records the pelagic sedimentation of recent 35 kyr with the sedimentation rate of 2.57 cm/kyr. Unit II (90-120 cmbsf) is a layer of silty sand which grades into unit I but having erosive contact with unit III. We interpret that this layer was deposited by a turbidite event, and the oldest age of Unit I can be represented by the timing of the turbidite event. Unit III (120-170 cmbsf) is a layer of sandy silt containing wood fragments. This is also a turbidite layer deposited at 40.929 kyr BP as suggested by AMS 14C dating carried out on the wood fragment within the layer (Table 2).

Table 2. Depths and ages used for establishing the age model.

Core depth (cm)	Age (ka BP)	Method
1.5	1.235	AMS ^{14}C dating on forams
14	9.316	AMS ^{14}C dating on forams
39.5	18.975	AMS ^{14}C dating on forams
78.5	30.274	AMS ^{14}C dating on forams
97	35.06	Core-core correlation
111	39.5	Core-core correlation
142	40.929	AMS ^{14}C dating on wood fragment
143	41.933	Core-core correlation
145	43.353	Core-core correlation
149	46.192	Core-core correlation
157	47.326	Core-core correlation
165	50.484	Core-core correlation

Geochemistry

To assess textural grading, mark geochemically distinctive beds, infer differences in provenance, and locate the interval of turbidite emplacement, element intensities such as Si, Fe and K are profiled though DY26111-Nig-S71-GC8 sediment core. Si, Fe and K are terrigenous indicators useful as a sediment-source and provenance indicator. Fe and Si have been used in provenance studies for example; turbidite sources. K is commonly associated with detrital clay, while Si is a major component of sand and silt derived through physical weathering of continental crust [14]. Figure 3 shows the variation of major elements of the core. The result of our unit I; which is a hemipelagic layer shows Si, Fe and K having little variations. Unit II; the turbidite layer, contains high Si, low Fe and K. Units II and III are separated by a thin mud cap of low Si, high Fe and low K contents. Unit III is also a turbidite layer, but has a reduced Si content compared with Units II. Fe reduced and K increased immediately after the thin mud cap. Afterwards, both elements show little variations.

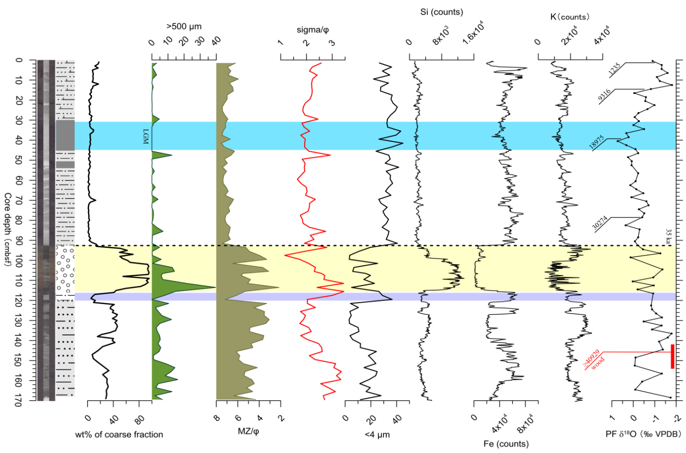

Figure 3. DY26II-Nig-S71GC8 record of weight (%) of coarse grain fraction, sand size fraction, mean grain size (Φ), sorting (Φ), clay size fraction, Si, Fe and K counts along with the $\delta^{18}O$ record of DY26II-Nig-S71GC8 core sediments.

Grain size characteristics

Grain size has been widely used for the classification of sediments to unravel transport dynamics [15]. It provides the ability to discriminate among the depositional environments in deep sea terrigenous sediments. The result of mean grain size of core DY26III-Nig-S71-GC8 shows that the upper section (unit I: 0-90 cm) is composed of mud, followed by silty sand layer (unit II: 90-120 cm) and lastly, by a layer of sandy silt (unit III: 120-170 cm) (Figure 4).The mean grain size varies from 225.3 to 5.3 μm (2.15 to 7.54 Φ) averages 16.63μm (5.91 Φ). Units I, II and III have average mean grain sizes of 7.8 μm, 88.4 μm and 44.1 μm (7 Φ, 3.5 Φ, and 4.5 Φ) respectively (Figure 4). According to the grain size parameters, the mean grain size and the sorting coefficient have a similar trend, which is in converse with that of skewness and kurtosis. The three units are poorly sorted; especially units II and III are very poorly sorted. Skewness (SK_1) is a measure of the asymmetry of the probability distributions of the grain sizes in the sediment samples. The skewness of the sediment samples from unit I range from -0.2 to 0.6 within the symmetrical distribution range, while units II and III are of the coarse grains fall within the positive distribution grades. The kurtosis (KG) of the sediment samples is within the range of 0.6 to 1.6, signalling medium and wide kurtosis.

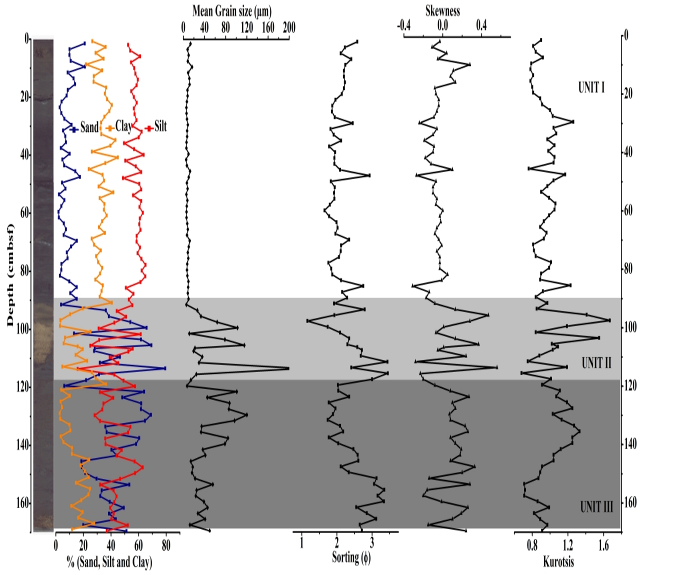

Figure 4. DY26II-Nig-S71GC8 core photograph, record of % sand, silt and clay, mean grain size (μm), sorting (Φ), skewness and kurtosis.

Characteristics of the grain-size frequency distribution

Based on the distributional characteristics of the grain size frequency curves, it is apparent that Unit I (0-90 cmbsf) represents hemipelagic deposits. The distribution of the individual grain size frequency signifies polymodal distribution (Figure 5).

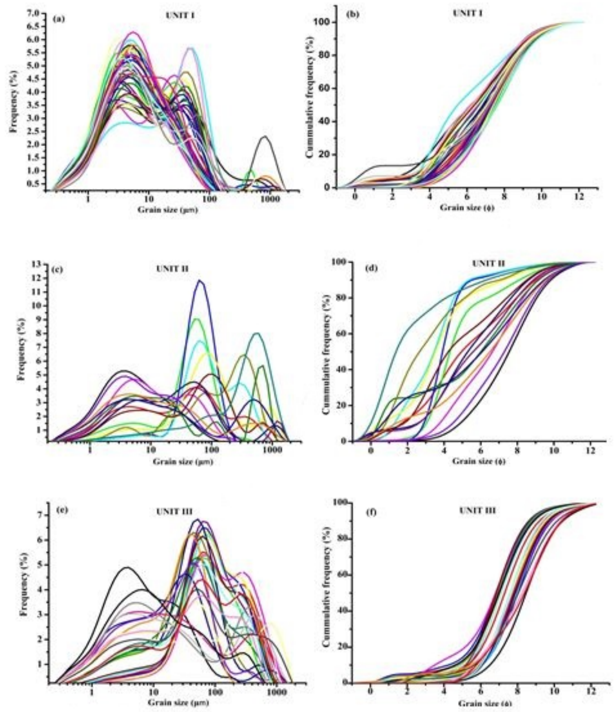

Figure 5. DY26II-Nig-S71GC8 core sediments individual and cumulative frequency curve distributions.

A modal value of 2 μm (9Φ) representing clay is the highest peak, closely followed by another high peak of 31 μm (5Φ), representing silt and a small peak of 500 μm (1Φ) representing medium sand. The coarse-grained component 250-231 μm (2-5Φ) is low, constituting 10%-15% of the total. The grain-size frequency of Unit II (90-120 cmbsf), display a polymodal type of distribution. The modal grain sizes are 500, 62.5 and 2.0 μm (1, 4 and 9Φ). The highest been 62.5 μm followed by 500 μm. The mean grain size is relatively coarser and the percentage of coarse grains 250-231 μm (2-5Φ) is high, forming 27%-90% of the total. The sorting is very poor, and the cumulative probability curve has multiple sections (Figure 5), reflecting mixing of sediment from various sources. Hence, the sediments of unit II represent turbidite deposits. The grain-size frequency of unit III (120-170 cmbsf) displays a bimodal type of distribution. The mean grain size is coarse. The percentage of the coarse grains 250-231 μm (2-5Φ) is high, forming 20%-90% of the total with a poor sorting. This layer also represents turbidite deposits.

The sand samples in unit II largely consist of feldspar and quartz grains. The quartz grains are predominantly rounded. Based on microscope observations, the quartz grains are dominated by sub rounded (43.3%) and rounded (36.5%) grains, with minor well rounded (7.2%), very angular (4.3%), angular (6.7%) and sub angular grains (1.9%) (Table 3 and Figure 6). Summarizing this result into categories of angular and rounded, we have 12.9% angular and 87.1% rounded quartz grains.

Table 3. Quartz grains micro-textures classification: Quartz grain surface microtexture classification methods are based on studies of Helland and Holmes and Strand, et al.

Depth (cm)	Very angular	Angular	Sub-angular	Sub- rounded	Rounded	Well rounded	Total per depth
101.5	1	2	1	20	24	2	50
103.5	3	3	3	16	17	8	50
105.5	2	4	0	20	23	1	50
111.5	3	5	0	34	12	4	58

Total count	9	14	4	90	76	15
Percentage	4.3	6.7	1.9	43.3	36.5	7.2

Figure 6. Micro-textures of the turbidite layer quartz grains: (A) General view, (B) Descriptive analysis of quartz grains (1-very angular, 2-angular, 3-sub-angular, 4-sub-rounded, 5-rounded and 6-well rounded).

Discussion

Identification of deep sea turbidite layer

Deep sea sedimentation records history of what has happened geologically both on land and under the oceans and preserve such records. Turbidites in marine sediments can be distinguished from the normal abyssal deposit by several criteria including colour, geochemical composition, micro fossil assemblages, and physical properties such as the mean grain size, sorting coefficient, skewness and kurtosis. Unit II and III of DY26111-Nig-S71-GC8 sediment core are depicted as turbidite deposits evidenced by the following indicators. Texturally unit II and III contain abundant coarse-grained materials, with the percentages of the coarse grains 27%-90% and 20%-90% respectively. They are characterized by poor sorting, wide kurtosis, a polymodal and bimodal type of frequency distribution and clear depositional variations. Particle size grading is also very important feature of deep-sea turbidite deposits and is clearly visible in Unit II that has layers of thin mud lenses (Figure 7). From the base to the top of this unit, the amount of coarse grained components decreases until reaching a depth of 90 cmbsf. The quartz grains are dominantly rounded. Furthermore, the poor sorting depict sediments deposited by strong waves and currents which characterize turbidite deposits. In their mineralogy, unit II and III sediment deposits are composed largely of feldspar and rounded quartz in the particles size of 4 mm, suggesting their terrestrial origin. In geochemistry, unit II and III are of high Si, low Fe and K contents, interpreted as sand turbidites.

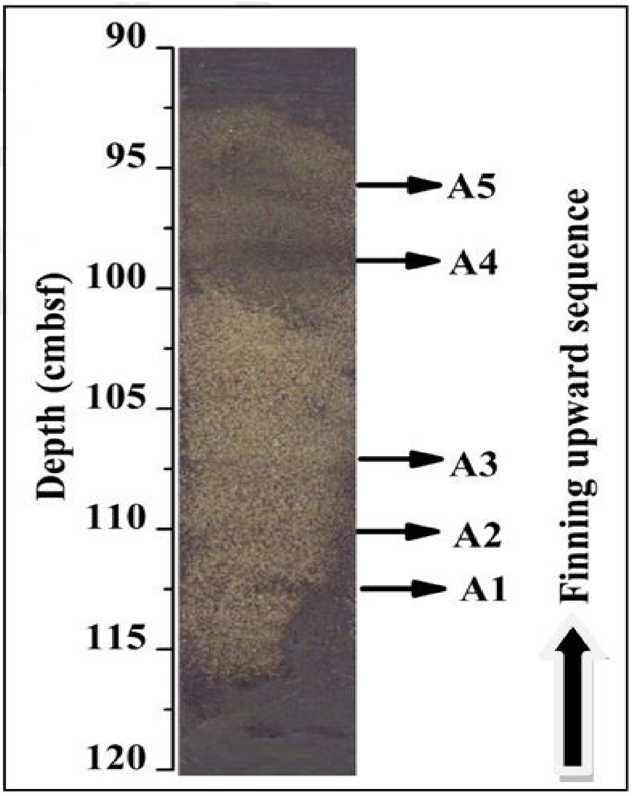

Figure 7. The sand layer within 26111-Nig-S71-GC8 core. A1-A5 represents the clay intercalations.

Provenance of the turbidite and mechanism of formation

Turbidites have been noted to be derived from several sources on the Northwest African margin and their emplacement has been linked to changes in climate and sea level over the past 700 ka. Two suites of sediments floor the present day Nigerian continental shelf namely the younger and the older suite. The older deposits believed to be of late Pleistocene and earlier Holocene age are generally well-sorted, and in some places well-bedded, coarse quartz sands locally enriched with shell and foraminifera debris, faecal pellets, and silt or clay referred to as “older sands”. These sands are mentioned in details by Deptuck, et al., as transgressive strand plain deposits (e.g. drowned barrier islands, mouth bars, and beaches) located at the shelf edge near the heads of the Benin canyon and other canyons along the margin. The quartz content of the older sands range in grade from very fine to very coarse sand, fine and medium sands being dominant, rounded and well sorted having poor sorting and strong skewness towards the coarser grades. The very fine sand dominating in the older sands at the shelf edge is replaced inshore by fine and medium sands surrounded by muddier matrix. Allen further mentioned that older sands show a generally sharp lower contact from which animal burrows often pass down and deposits below plant debris in underlying gray silty clays facies. The younger sediments date entirely from the later Holocene, forming a normally graded series. The later sediments, referred to as the Younger Suite, locally bury the older sands very deeply. It comprises of sands near shore, silts in moderate depths and clays in deep water. At present, the western continental margin of Nigeria is incised by Avon and Mahin canyons, and extensions of Benin and Escravos canyons whose nearshore parts are now burried. Within the submarine canyons, submarine channels are contained which act as the primary conduits for sediment transported by turbidity currents into the ocean. The turbidite deposit discovered in our location is probably analogous to the so-called "older sands" of Allen.

Formation mechanism

Nigeria continental margin is a passive margin, in which sediment instability may result from various processes. These can be, for example, slope failure associated with the destabilization of gas hydrates deposits resulting from pressure-temperature changes in relation to change of sea level or bottom water properties particularly at shallow depth. Secondly rapid sedimentation prevents effective dewatering, thus can lead to overloading of the continental slope by slumps from shallow water or rapid sedimentation. However, previous studies of Adegbie from the Niger Fan and Akinnigbagbe, et al., on the continental slope off Nigeria reported relatively low sedimentation rate.

Wei, et al., highlighted that the continental margin offshore Nigeria is undergoing slow deformation due to gravity driven tectonics that leads to rapid seaward progradation and loading of large sediments. It is consistent with reports of types of submarine landslides, which describe flow to the deep sea for several hundred kilometers and contain intact blocks of original terrigenous material. Allen and Damuth also suggested that the occurrence of tectonic and compactional subsidence during Late Pleistocene early Holocene might have assisted the sediments transport to the deep water beyond the Nigerian continental shelf. Another possibility is earthquake, Kutu reported that West Africa is far away from any major present-day tectonic inter-plate boundaries, active tectonoseismic or volcanogenic regions of the world, yet for centuries the region is seismically active.

Lowering of sea level is considered by several authors to have favoured downslope mass movement. On the other hand, Seibold reports of his studies performed off North-West Africa discovered that the last mass movements occurred in a period of fast sea level rise ca.10 kyr ago. These led to the suggestion that mass movements off Northwest Africa may operate randomly. In the present study it is shown that the turbidites making two units (II and III) were deposited during the late Pleistocene/glacialperiod/ca 35 ka and 40.9 ka, respectively. Unit II is predominantly medium to coarse quartz sand, rounded and having poorer sorting and strong skewness towards the coarser grades. Unit II has a sharp contact with the underlying layer unit III, which is an ungraded, compacted, and poorly sorted sandy silt facies from which some plant debris were recovered. Unit III may represent deposition due to flow division on the slope or rise, leading to different pathways where canyon or channel divides or there is canyon overspill, whereby mixed coarse grained to fine grained suspended load overspill from external levee onto terrace and finally on the channel floor (Figure 8). The above observation and interpretation is consistent with that of Weaver and Rothwell. The period of deposition coeval with glacial periods of low sea level and dry conditions over West Africa, which happens to be a period of weakened thermohaline circulation, stronger hemisphere temperature gradient coupled with intensified NE trade winds. The turbidite deposits in this location corresponds to 35 ka and 40.9 ka which is synchronous with the deep Eastern and deep Western mass transport deposits of Amazon fan that occurred during the periods of 35, 42 and 45ka. These are periods of rapidly falling sea level. The rapid drop in sea-level is estimated to be of 15-25 m/kyr rates according to McGuire, et al.

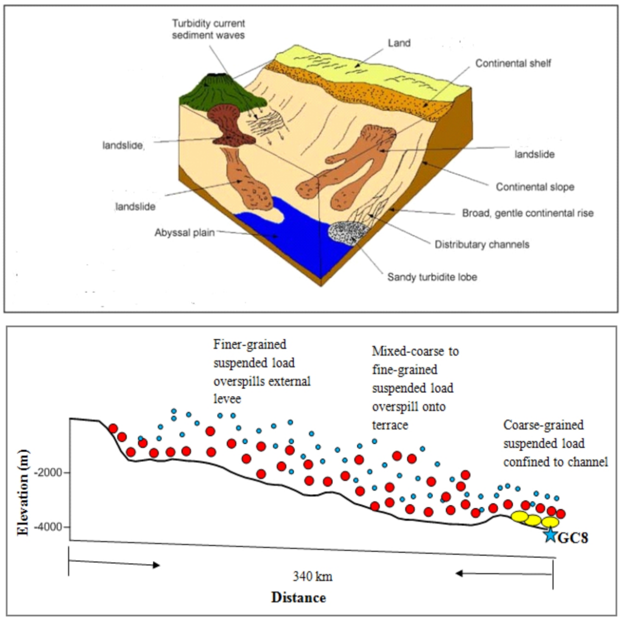

Figure 8. Sedimentation patterns along the West African continental margin. Canyons and channels are incised in the continental shelf and slope transporting sediments into the deep sea.

A record of major slide events from NW-African continental margin, of some thin turbidites that dates back at 60, 49, 28 and 23 ka, coincides with lower SST along the Iberian and NW-African continental margin and simultaneous with the timing of Henrich events in the North Atlantic. Active dune was reported to have provided a considerable source of sediment for gravity driven mass flow in submarine canyons off the shelf break. The scenario off Dakar, NW-African continental margin is similar to the one discovered off Nigeria, West-African margin. Based on this, we combine the turbidite records of four cores for the Dakar Canyon, NW Africa, with that of core DY26III-Nig-S71-GC8 off West-Africa.

Several authors have reported the occurrence of near seafloor of natural gas hydrates off the Nigerian continental margin. In recent, gas hydrates have been discovered in about 21 cores collected in Nigeria deep and ultra-deep water out of more than 800 collections on the Nigerian margin. This represents a 2.5% recovery ratio of gas hydrated cores on this margin. The observed presence of a fault adjacent to our study location adds to the possibility of the occurrence of gas hydrates according to the discovery of Brooks et al., that gas hydrates are related to faults and other conduits for gas migration. With respect to this, we also speculate the possibility of slope failure associated with the destabilization of gas hydrates deposits, due to the aforementioned reduced hydrostatic pressure caused by the lowering of sea level as a triggering factor. Examples of this potentially include those from the Amazon Fan, the Storegga Slide on the Norwegian continental margin, and those on the Ebro margin. On the other hand, there is a slim possibility of earthquake that has been reported by along West Africa margin. They observed that though the margin is far away from any major present day tectonic inter plate boundaries, active tectonoseismic or volcanogenic regions of the world, yet for centuries the region is seismically active.

Conclusion

Analysis of the sedimentary sequence of sediment core DY26III-Nig-S71-GC8 has been able to show the deposition of two turbidite events in the deep sea offshore Nigeria which is ca.340 km measured south from the mouth of Nun river where Niger river discharges into Atlantic Ocean. Based on grain size analysis, lithological and geochemical studies along with oxygen isotope stratigraphy of the core and ^{14}C dating using foraminifer's assemblages, the turbidites correspond to turbidity events that occurred at ~35 and ~40.9 ka.

The deep sea turbidite deposits are characterized by coarse grain sizes, poor sorting, wide kurtosis, a polymodal and bimodal type of frequency distribution and clear depositional variations. The grain size parameters and other components within the layers show obvious difference from hemipelagic deposits, along with high percentages of the coarse grains. Furthermore, the poor sorting depict sediments deposited by strong waves and currents which characterize turbidite deposits. and other components within the layers show obvious difference from hemipelagic deposits, along with high percentages of the coarse grains. Furthermore, the poor sorting depict sediments deposited by strong waves and currents which characterize turbidite deposits.

They are likely formed by the sediment gravity flow that might have been triggered by earthquake near the shelf along with 80-90 cm drop in sea level during MIS 3 period that contained a wide range of sediment type which ultimately made their way down into the canyons and adjacent plain or due to subsequent slope failure associated with the destabilization of gas hydrates deposits, triggered by the reduced hydrostatic pressure caused by the lowering of sea level. Therefore, the identification of the turbidite layers has important implications for the record of activity of this submarine geohazard in the past and has the implication for hydrocarbon exploration.

Acknowledgments

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