<table>
<thead>
<tr>
<th>Serial No</th>
<th>0264-3707/87/$3.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author 1</td>
<td>K. M. Onuoha</td>
</tr>
<tr>
<td>Author 2</td>
<td>D.E. Ajakaiye</td>
</tr>
<tr>
<td>Author 3</td>
<td>M.A. Daniyan and S.B. Ojo</td>
</tr>
<tr>
<td>Title</td>
<td>The July 28, 1984 Southwestern Nigeria Earthquake and its Implications for The Understanding of The Tec-Tonic Structure of Nigeria</td>
</tr>
<tr>
<td>Keywords</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>The July 28, 1984 Southwestern Nigeria Earthquake and its Implications for The Understanding of The Tec-Tonic Structure of Nigeria</td>
</tr>
<tr>
<td>Category</td>
<td>Physical Science</td>
</tr>
<tr>
<td>Publisher</td>
<td>Geophysical Press Ltd</td>
</tr>
<tr>
<td>Publication Date</td>
<td>1987</td>
</tr>
<tr>
<td>Signature</td>
<td></td>
</tr>
</tbody>
</table>
THE JULY 28, 1984 SOUTHWESTERN NIGERIA EARTHQUAKE AND ITS IMPLICATIONS FOR THE UNDERSTANDING OF THE TECTONIC STRUCTURE OF NIGERIA

D. E. AJAKAIYE¹, M. A. DANIYAN¹, S. B. OJO¹ and K. M. ONUOHA²

¹ Department of Physics, Ahmadu Bello University, Zaria, Nigeria.
² Department of Geology, University of Nigeria, Nsukka, Nigeria.

(Accepted January 3, 1986)

ABSTRACT


On 28th July, 1984 at about 12 hours 13 m UT an earthquake with an epicentral intensity of about VI occurred in the southwestern part of Nigeria, an area that has always been believed to be seismically inactive. This event was recorded at the LAMTO seismic observatory in Ivory Coast and its epicentre was located at around Ijebu-Ode. In Nigeria, the event was recorded only by a temporary monitoring station at Ahmadu Bello University (ABU) in Zaria, a distance of about 640 km from the epicentre. Two subsequent tremors that were reported in Ijebu-Ode in early August, 1984 were not recorded at Ahmadu Bello University.

Geological, geophysical and geodynamic studies indicate the possibility of the existence of large fracture zones trending generally in the NE-SW direction across the country. The recent earthquakes in southwestern Nigeria could therefore be evidence to support the existence of the Pelusium megashear system or similar fracture zones that penetrate deep into the continental crust of West Africa. There is therefore a need for more adequate coverage of the area by seismic stations to permit a precise location of future events and detailed data analysis which would help in identifying area where large scale crustal adjustments might be taking place.

INTRODUCTION

The recent earth tremors (late July and early August, 1984) in the southwestern part of Nigeria took many people by surprise since West Africa is generally considered as a stable area. Each year several millions of earthquakes occur throughout the world, varying in size from minor tremors that are perceptible only to sensitive instruments, to great ones that cause considerable damage, injuries, and loss of lives. The only indication of seismicity in this region, as shown by the world-wide distribution of earth-
quakes (e.g. Nelson and Ganse, 1980) is the isolated epicentre located in the Accra area of Ghana.

According to the theory of plate tectonics, manifestations of orogenic activities (such as volcanism and earthquakes) are confined mainly to Lithospheric plate boundaries, although there are many recorded cases of intraplate earthquakes. The West African region is located far from any of such plate boundaries. However, historical and recent instrumental evidence abundantly indicate that certain parts of the region have been scenes of spectacular and disastrous earthquakes (Krenkel, 1923, Junner, 1941, Gorskov, 1963, Burke, 1969, Blundell, 1976; Bacon and Quaah, 1981; Quaah, 1982, Kogbe and Delbos, 1984).

In Nigeria, the lack of seismological observatories with long-established traditions of data collection is a major cause of the paucity of information regarding the seismicity of the country. Previously reported cases of earth tremors in some parts of the country include: the 1933 tremor in Warri area; the 22nd June 1939 tremor that was felt in Lagos and environs and was so severe in some districts that many people rushed out of their houses in panic.

This tremor might be related to the Accra, Ghana earthquake of the same date (Bacon and Banson, 1979; Bacon and Quaah, 1981; and Quaah, 1982) (Table 1). Others are the 2nd July, 1961 tremor around Osaga/Ohafia area

### TABLE 1
Continental earthquake epicentres in the West African sub-region between 1936 and 1983.

<table>
<thead>
<tr>
<th>Source</th>
<th>Date</th>
<th>Time</th>
<th>Location</th>
<th>Depth</th>
<th>Magnitudes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>YEAR</td>
<td>MO</td>
<td>DA</td>
<td>HR</td>
<td>MIN</td>
</tr>
<tr>
<td>TRI</td>
<td>1936</td>
<td>08</td>
<td>05</td>
<td>09</td>
<td>36</td>
</tr>
<tr>
<td>ISS</td>
<td>1939</td>
<td>06</td>
<td>22</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>G-R</td>
<td>1939</td>
<td>06</td>
<td>22</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>ISS</td>
<td>1939</td>
<td>08</td>
<td>18</td>
<td>04</td>
<td>51</td>
</tr>
<tr>
<td>TRI</td>
<td>1942</td>
<td>04</td>
<td>07</td>
<td>22</td>
<td>35</td>
</tr>
<tr>
<td>PDE</td>
<td>1969</td>
<td>02</td>
<td>09</td>
<td>18</td>
<td>29</td>
</tr>
<tr>
<td>PDE</td>
<td>1976</td>
<td>05</td>
<td>15</td>
<td>08</td>
<td>09</td>
</tr>
<tr>
<td>PDE</td>
<td>1979</td>
<td>01</td>
<td>09</td>
<td>00</td>
<td>26</td>
</tr>
<tr>
<td>PDE</td>
<td>1983</td>
<td>12</td>
<td>22</td>
<td>04</td>
<td>11</td>
</tr>
</tbody>
</table>

Compiled from the National Geophysical Data Centre/NOAA Boulder Colorado

* BRK—Barkeley (Naviland), CA, USA
  G-R—Gutenberg—Richter
  ISS—International Seismological Summary—Kew, England, UK
  PAS—Pasadena, CA, USA
  PDE—Preliminary Determination of Epicentres
  TRI—Trieste, Italy.
JULY 28, 1984 SOUTHWESTERN NIGERIA EARTHQUAKE

near Umuahia in which a crack of about 10 m deep, 5 m wide and 90 m long was reportedly produced across the road; the 21 Dec, 1963 tremor near Ijebu–Ode with intensity of about V; the 1st July, 1975 tremor near Fagwalawar Garu in Danbata, Kano (Ige, 1984) and more recently in Yola on 8th December, 1984. Some of these tremors might have been caused by crustal movements, but lack of seismic coverage in the country did not facilitate the confirmation and study of these events.

There is a close association of the earthquake epicentres with deep fractures and rifts. The possible relationship between the epicentres of some of the West African earthquakes and the continent-ward extensions of oceanic fracture zones had earlier been pointed out by Burke (1969). The need for a good seismic observatory coverage for the country can not therefore be over emphasised especially with the possibility of the extension of oceanic fracture zones into the country (Neev and Hall, 1982; Ajakaiye et al., 1984) and the existence of the large dams.

GEOLOGICAL BACKGROUND

The general geology of Nigeria is outlined in Figure 1. About two-thirds of the area is underlain by a PreCambrian basement complex consisting of gneisses, migmatites, schists, and various metamorphic rocks and granites. These are in places intruded and interspersed by the “Older granites” which originated in the Pan–African Orogeny (600 Ma). The remaining third of the country is covered by various basins (the Chad, Benue, Niger and Sokoto Basins), with ages ranging from the Quarternary to the Cretaceous. In the Jos Plateau area, an uplift occurred as a possible consequence of Jurassic intrusions that took place along fracture zones as suggested by Ajakaiye et al.; (1982). These intrusives which contain alkaline feldspars are referred to as “younger granites” and they appear as ring dykes which represent old calderas or roots of volcanoes. The ring dykes aligned in NE–SW direction become progressively older 500 Ma) towards the Algerian border and this has been interpreted as evidence for the existence of a possible episodic plume trace in West Africa (Ajakaiye and Verheijen, 1983).

The Niger valley is possibly a graben and the Benue a sinistral shear zone that may be part of a fracture zone within the Pelusium Megashear system (Sheidegger and Ajakaiye, 1985). The Benue trough has also been considered as a “failed” rift since it contains no ophiolites. The Cretaceous sediments of the trough are occasionnally pierced by knobs of granites, which may represent thin sediment layers. The surface in most parts of the country is covered with laterite.
THE JULY 28TH EARTHQUAKE

Several earth tremors were felt in the southwestern part of Nigeria between Saturday, July 28 and Thursday, August 2nd, 1984. From a detailed study of radio, newspaper and individual eye-witness accounts, the epicentres lie close to the ancient city of Ijebu-Ode. The first major shock occurred at about 12 h 10 m (UT) on July 28, 1984 and was followed by a second one 5 minutes later. Three more tremors were felt in quick succession bringing the total to four within a period of about twenty minutes.

The event was instrumentally recorded in Nigeria only by the Department of Physics, Ahmadu Bello University (ABU), Zaria, Sprengnether MEQ–800 portable temporary seismic monitoring station. The event registered a very weak P-wave onset and a clear S-wave arrival at about 12 h 14 m (UT) (Fig. 2a). The event was also clearly recorded at the
LAMTO seismic observatory Ivory Coast (Fig. 2b) and the epicentre was determined to be near Ijebu-Ode (Tournier, personal communication). A maximum epicentral intensity of VI has been assigned to the July 28 shock on the basis of the macroseismic effects, some of which included the following accounts:

- houses and roads shook and rocked, vibrating as if explosions were occurring underground;
- books fell off the shelves; cups, bottles and plates fell off tables; people, old and young ran out of their homes bewildered; pictures hung on walls crashed to the floor; confusion took over at social parties with everyone running helter skelter. No severe damage or death was reported. The August 2, 1984 shock occurred at about 0030 h 0 m (UT) with an intensity of about V near Ijebu-Ode and it was felt for about 5 minutes.

Earthquake occurrences of large magnitude in the West African region have been very few (Fig. 3 Table 1). There is the possibility of low magnitude quakes occurring, but due to the lack of adequate coverage of monitoring stations in several countries in the sub-region they are often not recorded. Geological maps indicate several NW-SE trending faults along the Ijebu-Ode Ibadan-Oyo axis along which the earthquakes could have originated. There are also many mid-Atlantic ridge transform fracture zones (St. Paul, Romanche, Charcott and Chain) in the Gulf of Guinea which many believe form part of the pelusium megashear system that cuts across the continent of Africa from the West African Coast to the Nile basin in NE Africa (Fig. 1 of Neev and Hall, 1982; Ajakaiye et al, 1982). These recent earthquakes, (Nigeria, 1984; Ghana, 1964, 1969, 1977, 1980; Guinea, 1983) show that the geodynamic quiescence of this region is only relative (Scheidegger and Ajakaiye, 1985), and that there is a lateral movement along this pelusium line which began in the Paleozoic. The compressional trough which follows the line has been ascribed to an oblique collision between a NW African plate and a central plate consisting of southern and eastern Africa, the Arabia Peninsula and the Levant (Neev and Hall, 1982). The Pelusium Megashear system is expressed as a system of an echelon faults instead of a uniform geosuture which generally trend NE-SW across Africa with some lineament swarms. These fracture zones are most pronounced upon entering and leaving the African continent in the Gulf of Guinea and close to the Nile delta. There are other trans-Africa fracture zones, like the Guinea Bissau fracture zone which cuts across Africa in a NE-SW direction and the Angolan fracture zone which runs from SW Angola through Ethiopia to the Arabian Peninsula where it is called the Rub Al Khali (Neev and Hall, 1982).

Gravity studies of the central part of Nigeria (the younger granite region
Fig. 2b. Vertical component short period record of the Ijebu-Ode earthquake recorded by the LAMTO seismic array in Ivory Coast.
Fig. 3. Earthquake epicentre locations in the West African sub-region between 1896 and 1983.

and the Benue trough) (Cratchley and Jones, 1965; Ajakaiye, 1970; Osazuwa et al., 1981 and Ajayi and Ajakaiye, 1981) show evidence of the thinning of the crust beneath the Benue trough which might indicate that it is a tensional rift zone. Similarly, studies of the reduced aeromagnetic data in the younger granite region and the Benue trough indicate prominent ENE–WSW linear features whose extrapolation coincide with the St. Paul, Romanche, Charcot and Chain fracture zones in the Gulf of Guinea. The linear features have been interpreted as Precambrian fractures along which Jurassic intrusions could occur. The Benue river might have taken advantage of these Precambrian lineaments representing shear zones.

Unpublished seismic reflection surveys indicate that the sediments in the lower Benue are at least 6 km and those in Bornu basin at least 2 km thick (Ajakaiye, 1981). The basement near Maiduguri was found to be 3 km deep (Cratchley, 1960). The seismicity of this area is one of the least in the world, so there is lack of adequate studies of fault plane solutions of earthquakes.

Fault plane solutions for the 1939 and 1969 Ghanaian earthquakes obtained by Bacon and Quaah, 1981, indicate that there exists a compression from the NNE (Scheidegger and Ajakaiye, 1985). This conforms with the idea that the Pelusium zone is a sinistral megashear.

Recent geodynamic studies in Nigeria (Scheidegger and Ajakaiye, 1985) from “joint measurements” indicate that the total area of the (Nigerian) shield appears to be under a NW–SE neotectonic compression. However,
this stress field is rotated clockwise in the vicinity of the Benue Trough. Between Makurdi and Ibi, one of the preferred joint strikes parallels the course of the river. The joint orientation in this region indicate a compression from NNE, which implies that the Benue zone is a sinistral shear zone. This fits exactly with the idea of a Pelusium megashear proposed by Neev and Hall, 1982”.

CONCLUSIONS

Geophysical and geodynamic studies indicate the possibility of the existence of large fracture zones across Nigeria trending generally in the NE–SW direction. Although the fracture zones might be Precambrian, there could still be more recent crustal adjustments along them. The 1983 Guinean earthquake may be associated with such adjustments along the pre-existing Guinea Bissau fracture zone, whereas the other series of earthquakes reported in Ghana and the recent tremors in the southwestern part of Nigeria may be associated with slight movements along the Pelusium line.

There is an urgent need for the establishment of a network of seismic stations adequately located across the country in order to facilitate a closer study of possible movements along the Pelusium line. The effective study of data collected from such a network will help in identifying the pattern of seismic activity of the country and possible causes of intraplate seismicity which will have implications for earthquake hazard assessment for Nigeria. This will also contribute to a better understanding of the Nigerian crustal structure. More geological and geophysical studies are also needed for a better understanding of the tectonic structure of Nigeria.

ACKNOWLEDGMENT

We thank our colleagues for discussions related to this work. We also thank the LAMTO geophysical observatory, Ivory Coast, for providing us with a copy of the Ijebu-Ode earthquake record, and NOAA Boulder Colorado for providing us with earthquake listings for the West African sub-region. Mr. Oyebanji typed the manuscripts and Mr. Abayomi traced some of the diagrams.

REFERENCES


