Asian Journal of Geological Research

1(2): 110-114, 2018; Article no.AJOGER.43419

Variation of Earthquake Focal Depth in Parts of Oceanic Ridges

A. A. Abong[1*]

[1]*Department of Physics, Cross River University of Technology, Calabar, Nigeria.*

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJOGER/2018/43419
Editor(s):
(1) Dr. Ahmed Abdelraheem Frghaly, Associate Professor, Sohag University, Egypt.
Reviewers:
(1) Pavel Kepezhinskas, University of Florida, United States of America.
(2) Marvin Herndon, USA.
(3) Snehadri B. Ota, Institute of Physics, India.
Complete Peer review History: http://www.sciencedomain.org/review-history/27263

Original Research Article

Received 19 July 2018
Accepted 09 November 2018
Published 16 November 2018

ABSTRACT

This study was conducted to evaluate the variation of earthquake focal depth in parts of Oceanic Ridges. The data set for this work were extracted from the International Seismological Centre (ISC), Pipers Lane, Thatcham, Berkshire, United Kingdom. The selected data consisted of earthquakes with $M_b \geq 4.0$ for the study area from 1st January 1901 to 31st December 2015 (115years) with focal depth from 0 – 400 km. A total of 10,801 events were employed in the study with Chile Ridge having 1574, Mid-Atlantic Ridge 4924 and Pacific Ridge 4303. The result of this study revealed that in all locations, earthquake events concentrate in the depth range 0-50 km which falls within the shallow-focus earthquakes. In Pacific Ridge, the number of events was decreasing with increasing focal depth. It was also found that the earthquake events are highest in Mid - Atlantic Ridge (46%) as compared to Chile Ridge (14%) and Pacific Ridges (40%). The indication of this is that the processes accompanying seismicity which include the rate of tectonic divergence of oceanic plates, crustal and sub-crustal stress accumulations are widespread in Mid - Atlantic ridge. Hence the Atlantic Ocean is vulnerable to tsunamigenic earth dangers.

Keywords: Seismicity; oceanic ridges; shallow-focus earthquakes; stress concentration; focal depth.

**Corresponding author: Email: austine9u2008@yahoo.com;*

1. INTRODUCTION

A mid-ocean ridge is an underwater mountain system formed by plate tectonics when two oceanic plates move away from each other. It consists of several mountains joined in chains with a valley called a rift running along its spine. Mid-ocean ridges are geologically active, with new magma constantly evolving onto the ocean floor and into the crust at and near rifts along the ridge axes. The Mid-ocean Ridge divides the boundary between two tectonic plates called a divergent plate boundary. Spreading rate on earth varies between less than 10 mm/yr at the Gakkel Ridge in the Arctic Ocean [1] and 170 mm/yr at the East Pacific Rise [2]. The spreading rate comprises slow-spreading ridges (full spreading rates 55 mm/yr), intermediate-spreading ridges (55–80 mm/yr) and fast-spreading ridges (>80 mm/yr) [1] and [3].

Slow-spreading ridges are made up of axial rift valleys and general rough topography, while fast-spreading ridges consist of axial highs and a much smoother topography. Intermediate-spreading ridges may include axial highs, axial valleys and transitional structures shown by a faulted topography with neither axial high nor valley [4]. Also Kappel and Ryan [5] pointed out that ridges with intermediate spreading rates can also vary through time.

The present work deals with three oceanic ridges namely, Chile Ridge, Mid-Atlantic Ridge and Pacific Ridge (as shown in Fig. 1). Chile Ridge is one of the few regions with a triple junction (a place where three plate boundaries meet), the Pacific Ridge which is located within the Ring of fire (a major area in the basin of the Pacific Ocean where a large number of earthquakes and volcanic eruptions occur) and the Mid-Atlantic Ridge which is a divergent tectonic plate boundary situated along the floor of the Atlantic Ocean and in the South Atlantic. It demarcates the African and South American plates and plate boundaries within this Ridge (e.g. The African plate which moves at a speed of about 2.15 cm per year towards the Eurasian plate). Also, coastal communities within the Chile Ridge and Pacific Ridge are prone to high earthquake risks. It is against this backdrop that this study is conducted to evaluate the variation of earthquake focal depth in parts of oceanic ridges.

1.1 Seismicity of the Study Area

1.1.1 Chile ridge

The Chile Ridge also referred to as Chile Rise is an Oceanic Ridge, a tectonic divergent plate boundary that is situated between the Nazca and Antarctic Plates. Its eastern end is the Chile Triple Junction where the Chile Rise is being consumed below the South American Plate in the Peru - Chile Trench [6]. It extends westward to a triple point south of the Juan Fernández microplate where it cuts the East Pacific Rise [7] to the triple junction of the Antartic, Nazca and South American plates [8,9]. The coast of Chile has witnessed earthquakes of high magnitude greater than 7.0 since 1973. The greatest instrumentally recorded quake in the world happened off the coast of Chile in 1960 with magnitude 9.5. Earth scientists are concerned about Chile Ridge not because of the history of great earthquakes but because of its tectonic setting. Chile is one of the few regions where three major plates join i.e it is a triple junction.

1.1.2 Mid –Atlantic ridge

The Mid-Atlantic Ridge is the major geologic unit of Mid-Atlantic Ocean. It extends from Iceland to the Antarctic and is the longest underwater mountain range on Earth. The ridge was developed by an oceanic rift which demarcates the North American Plate and the Eurasian Plate in the North Atlantic Ocean. In the South Atlantic, the Mid-Atlantic Ridge divides the South American Plate and the African Plate. The Mid-Atlantic Ridge is a divergent boundary initially developed during the Jurassic period when a series of two arms of three-armed grabens joined to the supercontinent Pangea to form the ridge.

1.1.3 Pacific ridge

The East Pacific Rise (or Ridge) is a Mid-Oceanic Ridge, a divergent tectonic plate boundary situated along the floor of the Pacific Ocean. It separates the Pacific Plate to the west from (north to south) the North American Plate, the Rivera Plate, the Cocos Plate, the Nazca Plate, and the Antarctic Plate.

2. MATERIALS AND METHODS

2.1 Source of Data

The data set for this work were extracted from the International Seismological Centre (ISC),

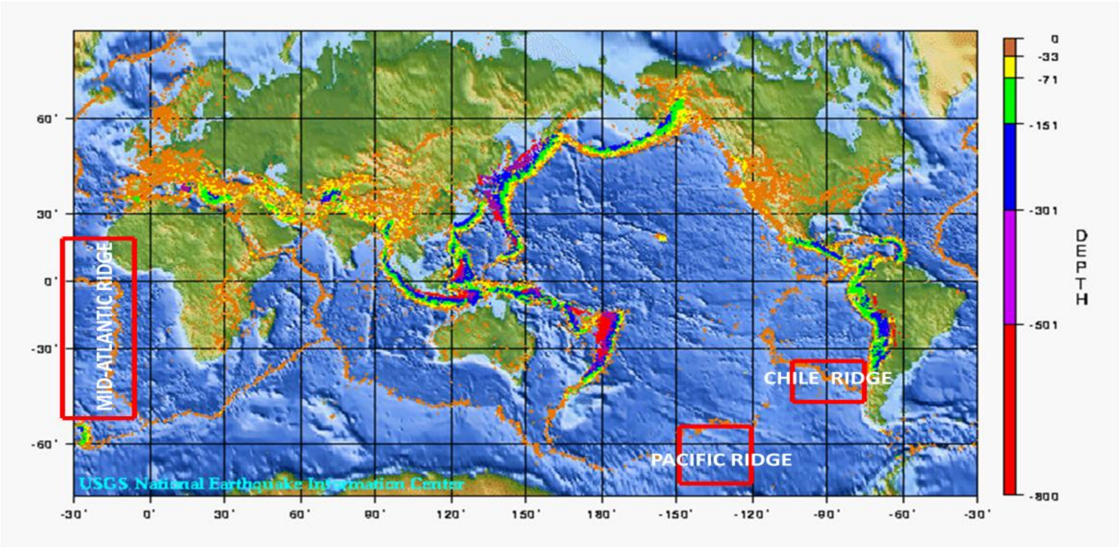

Fig. 1. Map of Global seismicity (1975 – 2010) colour- coded depth. (Source: National Earthquake Information Centre, US Geological Service) Modified from Hammed et al. [10]

Pipers Lane, Thatcham, Berkshire, United Kingdom (http://www.isc.ac.uk/). The selected data consisted of earthquakes with $M_b \geq 4.0$ for the study area from 1st January 1901 to 31st December 2015 (115 years) with focal depth from 0 – 400 km. The data set comprised of date of occurrence of an earthquake, origin time, coordinates of the epicentre, magnitude, event identification, the focal depth of earthquake and event ID. The region of study is situated within the coordinates; Chile Ridge latitudes: 48°S – 36^{0}S and longitudes: 110°W–75°W; Mid-Atlantic Ridge latitudes: 50°S – 20°N and 45°W – 10°W; Pacific Ridge latitudes: 68°S – 58°S and longitudes: 120°W– 150°W (Fig. 1). A total of 10,801 events were employed in the study with Chile Ridge having 1574, Mid-Atlantic Ridge 4924 and Pacific Ridge 4303 respectively.

2.2 Methods

The data were divided into eight groups based on the depth ranges of 0 – 50, 50 – 100, 100 – 150, 150 – 200, 200 – 250, 250 – 300, 300 – 350 and 350 – 400 km for Chile Ridge, the Mid-Atlantic Ridge and Pacific Ridge respectively. An overlap depth of 50 km (moving step) was used to maintain the inherent continuity of the data points.

3. RESULTS AND DISCUSSION

The results of this study revealed that the highest number of earthquake events concentrate in the depth range (0 – 50 km) in Chile Ridge, Mid-Atlantic Ridge and Pacific Ridge. But in Pacific Ridge, the number of events was decreasing with increasing focal depth with few intermediate and deep - focus earthquakes (Table 1). Figs. 2 and 3 show the depth distribution of total seismicity in the study areas.

The prevalence of shallow focus – earthquake could cause destructive waves within the interior or confine area of the oceanic ridges [10]. Also, the shallower an earthquake the more destruction it causes [11] and an earthquake with deep focus may generate only small surface wave train while shallow earthquakes cause very strong surface waves [12]. As a result, this may trigger tsunamis even with lower magnitudes.

Table 1. Earthquake focal depth and number of events

Focal depth (Km)	0-50	50-100	100-150	150-200	200-250	250-300	300-350	350-400	Total
Chile Ridge	1570	4	0	0	0	0	0	0	1574
Mid-Atlantic Ridge	4924	0	0	0	0	0	0	0	4924
Pacific Ridge	3861	201	146	64	13	11	6	1	4303
Total	10355	205	146	64	13	11	6	1	10801

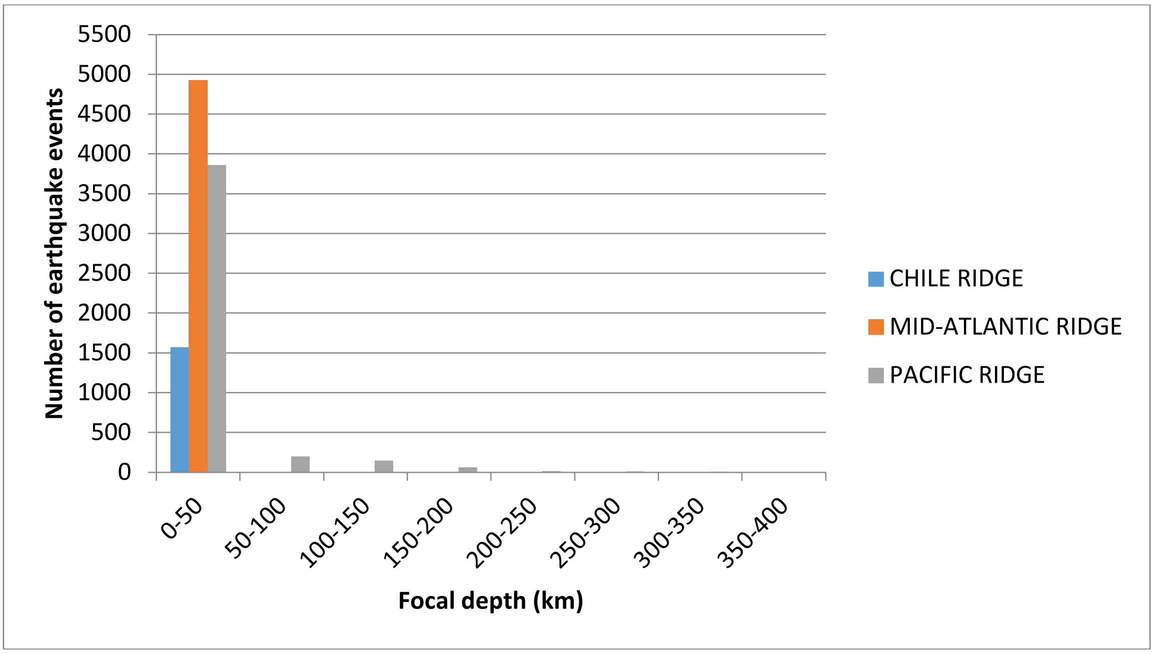

Fig. 2. Bar chart showing depth distribution of total seismicity in the study area during the period 1901 to 2015

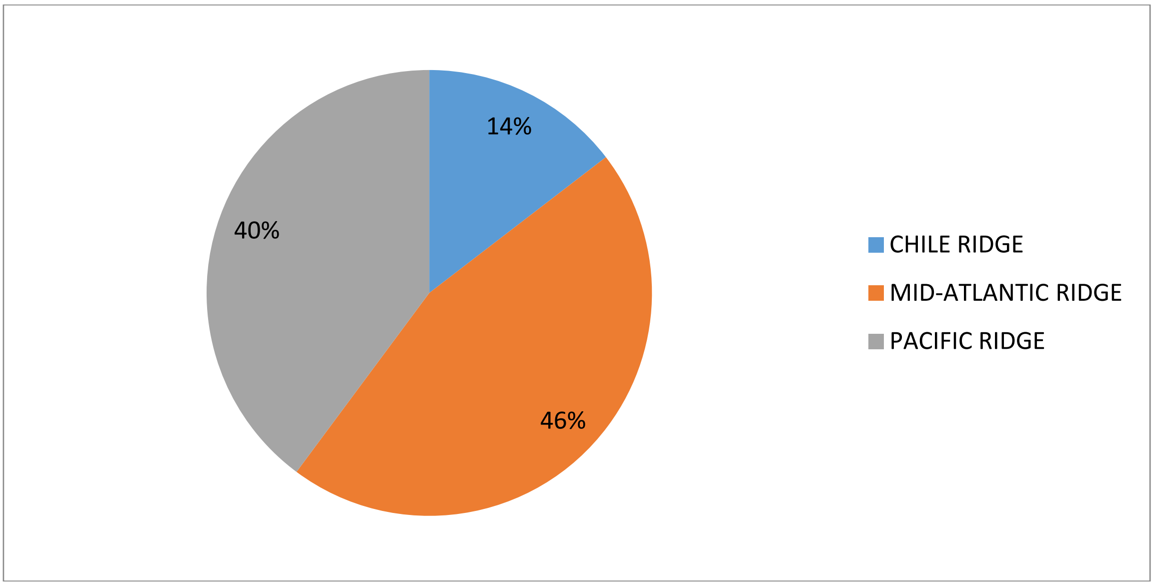

Fig. 3. Pie chart showing the total distribution of earthquakes in the study area during the period 1901 to 2015

It was also found that the earthquake events are highest in Mid – Atlantic Ridge (46%) as compared to Chile Ridge (14%) and Pacific Ridge (40%) (Fig. 3). The indication of this is that the processes accompanying the distribution of earthquakes which include the rate of tectonic divergence of oceanic plates, crustal and sub-crustal stress accumulations are widespread in the Mid- Atlantic ridge. Hence the Atlantic Ocean is vulnerable to tsunamigenic earth dangers [10].

4. CONCLUSION

The results of this study revealed that the highest concentration of earthquake distribution is found in the depth range (0 – 50 km) in all locations. It was also found that the earthquake events are highest in Mid – Atlantic Ridge (46%) as compared to Chile Ridge (14%) and Pacific Ridge (40%). This implies that the Atlantic Ocean is vulnerable to tsunamigenic earth dangers. This study implies that coastal communities should be enlightened about hazards associated with earthquakes in their domains and precautionary measures to take when they occur.

ACKNOWLEDGEMENT

The author is grateful to the International Seismological Centre (ISC), Pipers Lane, Thatcham, Berkshire, United Kingdom for granting access to their website to download data for this study.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Dick HJB, Lin J, Schouten H. An ultraslow-spreading class of ocean ridge. 2003;426: 405–412.
2. Macdonald KC. Mid-ocean ridge tectonics, volcanism and geomorphology. Encyclopedia of Ocean Sciences. Academic Press. 2001;1798–1813.
3. Buck WR, Lavier LL, Poliakov ANB. Modes of faulting at mid-ocean ridges. Nature. 2005;434:719–723.
4. Phipps MJ, Chen Y. Dependence of ridge-axis morphology on magma supply and spreading rate. Nature. 1993;364:706–708.
5. Kappel E, Ryan W. Volcanic episodicity and a non-steady state rift valley along northeast pacific spreading centers: Evidence from Sea MARC I. Journal of Geophysical Research. 1986;91:13925–13940.
6. Russo RM, Vandecar JC, Comte D, Mocanu VI, Gallego A, Murdie RE. Subduction of the Chile Ridge: Upper mantle structure and flow. GSA Today. Geol. Soc. Am. 2010;20(9):4.
7. Larson RL, Searle RCM, Kleinrock CH, Schoute RT, Bird DF, Naar RIR, Hooft EE, Lasthiotak H. Roller-bearing tectonic evolution of the Juan Fernandez microplate. Nature. 1992;3(56):571-576.
8. Herron EM, Cande SC, Hall BR. An active spreading center collides with a subduction: A geophysical survey of the Chile margin triple junction, in Nazca Plate: Crustal Formation and Andean Convergence Edited by L. D. Kulme et al., Mem. Geol. Soc. of Am. 1981;154:683-701.
9. Cande SC, Vogt PR, Fox PJ. Detailed investigation of a flow line corridor in the South Atlantic, II, A survey of 50 to 70 my old crust on the west flank (abstract). Eos Trans. AGU. 1987b;68:1491.
10. Hammed OS, Awoyemi MO, Igboama WN, Badmus GO, Essien UC. Seismicity associated with the African Lithospheric plate. Phys. Sci. Intern. Journ. 2016;10(3): 1-11.
11. Talukdar P, Barman NC. Seismic activity and seismotectonic correlation with reference to Northeast India. IOSR Journ. of Appl. Phys. 2012;3:31-440.
12. Lowrie W. Fundamentals of geophysics. Cambridge University Press, England. First Edition; 2007.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/27263