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Seismicity and Seismotectonics Of Sudan and South Sudan

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ABSTRACT

Earthquake data collected from regional and international seismological stations was compiled in order to produce a seismicity map for the Sudan and South Sudan. The seismicity and tectonic information were used to identify the relationship between the distribution of earthquakes and active geological structures and further to create seismic source zones. The results showed that the study area lies within seismically-active region which can be divided into three major seismic source zones, namely the Southern Seismic Source Zone (SSSZ; Ms=7.2), the Northeastern Seismic Source Zone (NSSZ; mb=5.9), the Central Seismic Source Zone (CSSZ; Ms=5.5). The SSSZ is bounded by latitudes 3º 00̀ and 10°00̀ N and longitudes 22º 00̀ and 36°00̀ E. The seismic activityassociated with this zone is attributed to the extension of the western branch of the East African Rift System into South Sudan, or possibly related to rejuvenation of movement in the fault-bounded basins of South Sudan. The NSSZ is located to the west of the presently active seismicity along the Red Sea trough. The third zone seismicity is possibly related to rejuvenation of movement along the Central African Shear Zone (CASZ). Additional minor seismic activity is probably related to Cenozoic volcanicity in Jebel Merra and Bayuda volcanic fields

INTRODUCTION

The study area of Sudan and South Sudan (Fig. 1) is no longer a seismic zone as formerly believed. Although seismic records are very limited, yet many earthquakes with high to low seismicity have been reported recently in several parts in the area. For instance, South Sudan recorded so far the highest seismic activity during the 1990 earthquake near Juba (*Ms=7.2*), which was followed by a series of aftershocks [6]. It was the largest earthquake occurred in Africa in the last century. Moreover, Berber and Merowi towns in northern Sudan suffered from historic earthquakes [1]. Central Sudan is also characterized by low seismicity compared to the southern part, though the area experienced many significant and frequent moderate earthquakes. The largest one was the Jebel Dumbeir earthquake (*Ms= 5.6*) in October, 1966 followed by series of aftershocks [7]. The earthquake of August, 1993 (*Ms =5.5*) was located 150 km southwest of Khartoum city, during which two people were killed and many buildings collapsed [2]. In November, 2003 Abu Deleig earthquake (*Ms=4.5*) which was located 100 km northeast Khartoum [9].In July, 2010 a recent earthquake at Khartoum (*Ms=3.3*) [10].

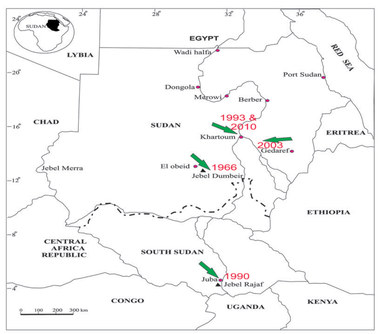

Fig.1 Sudan and South Sudan with important events

OBJECTIVES

The main objective of this study is to construct a seismotectonic map that reveals the seismically active zones based on the available seismic data.

GEOLOGY AND TECTONIC SETTING

The study area lies within an intraplate region in the center of Africa. It is bounded by active tectonic features, namely the Red Sea Rift in the northeast and the East African Rift System to the south and southeast (Fig. 2). According to Whiteman (1971), [12], (Fig. 3) are:

1/ Basement complex

2/ Phanerozoic sediments

3/ Cenozoic volcanic

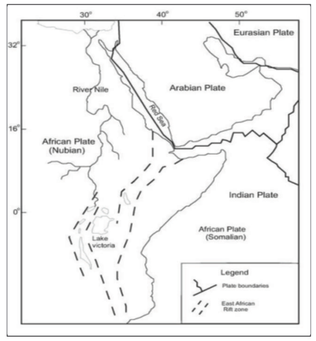

Fig.2 Rift System east and south east of the study area

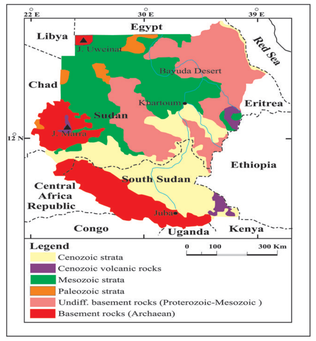

Fig.3 Geological map of the study area

METHODOLOGY

Earthquake data spanning the period between 1632-2009 covering Sudan and South Sudan compiled from regional and international sources was supplemented by the work of Babiker (2009), [3] in the Red Sea. The collected data was then plotted in a GIS layer in order to produce a seismicity map of the Sudan and South Sudan (Fig. 4). The integration of the seismicity and the tectonic maps resulted in the production of seismotectonic map (Fig. 5).

RESULTS AND DISSCUSSION

The Seismicity map (Fig.4) shows that the study area lies within seismically active region. The seismotectonic map enabled the identification of three major seismic source zones confined to South Sudan, northeast Sudan and central Sudan. A minor seismic source zone of low seismicity is attributed to volcanic activity in Jebel Merra and the Bayuda Desert.

1/ Southern seismic source zone (SSSZ)

The seismic activity in this zone is relatively higher than the other zones. It is possibly related to the extension of the western branch of the East African Rift system along the active Aswa Fault zone (AFZ) or alternatively to rejuvenation of movement in the fault-bounded South Sudan rifts e.g. Muglad and Melut Basins.The region around Aswa Fault zone experienced several earthquakes of various magnitudes during the last 150 years. The earthquake of May, 20, 1990 (*Ms*=7.2) was the largest earthquake in Africa and followed by a series of aftershocks (*Ms*= 6.2 and less).

2/ Northeastern seismic source zone(NSSZ)

This zone extends eastward from the River Nile to the Red Sea coast and is characterized by relatively low to moderate seismic activity compared to the SSSZ. The seismic activity in this zone could be attributed to reactivation of movement along older Precambrian lineaments; or possibly due to rejuvenation of movement in the fault-bounded interior basins in central Sudan.

3/ Central seismic source zone(CSSZ)

This zone occupies the central part of the area under present consideration (Fig. 5). Seismic activity within this zone (e.g. at Jebel Dumbier and Khartoum areas) might be associated with the rejuvenation of movement along the CASZ and/or to extensional tectonics related to the rift basins e.g. the Blue and White Nile Rifts [7], [8].

1/ Tectonic units related to sutures and shear zones

From the above results three major tectonic units related to the seismic activity in the study area can be recognized:
These are aligned in N-S or NE-SW directions; e.g. Allagi, Onib-Sol Hamid, Oko, Hamisana, Nakasib and Baraka suture/shear zones that occur mainly in the northeastern part of the Sudan (the Nubian Shield), together with the southeastern and southern parts of the study area (Fig. 6). Consequently, many recent earthquakes could be associated with rejuvenation of movement along this shear zone. In South Sudan the Aswa Shear Zone, a NW-SE trending fault, is responsible for the present seismicity related to the East African Rift Zone.

2/ Tectonic units related to sedimentary basins

The opening of South and Equatorial Atlantic Ocean in the Late Jurassic/Early Cretaceous has resulted in the development of strike-slip and extensional basins in West and Central Africa as far as Sudan and South Sudan [4], [5]. The Mesozoic extension resulted in the formation of major NW-SE rift basins in Central and South Sudan located north and south of the Central African Shear Zone (Fig. 7).

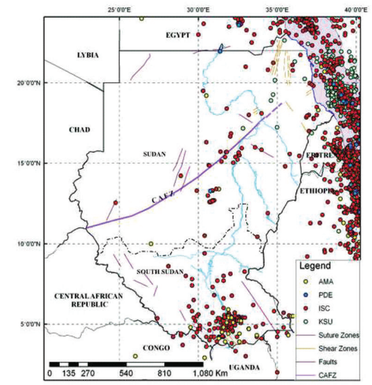

Fig.4 Seismicity map of the study area

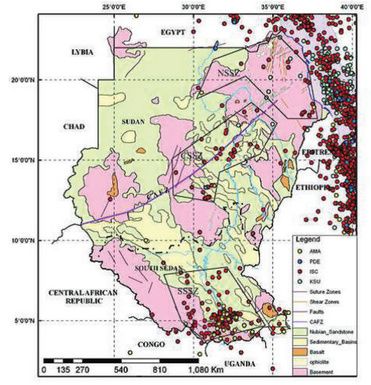

Fig.5 Seismotectonic map of the study area

3/ Tectonic units related to Cenozoic faulting

Cenozoic tectonics comprising recent faults are confined to the eastern part of Sudan where a number of N- and NE-trending sutures and shear zones (Fig. 6) are largely controlled by preexisting Precambrian fault system [12] and [11]. Many of the earthquakes in the area west of the Red Sea are attributed to the movements along those fractures. Recent faults associated with the volcanic activity in Darfur, central Sudan and Southern Kordofan are largely controlled by reactivation of the CASZ and subsequent movement in the fault-bounded sedimentary basins, e.g. recent faults of Jebel Dumbeir [7].

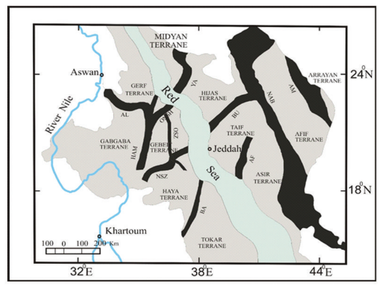

Fig.6 Tectonic map of the Nubian Arabian Shield

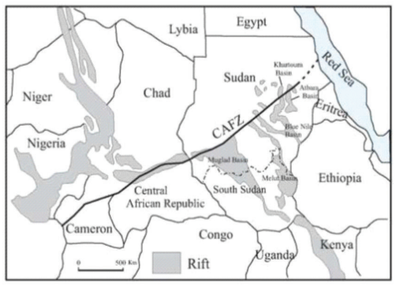

Fig.7 Central African Fault zone and Rift basins in Cental Sudan

REFERENCES

[1] Ambraseys N. N., Adams R. D., 1986. Seismicity of the Sudan, Bulletin of Seismological Society of America v.76, p. 483-493, No. 2.

[2] Ambraseys N. N., Melville C. P., Adams R. D., 1994. The Seismicity of Egypt, Arabia and the Red Sea a historical review. Cambridge University Press, 181p.

[3] Babiker M. O., 2009. Earthquakes catalogue and seismic hazard assessment of the Red Sea Region, PhD Thesis, Sudan Academy of Science, Khartoum, Sudan.

[4] Fairhead J. D., Green C. M., 1989. Controls on rifting in Africa and the regional model forthe Nigeria and Niger rift basins. J Afr Earth Sci. v. 8, p. 321-249.

[5] Guiraud R., Maurin J. C., 1992. Early Cretaceous rifts of western and central Africa.Tectonophysics. v. 213, p. 153-168.

[6] Mula A. H. G., 1990. Recent earthquake sequence of May 1990 in Juba area Sudan, unpublished report, university of Khartoum.

[7] Qureshi I. R., Sadig A. A., 1967. Earthquakes and associated faulting in central Sudan, Nature v. 215, p. 263-265. No. 5098.

[8] Schandelmeier H., Pudlo D., 1990. The Central African Fault Zone (CAFZ) in Sudan – a possible continental transform fault. Berliner Geowissenschaftliche Abhandlungen. Reihe A v. 120, p. 1:31-44.

[9] S.R.I., 2003. Analysis of Abu Deleig earthquake, Unpublished report, seismological research institute-Sudan.

[10] S.R.I., 2010. Report of Khartoum earthquake, September, 2010. Unpublished report, seismological research institute-Sudan.

[11] Vail J. R., 1978. Outline of the geology and mineral deposits of the Democratic Republic of Sudan and adjacent areas overseas geology and mineral resources No. 49 J GeolSoc London.

[12] Whiteman A. J., 1971. The geology of Sudan Republic Clarendon Press Oxford UK.