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Recent seismicity in the Mozambique region and its impact / effects on South Africa

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ABSTRACT:

The seismic pattern of the southern extension of the East African Rift in Mozambique is presented in this study with special reference to the M=7.0 earthquake that occurred on 23 February 2006. Seismicity in Mozambique is associated with tectonic activity along the East African Rift, which forms the boundary between the African (Nubian) plate in the west and the Somalian plate in the east. The seismic event that occurred in the Manica province of Mozambique on 23 February 2006 was the largest event prior to 2006 was recorded in 1951 as an M=6.6 earthquake. However, it should be noted that a maximum credible earthquake of M=7.3 was assigned during the Global Seismic Hazard Assessment Programme study for a broad zone encompassing the area. Damage caused by the earthquake was limited though it was felt across a large part of southern Africa. Reports of two fatalities were received from Beira indirectly linked to the earthquake while most damage was centered on the town of Machaze where an unconfirmed number of people were either killed or injured (unconfirmed reports indicate 5 fatalities and 30 injuries). Reports also indicated that numerous houses and businesses were damaged during the earthquake. The estimated intensity levels in Durban and Johannesburg from reports indicate II-III on the Modified Mercalli scale. The shaking levels of the event reveal a surprising trend that is counter-intuitive to normally observed damage from similar events, given that Durban is more than 1000km from the epicenter. This work looks at the Gutenberg-Richter frequency magnitude distribution of earthquakes in this region.

Keywords: Mozambique, intensity, attenuation relation, Gutenberg-Richter.

1. INTRODUCTION

On 23 February 2006, a Mw 7, earthquake occurred on a ‘blind’ fault near Chitobe in Mozambique’s Manica province (Fenton and Bommer, 2006). The earthquake affected South African high rise buildings in Durban. Shaking occurred and people were evacuated from the area, numerous reports of collapsed walls in Durban were made.

Therefore, the threat of Mozambique seismicity, whose magnitudes vary from 2 to 7, is a concern for South Africa. Seismologists from South Africa need to pay much more attention to the causes and effects of these events.

2. TECTONICS

The earthquake occurred near the southern end of the East African rift system, which is a diffuse zone of crustal extension that passes through eastern Africa from Djibouti and Eritrea on the north to Malawi and Mozambique on the south. It constitutes the boundary between the Africa plate on the west and the Somalia plate on the East African Rift System (EARS). The EARS (FIGURE 1) is divided into Eastern and Western branches which merge through a broad zone of faults at the northern tip of Lake Malawi in southern Tanzania (Fenton and Bommer, 2006).

At the earthquake's latitude, the Africa and Somalia plates are spreading apart at a rate of several millimeters per year (USGS, 2006). The largest earthquake to have occurred in the rift system since 1900 had a magnitude of about 7.6. The fault was mainly normal faulting with a small left-lateral slip along the fault plane (Feitio et al., 2008).

Figure 1: Tectonic setting of the East African Rift System (after Crossley and Crow, 1980). FZ = fault zone

3. SEISMICITY

Data captured in the South African National Seismological Database (SANSB) was used to determine the level of seismicity in the study area. The SANSB is a compilation of seismological data from the South African National Seismograph Network (SANSN), Goetz Observatory (Zimbabwe), the International Seismological Center (ISC) and the National Earthquake Information Seismological Bulletins since 1977. Declustering based on an algorithm by Reasenberg (1985), found 93 clusters of earthquakes, a total of 272 events (out of 2232). The declustered catalogue remained with 1960 events (FIGURE 2).

Due to limited coverage of the area by seismograph networks, small events are generally missing from the catalogue (FIGURE 3). Based on the magnitude histogram in Figure 3, the highest peak and mostly recorded events by our seismic stations are of magnitude 4.5. On the time histogram (FIGURE 3), a large fluctuation in number of events is observed in 2006. This is associated with aftershocks of the 23 February M7.0 event. The increase in seismicity observed after 1960 is a reflection of the increase in numbers of regional seismograph stations being set up.

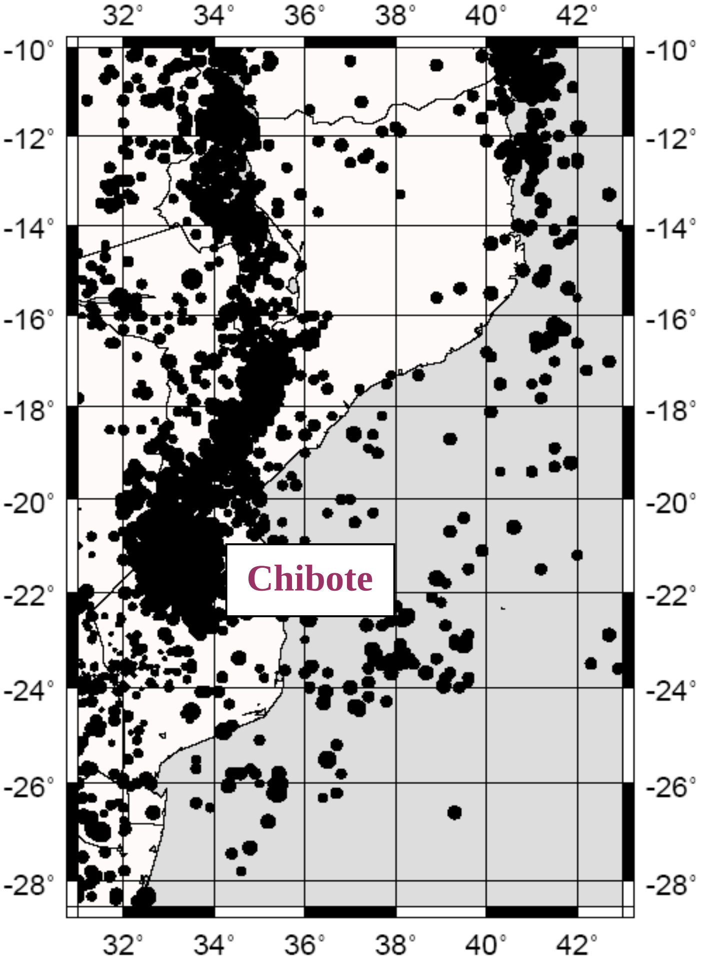

Figure 2: Seismicity map showing the hot spot from 1891-2008.

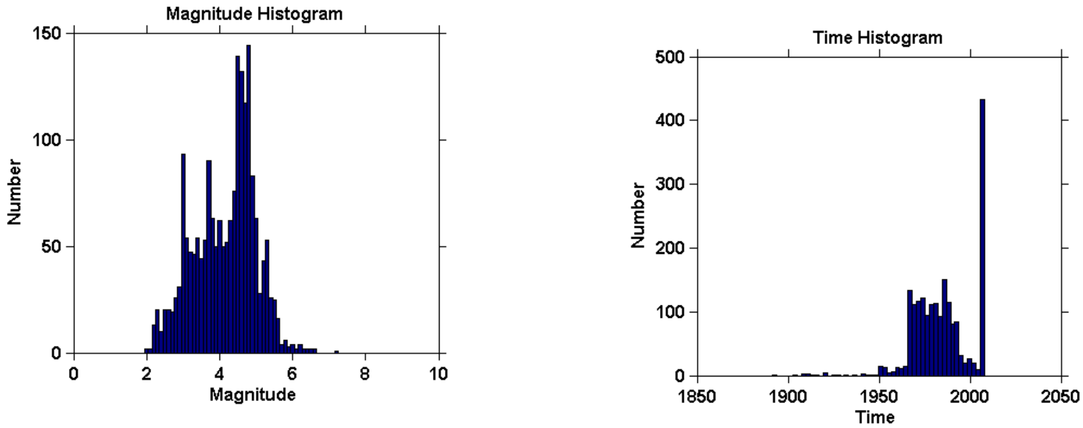

Figure 3: Magnitude and Time histograms

4. EARTHQUAKE MAGNITUDE RECURRENCE

The random earthquake magnitude, m, in the range of Mmin ≤ M ≤ Mmax, is distributed according to the doubly truncated Gutenberg-Richter relation.

$$\log_{10} N(m) = a - bm \qquad (4.1)$$

Where N(m) is the number of earthquakes with magnitude m, and stronger, a and b are activity rate and b – values parameters respectively (FIGURE 4). The Gutenberg – Richter b-value gives the slope of the frequency–magnitude curve and defines the ratio between the number of large and small earthquake occurrences. Thus it is indicative of the tectonic characteristics of a region

In this study the maximum likelihood method was used to fit the data and determine the recurrence parameters. A b-value of 0.988 was obtained which compares to that of 0.929 published for the same zone by Midzi *et* al., (1999). Given that small earthquakes are missing from the catalogue (FIGURE 3), it is necessary to determine the magnitude above which the catalogue can be considered to be reasonably complete. The Gutenberg Richter equation (FIGURE 4) is used to find that the threshold lies at a magnitude of 4.5. An activity value (a) of 5.3 was observed for earthquakes of magnitude greater than 4.5.

Mmax can also be obtained by determining the magnitude recurrence for the area of study (FIGURE 5). It is shown that in a return period of 475 years, a maximum possible regional earthquake of magnitude, M_{max} = 7.7 is possible.

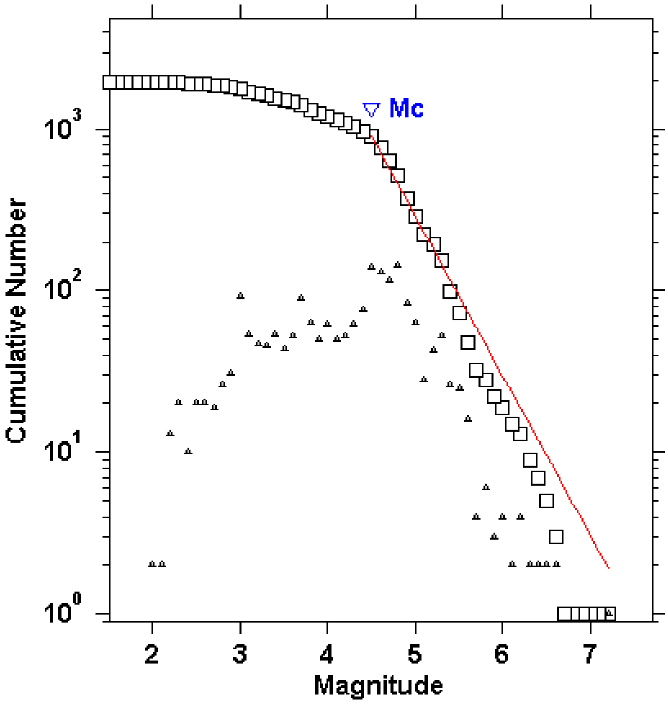

Figure 4: Showing the maximum likelihood solution with b-value, activity rate and magnitude of completeness

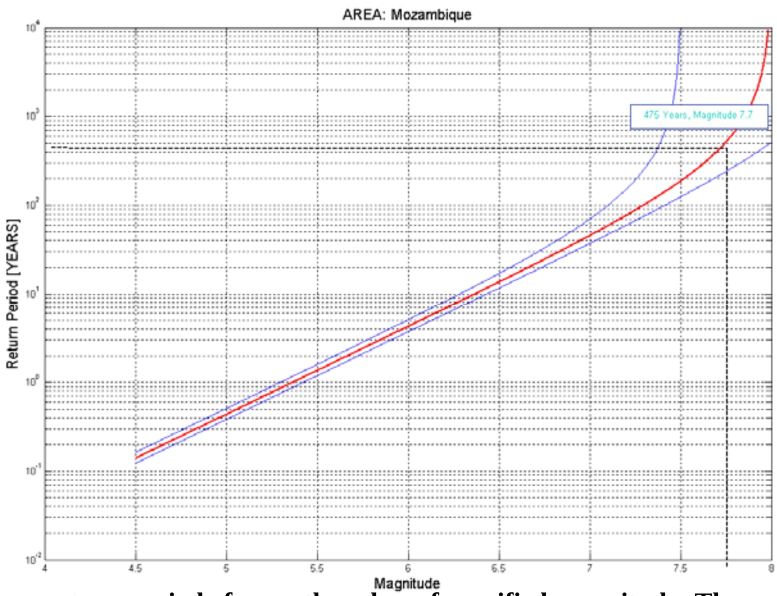

Figure 5: The mean return periods for earthquakes of specified magnitude. The red curve shows the mean return period, while the two blue curves indicate the mean return periods plus and minus the standard deviation.

5. EFFECTS OF MOZAMBIQUE EARTHQUAKES IN SOUTH AFRICA

5.1 Intensity values

According to the USGS (2006), the earthquake was felt throughout southern Africa with South African cities experiencing shaking of intensity levels (IV) for Louis Trichardt and Phalaborwa, (III) for Durban and Middelburg, (II) for Johannesburg and Pretoria The shaking levels of the event reveal a surprising trend that is counter-intuitive to normally observed damage from similar events, given that Durban is more than 1000km from the epicenter. Suggestions to explain this trend include that the waves are not attenuated as much as previously thought. Site effects may have also played a part in amplifying the signals. These observations show that much more research is necessary in the region to investigate the earthquakes, attenuation and site effects.

5.2 Seismic Hazard

Seismic hazard can be described as the physical effects of an earthquake. Examples of such phenomena include surface faulting, ground shaking and liquefaction. Seismic hazard has previously been investigated in this region (Midzi *et al.*, 1999 and Kijko *et al.*, 2003) and in all cases expressed as peak ground acceleration. The probabilistic seismic hazard map of South Africa (FIGURE 6) published by Kijko *et* al., (2003) shows peak ground acceleration of approximately 0.01g to 0.24g in the Durban and Johannesburg regions. However, most of this hazard is associated with mining related activity in the South African gold mines. It will be necessary to determine the effect on South African seismic hazard of the M7.0 Mozambique earthquake. In such an investigation reliable attenuation relations are important.

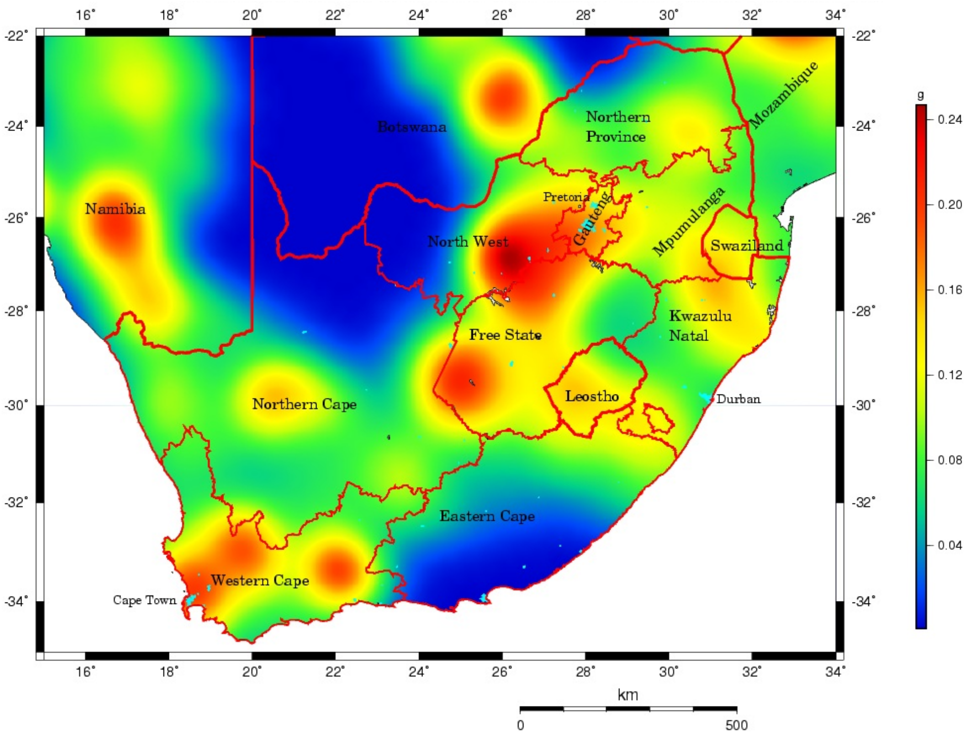

Figure 6: PGA with a 10 % probability of being exceeded in a 50 year period

6 CONCLUSIONS

There is potential for large earthquakes occurring at the southern extent of the East African Rift System in Mozambique. Based on the observations presented in this study, the earthquakes occurring in the South western part of Mozambique can potentially have a devastating effect through poorly attenuated and amplified ground motion on South African structure. It is clear that much more work needs to be carried out to investigate these earthquakes and their effects in the region.

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