

Contribution of the IMS in localization of the 28th March 2016 Okavango Delta Tremor, Botswana

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INTRODUCTION

The event in the Botswana's Okavango Delta Region (ODR) was the largest in the year 2016. The shaking was felt and reported by people living in the surrounding areas. Although the tremor was relatively small (3.7 ML Magnitude), the event prompt for study of the Kunyere and Thamalakane faults which together represent a southwestern extension of the East Africa Rift System (Modisi et al., 2000). The focal region was localized using seismographs from the IMS stations located in Southern Africa, supplemented by recordings from the South African National Digital Seismic System. The combined datasets from the different seismic networks provided improved observational and azimuthal coverage, and improved event location, showing the usefulness of data sharing, collaborative problem solving and regional cooperation in promoting preparedness. Moreover, the present work demonstrates the potential of IMS data for civil and scientific applications and its contribution to the global promotion of benefits from the CTBTO.

LOCATION AND TECTONIC SETTING

In northwestern Botswana lies the famous alluvial Okavango delta (Figure 1), which is one of the world's largest inland water systems. The delta's headwaters initiate the western highlands of Angola, with numerous tributaries interconnecting to form the Cubango river. Tectonic activity and faulting interrupted the flow of the river and caused it to backup and form what is now the Okavango delta. This has created a unique system of water ways that now supports a vast array of animal and plant life that would have otherwise been a dry Kgalagadi savanna.

The Okavango Delta is located on the North-East trending Neoproterozoic Pan African orogenic known as the Damara Belt. Below the Okavango Delta, there are extensional tectonic movements that created a topographic low region referred to as the Okavango Rift System (ORS). The tectonic activity has led to high incidence of earthquakes in the area (Reeves, 1972; Hutchins et al., 1975 and Scholz 1975). Thus according to scholars, the 18000 square-kilometer delta owes its origin to a southwesterly extension of the East African Rift system or EARS which has given rise to the ORS (Figure 2). The ORS is a described as a large graben structure transecting the course of the Okavango river (Shemang and Molwalefhe, 2011) with the main faults in this area being the Gumare, Thamalakane and Kunyere faults all trending North East – South West (Figure 3).

THE 2016 MARCH 28TH SEISMIC EVENT

The minor earthquake was the latest to occur in the ORS. It happened on the 28th March 2016, 20:10:06.90 (UTM) and had a Richter local Magnitude (ML) 3.7. The Epicenter was 83 Km North-West of Maun (-19.3210, 23.7960) with the depth fixed at 10 Km. The tremors were reported to have been felt by some local residents and some may have not recognized as an earthquake. Figure 2 shows the location of the event in relation to the historical seismic events. According to the International Seismological Centre, there are 107 seismic events recorded in the ORS. The catalogue of events with Magnitudes of above 4.0 are listed in Table 1 from the period of 1950 to 2016.

The International Monitoring Stations (IMS) stations in the area recorded the seismic disturbance and were used for epicentral location and analysis. The waveform data was requested using the *ctbto* secure web portal. Waveforms from Five (5) IMS stations were analyzed in Geotools (Figure 4) to derive the epicenter and its associated magnitude. The location agreed very well with South African Council for Geoscience event bulletin, which used total of 20 stations from South African National Seismograph Network (SANS) (Figure 5). The map option on the Geotools shows the epicenter location and the regional IMS stations used for localization (Figure 6).

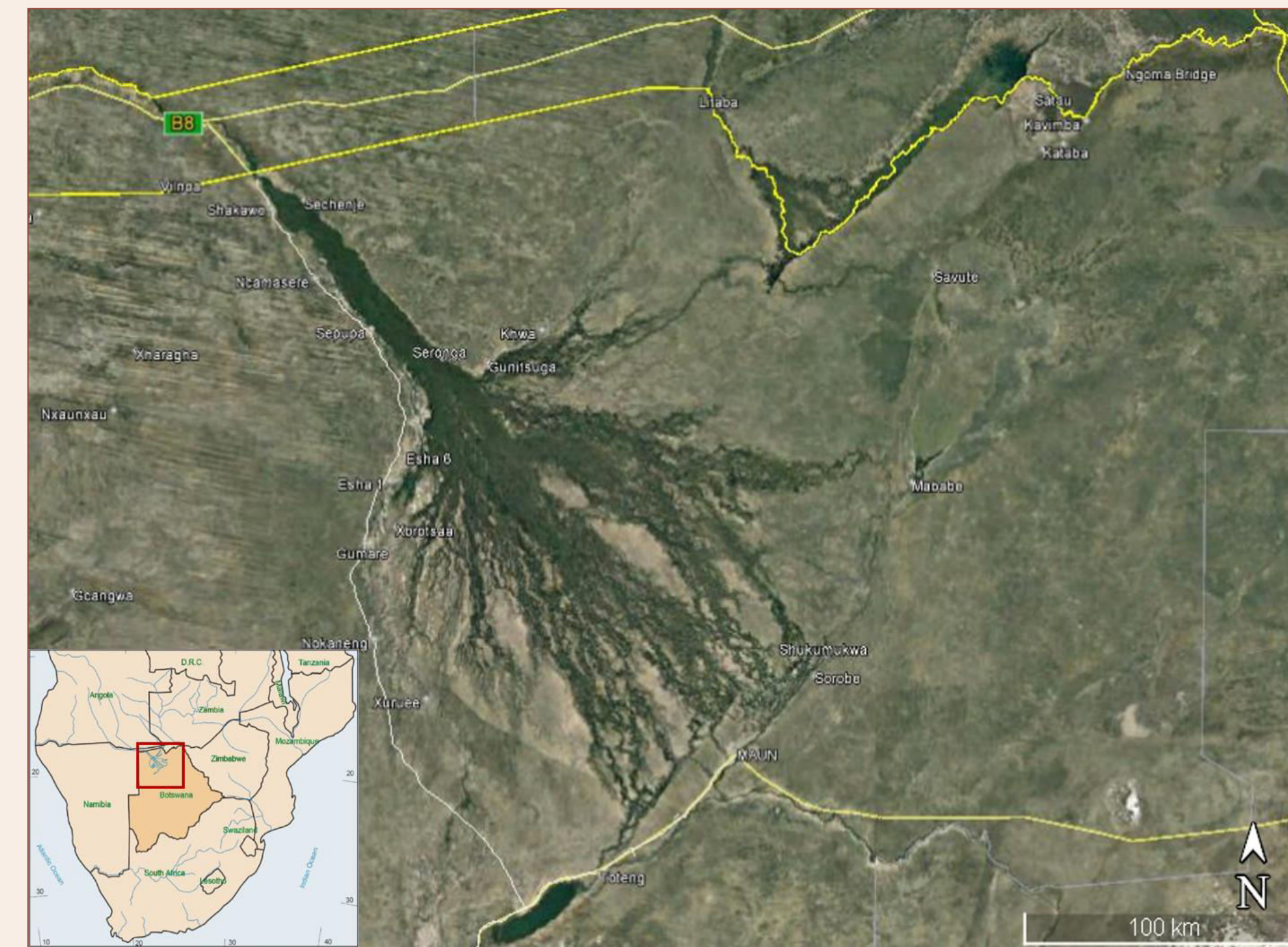


Figure 1: The locality map of the Okavango Delta Region (ODR) in Botswana.

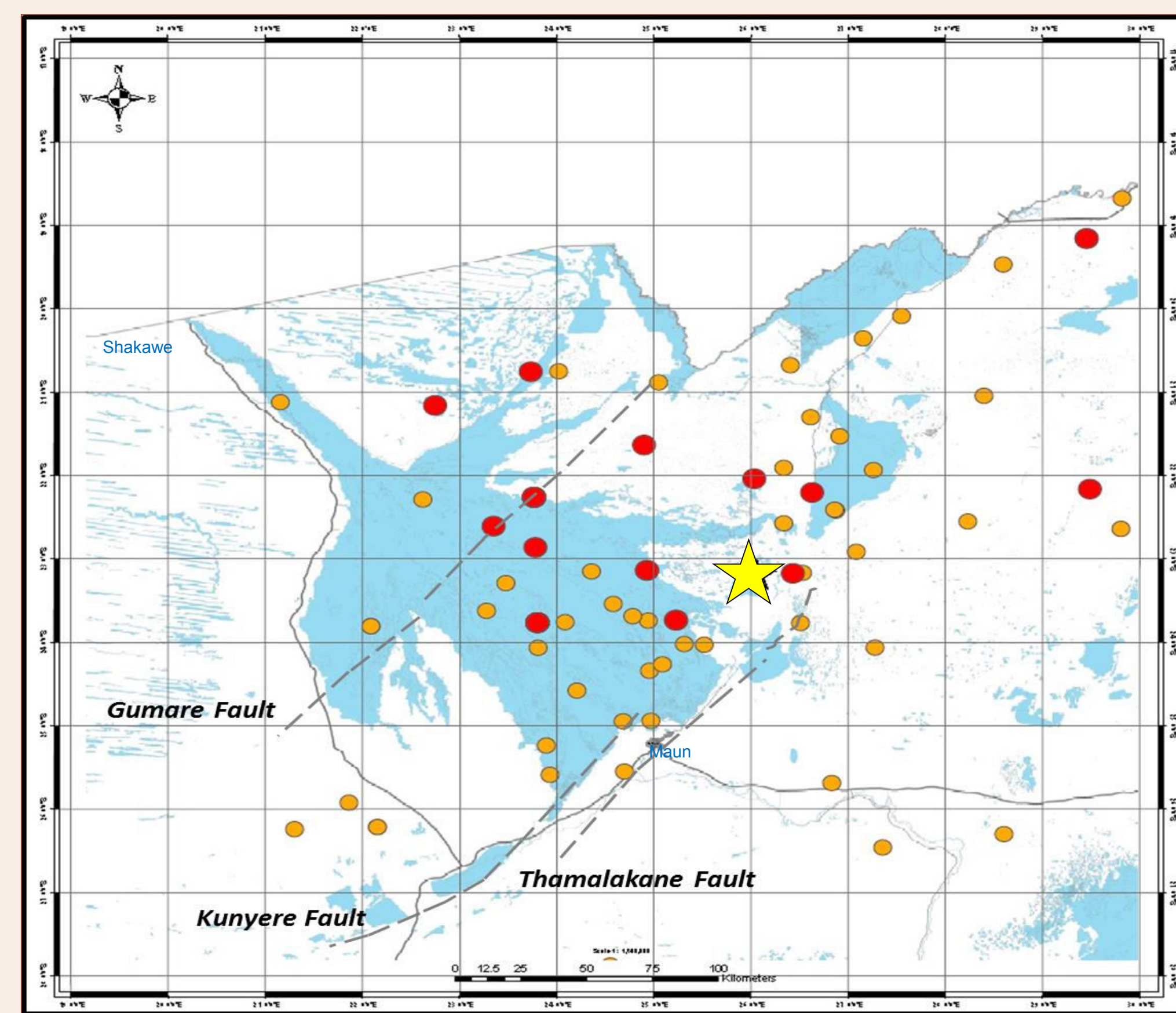


Figure 3: Map showing the epicentral location of the 2016 March 28 tremor (Yellow Star) in relation to the seismicity of the Okavango Delta for the period 1950 to 2016 and the NE-SW trending Kunyere, Thamalakane and Kunyere faults.

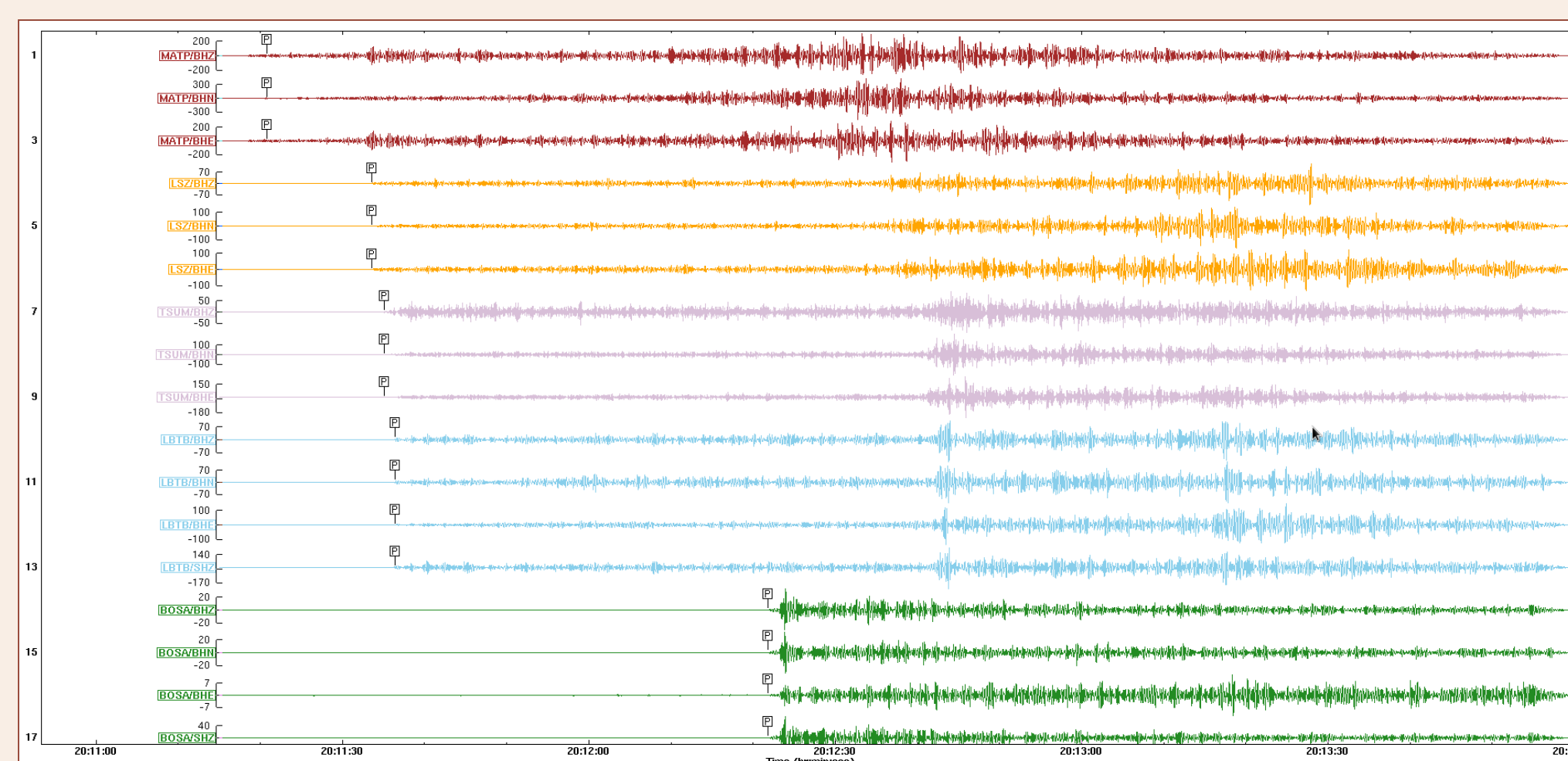


Figure 4 Waveforms from IMS stations as displayed on GEOTOOLS

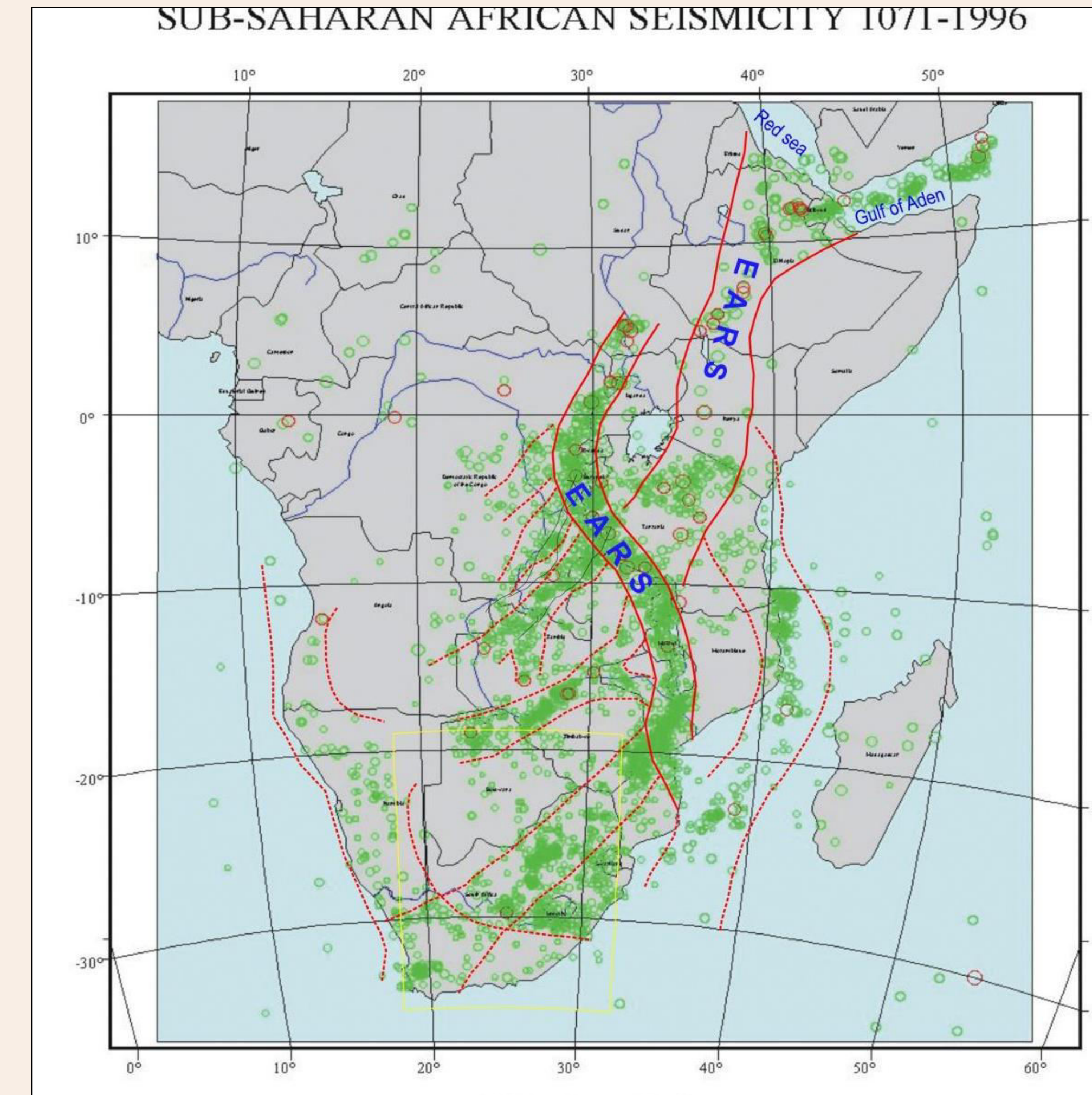


Figure 2: Seismicity of Sub-Saharan Africa (Council for Geoscience, 2002) with solid red lines outlining the main East African rift system or EARS, while dashed lines indicate regions of high seismic activity outside EARS (Kwadiba, 2006).

DATE	LAT	LON	DEPTH	AUTHOR	MAG_TYPE	MAG
11/09/1952	-19.63	23.26	15	ISC	MS	5.7
11/10/1952	-19.61	23.27	15	ISC	MS	5.6
5/07/1971	-19.32	23.93	20	BUL	M	5.1
16/12/1971	-18.78	24.10	30	BUL	M	4
22/01/1972	-19.54	23.41	17.9	BUL	M	4.6
6/03/1972	-20.87	23.23	120.2	NEIS	mb	4.7
15/05/1974	-20.16	23.29	0	BUL	M	4.1
3/06/1976	-18.61	23.10	0	BUL	M	4.2
20/01/1986	-18.93	21.95	10	ISC	mb	4.3
18/09/1987	-17.52	25.17	10	ISC	mb	4.1
2/12/1991	-19.60	23.54	10	ISC	mb	4
22/07/1993	-18.55	23.46	10	ISC	mb	4.4
14/02/1999	-19.27	21.26	5	PRE	ML	4.5
6/12/2008	-19.75	23.63	5	PRE	ML	4.8
1/05/2009	-18.94	23.79	10	ISC	mb	4
31/10/2014	-20.20	21.10	10	EAF	md	4
24/12/2014	-20.98	21.69	0	BUL	MD	4.2
24/12/2014	-19.50	24.17	0	EAF	MD	4.1
30/12/2014	-20.34	23.79	51.2	BUL	MD	4.6

Table 1: A Catalogue of some events (M ≥ 4.0) in the Okavango Delta region.

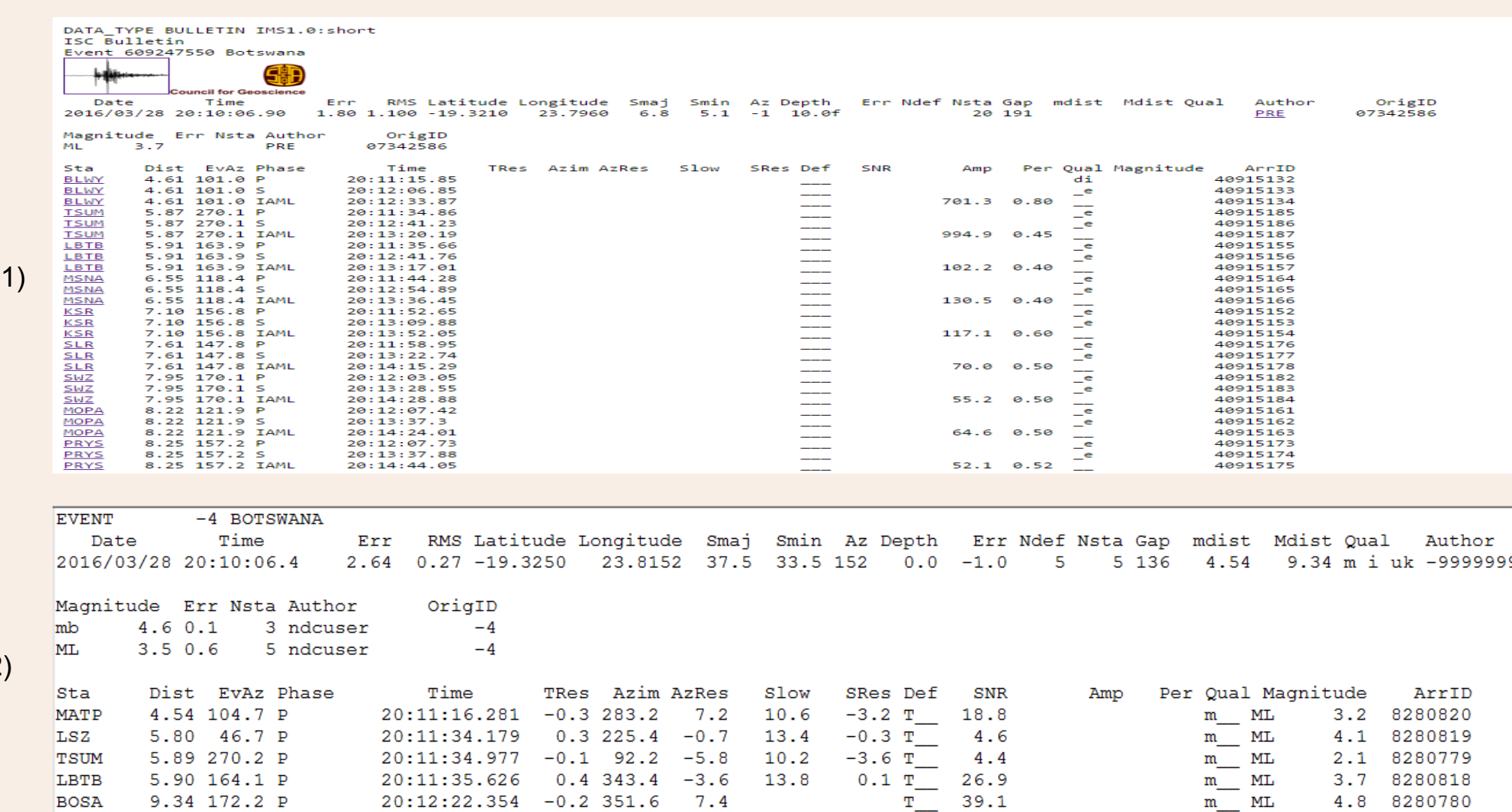


Figure 5: (1) A single-event seismic bulletin of the 2016 March 28 from the Council for Geoscience (<https://www.geoscience.org.za>) and (2) Bulletin from the IMS stations

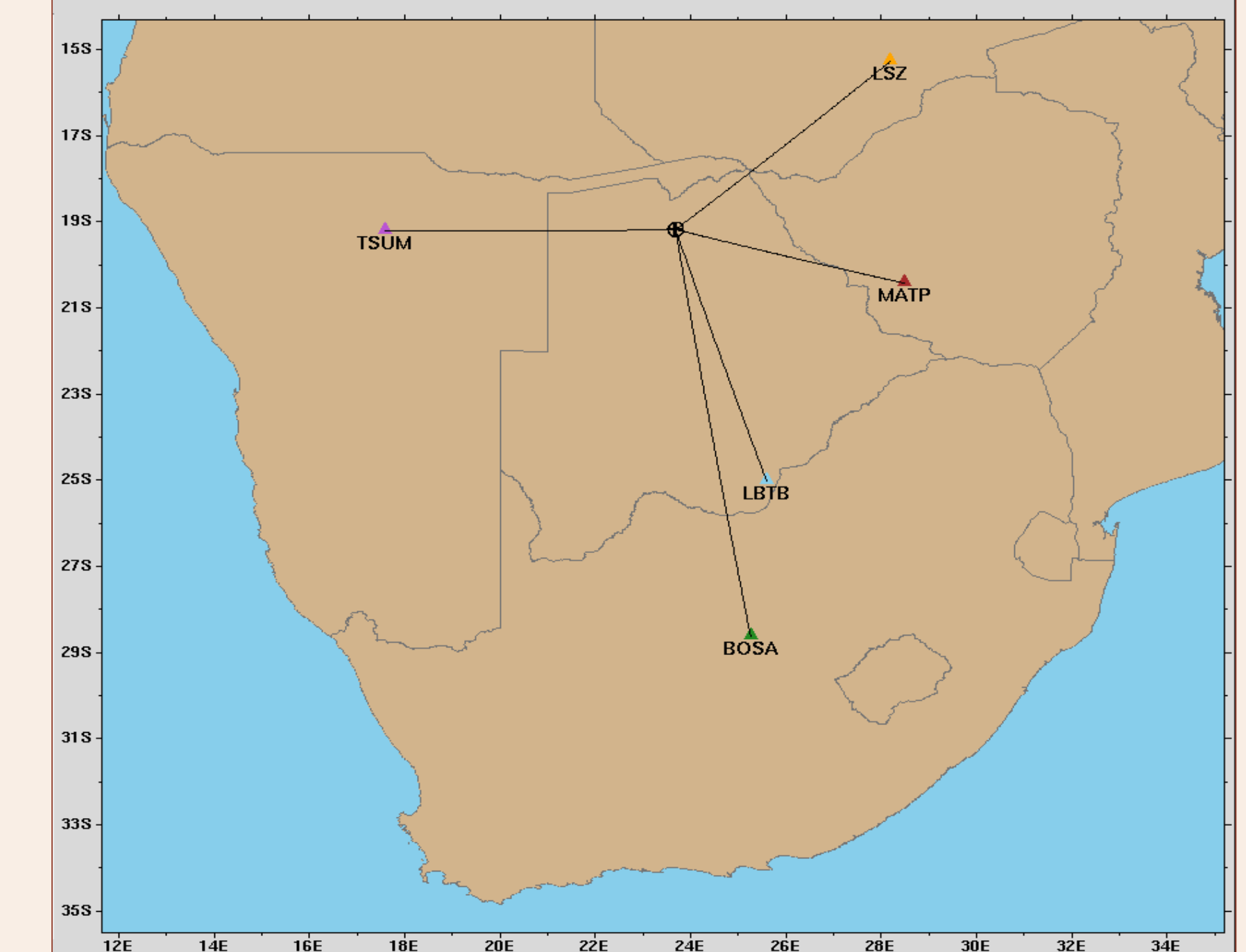


Figure 6: Epicentre location in relation to IMS stations (LBTB - Botswana, MATP - Zimbabwe, TSUM - Namibia, LSZ - Zambia and BOSA – South Africa)

DISCUSSION AND CONCLUSION

A total of more than 142 seismic events were recorded in the area of interest according to the ISC event catalogue. The largest event occurred during the earthquake swarms of the period May 1952 – May 1953, having magnitude of 6.7 M_L (5.7 MS) in September 11 1952 and epicentral location -19.628° S and 23.258° E. According to Pike (1970), these 1952 events altered the drainage pattern of the Okavango delta. There are some historical information that shows that some of the tremors may have been felt by people or recorded by seismographs but without epicentral location (Ngwisanyi and Kwadiba, 1999).

The location of the 28 March seismic event is approximately 65 km NE from the epicentre of the largest earthquake to hit the region. This seismic disturbance confirm the previous studies that shows that faults (Thamalakane, Kunyere and Gumare faults) associated with tectonic rifting are still active and thus they is a need of seismic monitoring.

With the challenges that Botswana's National Data Centre is having with deploying real-time seismic stations in the ODR, The IMS stations provide an alternative for locating seismic events such as those in the area for the benefit of both local residents, policy makers and for academic purposes.

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