Seismic Observation and Seismicity of Zimbabwe

Mr. Innocent Gibbon Tirivanhu MASUKWEDZA (2016 Global Seismology course)
Meteorological Services Department of Zimbabwe

1. Introduction

The Seismology section falls under the Meteorological Services Department of Zimbabwe. Currently, the department is functional under the Ministry of Environment, Water and Climate as a result of its main purpose being to contribute towards the safety of both life and property of Zimbabwe inhabitants.

2. Historical Background of Seismicity Measurements

The need to monitor the seismicity of Zimbabwe came about by the construction of the Kariba dam as a way to monitor reservoir induced seismicity, but the idea was further expanded to include natural earthquakes. By then, the seismological station network composed of four analogue stations namely Bulawayo, Karoi, Mt Darwin and Chiredzi and these operated up to early 1990s. Although the dam construction began early in the 1950's, seismograph stations were not deployed to monitor seismic activity until 1959, the year the dam was impounded. Since then, seismic activity in and around Zimbabwe has continuously been monitored.

For the period 1959 to date, over 4,000 earthquakes in and around the country have been recorded. The largest earthquake recorded is that of magnitude 6.1 which occurred at Lake Kariba on September 23, 1963. The instruments to measure the seismicity of the country were issued to St George's School (located in the city of Bulawayo) and later transferred to the Lawley Road site (situated in the same city) in 1903 with the arrival of Father Goetz.

The main historical events after the arrival of Father Goetz are:

- **1950** – Dam wall construction of Lake Kariba and the sudden need for a seismological station.
- **1959** – The first seismological network is setup after the completion of the Kariba dam wall. It was run by the Geological Survey of the Federation of Rhodesia and Nyasaland Government until 1960 when it was handed over to the Rhodesia Meteorological Services Department.
- **1963** – Six-component World Wide Seismograph Station Network (WWSSN) is set up in Bulawayo.

- **1966** – Six permanent seismological network stations are set up throughout the country increasing the accuracy and reliability of our data namely in Chiredzi, Bulawayo, Kamativi, Karoi, Kariba, and Mount Darwin.

- **1980** – The Republic of Zimbabwe breaks away from the network stations to the north and recognizes its own network as independent.

- **1994** – Zimbabwe joins the Eastern and Southern Africa Seismology Working Group (ESARSWG) which works in cooperation with the International Association of Seismology and Physics of the Earth's Interior (IASPEI).

- **2002** – The new Matopo's Seismic station is initiated together with a Modernized Seismic Monitoring System marking an end to manual earthquake analysis at the observatory and paving the way to computerized seismic monitoring.

- **2003** – Installation of advanced Global Communications Infrastructure (GCI) at the NDC/Goetz Observatory and equipment give us the opportunity to receive and send seismic data in real time.

- **2004** – The Matopos Seismic station is certified for the International Monitoring System (IMS) as an Auxiliary Seismic station (AS 120) by the preparatory Commission for the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO).

- **2013** – Installation of Chipinge station and the reintroduction of Karoi station to the Zimbabwe network.

3. Current Zimbabwe Seismological Network

The seismological network is made up of four broadband stations (shown in Fig. 1): Bulawayo's Goetz Observatory (BLWY), Karoi (KRI), Chipinge (CHIPN) and Matopos (MATP). The MATP station is also an auxiliary station for International Monitoring System (IMS).

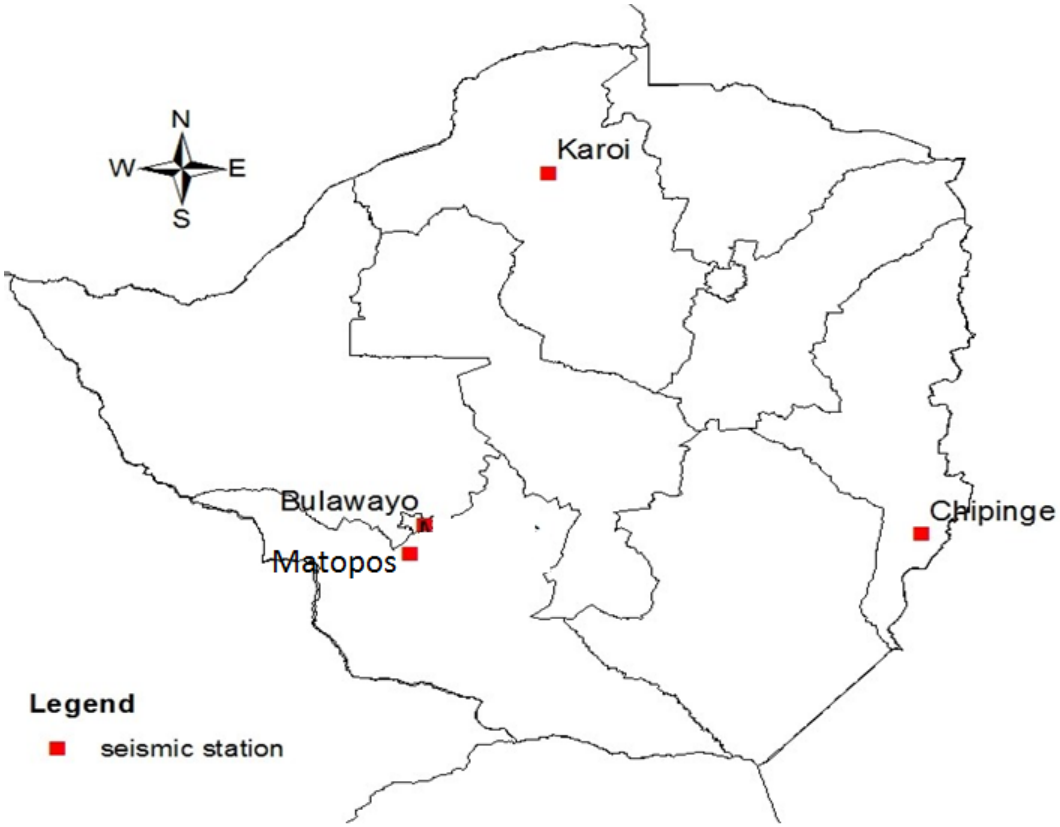

Figure 1. Seismic Observation Network.

4. National Data Centre (NDC): Goetz Observatory Zimbabwe

Meteorological Services Department's Seismology section in Bulawayo at Goetz Observatory operates the seismic network for Zimbabwe, where the data coming from Matopos (MATP), Bulawayo (BLWY), Karoi (KRI), and Chipinge (CHIPN) is received. Data from other regional networks and from International Monitoring System (IMS), products of the International Data Centre (IDC) from Vienna, Austria, are received and analysed at the NDC. Data acquisition as well as the processing systems running at Goetz Observatory in Bulawayo (BLWY), consist of the following:

a) Data acquisition and post-processing workstation.

b) VSAT communication equipment for the connection between MATP and IDC.

c) Network timeserver with GPS antenna [True Time].

d) Uninterruptible power supply unit, hub.

Zimbabwe NDC (ZIM_NDC) collaborates with national and international organizations for upgrading and maintaining the AS120-MATP seismic station at the technical and operational standards required by the CTBT. Since October 2001, the seismic system at AS120-MATP station consists of: Seismic equipment at MATP site and seismic sensors located in the tunnel. Some of the equipment includes a broadband seismic sensor model: STS-2 (Streckeisen), communications modules (modem, wireless router); data acquisition software installed on the local PC and an uninterruptible power supply unit (UPS).

The comparison between reviewed bulletins produced by ZIM_NDC and IDC shows that most of the earthquakes with magnitudes mb>3.5 located with ZIM_NDC (using the national seismological network) are also located by IDC using the global seismological network. For the majority of common events, the locations are in good agreement regarding epicentre, depth and origin time estimations.

5. Zimbabwe Seismicity

Zimbabwe, in southern Africa, lies at the southern tip of the East Africa Rift System. The Meteorological Services Department is responsible for earthquake monitoring in Zimbabwe with Goetz Observatory as the National Data Centre. The map below (Fig. 2) shows that the country can be divided into at least three broad seismic zones, namely; the Eastern border area, Zambezi area and the Central Area.

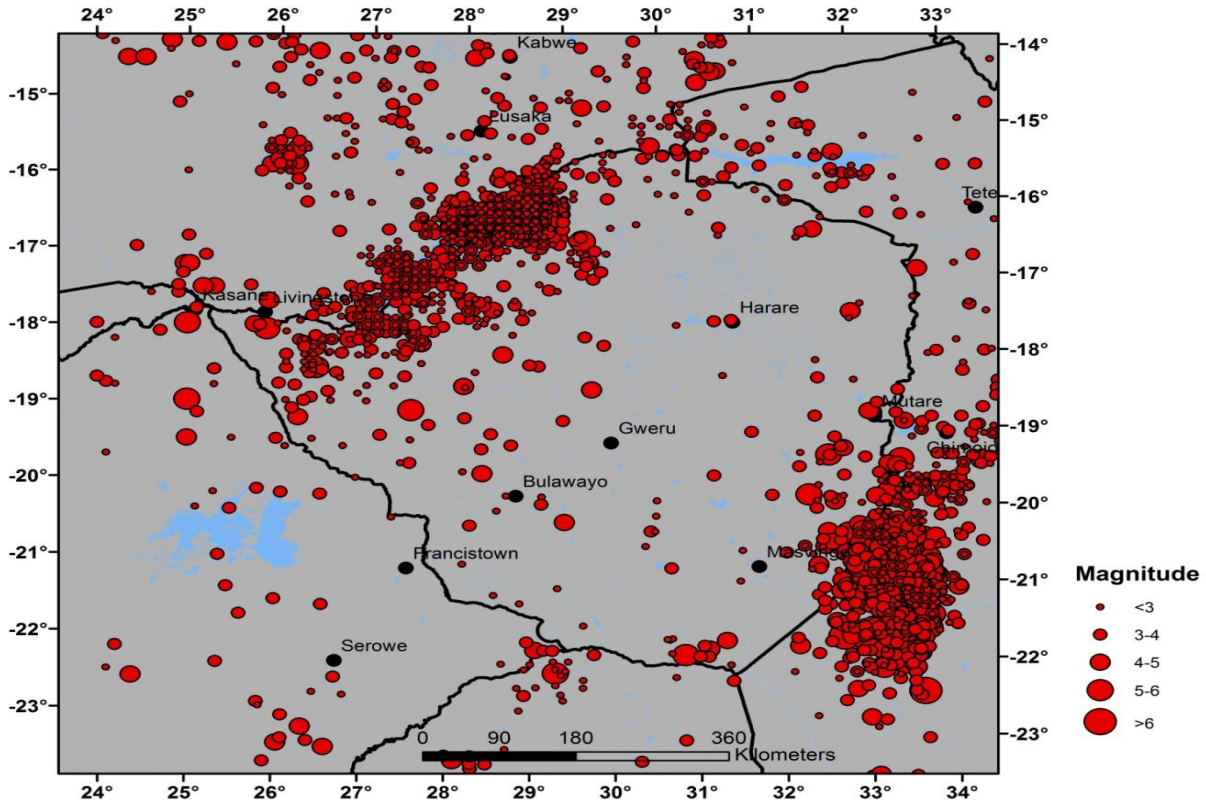

Figure 2. Zimbabwe's seismicity for the period 1959-2015 (Marimira et al., 2015).

I. Zambezi area

This region extends from the northern tip of the country, in a south-westerly direction through Lake Kariba, Devil's Gorge, the Deka Fault, to the westerly edge of the country. This region is the most active seismic region in Zimbabwe. Earthquakes of magnitudes higher than 5.0 occurred in this region. The largest one was a magnitude 6.1 that occurred on the 23rd of September 1963.

II. Eastern Border area

The Eastern Border area shows high earthquake activity. This area is the southern part of the Great East Africa rift system that is the dormant tectonic feature on the African continent. This system controls seismic activity in eastern and southern Africa and is considered by many to be the best example of continental rifting. Major seismic activity takes place on the eastern (Mozambique) side. The recent earthquake event of 23rd February 2006 which measured 7.4 on the Richter scale emanated from this region (21.22S Latitude and 33.34E longitude). This event was followed by aftershocks some of which, like the three aftershocks of the 15th of March 2006, were felt in the eastern parts of the country as well as some parts of Harare. Aftershocks from the event are still being recorded.

III. The Central area

This area's geology is predominantly stable (granitic) continental shield and may be regarded as aseismic. Earthquakes do, of course, occur in this region but they are both small and very infrequent. An event of magnitude 5.0 occurred in the southern part of the country which is associated with faulting along the Sabi-Limpopo mobile belt. Quite recently, two earthquake events occurred in this region around midnight of the 21st of May 2006 in the Wedza area. The shocks were felt in the eastern, northern and central parts of the country including Harare. The magnitudes were around 4.0.

Notable events

For the period 1959 to present, over 3,800 earthquakes in and around the country were recorded. The largest earthquake recorded is of magnitude 6.1 which occurred at Lake Kariba on September 23, 1963. Some notable events that have occurred quite recently are mentioned below. An earthquake of magnitude 3.0 occurred in the SE of the country, in the Chiredzi area in 1994. This earthquake was widely felt in the southeast over a radius of about 60km into Chiredzi town. Damage to structures was reported in the Ngundu area at Kushinga Secondary School. In the Western region of the country, three events were felt in the Bulawayo and the surrounding areas. The events occurred on the 3rd and 19th of February and 29th of March 1999. The magnitudes of both events were about 3.0 and less. On the 25th of June, 2004, the region was struck again by another earthquake. The event whose magnitude was about

3.5 was felt widely throughout the region. On the 1st of August 2005, another earthquake was felt in the Hwange mining area and the resort town of Victoria Falls and as far as Livingstone on the Zambian side. The epicenter of the event was in the Batoka area and the magnitude was about 3.6.

6. Zimbabwe Participation to the Comprehensive Nuclear Test Ban Treaty (CTBT)

Zimbabwe is a signatory state of CTBT since 21st December 2004. The CTBT bans all nuclear explosions on Earth whether for military or peaceful purposes. Matopos (MATP) AS 120 Seismic Station is presently fully operational as part of an auxiliary network of International Monitoring Network (IMS), fulfilling its mission by locally recording continuous seismic data and forwarding directly to the International Data Centre (IDC) upon request, at any time through online connections and VSAT transmission. Zimbabwe participates in the implementation of the Treaty with the certified seismic station MATP, included in the auxiliary seismic network of the IMS, and with the Zimbabwean National Data Centre. Zimbabwe is also an active part of the Facility Agreement signed with the Preparatory Commission (PTS) for granting the Preparatory Commission the necessary legal authority to carry out work on IMS facilities on Zimbabwe territory. ZIM_NDC team members have participated in numerous training courses and workshops provided by the IDC/IMS thus improving their knowledge and getting more experience in operating an IMS/NDC.