THE EFFECTS OF FEBRUARY 3rd, 2008 EARTHQUAKE IN THE LAKE KIVU BASIN, WESTERN RIFT VALLEY

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ABSTRACT

The lake Kivu basin had experienced an earthquake of local magnitude m_l= 6.1 on February 3rd, 2008 at 7h34' UT, in its south-western part. Many phenomena were generated in the lake Kivu and on the shorelines. At several places were observed land subsidence on the shoreline where several children were killed in D.R. Congo and Rwanda sides. At other places land uplift was observed. According to the fishermen, small tsunami was generated and attacked the coast lines. The highest level accessed by the tsunami was estimated to 4m at Ibindja Island. The small gas escaping generated by the tsunami was observed at several places in the lake Kivu. Many damages were recorded in Bukavu city and surrounding areas in D.R. Congo and Rwanda, characterized by the fissures on the walls or collapse of houses. Total 49 people were killed by the earthquake and aftershocks, more precisely 10 in D.R.C. and 39 in Rwanda. This event was preceded by many foreshocks and followed by a long duration of felt aftershocks. The focal mechanism of this event indicates a normal fault. The maximum intensity was recorded close to the epicentre area and estimated to VIII-IX.

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INTRODUCTION

The East African Rifts system extends from the Red Sea and Gulf of Aden at Afar triangle, Ethiopia in the north to Mozambique in the south, and divided into two branches; the Eastern and the Western which come across at the lake Malawi **(**Figure 1). The Western branch also called Western Rift Valley of Africa includes six lakes; namely: Albert (619 m), Edward (912 m), Kivu (1462 m), Tanganyika (771 m), Rukwa (782 m) and Nyasa (472 m) (Malawi).

The Western Rift Valley is seismically very active region in the East African Rift System. Both the East African Rift System and the mid-oceanic ridge are characterized by the seismic activity confined to shallow depths. However, the seismic belt within which earthquakes occur is narrow under the mid-oceanic ridges, while it is rather broad in the African Rifts (Tanaka et al. 1980).

The different seismic studies on the Western Branch of the East African Rifts System reveal that the seismic activity is confined in the following regions:

- the region of the lakes Malawi and Rukwa;
- the region of the lakes Moero and Upemba;
- the South-Eastern, the Central and Northern border of the lake Tanganyika;
- the Ruzizi plain;
- the lake Kivu basin, including the Ngweshe, Masisi and Walikale regions,
- the lake Edward region;
- the Mt. Ruwenzori region;
- the lake Albert region ;
- the South Sudan region.

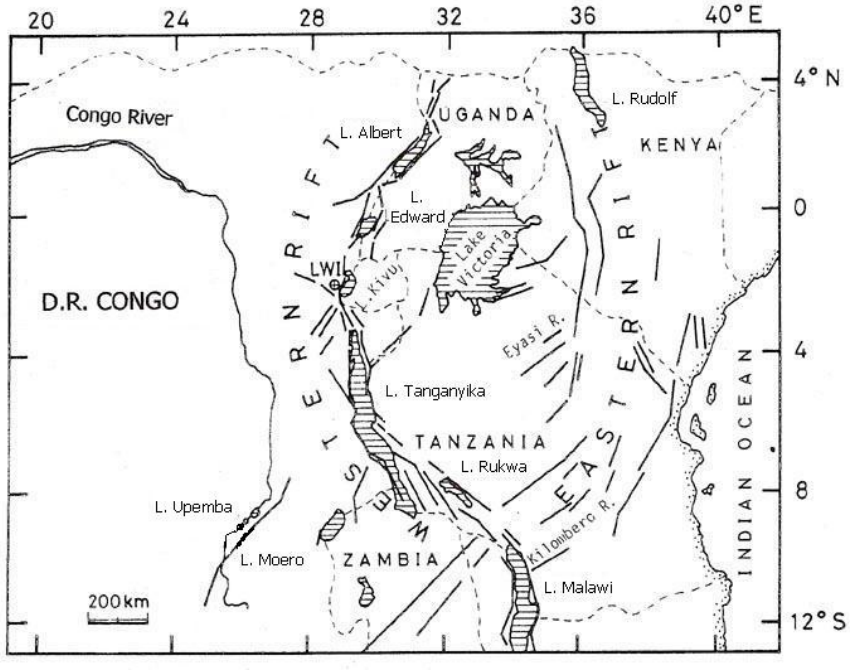

Fig.1 The East African Rifts System (Hamaguchi and Zana, 1983a).

The lake Kivu basin in this paper includes the Ngweshe, Masisi and Walikale regions. This lake is the highest lake in the Western Rift Valley, implying that the center of doming accompanying the Rift formation must be located around this lake (Hamaguchi and Zana 1990). The tectonic conditions of the dome uplift, faulting, volcanism and shallow seismicity around the lake Kivu are believed to be the indications of actual rifting and may represent a nascent stage in the development of plate boundary (Wong and Von Herzen 1974).

In the Kivu lake basin, the faults of the rift are concentrated in netting following three main directions NE-SW, N-S and NW-SE (Figure 2).

The result obtained from December 1979 to December 1980 had shown an important concentration in the basin (Zana et al. 1989) (Figure 3). The seismic activity is mostly concentrated in the South-Western part of the basin with extension to adjacent regions of the rift margin the Masisi and Walikale.

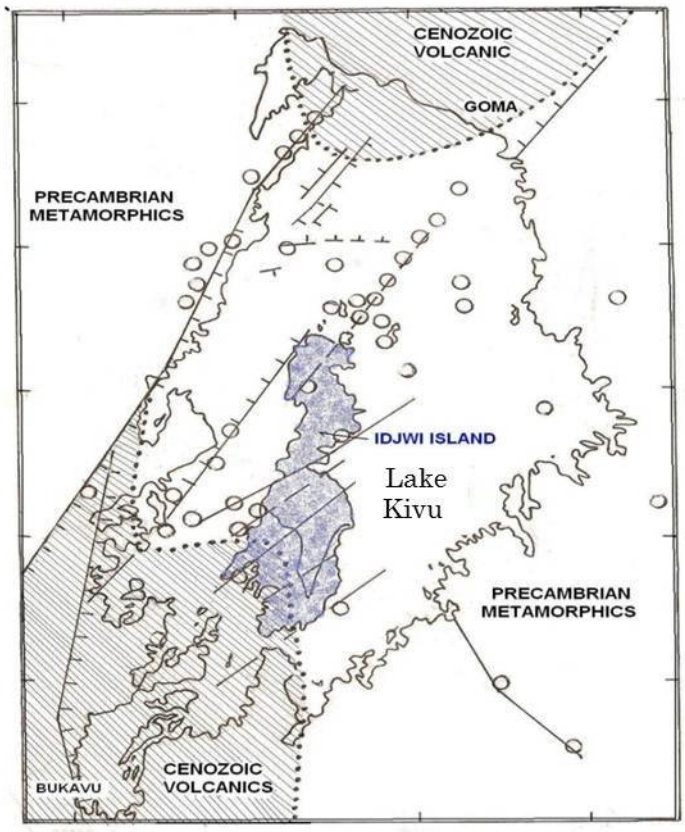

Fig.2 Geological structure of lake Kivu. Open circles represent Earthquake epicentres, lines represent fault and areas of enozoic volcanics are shaded (Wong and Von Hen 1974, modified).

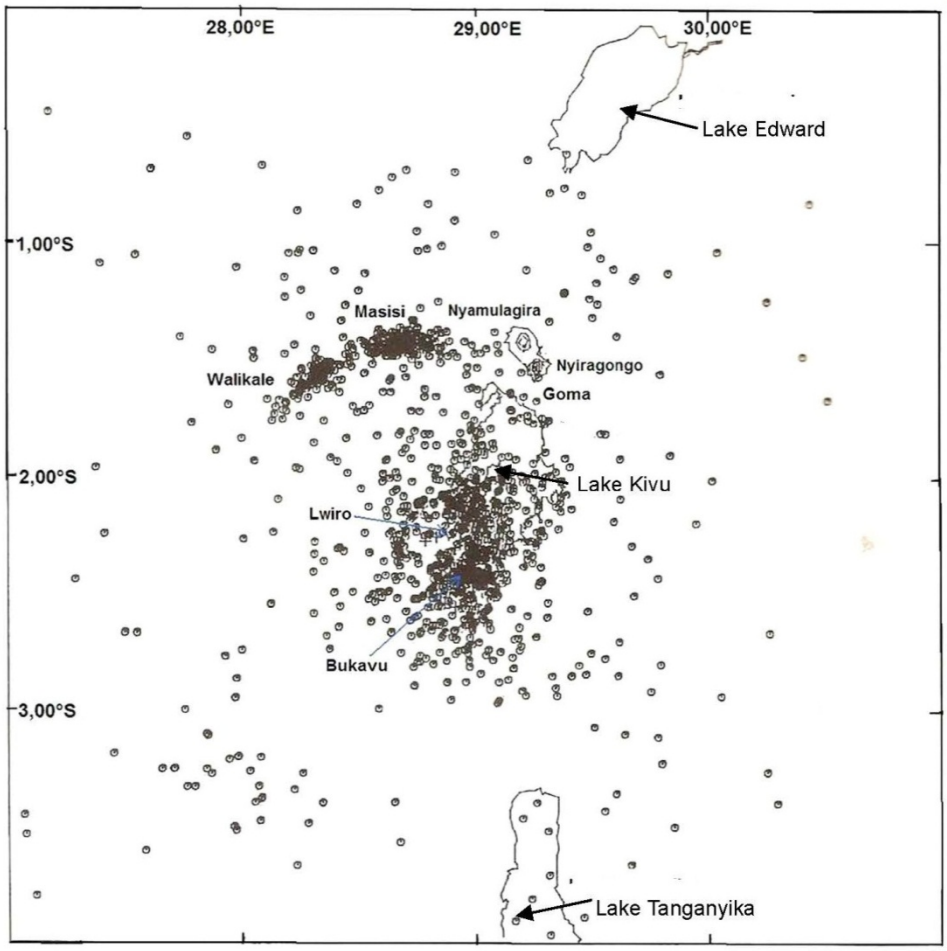

Fig.3 Seismicity of lake Kivu basin December 1979 December 1980
Solid circle: earthquakes (modified)

Since 1997, the lake Kivu basin has been experiencing an unusual high seismic activity; many earthquakes are felt by local inhabitants. On October 24, 2002 an earthquake of magnitude M_w= 6.2 had struck the Region. This event generated damages on buildings, land subsiding at some place on the lake Kivu shore, and took the life of 8 people. Many aftershocks followed this main event.

In regard to the earthquake mechanism, it is noticed that the focal mechanism of normal faulting type prevails widely in the Western Rift Valley with the tension axis approximately perpendicular to the strike of the East African Rift System as a whole or the local fault trends in detail (Zana and Tanaka, 1981, and Wafula and Zana, 1990).

This paper focuses on the effects and associated phenomena to the recent earthquake which struck the Lake Kivu basin on February 3rd, 2008.

METHODS AND MATERIALS

The seismic activity in the lake Kivu basin is recently studied using the Lwiro station located on the western part of the lake Kivu, constructed since 1953 by CRSN/ Lwiro, previously IRSAC and IRS. The station was equipped with the Benioff short period seismographs (T_o= 1sec, T_g=0,25 sec, Mag= ca.100k). Recently, Lwiro station is equipped with a short period Kinemetrics vertical component SS-1 ranger seismometer (T_o=1s) connected to PS-2 seismic recorder.

To the Lwiro station is added since 1983 a seismic network constructed in the northern end of lake in the Virunga volcanic region. The seismic stations are distributed around the active volcanoes Nyiragongo and Nyamulagira. Recently all stations are using the same equipment than the Lwiro station which is inemetrics.

In May, 2004 a new telemeter network was installed using the same stations. The signals from these stations (three components; one horizontal and two vertical) are locally digitized from a data logger with sampling frequency of 50 Hz and an A/D resolution of 24 bits, and telemeter to Goma base station where they are recorded in triggered and continuous files. Actually the seismic network in the Virunga region is shown in Figure 4.

Geophysical observations were carried out around the lake Kivu basin to evaluate the damages caused by the main shock and aftershocks. During the field observations the temporary seismic stations were installed around Lwiro located about 10 km from the epicentre area and the GPS were used to determine the geographical coordinate of investigate areas.

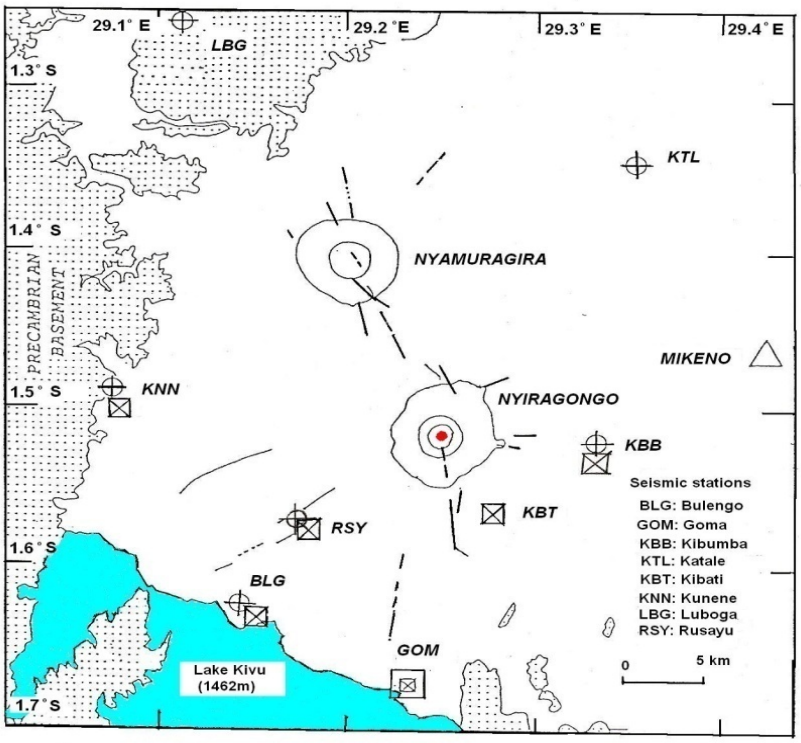

Fig.4 Seismic network around the volcanoes Nyiragongo and Nyamuragira in the Virunga region Circles and crosses indicate the analog seismic stations and squares and crosses indicate the telemeter seismic stations

RESULTS

The results obtained from our observations are presented in two subheadings.

Seismicity

The earthquake which struck the lake Kivu basin on February 3rd, 2008 at 7h34' UT had a magnitude m_b= 6.0. The event occurred on the western part of the lake Kivu at latitude 2.30 °S and longitude 28.90 °E at 10km depth. One foreshock considered as precursor of this event was recorded on September 07th, 2007 with magnitude m_b= 4.6. Many aftershocks followed this main event for long-time (Figure 5).

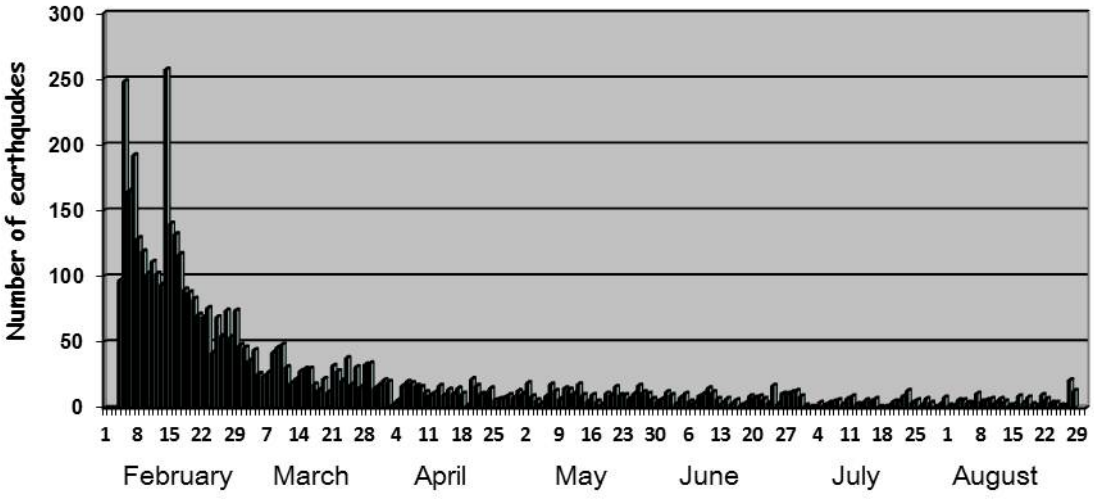

Fig. 5a Number of earthquakes recorded at Lwiro station, February to August 2008

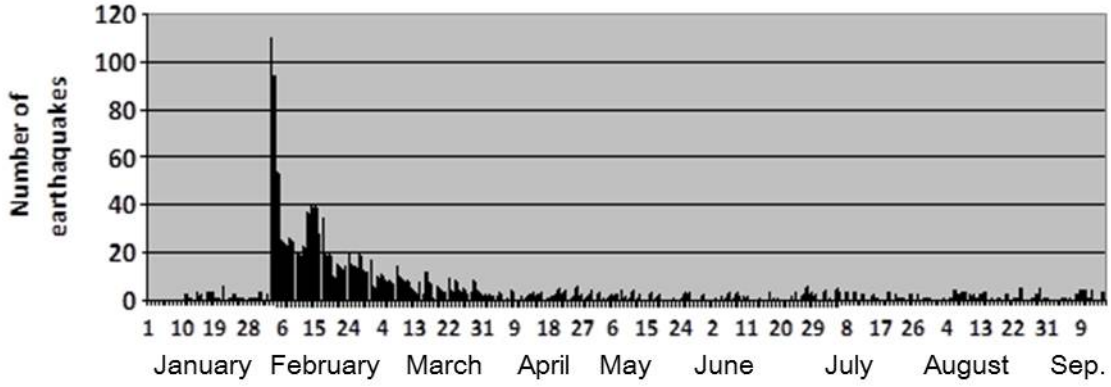

Fig. 5b Number of earthquakes recorded at Rusayu station, February to September 2008

Many aftershocks were strongly felt such as: the February 3rd, 2008 at 10h56 UT with magnitude 5.10 m_b at latitude 2.40°S and longitude 28.97°E at 10km depth, the February 14th, 2008 with magnitude m_b= 5.4 at 02h07 UT latitude 2.39°S and longitude 28.88°E at 10km which was the main aftershock, and the last strongly felt earthquake recorded on June 8, 2008 with magnitude m_b= 5.0, about for month late. It was clearly observed that the aftershocks were felt up to June 2008 in Bukavu city and surrounding areas. The seismic activity of lake Kivu basin for earthquakes with magnitude ≥ 4.0 for the period from 1970 to 2008 is shown in Figure 6a.

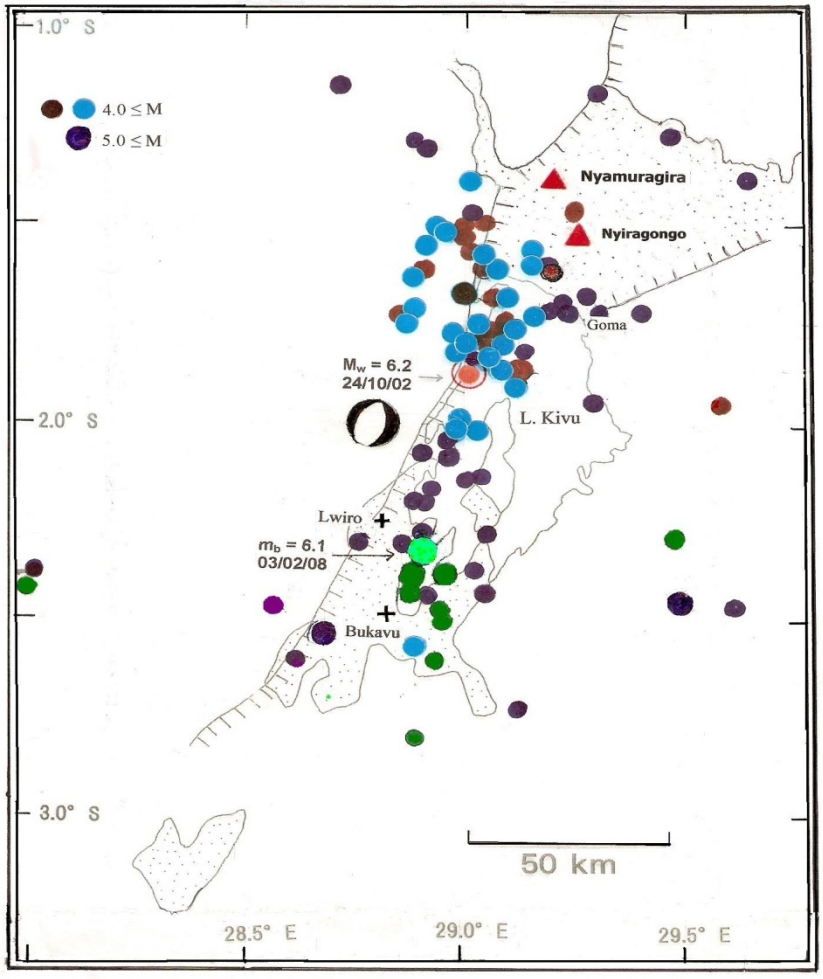

Fig.6a The seismicity of lake Kivu basin for earthquakes with magnitude ≥ 4.0, for the period from 1960 to 2008
(Solid circles: earthquakes; Blue solid circles: aftershocks associated to the October 24, 2002 earthquake, encircled red solid circle; Green solid circles: aftershocks associated to the February 3rd, 2008 earthquake represented by solid circle with clear green color.)

The epicentre distribution of aftershocks associated to the February 3rd, 2008 and earthquake in Birava for the period from April 28 to May 27, 2008, are shown in Figure 6b.

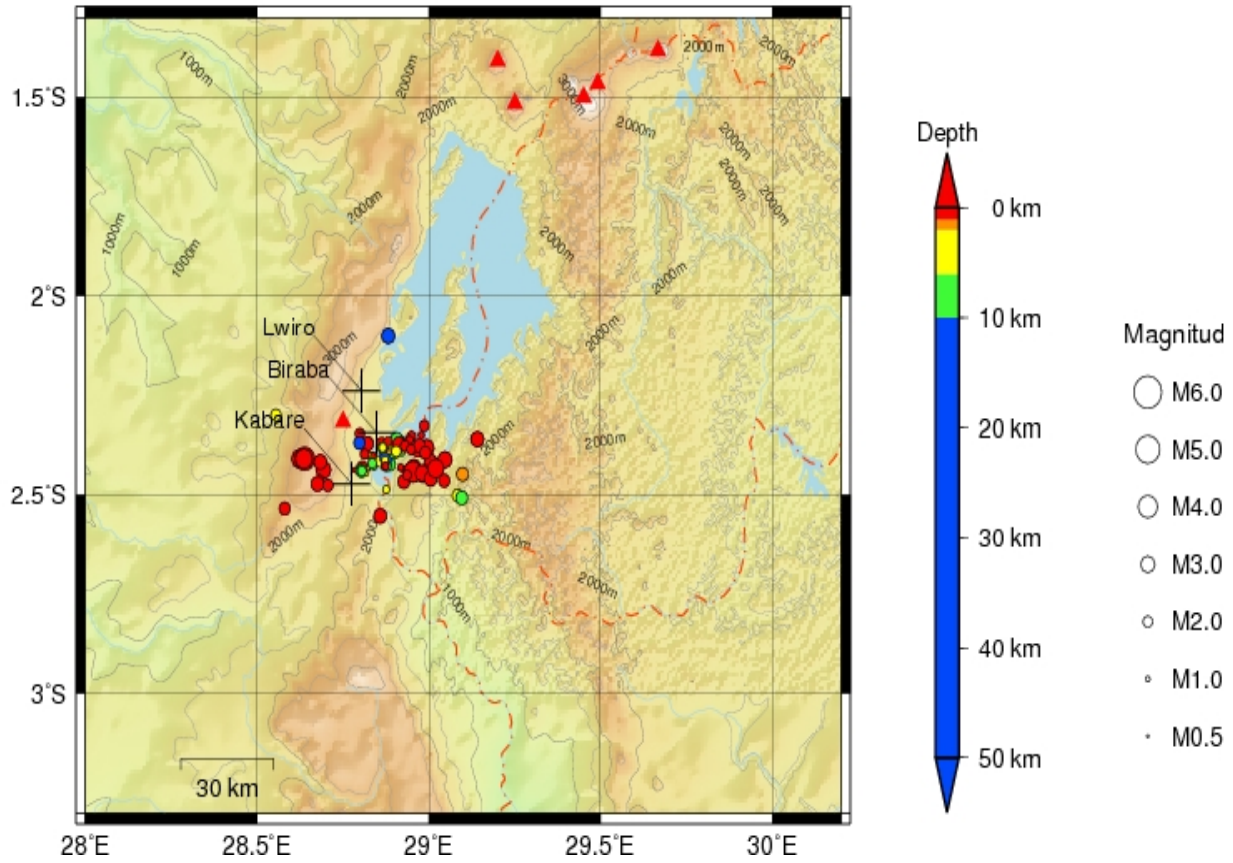

Fig. 6b Epicenters of aftershocks associated to the February 3rd, 2008, earthquake for the period from April 28 to May 27, 2008

The geology of Katana sector was studied by Villeneuve (1983) Figure 7. In this sector three main directions of faults are NE-SW, NW-SE and NEE-SWW are seen. The Kakondo-Birava fault is believed to be the most impressive and the most active observed.

Field observations

Many phenomena were generated inside the lake and on the shoreline. At several places was observed land subsiding on the shoreline. Five children were killed, two at Ibindja island in D.R. Congo side (Figure 8a) and three at Nkombo island in Rwanda side (Figure 8b).

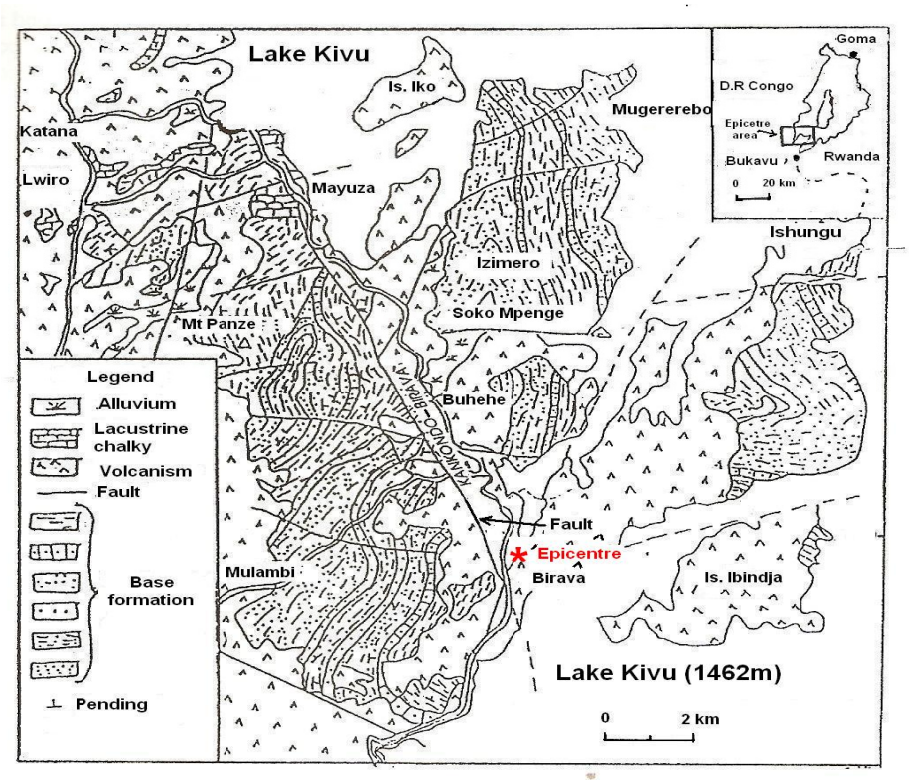

Fig. 7 Geology of Katana sector.

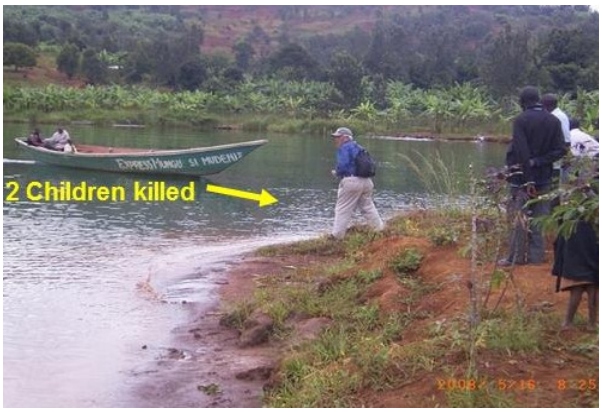

Fig. 8a Land subsiding on the shoreline at Ibindja island (©Wafula)

Fig. 8b Land subsiding on the shore line at Nkombo island. (©Wafula)

The two islands Ibindja and Nkombo are close to the epicenter area. At other places land uplift was observed. According to the fishermen; small tsunami was generated and attacked the coast line. The highest level accessed by the tsunami was estimated to 4m at Ibindja island. The small gas escaping generated by the tsunami was observed at several places in the lake Kivu.

Many damages were recorded in Bukavu city and surrounding areas in D.R.C. and Rwanda, characterized by the fissures on the walls or collapse of houses Figure 9. Fissures were observed also on the soil with directions approximately 320ºN (N-S) and others N60º (E-W). At the crossing point of these two directions the damages were more important on the walls of houses. These observations have been made in the Bukavu region as to Rwanda.

Fig. 9a Collapsed house with three floors, Bukavu city (Feb. 7, 2008) (©Wafula)

Fig. 9b Collapsed house with two floors, Bukavu city (Feb. 7, 2008) (©Wafula)

Fig. 9c Collapsed house at Bushenge hospital (Rwanda) (Feb.19, 2008) (©Wafula)

At the epicentre area Birava, it was noticed the total collapse of the chimneys of house Figure 10. The fissures observed on the wall were very diversify, some were vertical and very wide (Figure 11a), and some others complex. (Figure 11b) Total 49 people were killed by the earthquake and aftershocks, more precisely 10 in D.R.C. and 39 in Rwanda. The latest aftershock with magnitude greater than 5.0 was felt on June 8, 2008, 4 months after and killed one people. The main fault was in the direction approximately N-S (N320º) according to the magnitude of the main shock its length was estimated to about 10 km.

Fig. 10 The collapse of the chimney of house at Birava (the closest town to the epicentre area) Apr. 19, 2008 (©Wafula)

Fig.11a Wide vertical fissures observed on the wall at Kankule (D.R.C.), Apr. 28, 2008, (©Wafula)

Fig.11b Complex fissures on the Wall at Bukavu, Feb.18, 2008, (©Wafula)

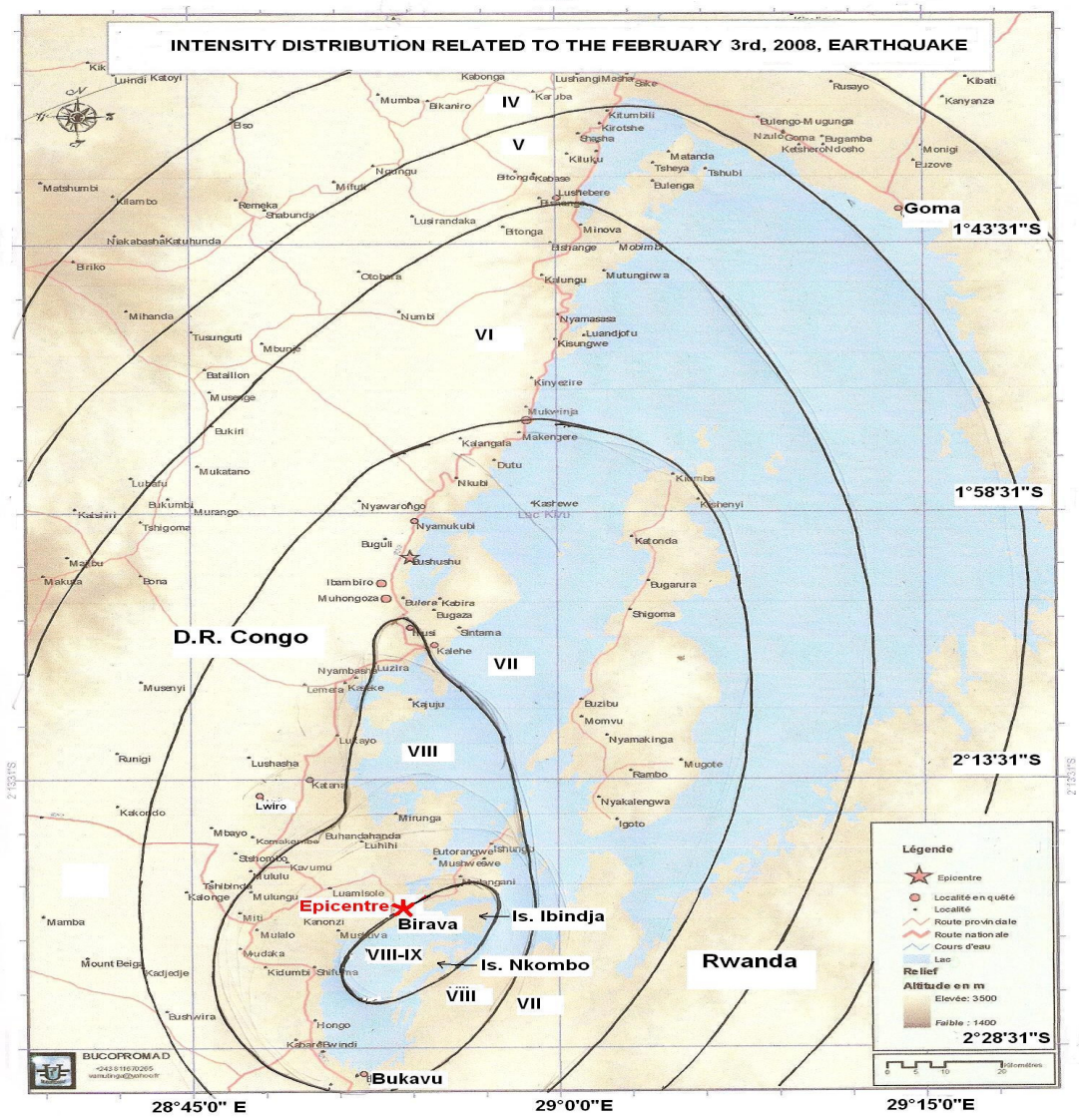

Fig.12 Intensity distribution of February 3rd 2002 earthquake at Birava.

The maximum intensity recorded was VIII-IX at Ibindja and Nkombo islands in Figure 12.

CONCLUSIONS

Since 1997, the lake Kivu developed a high seismic activity. Two earthquakes with magnitude more than 6.0 already occurred in the basin. The earthquake on February 3rd was the most destructive event because it occurred near the big city of Bukavu.

Total 49 people were killed by the earthquake and aftershocks, more precisely 10 in D.R.C. and 39 in Rwanda. This event was preceded by many foreshocks and followed by a long duration of felt aftershocks.

During the earthquake small tsunamis occurred. This fact is confirmed by the lake Kivu water which arisen the cost line at Ibindja island up to 4 meters and the occurrence of bubbles observed in the water as tested by the people staying on the cost lines during the earthquake.

In the lake Kivu is concentrated a huge amount of carbon dioxide and methane gases dissolved in the water and keeping a stable condition. In case the earthquake generated a big tsunamis in the water of lake Kivu, it may be possible to assist to the phenomena of explosion of gases that may be the most fatal catastrophe for which scientists should pay much attention.

The maximum intensity recorded was VIII-IX at Ibindja and Nkombo islands. These two islands were the most affected area the earthquake.

According to the recent seismic activity developed in the lake Kivu basin it is rather to conclude that this region remains among the most seismically active region in the Western Rift Valley, so the resilient structure should be performed for buildings, dams, bridges, to avoid any surprises that may stop the development around the lake Kivu basin. In case of Bukavu city and surrounding areas it is necessary to limit the uncontrolled construction on unstable terrain such as steep slopes, the edge of Lake Kivu.

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