Advanced Workshop on Evaluating, Monitoring and Communicating Volcanic and Seismic Hazards in East Africa

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Monitoring Seismic and Volcanic activity in Cameroon

Bekoa Ateba
Inst. for Geological and Mining Research
Yaounde'

Charles Tabod
Univ. de Yaounde' 1
Republic of Cameroon
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Monitoring Seismic and Volcanic Activity in Cameroon

Charles Tabod – Physics Department, University of Yaounde I, Cameroon
Ateba Bekoa – Institute of Geological and Mining Research, Cameroon
Plan

• Part I: Seismological Activities
  • Main experiments carried out in Cameroon
  • Results

• Part II: Monitoring Volcanic activities
  • Mount Cameroon
  • Crater Lakes
Part I

Seismological Activities
Introduction

- The Cameroon Volcanic Line (CVL) is a chain of 12 volcanoes running for ~1600 km from the island of Pagalu in the Gulf of Guinea to the Biu plateau (N.E. Nigeria).
- It comprises 3 parts:
  - Oceanic
  - Continent/Ocean boundary, and
  - Continental sectors
- There is no defined pattern of the ages for these volcanoes.
Introduction

- By World standards Cameroon is not considered very seismically active
- Mount Cameroon is the highest peak (4095 m) and the most active volcano in West Africa.
- The last eruption occurred in the year 2000.

Seismic Activity

- However at a local scale, both felt and instrumentally recorded earthquakes have been recorded in Cameroon.

- The vast majority of these events have occurred along or close to the Cameroon Volcanic Line.

- The overall seismic activity is concentrated in the Mount Cameroon region.
Seismic Activity-Northern Cameroon

- The first seismographic station was installed in Yaounde in 1982
- In 1982, a seismic refraction experiment along a 300 km long profile was carried out in the north of Cameroon
- Total of up to 40 short period (1 Hz) seismic stations were installed along this profile
- Signals were recorded on tape recorders (Geostore) via radio links
Location of seismic stations.

Quarries are shown as full circles.

Stuart et al, 1985;
Dorbath et al, 1986
Seismic Activity—Northern Cameroon

- The results show that:
  - The crust thins to about 23 km beneath Garoua rift
  - The crust has a normal thickness of ~33 km to the southern part of the Adamawa plateau
  - The Upper Mantle P-wave velocity is found to be about 7.8 km/s beneath the rift, and
  - About 8 km/s south of the Adamawa plateau
  - No local seismicity was recorded
Seismic Crustal Model

Stuart et al, 1985
Seismic Activity-Northern Cameroon

- The Adamawa plateau therefore seems quite unaffected by the presence of the Cameroon Volcanic Line.

- The rise of magma in this region might have used the crustal flexure during the post cretaceous uplift of the Adamawa and the reactivation of the Foumban Shear Zone (FSZ).
Besides recording quarry blasts, the seismic stations also recorded teleseismic events from around the world.

Some of these were inverted for Upper Mantle structure.

Earthquakes used in the teleseismic study

Dorbath et al, 1986;
Plomerova et al, 1993
Seismic Activity-Northern Cameroon

- The teleseismic study shows
  - That this part of the CVL is divided into 3 ENE blocks

- Velocity contrasts are low (<2.5%) down to about 190 km

- The middle block is 2% slower than the adjacent blocks and corresponds to the shear zone in central Cameroon

- That the lithosphere thins beneath CASZ

- The asthenosphere upwells from 190 to 120 km
Seismic Activity - Mt Cameroon/CVL

- In 1984 a permanent network of 6 stations was set up around Mt Cameroon
- Mainly Wilmore MK III short period seismometers
- In 1986 these stations were augmented by 8 temporary ones
- Recordings were by telemetry on drum/chart/magnetic tape recorders
Summit View of Mt. Cameroon with trails

http://www.caboose.org.uk/journeys/CMintro.html
1984 permanent stations (6)

Ateba et al, 1997

1990 permanent stations (6)
Mt Cameroon Digital Seismic Network since 2003.

▲ (1C Station), △(3C Mobile Station), ■(3C Station)
Seismic Activity - Mt Cameroon/CVL

- The Mt Cameroon area is characterised by
  - swarm events lasting up to 14 months, and
  - regular deep seismicity (down to ~60 km)

- Subcrustal events occurring in the SE flank of the mountain and at a frequency of ~9-15 events per day

- Duration magnitudes are generally < 3
- This activity may be attributed to the presence of a zone of weakness - a magma conduit
Seismicity of Mt Cameroon

Ambeh et al, 1989;
Ateba et al, 1997
Seismic Activity - Mt Cameroon/CVL

- In 1984 (Monoun) and 1986 (Nyos) two of Cameroon’s crater lakes within the Cameroon Volcanic Line emitted toxic gases

- These killed 37 (Monoun) and 1700 (Nyos) people

- Seismic monitoring of Mt Cameroon was extended to include the regions of these lakes in 1987

- Temporary networks were set up for up to 4 months in 1988/1989
Temporary Seismic Stations
North of Mt. Cameroon

Tabod et al, 1992
**Seismic Activity - Mt Cameroon/CVL**

- Local seismicity in the region north of Mt. Cameroon is minimal.

- Most seismicity recorded by temporary array originates from Mt Cameroon area.

- A few felt earthquakes do occur in this region and are most likely related to the tectonic activity along the Foumban Shear Zone.

Tabod et al., 1992
Seismic Activity - Cameroon Seismic Project

- From 2005 to 2007 a network of 32 broad band stations was installed over the CVL and the Congo Craton to the south
- 8 stations were installed in 2005
- Stations upgraded to 32 in 2006
- Stations were dismantled in 2007 except 2 (AfricaArray):
  - EKONA (Mt Cameroon)
  - YAOUNDE
Seismic Activity - Cameroon Seismic Project

- Surface wave phase velocity maps from this BB dataset imaged:
  - a low-velocity anomaly beneath the CVL as well as
  - high velocities associated with the lithosphere of the Congo Craton.

- P- and S-wave travel time tomography show a linear negative velocity anomaly directly beneath the CVL that
  - This anomaly extends from shallow mantle depths to at least 400km.
Seismic Activity - Cameroon Seismic Project

The joint inversion of Rayleigh wave Group velocities and Receiver has been carried out:

- A thin intrusion of < 5 km thick is present in the upper crust with a high shear velocity contrast.
- Crust thins to ~25 km under Garoua and Mt Cameroon
- Crust thickens to about 37km under the Adamawa plateau
- Shear velocity ranges between 3.8-4.0 km/s in the lower crust.
- In the uppermost mantle, shear wave velocity reach 4.2-4.4 km/s.
Crustal thickness along Profile 1 from South to North East
Part II

Monitoring Volcanic Activities
The CVL an alignment of:
- Volcanic Iceands from Atlantic Ocean
- Volcanic Centres
- Plutons Complexes
- Sedimentary basins

Fitton et al., (1980)
The main natural hazards along the CVL are associated with:
- Mount Cameroon, an active volcano and,
- The crater lakes (Nyos & Monoum).

Fitton et al., (1980)
Mount Cameroon

- Dimensions
  50 x 35 km
  4095 m

- Mt Etinde

Déruelle et al., (1987)
Mount Cameroon

- **Recent Mt Cameroon Eruptions**
  - 1909, NE flanc
  - 1922, 2 eruptions: Summit & SW flank
  - 1954, Summit
  - 1959, East flank
  - 1982, SW flank
  - 1999, SW flank
  - 2000, Summit and SW flank.
Monitoring Mt Cameroon Volcano

Scientific approach Performed

1. Ministry of Scientific Research (Research Institute)
2. Ministry of higher Education (Universities - Yaounde & Buea)
3. Ministry of Industries Mines and Technological Development (MINIMIDT)
Scientific studies

1. Volcanological studies

- Geological mapping
- Geochemistry (Pb and He isotopes)
- Natural Hazards

Recent lava flows on Mt Cameroon
Monitoring Mt Cameroon Volcano

2. Seismological studies

Mt Cameroon Digital Seismic Network since 2003.

▲ (1C Station), △(3C Mobile Station), ■(3C Station)
Monitoring Mt Cameroon Volcano

Histogram of 1999 Mt Cameroon Eruption

Mt Cameroon Seismicity
March-April 1999

Daily frequency of earthquakes

Date

0 20 40 60 80 100 120


Eruption

Fig. 3. Histogramme de la sismicité du Mont Cameroun pendant l'éruption de 1999.
Monitoring Mt Cameroon Volcano

Volcanic Hazards

- Earthquakes
- Lava flows
- Ashes
- Landslide
Monitoring Mt Cameroon Volcano

Volcanic Hazards

Results from a partnership between:

- BRGM (French Geological Survey) and
- MINMIDT (Cameroon).
Monitoring Mt Cameroon Volcano

Traditional approach

Local inhabitants around the volcano think that the mountain is a half-god kingdom whose anger results in eruption.

Libations need to be made to calm down the anger.

Scientific equipment is also suspected to upset the spirits of the mountain
Monitoring Mt Cameroon Volcano

Crisis Management

Purpose: help local authorities to take appropriate decisions for civil protection.

National level
Chairman: Prime Ministre
- Ministries: Territorial Administration, Higher Education, Scientific Research, Defense, Health, Social Affairs, Communication

Local level
Chairperson: Governor of the Region
- Delegates of Ministries involved
- National Scientific Committee
- Traditional Rulers
- Non Governmental Organizations (NGOs)
Monitoring Mt Cameroon Volcano

Social:
- Defense
- Social Affairs
- Communication
  - News papers
  - Radio and T.V.
  - Governor of Region
    - Local Committee

Scientific:
- Prime Minister
  - Territorial Administration
    - Research
      - IRGM / INC
        - Observatory
        - Directorate of Geology
      - University
      - Preventive and clinical medicine
    - Higher Education
      - Faculty
      - Department
    - Health
      - Mines
Monitoring Mt Cameroon Volcano

Communication

⇒ The local committee is split in different teams.
⇒ On a daily basis the governor calls for meetings during which each team gives a report of its activities in a hall.
⇒ Meetings are open. It is the best place to update the information to give to the public about the ongoing eruption. Then false rumors can be avoided.
## Evaluation

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<td>- IRGM</td>
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Monitoring Volcanic Activity

Crater lakes

- Monoun (1984 – 37 dead)
- Nyos (1984- 1700 dead)

Degasing Project going on
CONCLUSION

- Scientific Monitoring program is based on study of local seismicity and deformation.
- Eruptions are associated with earthquake swarms.
- Crisis Management Committee is set up when the eruption starts. It is in charge of Civil protection and collects informations to give to the public. A permanent structure is yet to be created.
- Traditional beliefs are an handicap for the monitoring program.
- Multi-disciplinary approach is still to be well implemented.
- Degasing project is going on the Crater lakes.
Thanks for your kind attention

Crater Lake Barombi Mbo

Field trip up Mt Cameroon