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Risk Link to the Volcanic Activity of the Mt. Cameroon in Cameroon

By

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with 5 Tables, 14 Text-figures

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Abstract: The Mt. Cameroon is a large volcanic horst belonging to the majure tectonic line (Cameroon volcanic line). The geographical morphology of the mountain is controlled by regional tectonics. The Mt. Cameroon is consisted of precambrian metamorphic basement covered with Cretaceous to recent sediments distributed mainly in the Douala and Riodel Rey basin. The oldest lava could be of upper Miocene age. The Mt. Cameroon has erupted six times in the 20th century. The 1982 eruption took place inside the crater of an ancient cone.

The lavas are picrites (with forsteritic olivine phenocrysts), alkali basalts (with salitic augite phenocrysts), hawaiites (with labrador-bytownite plagioclase phenocrysts) and mugearites (with scarce kaersutite phenocrysts and microlitic phlogopite or nosean). According to Deruelle et al.(1987), the Mt. Cameroon lava series is typically alkaline with no tholeiitic or transitional trend.

Risk related to volcanism is actual for the human constructions especially along the axis of the horst. The severe volcanic risk has been limited to explosion, lava flows and lahar. It is possibility that explosion, laver flow and earthquarke take place anywhere on the volcanic mountain. Nevertheless, these explosions are most likely to occur in the delimited sector which is shown in a map presented in this paper.

Even if we could divert the course of the lava flows to certain safer direction, flows caused by sudden earthquarke and explosion may cause serious damages.

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I. Introduction

The Cameroon main volcanic batholith are intimately linked to the fractures whose the main direction is southwest-northeast from the Atlantic ocean to the north Cameroon and is situated on a regional tectonic zone called "Cameroon line" (Tchoua, 1974). Several volcanic regions are included in this zone. These are : the Mt. Cameroon together with its satellite, the Mt. Manengouba, the Mt. Bambouto, the Mt. Adamaoua and the Mt. Mandara. Among them, only the Mt. Cameroon is active volcano. The last eruption happened in 1982 produced ashes extended to the Atlantic ocean.

The Mt. Cameroon is 4100m in height at Fako and cover about 30000km^2. The steepness of the valleys is reached to 30-40 degree (Geze, 1943). Above 2000m the flank is intersected with steep slope which limits the plateau with about 1 hundred cones. The Mt. Cameroon presents several fractures system (Zoning, 1988) and layer deposit surrounding the eruptive point, it is a strato volcan (Gouhier et al., 1974). Geze (1943) identified three eruptive dynamism (strombolian, hawaiin and explosive) based on the nature of products: the pyroclastic cones (lapilli and ashes), the block lava, the scoria lava and ropy lava.

The studies of physical and geological feature in the Mt. Cameroon region were carried out by many investigators (Geze, 1943; Gouhier et al., 1974 : Deruelle 1982; Deruelle et al., 1983a; b; 1984; N'ni, 1984; Zoning, 1988). According to their results, the Mt. Cameroon and its surrounding regions are high risk zones for the humans and their investment, such as volcanic eruption, pyroclastic flow and volcanic gas. The Mt. Cameroon and it's surrounding regions are occupied by the most habitants and industrial communities of the republic of Cameroon. The population is estimated at 250000. This population and their investment are exposed at the eventual risk link to the volcanic eruption.

After the catastrophic events of the lake Monoun occurred in 1984 and the lake Nyos in 1986, which caused about 2500 injurities, the government and researchers work together to bring about solution of natural risk for example how to prevent matters getting worse and to insure against the volcanic activity. Some seismographs are installed in certain province of Cameroon (Ambrazey et al., 1984).

The main purpose of this study is to evaluate the main natural risk related to the Mt. Cameroon and propose the perspective of surveying the volcanic activity.

II. General geology of volcanic region

The first study on volcanism of the district were carried out by the German explotators in 1941 and 1943 (Jeremine, 1941; Geze, 1941; 1943). Subsequently The results of the investigation show that the volcanic activities produced the fault network along tectonic direction of NE-SW. This active zone is called "Cameroon line" (Tchoua, 1974). The Cameroon line is characterized by the volcanic activities since Cretaceous age (Fitton, 1983). Along this line, many volcanoes are arranged i.e., Mt. Cameroon, Mt. Manengouba, Mt. Bambouto, Mt. Bamenda, Mt. Bamoun, Mt. Adamaoua and Mt. Mandara from southwest to northeast (Fig. 1).

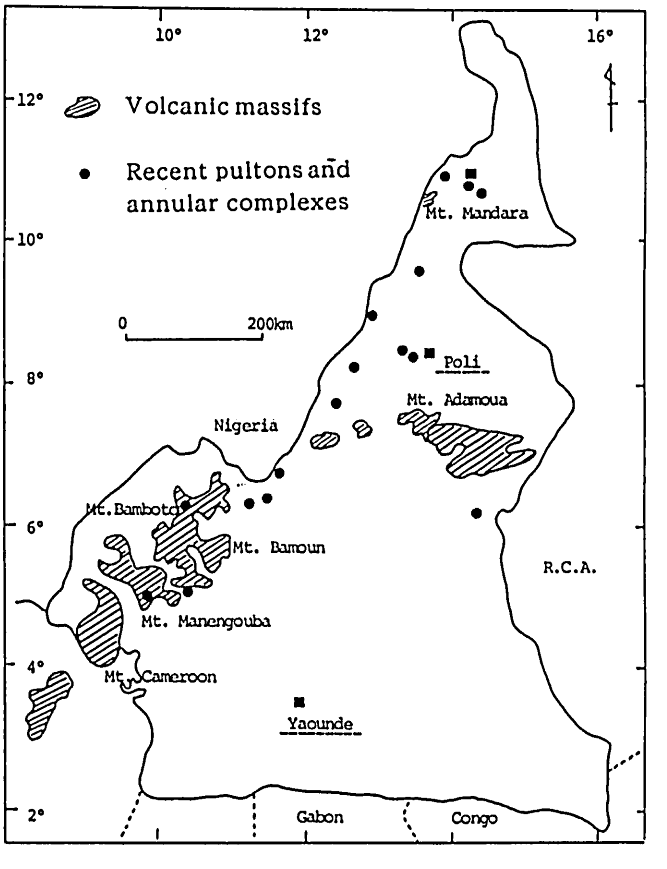

Fig.1 Alignment of volcanic massif and recent plutons of the Cameroon line

In the district of Mt. Cameroon, four major tectonic directions (A:the Cameroon trend, B: the Adamaoua trend, C: the Erythrean trend, D: the Somalian trend) are distinguishable (Fig.2) as is described in following;

A) N30°E. Along this line most of volcanic massifs and mylonite are aligned with the length of more than 1200km from the Atlantic ocean to the Republic of Tchad.

B) N65-80°E or Adamaoua direction dominated by the shear fault characterized by the Djerem Mbere graben and the Benoue plain.

C) N45°W-N50°W or Erythrean direction of Krenkel underlined by the mylonite band.

D) N-S or Somalian direction of Krenkel underlined also by the mylonite band.

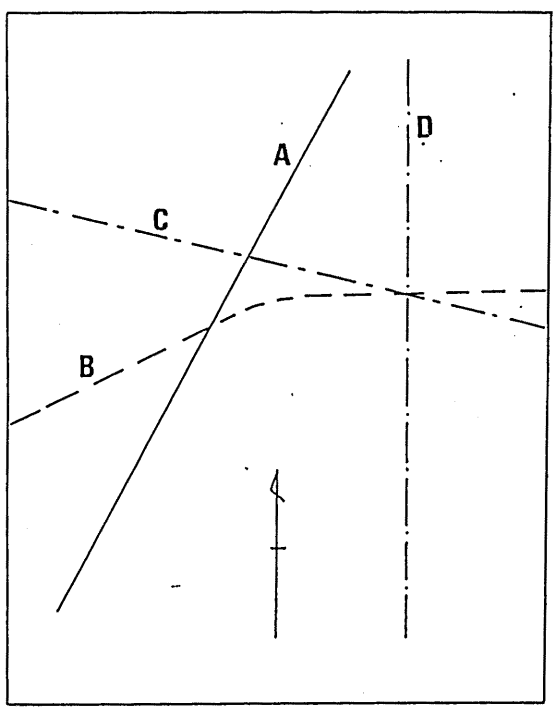

Fig.2 Main trend found in the Cameroon line
A: The Cameroon trend B: The Adamaoua trend
C: The Erythrean trend C: The Somalian trend

Gouhier et al.(1974) compare the Cameroon line to the system of rift valley of East African. Tchoua (1974) considered the Cameroon line at the beginning of oceanic rift. N'ni (1984) is the opinion that the Cameroon line is as the result of the hot spot movement from NE to SW.

Actually the geological history of Cameroon is still unknown very well. According to previous authors such as Jeremine (1941), Geze (1941; 1943), Tchoua (1974), Gouhier et al.(1974), the great volcanic regions of Cameroon comprise from southwest to northeast of Cameroon.

The Mt. Cameroon is elongated along NE-SW direction (Fig.3). It is composed of some small mountains, such as Mt. Fako (4100m) and Mt. Etinde (1713m). The Mt. Fako is characterized by the alkaline basalt. the Mt. Etinde is located on it's SW slope, and is characterized by the lava called nephenilite and etindite (Mouafo,1988).

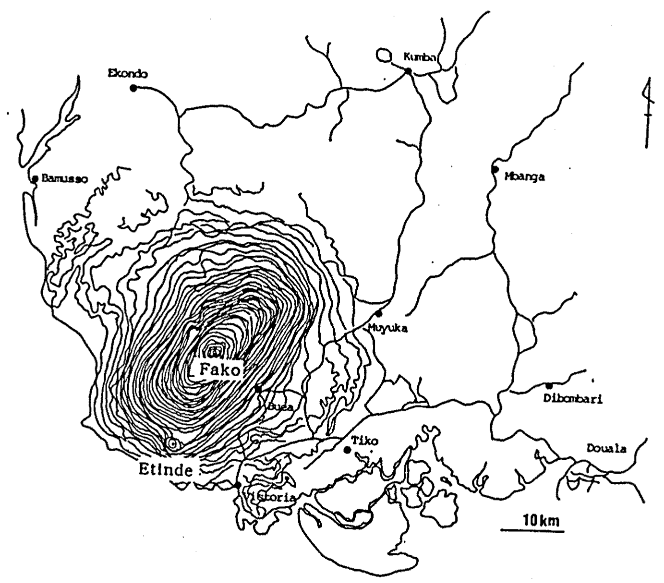

Fig.3 Topographical map of the Mt. Cameroon

The Mt. Manengouba (2650m) is located at NE (50-60km) of the Mt. Cameroon (Fig.1). It consists of basalt, trachyte and rhyolite. The graben of Tombel is essentially characterized by the tension fault and slip fault (Tchoua, 1974).

The Mt. Bambouto (2046) is characterized by three types of volcanism, namely pelean, fissural and extrusive. It consists of alkali basalt, trachyte, phonolite and rhyolite. The Mt. Banenda is located at the NE (2km) of the Mt. Bambouto (Fig.1). The Mt. Banenda is characterized by an effusive volcanism, the explosive one accompanied with many cone frequently associated with the crater lakes. According to Gouhier et al.(1974), the main geological feature of this region is the presence of ignimbrite.

The Mt. Bamoun is located at east of Mt. Bamenda (Fig.1). It is characterized by a fissural volcanism, the strombolian volcanism and explosive have formed several pyroclastic cone and explosive crater all occupied by the lake. The products are essentially pyroclastite with alkali basalt.

The Mt. Adamaoua is located at the north of Mt. Bamoun (25-30km) (Fig.1). According to Temdjim (1986), the Adamaoua is characterized by a fissural volcanism, strombolian and explosive. The products are alkali basalt, trachyte and phonolite.

The Mt. Mandara is located at the north Cameroon (Fig.1). It is characterized by a strombolian volcanism. The products are basalt, trachyte associated with sedimentary rocks (sandstone and conglomerate).

Ages of volcanic rocks distributed on these mountains are summarized in Table 1.

III. Geology of the Mt. Cameroon

The Mt. Cameroon is really not a volcano but is rather a volcanic mountain or a sort of volcanic horst. It is situated on the Cameroon line and is believed to result from an intraplate shearing zone (Regnoult et al., 1986). On the field, the line appears as an alternation of horst and grabens. According to Dumort (1968), the continental substratum is a precambrian metamorphic basement composed of schiste, gneiss, amphibolite intruded by granite, diorite and pegmatite dike, covered with Cretaceous to Plio Quaternary sediments(sandstone and conglomerate). All of the lavas accumulated on the Mt. Cameroon are younger than 25Ma (Dunlop, 1983).

The Mt. Cameroon is situated on a horst of about 30km width and on the both sides subsident basins of Douala and Rio del Rey where sediment have accumulated to a thickness greater than 7000m since the Cretaceous (Njike, 1984). It is known that the alkaline volcano do not slope as steep as Mt. Cameroon (Deruelle et al., 1987). The steep slops of the Mt. Cameroon are fairly well explained by a horst graben structure. The horst structure of the Mt. Cameroon with pivotal fault appears clearly on N30 E profile (N'ni, 1984). From the observation fact that basement nowhere outcrops on the flank of Mt. Cameroon, it is likely that the horst uplift has not prevailed against the graben subsidence. The southeastern and northwestern flanks are strongly notched by deep gullies which show only piles of lava flows and scoria deposit. At the summit, lava flows are ropy elongating various directions. At the bottom of the mountain pile of ashes are observed. On the northeastern flank outcrop the mud flow or lahar.

The lavas described below were collected on southwestern, southwestern and southeastern flank of the Mt. Cameroon as well as in the summit. These lavas have been classified according to the differentiation index indicated by Thornton and Tuttle (1960) into picrite, alkali basalt, hawaiite and mugearite.

Picrite: Picrites are easily recognizable in hand specimens because of the great abundance of large (up to cm) olivine phenocrysts disseminated in a dark gray groundmass. Under the microscope, these phenocrysts (Fo 80-90) are corroded by the mesostasis and round or frankly euhedral. Olivine microphenocrysts are frequent. The olivine phenocryst commonly contain small crystals of augite, magnetite and plagioclase (An 25-55). Occasionally the grandmass is glassy (Fig.4).

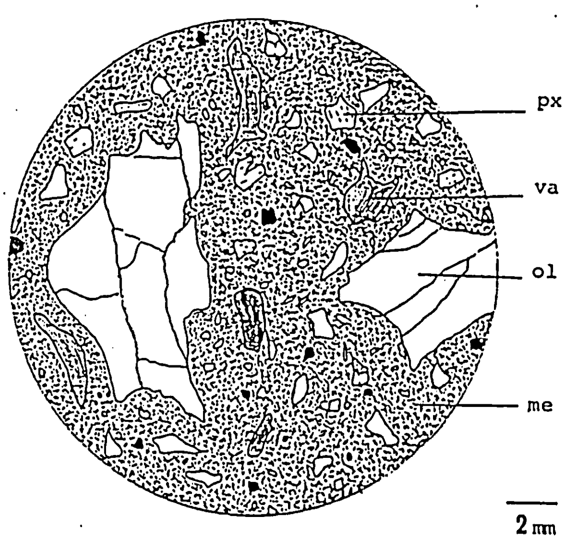

Fig.4 Microscopic observation of picrite
ol: olivine, px: pyroxene, me: groundmass, va: vesicle

Alkali basalt: The rock shows microlitic porphyritic structure and is characterized by the great abundance of augite and olivine phenocrysts, and augite being predominant. All of augite is pleochroic with the yellow color, sometimes twinned and contain frequently small crystals of plagioclase as inclusions. Cumulates of olivine phenocrysts rimmed with augite are found in the less differentiated basalt. Xenocrysts are rather rare and rich in variety such as olivine, plagioclase, oxide and pyroxene. Thus inclusion of tiny crystals of augite, plagioclase and magnetite are not infrequent in olivine phenocryst (Jeremine, 1943) and phenocrysts of plagioclase sometimes contain crystal of magnetite(Fig.5).

Region	Ejecta	Age(Ma)	Reference
Mt. Cameroon	basalt	0.05-4	Hedberg(1969)
	etindite	0.07-0.065	Dunlop(1983)
Mt. Manengouba	basalt	29.93	Tchoua(1974)
	rhyolite	1.55-0.40	Dunlop(1983)
	trachyte	11.8	Gouhier et al. (1974)
Mt. Bambouto	basalt	38.58	
		14.33-11.80	Tchoua(1974)
and		21	Dunlop(1983)
Mt. Bamenda	phonolite	10	Dunlop(1983)
	ignimbrite	17.17-12.7	Tchoua(1983)
	trachyte	22.7-22	Dunlop(1983)
	rhyolite	22.32-0.49	Dunlop(1983)
Mt. Bamoun	basalt	0.24-0.12	Kamgang(1986)
Adamaoua	basalt	7.02	Gouhier et al. (1974)
		9.9-8.2	Dunlop(1983)
		10.36-8.22	Temdjim(1986)
	trachyte	9.8-7.9	Gouhier et al. (1974)
	phonolite	6.8-6.5	Temdjim(1986)
Mt. Mandara	basalt	27.4	Vincent and Amstrong(1973)
and			
Kapalki	trachyte	34	Dunlop(1983)

Table 1. The isotopic ages of ejectas

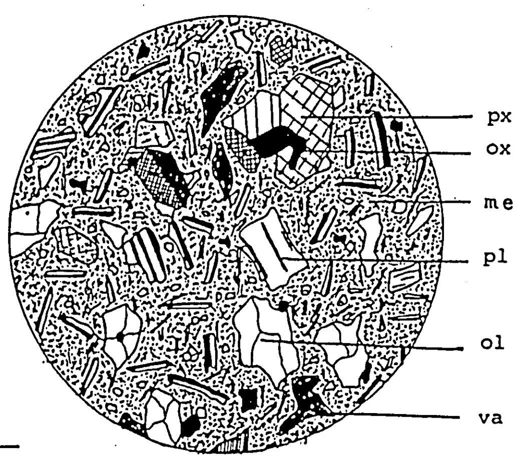

Fig.5 Microscopic observation of alkali basalt
ol: olivine, pl: plagioclase, px: pyroxene,
oz: oxide, me: groundmass, va: vesicle

Hawaiite: In the hawaiite, plagioclase (An60-85) is predominant than augite. Olivine phenocrysts appear in small fine grain (<0.5mm) and plagioclase phenocrysts commonly show the crystals are in general irregular, zoned and rimmed by augite and have embattled ends. Phenocrysts of magnetite are rather rare (1%) and associated with augite phenocrysts. The crystallization sequence of the phenocryst is the same as for the basalt.

Mugearite: Mugearite has microlitic porphyritic or doleritic structure. One millimeter size phenocrysts of plagioclase (An 50-55), augite and magnetite are found in a groundmass of the same minerals. The phenocrysts of plagioclase are frequently untwined and xenomorphic. Apatite, phlogopite and alkali feldspar are sometimes found in the groundmass (Fig.6).

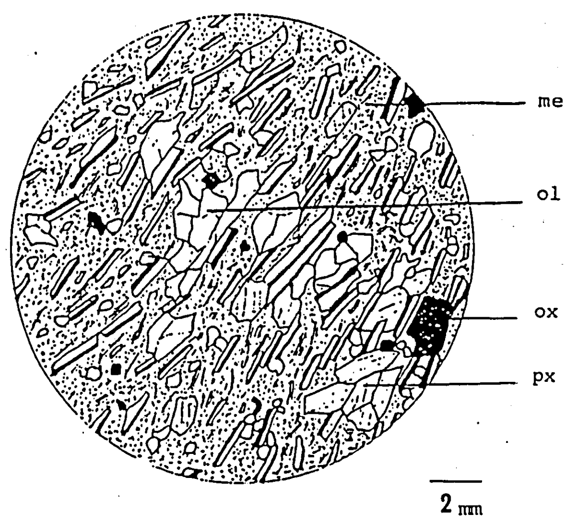

Fig.6 Microscopic observation of mugearite
ol: olivine, ox: oxide, px: pyroxene,
me: groundmass

IV. Chronology of volcanic event in the Mt. Cameroon

According to Geze (1943), earliest reference to the Mt. Cameroon as active volcano is the famous narration of the carthaginian navigator Hannon in his periplus along the African coast more than 25 centuries ago. The frequency of eruption are shown as follows;

1800-1815

Great eruption at 2600m altitude.

The lava flows reached the village of Mapanja (Fig.7).

Before 1835

Eruption without any information.

1838-1839

Eruption near The Fako (summit of Mt. Cameroon).

1845

Eruption above Buea.

1852

Eruption on the western flank.

1865

Eruption on the summit area.

1866

Eruption without other information

1868

Eruption on the north western flank.

1909

Only eruptions which occurred during the 20 century are well documented. However the 1909 eruption is still imprecisely located whilst the path followed by the differs greatly according to different writers (Geze, 1943; Vincent, 1980). Observation of aerial scenes and field work investigation confirm that the 1909 lava flew toward the east.

1922

Eruption took place near the Fako and on the southeastern flank. Large extracts of these reports have been summarized in Geze (1943). The trajectory of the 1922 lava flow which reached the ocean can be easily observed (Fig.7).

1925

An eruption probably took place near the Fako (Geze, 1943), but nothing more has been reported on it.

1954

The eruption located in the summital, was not of great extent (De Swardt, 1954). A crater seems to have originated from the reactivation of the large subactive crater (Geze, 1943). A small lava flow was emitted at the western base of this crater.

1959

The eruption took place on southeastern flank of the massif. Four craters erupted and three lava flows were emitted. The main flow stopped close to the village of Ekona where the steep slope of the flank suddenly ceases.

1982

The eruption was located at mid slope on the southwestern flank of the mount. An ancient cone was reactivated(Deruelleet al., 1983; Fitton et al., 1983).

V. Natural risk link to Mt. Cameroon

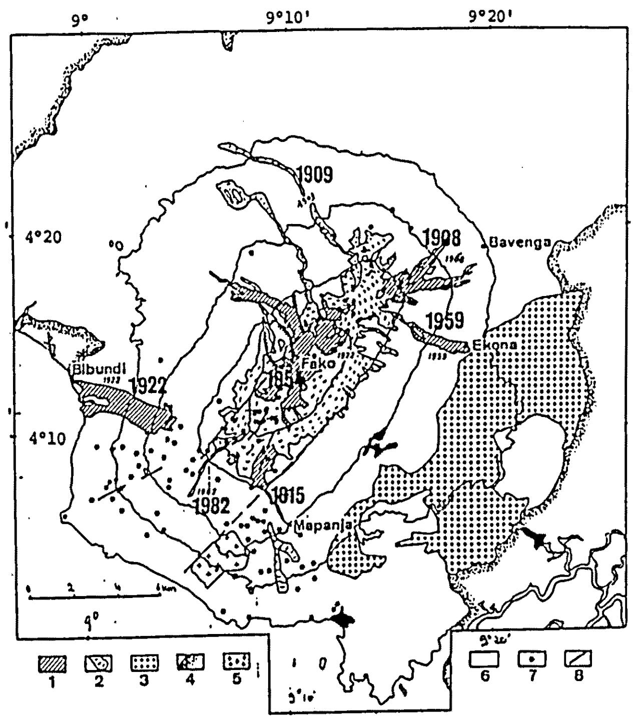

Fig.7 Geological sketch map and historical activity of the Mt. Cameroon
1: Registered historic lava flows,
2:Unregistered historical lava flow,
3: Lahar deposit,
4: limit of sedimentary rock,
5: Etindite of the Mt. Etinde,
6: Volcanic rocks,
7: Pyroclastic cones,
8: Faults or opened cracks

Recently, various kind of geological disaster have become more frequent due to the development of human society. The loss of human life, land and property due to the volcano is serious problem in Cameroon in general and particularly in Mt. Cameroon. The most recent and representative disaster related to active volcano is that of Saint Pierre in 1902 (Rittman, 1963). In Cameroon in 1922, a destruction of the village Bibundi (SW Cameroon) with over 100 casualties was caused by the lava flow and ashes. In 1984 and 1986, 2500 casualties at Monoun and Nyos (west and NW Cameroon) caused by toxic gas. The volcanic activity in Cameroon in general and particularly in Mt. Cameroon make worry the population settled in the region. Three categories of risk are distinguished in Mt. Cameroon : risk which happen before the volcanic activity for example earthquake, risk happen during the volcanic activity for example lava flow and risk happen after the volcanicactivityfor examplemud flow.

1.Natural risk before the volcanic activity

The Mt. Cameroon is considered as a horst volcano tectonic (Gouhier et al., 1974; Zoning, 1988) and is composed of in majorityby the pyroclastite. The volcanic events are principally controlled by tectonic lines (Morin et al., 1985) (Fig.8).

The geomorphology of Mt. Cameroon is composed of:

The lower zone between 0 and 1200m altitude in which the Tiko plain in the southeast, the Bibundi plain in the southwest are developed and limited by the fault whose main trend is N30-40°E. This zone is largely developed. The slope is gentle (less than 10°C).

The zone between 1200-2000m altitude is composed of Buea and Bambuko side, sloping slightly steeper (15-30 C). The Bambuko's side is characterized by great fracture zone with a high seismic activity (Ambey et al., 1987). This zone is exposed to natural risk due to the closest location to the out pouring of lava.

The third level 2200-3500m altitude is a cliff zone, the steepness have 60 to 70. A hundred of volcanic cones can be identified (nested cone and ringed cone) lined up following the direction of N30 E. This zone is particular dangerous. The landslide occurs often frequently.

The fourth level 3500 to 4100m is the arid zone. Many fractures are observed here for example having the trend N45-40°W, N80-70°W and the trend N30-40°E or axial trend (Fig.8). According to its altitude, this zone can be considered as sutured a wide scattered zone of volcanic product (pyroclastic and lava

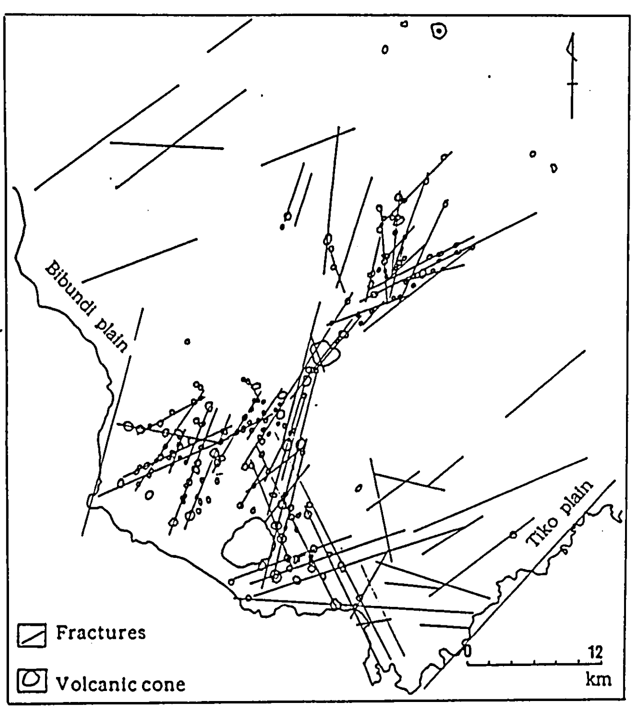

Fig.8 Distributions of fractures and cones in the Mt. Cameroon region

2. Earthquake

Earthquakes in the Cameroon line is frequent especially in the Mt. Cameroon and cause many damages (Fig.9). The study of historical eruption of the Mt. Cameroon show that many earthquakes took place often before the volcanic eruption. According to Geze (1943), Vincent (1971) and Ambrazey et al.(1984), seven earthquake of 1909 has cause an serious landslide at the summit of the Mt. Cameroon. An extensive dust cloud have been seen from Buea town. According to Geze (1943), eight and nine months after the eruption of 1909, a series of over 130 shocks has attacked to demolish the Limbe city. In 1948 violent shock were felt at Limbe Tiko, Douala and Kumba. Some habitations were damage at Limbe and Buea. In 1982 a shock was record at Buea but its intensity was low 3.8 in Richter scale (Fairhead, 1983). Before 1982 the earthquake taken place in the region of the Mt. Cameroon were evaluated empirically because of lack of appropriated material. Since 1982, the earthquake has been recorded with precision. The high intensity nowadays is about 3.4-4.5 in Richter scale (Ambeh et al., 1987). This low intensity is underlined by the location of the Mt. Cameroon and the epicenter far from the city and town. No damage has yet been record.

3. Volcanic eruption period

Two types of risk related to volcanic activity are identified. One is volcanic ashes and/or pyroclastites, and other is lava flow.

Extension and distribution of the disaster are emphasized by the nature of magma, the location of crater related to the direction of wind and the duration of eruption. According to Geze (1943), the eruption of 1922 was accompanied with a great quantity of ashes which could be observed at Bibundi, Debundsha and ocean located at 9km from the crater. These ashes cause an important damage in the region. Many houses made of wood were burnt, 100 people were died. At Batoke near the ocean 15 to 20m height of pyroclastic deposit were formed. Most habitation in Mt. Cameroon are built with wood. These houses can catch fire easily. During the 1982 eruption 0.8 and 2m thick paleosoil buried under pyroclasticdeposit were exposed (Deruelleet al., 1983).

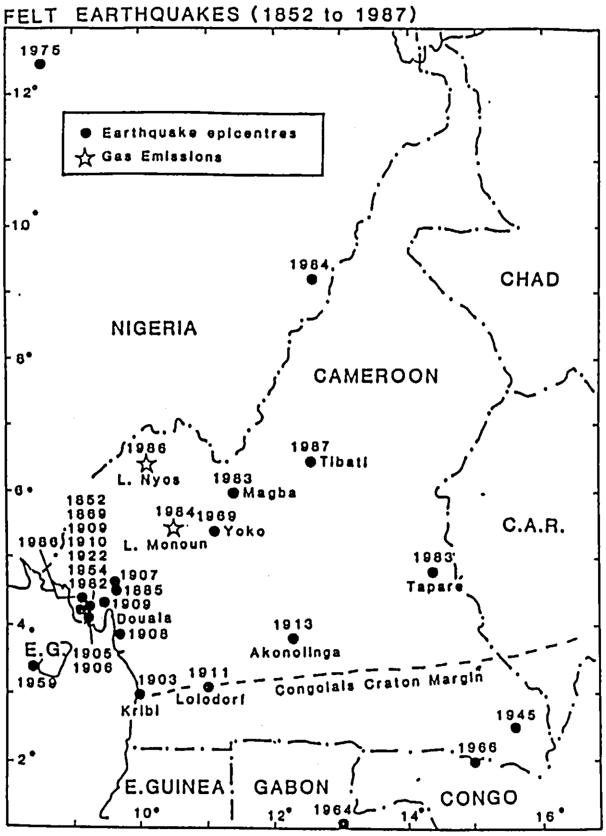

Fig.9 Felt earthquarkes in Cameroon from 1852 to 1987

4. Lava flow

The risk link to the lava flow depends on topography of the region, on the magma fluidity and on volume of lava. The Mt. Cameroon is high 4100m. The rapid flow zone correspond to the steep slope as those in Buea and Bambuko upper part. The low flow zone corresponding to the weak slope constituent rather a reception basin where lava accumulate and spread for a wide area for example at Bibundi. The lavas are essentially fluid and they can move rapidly or slowly follow on the slope. The flowing speed is variable300m/h during the 1909 eruption (Geze, 1943), 20km/hour during the 1959 eruption (Fitton et al.,1983). The volume of lava flowing in the Mt. Cameroon is considerable, i.e., 10 million of meter cubic for 1922 eruption (Jeremine, 1943). The lava of 1815 eruption had reached to Mapanja village from the summit(SW), the 1909 one had oriented to Bavenga village from the summit(NE), the 1922 reached to the sea from the bottom (SW) (Fig.7).

The lava damages forest, farm, rail way, about 100 causalities in Bibundi village (Geze, 1943). In 1959, during the eruption, the lava damaged forest, farm and many habitations without causality in Ekona village located at the NE flank of mount. In 1982 the lava flow have been oriented toward Bakingili and Isongo village. The population was very afraid but the lava didn't reach to the village. The later and the recent eruption don't present any preferential direction of lava flow. The flanks are exposed to the risk of lava flow which can spread up to 25km.

5. Mud flow or lahar

The lahar are the main products of volcanic activity (hot ejecta) due to the saturation of enormous quantity of water from the lake or layer underground water and snow or ice melting (Rittman, 1963). The lahar appears on a large area at the bottom of the Mt. Cameroon and spread on over 20-25km^2. It has been constituted by pyroclastite products and blocks. The pyroclastite products are ashes, scoria, lapilli and volcanic bomb. The blocks (3 to 5m) are essentially constituted of basalt. There is no graded bedding. The percentage of blocks is variable from 40 to 60% in volume. The lapilli are more abundant than ashes. The blocks can remove easily, their form and height are variable: angular, rounded from centimeters to meters. These lahar would be come from the summit with 15 to 25km/hour speed which permit them to reach the Tiko plain. According to Tchoua (1978), Deruelle et al. (1982; 1987), Zoning (1988), two hypothesis of their origin are presented: The great quantity of water should be come from either heaviest rain fall or glacial in origin. According to the distribution of rain fall and the position of lahar (Fig. 10), the origin of lahar will be ascribed to the volcanic eruption during the period of heaviest rain. The damages cause by lahar are serious as that caused by lava flow. Since the last century we did not have the lahar in the Mt. Cameroon.

VI. Perspectives

Since the last volcanic eruption in 1982 in the Mt. Cameroon and catastrophic disaster of toxic gas in lake Monoun in 1984 and lake Nyos in 1986 (Fig.9) the government pay attention to the problem of natural risk found in the country.

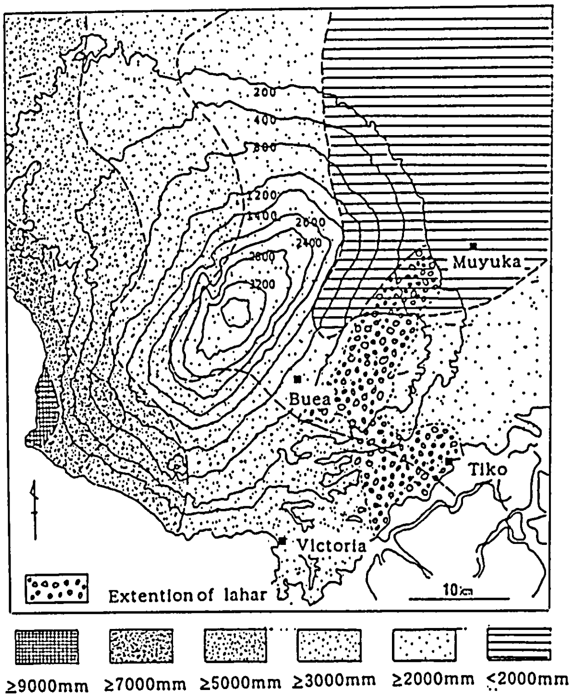

Fig.10 Rain fall distribution and lahar of the Mt. Cameroon

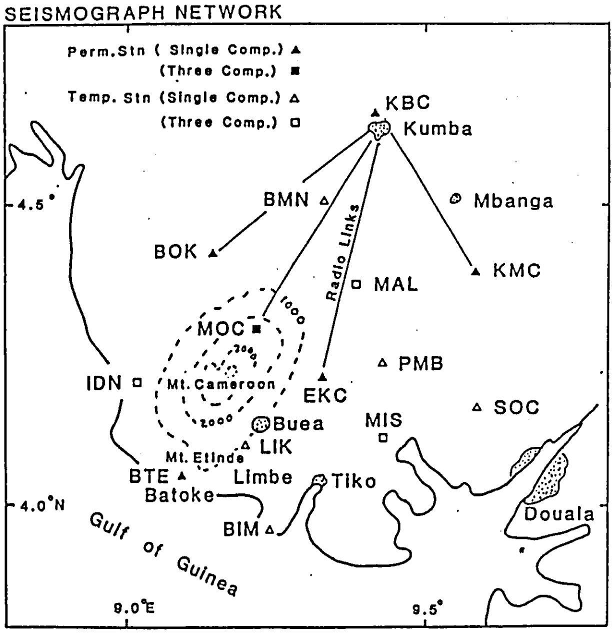

Fig.11 Seismic stations operating in the Mt. Cameroon region

Following the volcanic eruption of the Mt. Cameroon in October 1982, a network of 13 permanent seismic station were installed around the Mt. Cameroon (Fug.11).

The station on the Mt. Cameroon has two horizontal component seismometers. Signals from all seismometer sites are amplified, modulated and telemetered into two records linked to drum records.

The general frequency of seismicity is about 2 events every 3 days upon which is superimposed the temporal variation mainly caused by earthquake swarn.

Event from the seismic activity to the west and northwest of the Mt. Cameroon have impulsive P phase at stations and distinguishable S phase at relatively far stations. Epicenter is usually less than 25km. The concentration of epicenter is found in a small area close to Bokosso (BOK) which is due to a swarm (Fig.12).

Earthquakes in Ekona-Likomba-Tiko (EKC-LIK) have epicenter greater than 30km and characterized by emergence of P phase. Distinguishable S phases are also observed at relatively far station such as Kumba. All the deepest earthquakes are originated from this area.

Earthquake located off shore of immediately south of Bimbia (BIM) are due mainly to a single swarm which occurred on February 1986 (Ambeh et al., 1987). The events possess good P and S phase and occurred at depths between 10 and 20km.

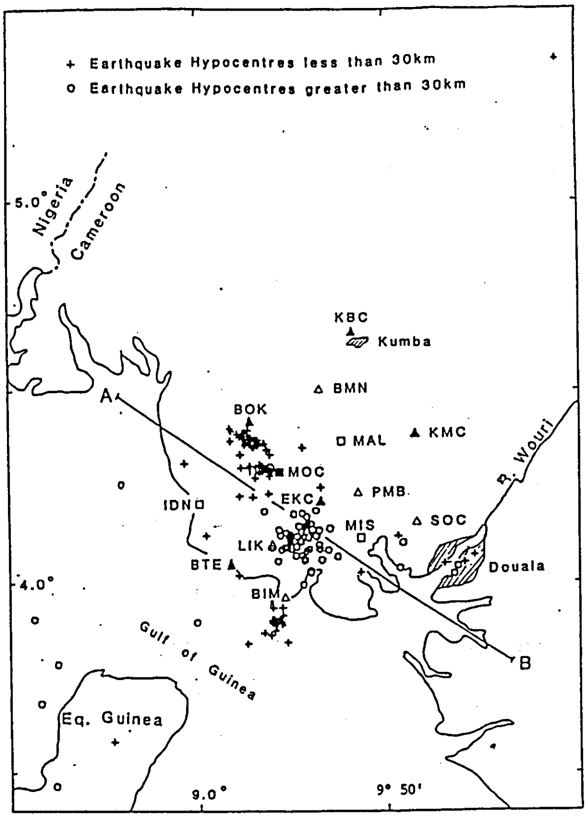

Fig.12 Seismicity of the Mt. Cameroon region
Crosses and circles represent event shallower and deeper than 30km respectively

Event on the Mt. Cameroon (MOC) occur mostly close to the station. The impulsive P phase and epicenter exhibit less than 15km in depth. Signal duration magnitude estimates for the local earthquake range from about 1.0 to 4.0 whilst Fairhead (1983) obtained magnitude estimation of about 2.8-3 for this earthquake. This difference is attributable to the fact that the data base presented here is from instruments in the source area. Event of magnitude greater than 3.5 are limited to felt earthquake associated with the Bokosso (BOK) swarm (Fig.12).

Our observation and result have confirmed the result of previous workers such as Fairhead (1985), Ambraseys and Adam (1986), Ambeh et al. (1987), that the seismicity in Cameroon is confined mostly to the Mt. Cameroon region. This seismicity show a background activity of about 2 events per 3 days (Fairhead, 1985) and is characterized by the occurrence of both single and multiple shock. The intensity of the earthquakes nowadays is about 3.4 to 4.5 (Ambeh et al., 1987).

VII. Discussion

Amongst the great geological assemblages of west Africa such as the Precambrian cratons, the mobile zones and the sedimentary basins, the Mt. Cameroon finds itself inclusive in the geological context of the Cameroon line which is composed of several volcanic and plutonic cycles cutting the mobile zone (Lassere, 1966). This has known Many controversial definitions have been proposed concerning the geology and tectonics. Geze (1943) defined the Cameroon line as a succession of horst and graben limited by fault with a N30°E trending lineament; Tchoua (1974) defined it as an incipient oceanic rifting; and Fitton (1983) defines as associated to an incipient continental rifting; and most recently, it has been defined as an intraplate accident which corresponds to a senestral crustal megashear zone with the volcano-plutonic complexes emplaced along the resulting tension gashes (Regnoult et al., in printing). The Mt. Cameroon is a large volcanic horst which belongs to the Cameroon line. The morphology of the Mt. Cameroon is controlled by tectonic movements. Aerial photo analyses reveal that the Mt. Cameroon is an elliptical mountainous relief characterized by cones, flows and rare necks. These rock out crops are either gentle or abrupt marked by stream channels. Many faults and fractures are identified (Fig.8). They are underlined by the dislocation and bumps, resulting lina alignments of volcanic cones. Lineaments have a radial arrangement at the peripheries of most mountains. The main trend at the summit is N30-40 E corresponding to the Cameroon line. At the bottom of the Mt. (SE) the main trends are N50-40°W and N50-60°E. According to Regnoult and others (in printing), the 55 W direction does not play the role of a sufficient shear to engender large scale fracture, since it does not correspond to any major accident in the Cameroon line. Radial structure are common in the Mt. Cameroon than ring dikes. The crescent from structures are found at the peripheries southeastern and northwestern flank of the Mt. Cameroon. They crop out nearly perpendicular to the radial structure. To clarify well the inner structure of volcano, it will be necessary to increase the number of observation station around the Mt. Cameroon. Actually the data from the 3 stations (Kumba KBC, Ekona EKC and Batoke BTE) (Fig. 11) show the low seismic intensity of 3.4 to 4.5 in Richter scale (Ambeh et al., 1987). These low value are due to the distance from the station to seismic focus (Fig.13).

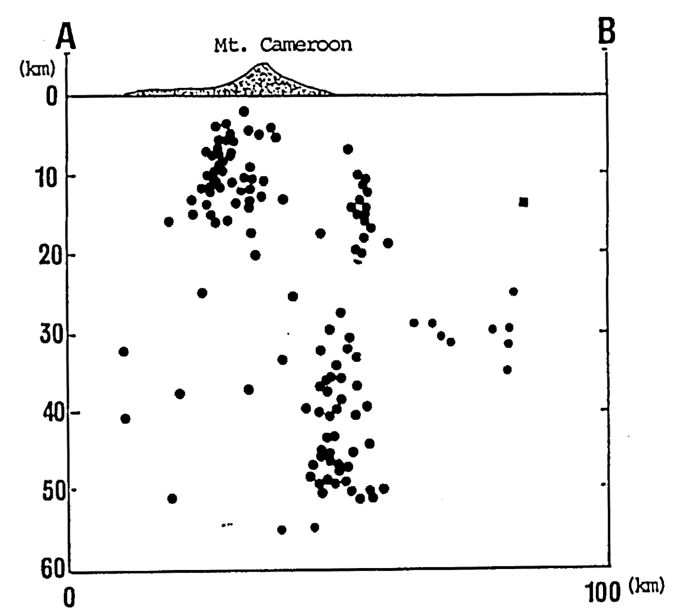

Fig.13 Hypocenter projected on to a NW-SE vertical plane. AB: for location of line, see in Fig.12.

To avoid fire caused by, not only th eject products but also by human activity the government should install many fire hydrant around the human settlement zone. In case of volcanic eruption, the lava flow shall not orient toward the area occupied by the population. A map of the volcanic risk (Fig. 14) has been proposed; it takes into account the socio-economic, natural (based upon morphology, geology, historic activity of the mount) and unsettled (climatic, hydrogeological, tectonic) factors. The zonation of volcanic risk has been limited to explosion. Explosions are possibility to take place anywhere on the mount. Nevertheless these explosions are most likely to occur in the delimited sector shown in Fig. 14. This map will be effective, if the population avoid to settle on the flank, in the deep valley and on the fracture zone. The most dangerous zone in the Mt. Cameroon is along the Cameroon line trend N30°E. This zone can be the head zone of explosive volcanism with extensive ejectas and formation of pyroclastic cone. Lahars have deposited voluminous material at Buea and along the bottom of the southeastern flank of the mount. Lahar has also possibly occurred during the glacial period (Deruelle et al., 1987).

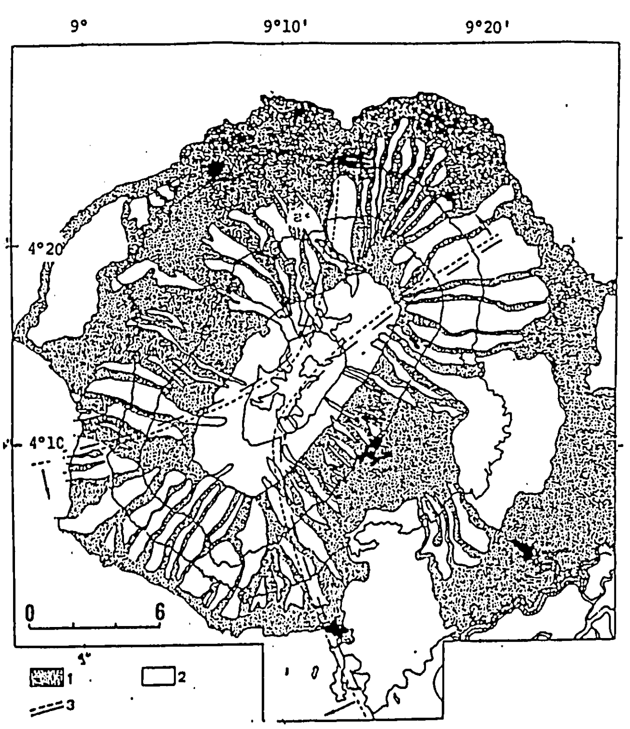

Fig.14 Map of volcanic risk of the Mt. Cameroon
1: Area below 3000m in altitude and supported to be covered by possible lava flows
2: Area theoretically protect from lava flows
3: Area limited by the four dashed line (between the arrows) and possible site of explosive volcanism (Pyroclastic projection and building of cones)

The population should be informed about the type of risk and how to behave at such event.

VIII. Conclusion

The petrographic study shows that the products of the volcanic activities are basic lavas constituted of picrites, alkali basalts, hawaiite at the margin of mugearites. Main constituent minerals are olivine, labrador and augite. The mineralogical and geochemical study carried out by N'ni (1984) show that the Mt. Cameroon lavas are typical of (undersaturated) alkaline lavas series. Any other origin than that of alkaline intraplate volcanism is inconceivable for the Mt. Cameroon. All these lavas are essentially fluid and flowing downward at 15 to 25km/h (Deruelle et al., 1982). Due to the relief the lava can spread at 20km. The abundance of pyroclastic product on the flank and its bottom show the variation of explosity index, low at the summit and strongly high in the low land zones, respectively. The tectonic characteristic, the large volcanic activity (10 times in the last century), the large volume and nature of products, depositions and their extensive weathering degree show that the Mt. Cameroon is a zone of high risk. Volcanic risk is actual for the human construction, mostly along the axis of the horst. The population and their investment are exposed to permanent risk such as earthquake, lava flow and lahar. These risk can also generate secondary disaster such as fire and flood. The zonation of volcanic risk has been limited to explosion and lava flow. No part of the mountains is actually free from volcanic risks excepting perhaps the Mt. Etinde itself.

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