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# **Nyos: Limnological catastrophe**

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## Limnological catastrophe

**The Limnological catastrophe** represents the physical phenomenon, at which are included by obligatory constituting part, ruinous for people and for animals, the ejection of gas from open water basin.

The Limnological catastrophe characterize by chemical compound, by mass and origin of gas, by duration of the ejection of the gas, by the trigger mechanism of catastrophe.

The Limnological catastrophe occurs since moment of time, when was switched on the trigger mechanism of catastrophe.

Limnological catastrophe can accompany, occur simultaneously or as a result of beginning of other catastrophes in the water basin or in his vicinity. For instance, at undersea eruption of the vulcan, at penetration of flow of the lava into the water basin and at other disastrous events. At such events more powerful catastrophe on consequence masks presence not so powerful, in count; calculate; list which can be limnological catastrophe. At such events more powerful, relatively of aftermath, catastrophe masks presence not so powerful by which can be of the limnological catastrophe. The Typical example the limnological catastrophes represent the catastrophes in **Cameroon**:

- **August 21 1986** on lake **Nyos**, at which had perished **1700** persons;
- **August 15 1984** on lake **Monoun**, at which had perished **37** persons.

The Conditions required for the beginning of limnological catastrophes, exist in lake Cameroon not only, but also in others the open water basins of our planet, for instance:

- on lake Kivu in east Africa;
- in lakes near mountain Mammoth Mth in USA;
- in lake Mashu in Japan;
- in maar Eifel in Germany;
- in lake Pavin in France.

The Conditions required for begining limnological catastrophes, can be created by leakage of carbon dioxide (CO<sub>2</sub>), who are swinging to the deep geological structure for long-term storage. The Gas, in the open water basins, can have magmatic origin (Nyos and Monoun), biogenic origin (lake Kivu) or technogenic origin (the gas, which are swinging into deep geological structure for long-term storage).

### «The Trigger mechanism»

The Trigger mechanism of limnological catastrophe characterize by composition, by location (the combination) of the forming parts and by the mass transfer.

In composition of the trigger mechanism of limnological catastrophe the parts can falls into varied of combination:

- **lake's waters, characterize by greater gradients of the temperature, of masses and of concentration of the solutes;**
- **earthquake;**
- **landslide;**
- **mudslide;**
- **wind;**
- **atmospheric precipitation;**
- **underground geological structures.**

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## The Mass transfer

The Mass transfer in trigger mechanism define by composition, by location of the forming parts and by physico-chemical properties of the flows of substances of these parts. At least one of the flows of the substances in obligatory order contains the components, which have ability are generating the gas.

## To Switch on

The parts, forming **the trigger mechanism** of **limnological catastrophe**, switch on the trigger mechanism, when features of parts become **critical**.

## The Prevention

Blocking of ability to switch on, of **the trigger mechanism**, prevents from **limnological catastrophe**.

By The Manner of blocking of ability to switch on, of **the trigger mechanism** can be:

- fortification of coasts of the water basin;
- the **degassing** of waters of the water basin;
- increasing or reducing of the level of waters in the water basin;
- the swinging (or evacuating) of the water and the water solutions into the aquifer;
- soak of solid stratum, which are situated under bottom of water basin, by the watertight substance;
- by intrusion into the geological structures of the microorganisms, whose products of vital activity reduce porosity of the geological structures.

## Monitoring

The Permanent actions on prevention of limnological catastrophes shall be accompanied by monitoring of the state of "trigger mechanism of" catastrophe.

## Nyos

High elevated (1090 m. above of sea level) the lake **Nyos** is formed 400 years ago by surface and underground waters, which have filled the **crater** of **maar**, what had formed as a result of the hydrothermal blast. The Explosion has occurred when the flow of the **lava** have met with underground water.

The Lake **Nyos** (6.44N 10.30E ) is located in Northwest province of **Cameroon** on the declivity of the mountain formation belonging to the volcanic chain , which has stretched in northeasterly direction from Atlantic ocean till the alpine of **Cameroon**. On big depth under mountain formation is situated magma, which continuously emits carbon dioxide (CO<sub>2</sub>). Carbon dioxide (CO<sub>2</sub>) moves upwards (the leakage) and dissolves in underground waters.

The Depth of lake **Nyos** 209 m., length 1400 m., width 900 m.. In the vicinity of lake there are numerous springs , in which water are carbonated ( contains the **carbon dioxide** (CO<sub>2</sub>)).

North coast of lake are confined by natural **dam** from volcanic rocks, and with height till 40 m.. Lake's waters via natural spillway on surface of the **dam** flow down along mountain declivity into river **Katsina**. The **Dam** has needs for urgent repair. The Progressing corrosion of the volcanic rocks, which are forming body of the **dam**, relaxes the **dam** and can be by cause her of destruction. The Destruction of the **dam** will cause the disastrous flood of the adjoining territory of **Cameroon** and **Nigeria**, will lower the level of lake's waters and will be disturbing of the ecology of the lake and of the adjoining territory.

On opposite declivity of the mountain formation at south-east direction on distance 95 km. are located another ( are cognates with lake **Nyos**) lake **Monoun** (the depth 95 m.) (5.58N 10.95E), which is also formed by the water, which have filled **crater** of the **volcano**.

The big mass of **carbon dioxide** (CO<sub>2</sub>), from terrestrial depths, continuously are supplying into (**leakage**) the lake with the underground waters.

Lake's waters characterize by the positive temperature (practically unchangeable on volume and at time), by high concentration of **carbon dioxide** (CO<sub>2</sub>) and by big gradient of this concentrations. Resemblance of the lake **Nyos** with the lake **Monoun** are complemented by the unified (for lakes) the atmospheric precipitation and by the unified (for lakes) the source (the **magma**) of **carbon dioxide** (CO<sub>2</sub>).

## Limnological catastrophe

At **August 21 1986** on lake **Nyos** has occurred of the **limnological catastrophe**, which has carried away the lifes of 1700 mans. Two years before that, at **August 15 1984** the similar **limnological catastrophe** has occurred on lake **Monoun** in **Cameroon**, which has carried away the lifes of 37 mans.

In both catastrophe the enormous mass of gaseous **carbon dioxide** was thrown away from lake's waters during several hours (CO<sub>2</sub>).

The Gas thrown away from the lake **Nyos** at **August 21 1986**, was moved quickly by two flows along mountain declivity, and all alives on distance till 25 km. from lake was killed by gas.

## «The Trigger mechanism»

The Distinguishing features of **limnological catastrophes** are «**Trigger mechanism**» and condition for his **to switch on**. The different variants of the composition «**Trigger mechanism**», responsible for different variants of **limnological catastrophes** on the lake **Nyos**, could be Possible:

- The Composition, by a parts for which could be: water solutions of **carbon dioxide** (CO<sub>2</sub>) in lake, the **landslides**, **mudslides**, **earthquakes**, **winds**, and **rains**. The needful condition of , **to switch on**, «**Trigger mechanism**» with such composition, is realizing by the moving of greater volume of water solution of **carbon dioxide** from bottom lake's layer to upper layer. Moving of water solution to upper layer of lake be accompanied by **decompression**, at which the gaseous **carbon dioxide** stands out from solution. Moving of greater volume of water solution of carbon dioxide from the bottom layers of lake to upper layer can occur because of **landslides**, **mudslides**, **earthquakes** and of **wind**, creating tidal wave, as well as because of fallout only at one half of lake of the **cool rain**.
- The Composition, by a parts for which could be: water solutions of **carbon dioxide** (CO<sub>2</sub>) in lake, and the small **vulcans** on the **maar's** bottom. The needful condition of, **to switch on**, «**Trigger mechanism**» with such composition, is realizing by the undersea eruption of the **vulcan**.

In maar's bottom at lake **Nyos** (and **Monoun**) not be discovered tokens of **landslides**, **mudslides** or of undersea **eruptions of the vulcans**, which could cause the **limnological catastrophe** on **August 21 1986** (and **August 15 1984**).

No , of the authentic datas about **earthquake**, about **winds**, by which are created the **tidal waves**, as well as about fallout only on one half of lake **Nyos** ( and **Monoun** ) of the **cool rains**, capable to cause **limnological catastrophe** on **August 21 1986** (and **August 15 1984**). In this connection , there are no base think that two mentioned variants of the **composition «Trigger mechanism»**, are being responsible for **limnological catastrophe** on **August 21 1986** on lake **Nyos** (and **August 15 1984** on lake **Monoun**).

Besides two mentioned variant of the **composition «Trigger mechanism»**, possible third variant of the composition , which validly can be considered responsible for **limnological catastrophe** on **August 21 1986** on lake **Nyos** (and **August 15 1984** on lake **Monoun**):

### *The Composition*

The composition of «**Trigger mechanism**» of **limnological catastrophe**, which has occurred on lake **Nyos** (and **Monoun**), includes:

- lake's waters , which characterize by greater gradient of the concentrations of **carbon dioxide** (CO<sub>2</sub>) , dissolved in them;
- the **solid (water-permeable)**, **sediment stratums**, situated under lake's bottom ;
- the **pressure aquifer**, situated under **solid (water-permeable)**, **sediment stratums**;
- the **magma**, situated under **pressure aquifer**;
- **atmospheric precipitation** at lake's vicinities.

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### *Atmospheric precipitation;*

The Distinguishing particularity, of the mass of **atmospheric precipitation** annually falling out since **October** till **May** (inclusively) month (the **dry period**) at the vicinities of lake **Nyos** (and **Monoun**), at this, that in **1983** the value of this mass are turned out to be the smallest (**critical**) of during the period of the observations since **1929** till **1988**.

### *The Mass transfer*

The **Mass transfer** in the **trigger mechanism** of the **limnological catastrophe** on lake **Nyos** (and **Monoun**), composes of from atmospheric precipitation, from flows of gaseous carbon dioxide (CO<sub>2</sub>), from flows of the water and the water solution of carbon dioxide, in such the sequence:

- In pressure aquifer the water flow is directed from the water recharge zone of pressure aquifer in the water discharge zone of pressure aquifer.
- Atmospheric precipitation, in the water recharge zone of pressure aquifer, enter into the mentioned water flow.
- The carbon dioxide from magma be supplying upward to the water flow, of pressure aquifer.
- The carbon dioxide dissolves in water of the water flow, and by this be formed of the water solution of carbon dioxide .
- Part of water solution of carbon dioxide from the pressure aquifer flows into the solid (water-permeable) sediment stratum.
- Water solution of carbon dioxide from solid (water-permeable) sediment stratum flows into lake's waters.
- Concentration of carbon dioxide in water solution in pressure aquifer are adjusting by velocity of the water flow and by the mass of carbon dioxide, which are supplying from magma into the water flow.
- Velocity of the water flow in pressure aquifer are adjusting by amount of the atmospheric precipitation, falling out in the water recharge zone of pressure aquifer.

### *To Switch on*

Limnological catastrophe in 1986 on lake Nyos (and in 1984 on lake Monoun) has occurred after enabling in 1983 by atmospheric precipitation of «trigger mechanism» of the catastrophe in the following sequence:

- Reduction during of the dry period of 1983 amount of the atmospheric precipitation has caused the reduction of velocities of the water flow at pressure aquifer and , simultaneously, has caused the magnification in water flow ,till anomalous high (critical) of the importances, of the concentration of the dissolved carbon dioxide.
- Water solution with the anomalous high (critical) importances of the concentration of carbon dioxide has moved in solid (water-permeable) sediment stratum under lake's bottom of Nyos at August 1986 ( and under lake's bottom of Monoun at August 1984).
- Emission of gaseous carbon dioxide from the supersaturated (critical) water solution of carbon dioxide , which are flowing in solid sediment stratum under lake's bottom, has caused the destruction of solid sediment stratum, and after that the surfacing and ejections in atmosphere of the enormous amount of gaseous carbon dioxide.

## The Prevention

The Prevention of the possibility of the repetition of the limnological catastrophe, which has occurred in 1986 on lake Nyos, can be realized by manner:

- by the increasing of water's level in the water basin;
- the swinging (or evacuating) of the water and the water solutions into the aquifer;
- soak of solid stratum, which are situated under bottom of water basin, by the watertight substance;
- by intrusion into the geological structures of the microorganisms, whose products of vital activity reduce porosity of the geological structures.

For prevention on lake Nyos of limnological catastrophes, which are characterized by trigger mechanism with the first variant of the composition (the water solutions of carbon dioxide (CO<sub>2</sub>) in lake, the **landslides**, the **mudslides**, the earthquakes, the winds, the rains), and which are differing against the catastrophe 1986, can turn out to be the sufficient manners:

- fortification of coasts of the water basin;
- the **degassing** of waters of the water basin;
- reducing of the level of waters in the water basin.

Since 2001 are realizing of the **degassing** of lake's waters of Nyos (and Monoun).

## The Monitoring

Data about natural leakage of carbon dioxide (CO<sub>2</sub>) from terrestrial depths in lake Nyos, about consequences (the catastrophe) of the leakage and about the manners of the prevention of the undesirable phenomena, are useful not only for prevention of the catastrophes on lake, but also for assessments of possible consequences of the sequestrations in the terrestrial depth of greater volume the technogenic carbon dioxide (CO<sub>2</sub>).

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