MECHANICS of be *SWITCHING ON of* the *TRIGGER MECHANISM of* *LIMNOLOGICAL CATASTROPHES*, happened in CAMEROON on lake "MONOUN" in 1984 and on lake "NYOS" in 1986., by the *INFLUENCE* of the ATMOSPHERIC PRECIPITATION in 1983.

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The Calculation with using the computer program "SONATA" has shown, that, *trigger mechanism of the limnological catastrophes*, who be happened in CAMEROON on lake "MONOUN" in 1984 and on lake "NYOS" in 1986 , *was switched on* by influence of the atmospheric precipitations in 1983.
The data of the monitoring of the monthly atmospheric precipitation in vicinities of the lakes "NYOS" and "MONOUN" per period with 1929 till 1988 are used in the calculation.
Limnological catastrophes on lake "MONOUN" in 1984 and on lake "NYOS" in 1986, were caused by the *instantaneous ejections of the gaseous* carbon dioxide from the sediment stratums under the lake's bottom.
The *Degassing* the waters of the lakes "NYOS" and "MONOUN" can not prevent from the repetition in lakes "NYOS" and "MONOUN" of the limnological catastrophes, similar to the catastrophes of 1984 and of 1986 , in which the trigger mechanism was switched on by the influence of the atmospheric precipitations.
Under influence of the atmospheric precipitation *the trigger mechanism of the the limnological catastrophes* in the lake "Nyos" and the "Monoun" , in any time may *to be switched on* and in a certain time hereon *will happen of the limnological catastrophes*.
As of the data of long times of the monitoring of the monthly atmospheric precipitations the program "SONATA" may do of the forecast of the gaseous ejections(of the *instantaneous* or of the *slow* , including *catastrophical*) from the sediment stratums of the lakes "Nyos" and "Monoun".

Расчёты с применением компьютерной программы «SONATA» показали, что *спусковой механизм лимнологических катастроф*, произошедших в Камеруне на озере "MONOUN" в 1984г. и на озере "NYOS" в 1986г., был *включён* в 1983г. воздействием атмосферных осадков.
В расчётах использованы данные мониторинга ежемесячных атмосферных осадков в окрестности озёр "NYOS" и "MONOUN" за период с 1929г. по 1988г..
***Лимнологические катастрофы* на озере "MONOUN" в 1984г. и на озере "NYOS" в 1986г. были вызваны *мгновенным катастрофическим выбросом диоксид углерода из водопроницаемого осадка, расположенного под дном озёр*.**
Дегазация* вод озёр "NYOS" и "MONOUN" не может предотвратить повторение в озёрах "NYOS" и "MONOUN" *лимнологических катастроф, подобных катастрофам* 1984г. и 1986г. *, спусковой механизм которых был включён воздействием атмосферных осадков.
***Включение спускового механизма* под воздействием атмосферных осадков *и последующие лимнологические катастрофы* на озере "MONOUN" и на озере "NYOS" *могут произойти в любое время*.**
По данным долголетнего мониторинга ежемесячных атмосферных осадков программа "SONATA"может прогнозировать *мгновенные* и *постепенные* (в т.ч. *катастрофические*) выбросы газа из водопроницаемого осадка озёр «Nyos» и «Monoun».

The Catastrophical ejections of the gaseous carbon dioxide (CO_2) in Cameroon (22) from lake "Nyos" (August 21 1986) and from lake "Monoun" (August 15 1984) have caused the mass ruin of the people and animal, as well as have endamaged to vegetation.

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МЕХАНИКА *ВКЛЮЧЕНИЯ СПУСКОВОГО МЕХАНИЗМА* *ЛИМНОЛОГИЧЕСКИХ КАТАСТРОФ*, произошедших в КАМЕРУНЕ на озере «MONOUN» в 1984г. и на озере «NYOS» в 1986 г., ВОЗДЕЙСТВИЕМ АТМОСФЕРНЫХ ОСАДКОВ в 1983 г..
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The Catastrophes in Cameroon on the lake "Nyos" and on the lake "Monoun" have distinctly shown the mortal danger of the sudden ejections from the terrestrial depths of the greater amount of the carbon dioxide on the surface of the land.
The Study of the reasons of the sudden ejections of the carbon dioxide particularly timely in connection with the influence of the carbon dioxide on the rates of the global warming, and in connection with the work to ***sequestration*** of the greater amount of the carbon dioxide in the depth geological structures (24).

There is other places on our planet (the lake "Kivu" in east Africa, lake "Mashu" in Japan, maar "Eifel" in Germany, lake "Pavin" in France, "Mammoth Mountain" in USA, some territory in Italy) (1,2,3,22), in which, according to result of this article, the ejections of the gaseous carbon dioxide and methane can cause the disastrous consequences.

The Catastrophes can be by the consequences of the leakage the carbon dioxide from underground geological formations, in which carbon dioxide injects on permanent (for instance, project Statoil CO2 injection at the Sleipner field) storage (4,23).

For the last twenty years (5,6,7,8), were studied physics -chemical processes in volume of the waters in the lakes "Nyos", "Monoun", "Kivu", was valued contribution of the mentioned processes in limnological catastrophes, and was declared the supposition about *trigger mechanism* of the *limnological catastrophes*.

The authors of the works (5, 22) holds the hypothesises , according which at the lake Monoun (and Nyos) gas burst originated by the release of huge amounts of pressurized carbon dioxide, previously dissolved in the lower layers of the lakes. As of the hypothesises, by the *trigger mechanism* are offered any exogenous disturbance (the collapses, winds, rain, earthquakes and others) or intrinsic instability (change to density, the temperature, acidity, saltiness and others) of the lake's water.

According to article (6), gas is formed on big depth in magma, then, near the Earth's surfaces, gas was dissolved into underground water.
Dissolved in underground water CO2, through the springs on bottom of the lake, was entered with underground water in the lake and are accumulated in the deep water.

According to the *limnic eruption* hypothesis (7), the carbon dioxide, with high concentrations, slowly was built up in the lake water column, but hereafter, a large part of the carbon dioxide was released after by a *trigger mechanism* was provoked of the local supersaturation.

Authors of the work (8) support the hypothesises of the *limnic eruption* for the lake "Kivu". They assumed, that the release of the gases (CO2, CH4), can be *triggered* by the magma eruption within the lake.

According to article (7), the exact nature of the *trigger mechanism* remains unknown.

As a whole, in study of the *limnological catastrophes* for the last twenty years prevails the study of the processes in volume of waters of the lakes "Nyos" and "Monoun".

In ditto time, slightly were studied contributions to *limnological catastrophes* of the processes outside of volume of lake's water, including:
the process the recharging the pressure aquifer by the water of the atmospheric origin,
the process the recharging of the water of the pressure aquifer by the carbon dioxide and methane of the magmatic origins,
the process of the flow of a part of the water solution of the carbon dioxide (CO2) and methane (CH4) from the pressure aquifer to lake through sediment stratum, which situated under the lake bottom,
the process of the flow of the water solution of the carbon dioxide and methane under lake bottom in the sediment stratum.

Together with that, for reasonable interpretation of the facts, characterizing *limnological catastrophes* on lakes "Nyos" and "Monoun", side by side with estimation of the contribution of the processes, occurring in volume of lake's waters, necessary to do of the estimation of the contribution of the processes, which occurs outside of volume of waters the lakes "Nyos" and "Monoun".

Qualitative and quantitative description *mechanics of switching on of the trigger mechanism* disastrous gaseous ejections on lake "Nyos" and "Monoun" - a key to decision of the problems of the forecasting of the time and scale of the disastrous gaseous ejections , obligatory condition of the motivated choice of the measures of the reduction of the destructive consequence after disastrous gaseous ejections , provision of the hold-harmless of the greater amount of the carbon dioxide in the underground geological stratum.

Qualitative and quantitative description mechanics of *switching on of the trigger mechanism* of *limnological catastrophes* must give the simple logical explanation of the following phenomenon:

The disastrous gaseous ejections on lake "Nyos" and "Monoun" have occurred at the August 21 1986 and at August 15 1984, and had a no place in foreseeable past;
The disastrous gaseous ejections existed on lake "Nyos" and "Monoun", and had no a place at any other the lake, located in the same region;
The values of the concentrations of the carbon dioxide in the water solution on the bottom of the lake "Nyos" and on the bottom of the lake "Monoun" vastly differ;
The values of the concentrations of the carbon dioxide in the water solution, on the bottom of the lake "Nyos" and on the bottom of the lake "Monoun", all time continuously are changing.

The Lake "Nyos" and Lake "Monoun" are located in the maar craters, was formed several hundred years ago, after blast of the overheated lava appeared at contiguity with the underground water.
Located on opposite side of the mountain massif "Mount Oku" on distance 95 km one till other, the lake "Nyos" and the lake "Monoun" possess by the *resemblance*.

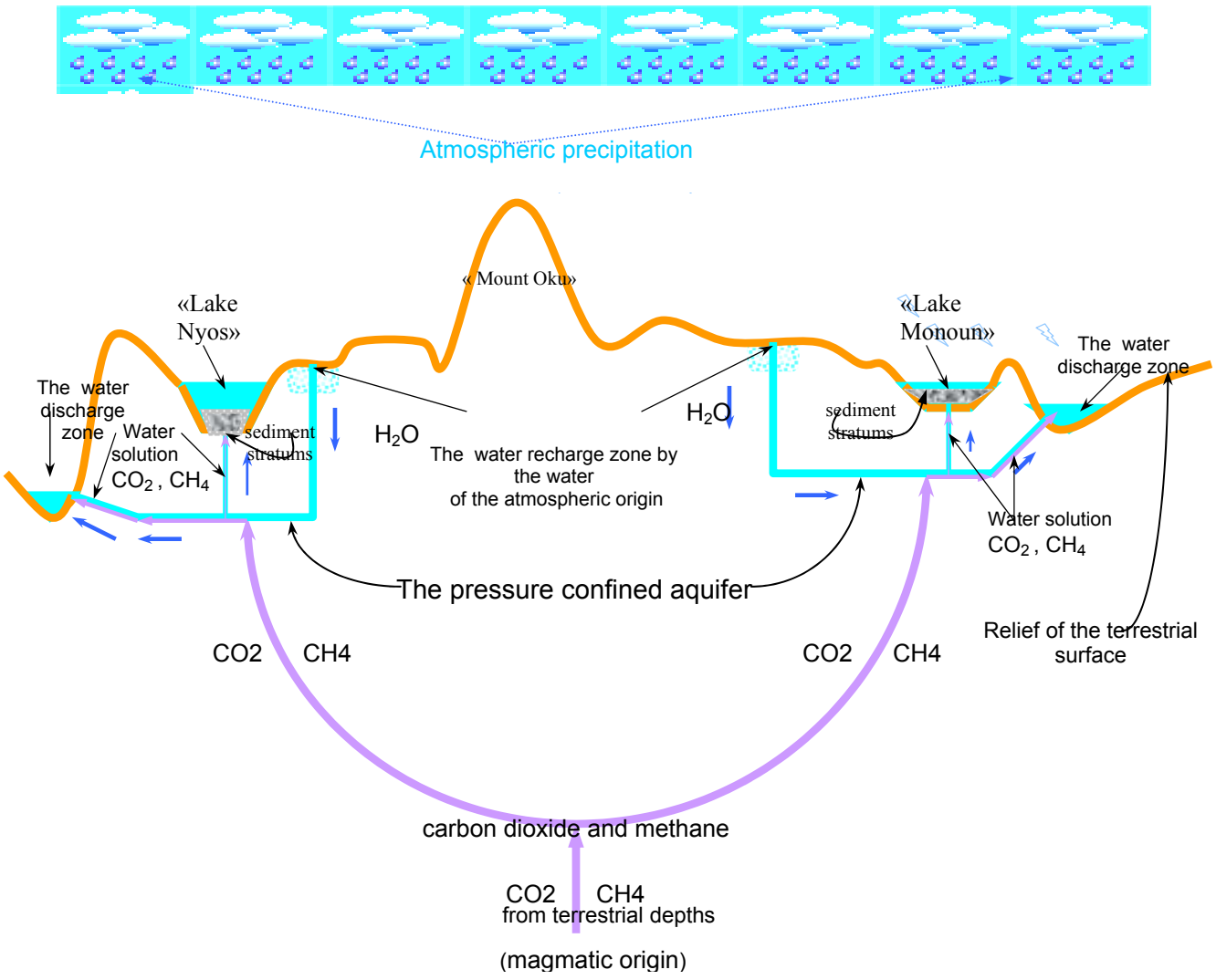

Fig.1. The Scheme of the forming of the water solution of the carbon dioxide and the methane , supply of this solution to the lakes "Nyos" and "Monoun".

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МЕХАНИКА *ВКЛЮЧЕНИЯ СПУСКОВОГО МЕХАНИЗМА*
***ЛИМНОЛОГИЧЕСКИХ КАТАСТРОФ*, произошедших в КАМЕРУНЕ на озере «MONOUN» в 1984г. и на озере «NYOS» в 1986 г.,**
ВОЗДЕЙСТВИЕМ АТМОСФЕРНЫХ ОСАДКОВ в 1983 г..
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Resemblance of the lakes "Nyos" and "Monoun" reveals itself in *resemblance* of their origin, in that, that they belong to same volcanic area (Oku Volcanic Field), in practically coincidence of the sequences and amount of the atmospheric precipitation, falling out in their vicinity, in presence in lakes of the water solution of the carbon dioxide and methane, and in the negligible changes the temperature of the water on lake's bottom.

In our work for description mechanics of the processes, generating *limnological catastrophes*, is accepted, shown on Fig.1., scheme of the flowing of the water in the pressure confined aquifer, under the lake's ("Nyos" and "Monoun") bottom, and in the lake's sediment stratum.
Every pressure confined aquifer (Fig.1.) has the water (atmospheric origin) recharge zone, gas (carbon dioxide and methane magmatic origination) recharge zone, pressure zone, fractional water discharge zone, and water discharge zone.
At the gas recharge zone, carbon dioxide and methane (magmatic origination) dissolves in the water (atmospheric origination) which are flowing in the pressure confined aquifer.
The fractional water discharge zone connects pressure zone of the pressure confined aquifer with sediment stratum under the lake bottom.
Sediment stratum, under the lake bottom, is permeable for the water solution (carbon dioxide and methane) which are flowing from the pressure confined aquifer.
Small part of the water solution (carbon dioxide and methane) from the pressure confined aquifer flows through the sediment stratum to the lake.

Taking into consideration *resemblance* of the lakes "Nyos" and "Monoun", description, abovementioned scheme of the flowing of water in the pressure confined aquifer and in the sediment stratum under the lake bottom (Fig.1.), formulates as follows:

The sequence and amount of the atmospheric precipitation, which are falling out in vicinities of the lake, alike for each of lakes "Nyos" and "Monoun";
The amounts and the ratio of the methane and the carbon dioxide, by which the terrestrial depths do charged of the water of the pressure confined aquifers, unchangeable and alike in foreseeable gap of time for each pressure confined aquifers;

Every of the lakes "Nyos" and "Monoun" is located over of the pressure confined aquifer;
Every of the lakes "Nyos" and "Monoun" are connected with pressure zone of the single pressure confined aquifer;

Under the bottom of each lake "Nyos" and "Monoun" are disposed sediment stratum, which is permeable for the water solution (carbon dioxide and methane) which are flowing from the pressure confined aquifer;
The sediment stratum of each lake "Nyos" and "Monoun" are disposed on penetrated faults and microcracksof the rock, which is located between of the sediment stratum and between of the pressure confined aquifer;

The faults and microcracks at rock are filled by the water-bearing rock, in which the water solution of the carbon dioxide and of the methane (magmatic origins) are flowing from the pressure zone of the pressure confined aquifer ;

The pressure confined aquifer contains the water-bearing rock, which are stretched from the water recharge zone till the water discharge zone;

Between area of the water recharge zone and the water discharge zone is located pressure zone of the pressure confined aquifer;

The water-bearing rock leave on surface of the land in the water recharge zone and in the water discharge zone;
The water recharge zone are located above of the water discharge zone;

The water recharging, of the water-bearing rock, leaving on surface in the water recharge zone of the pressure confined aquifer, are realizing due to infiltration in them part of the atmospheric precipitation, which are falling out in this area;

A part of atmospheric precipitation, which are seeping in the water-bearing rock in the field of water recharge zone, alike for each pressure confined aquifer;

The water of the pressure confined aquifer flows in the water-bearing rock from water recharge zone pressure confined aquifer in the water discharge zone pressure confined aquifer;

In the pressure zone of the pressure confined aquifer from below, across faults and tectonic rift in volcanic rock, from magma at heart land, rise and dissolve in water of the pressure confined aquifer the carbon dioxide and the methane, forming water solution CO2 and CH4;

The pressure confined aquifers differs one of other by the linear vertical and horizontal size;

The sediment stratums of the lakes, permeables for the water solution and differs one of other by the linear vertical size;
The lakes differs one of other by the linear vertical size;

The ratios ($\mathbf{n'}_{CH4}/\mathbf{n'}_{CO2}$) of the molar concentration $\mathbf{n'}_{CH4}$ methane and molar concentration $\mathbf{n'}_{CO2}$ carbon dioxide, rising from magma at terrestrial depths, were remained, within foreseeable time cell, the constant;

Comparatively small part of the water solution of the carbon dioxide and of the methane from the pressure zone of the pressure confined aquifer flows upward in the water-bearing rock,which are filling the faults and the tectonic rift of the volcanic rock, from the pressure zone till the sediment stratums under the lake's bottom;

The main amount of the water solution of the carbon dioxide and methane in the pressure confined aquifer flows from the pressure zone to the water discharge zone;

The sediment stratums, which are permeable for the water solution, and the water-bearing rock are considered as heterogeneous mixture of the solid porous phase (the bodies) with liquid (the water solution of the carbon dioxide and methane, the fluid carbon dioxide) and gas (the mixture of the gaseous carbon dioxide and methane);

The water solution of the carbon dioxide and methane are considered as the viscous incompressible liquid;

The temperature of the water solution of the carbon dioxide and methane constant and positive on the Celsius scale;

The gas is considered as ideal compressible liquid;

Solid porous phase (the body) are incompressible, has the limited breaking stress and has the destruction at the tensile stress in her, when the tensile stress are equaling or more than the breaking stress;

The breaking stress of the solid porous phase of the sediment stratums negligible in contrast with the breaking stress of the solid porous phase of the water-bearing rock of the pressure confined aquifer and in contrast with the breaking stress of the solid porous phase of the water-bearing rock, which are filling of the faults and of the tectonic rift of the volcanic rock .

The qualitative description of the abovementioned scheme of the flow of the water in the water-bearing rock and in the sediment stratums is used by the authors of this work at conclusion of the closed system of the equations of the mechanics of the processes (20), which are generating the limnological catastrophes, including, the condition of the the destruction of the solid porous phase of the sediment stratums, which are permeable for the water solution.

By the authors of this work, was applied to heterogeneous mixture of the conception about multi-velocity continuum (9), and was shown that condition of the destruction of the solid porous phase of the sediment stratums can be recorded (20) in the manner of:

$$\sigma_{прт}(\theta^z,\tau) - \left(- [1/\varphi_т]\bullet\{ [P_{fж}(\tau)]+[(\langle \rho'_{ос}(\tau,\theta^z)\rangle_{ос})/\rho^0_{H2O}]\bullet[(\theta^z_{ос} -\theta^z)]- -\varphi_g(\tau,\theta^z)\bullet P_g(\theta^z,\tau)-[\varphi_f(\tau,\theta^z)\bullet\left([(P_{fж}(\tau))-(P_{fДН}(\tau))]\bullet(\theta^z/\theta^z_{ос})+(P_{fДН}(\tau))\right)] \}\right)\le 0, \quad \textbf{[1.]}$$

where

$\sigma_{прт}(\theta^z,\tau)$ – the breaking stress (the non-dimensional, non negative value) of the solid porous phase (the body) at the moment τ in the point with the coordinate θ^z;

the subtrahend in left part of expression (1.) describes the stress (non-dimensional) in the solid porous phase (the body);

$\varphi_{т}$ - a volumetric concentration of the solid porous phase (the body) in the sediment stratums, which is permeable for the water solution;

$\varphi_{g}(\tau,\theta^{z})$ - a volumetric concentration of the gas (the gas mixture) at the moment τ in the point with the coordinate θ^{z} in the sediment stratums, which is permeable for the water solution;

$\varphi_{f}(\tau,\theta^{z})$ - a volumetric concentration of the water solution of the carbon dioxide and the methane at the moment τ in the point with the coordinate θ^{z} in the sediment stratums, which is permeable for the water solution;

$\mathbf{P}_{fж}(\tau)$- a hydrostatical pressure (non-dimensional) of the water on the boundary of the sediment stratums – the lake's water ($\theta^{z}=\theta^{z}_{oc}$);

$\mathbf{P}_{g}(\theta^{z},\tau)$ - a pressure (non-dimensional) of the gas (the gas mixture) at the moment τ in the point with the coordinate θ^{z};

$\mathbf{P}_{fДН}(\tau)$-a pressure (non-dimensional) in the water solution of the carbon dioxide and the methane at the moment of time τ on the boundary of the sediment stratums - the water-bearing rock ($\theta^{z}=0$), which are filling the faults and the tectonic rift of the volcanic rock.

[$\mathbf{P}_{fДН}(\tau)$ is a function of the linear and vertical sizes of the pressure confined aquifers, of the characteristic of the water-bearing rock, of the sequences and amount of the atmospheric precipitation, which are falling out and are seeping in the water-bearing rock of the water recharge zone of the pressure confined aquifer];

$(\langle \rho'_{oc}(\tau,\theta^{z}) \rangle_{oc})$ - is a value of the mean density of the sediment stratums;

ρ^{0}_{H2O} - is a value of the density of water;

θ^{z} - is a coordinate (non-dimensional) along of the vertical line in volume the sediment stratums ($0\le\theta^{z}\le\theta^{z}_{oc}$);

θ^{z}_{oc} - is a coordinate (non-dimensional) of the point along the vertical line on the border of the sediment stratums–the lake's water;

τ- is a moment of time (non-dimensional).

The value of a pressures of the gas $\mathbf{P}_{g}(\theta^{z},\tau)$ are defined by the values of the mole-fraction of the carbon dioxide $\mathbf{c}_{0}(\theta^{z},\tau)$ and of the pressures $\mathbf{P}_{f}(\tau,\theta^{z})$ in the water solution of the carbon dioxide

and the methane at the moment of the time τ in the point of the sediment stratums with the coordinate θ^z in accordance with the expressions:

$[c_0(\theta^z,\tau)-\chi_B \bullet [P_g(\tau,\theta^z)]] = 0$ under conditions $[c_0(\theta^z,\tau)/\chi_B] \geq [P_f(\tau,\theta^z)]$, **[2.]**

$[P_g(\tau,\theta^z)] = [P_f(\tau,\theta^z)]$ under conditions $[c_0(\theta^z,\tau)/\chi_B] < [P_f(\tau,\theta^z)]$, **[3.]**

where

$$c_0(\theta^z,\tau)=[n_{CO2}(\tau,\theta^z)/\{n_{H2O}+n_{CH4}(\tau,\theta^z)+n_{CO2}(\tau,\theta^z)\}], \quad [4.]$$

$$\chi_B = [\xi_g \bullet \rho^0_{H2O} \bullet g]/[\gamma_{CO2} \bullet K'_{CO2} + (n'_{CH4}/n'_{CO2}) \bullet (\gamma_{CH4} \bullet K'_{CH4})], \quad [5.]$$

$n_{CO2}(\tau,\theta^z)$- is a molar concentration of the carbon dioxide in the water solution of the carbon dioxide and the methan at the moment of the time τ in the point of the sediment stratums with the coordinate θ^z,

$n_{CH4}(\tau,\theta^z)$ – is a molar concentration of the methane in the water solution of the carbon dioxide and the methane at the moment of the time τ in the point of the sediment stratums with the coordinate θ^z,

n_{H2O} - is a molar concentration of the water in the water solution of the carbon dioxide and the methane at the moment of the time τ in the point of the sediment stratums with the coordinate θ^z,

ξ_g - is a typical length of the tubular cavities in the solid porous phase of the sediment stratums,

g - is a value of the acceleration of gravity,

K'_{CO2} - is a constant Henry for carbon dioxide,

K'_{CH4} - is a constant Henry for methane,

γ_{CO2} - is a activity coefficient for carbon dioxide,

γ_{CH4} - a activity coefficient for methane.

$[\chi_B \bullet P_f(\tau,\theta^z)]$- the threshold value of the mole-fraction $c_0(\theta^z,\tau)$ of the carbon dioxide in the water solution at the moment of the time τ in the point of the sediment stratums with the coordinate θ^z, $(\theta^z_{oc} \geq \theta^z \geq 0)$.

If the mole-fraction $c_0(\theta^z,\tau)$ of the carbon dioxide are less or equals an threshold value, that the pressure of the gas $P_g(\theta^z,\tau)$ equals a pressure in the water solution of the carbon dioxide and the methane (the viscous incompressible liquid) $P_f(\tau,\theta^z)$ at the moment of the time τ in the point of the sediment stratums with the coordinate θ^z.

Increasing of the mole-fraction $c_0(\theta^z,\tau)$ of the carbon dioxide more than threshold value are causes the increase of the pressure of the gas $P_g(\theta^z,\tau)$ till the values exceeding of the pressure $P_f(\tau,\theta^z)$.

With increase the pressure of the gas $P_g(\theta^z,\tau)$ the stress of the compressions of the solid porous phase are applies to zero and, instead of he, appears and grows the tensile stress.
At moment of time, when the tensile stress of the solid porous phase are becomes equal or more than the breaking stresses of the solid porous phase $\sigma_{прт}(\theta^z,\tau)$, the solid porous phase will be ruined.

If mole-fraction $c_0(\theta^z,\tau)$ of the carbon dioxide in the water solution of the carbon dioxide and the methane in any point of the sediment stratums less than the threshold value, are executed the correlation [3.], but the correlations [1.], [2.] are not executed. At this, the ejections of the gas from the sediment stratums in the lake's water does not occur, i.e. the ejection of the gas are the *null*.

The transportation of the carbon dioxide and the methane from the sediment stratums in the lake's water in this case it are realized by the water solution, which flows from the sediment stratums to the lake's water.

If the mole-fraction concentration $c_0(\theta^z,\tau)$ of the carbon dioxide in the water solution of the carbon dioxide and the methane in some point (immovable) of the sediment stratums with the coordinate θ^z during of the time will increased , that, are becomes equal or more than of the threshold value of the mole-fraction of the carbon dioxide, can will come such length of time, when in this point is executed the correlation (2.), but the correlations (1.), (3.), are not executed.

If this occurs in the surface layer of the sediment stratums, at the mentioned length of time, then, when water solution of the carbon dioxide and the methane are moving from the sediment stratums in the lake's water, the carbon dioxide and the methane, on the border of the sediment stratums-the lake's water ($\theta^z=\theta^z_{oc}$), be are diffuses from the supersaturated water of the solution in the nucleuses of the gas bubbles, which are being present (11) in the lake's water.

Herewith from the sediment stratums in the lake's water, with solution, during unit of time, will be transporting of the carbon dioxide and the methane in the amount to proportional the velocities of the flow of the water solution of the carbon dioxide and methane.

The gas bubbles, forming on border of the sediment stratums - lake's water, saltatory are increasing in volume, radiate changing of the pressure in the time.

Changing in the time of the pressure can be perceived in atmosphere on the lake as the bubling or the low rumbling, the explosions, the seethe, the whistle and the hissing of different loudness.
Loudness is defined by amount of the forming gas bubbles, by the sound spectrum, which are create during of the changing of the sizes of the gas bubbles on the border of the section of the sediment stratums - the lake's water and by the pulsation of the shell of the gas bubbles.

Formed at the border of the sediment stratums - the lake's water, the gas bubbles are pulsing and are increasing in the volume, and are surfacing to the surface of lake.

The surfacing gas bubbles, except gas, from the lake's bottom are transporting (flotation) of the ferric minerals and the other mineral, which hereinafter will produces the appearance on the lake's surfaces of the painted area.

So are realized *slow* (not *Instantaneous*), comparatively small and regular (not disastrous) the ejections of the gas. Duration of the *slow* gas ejection is a day and more. The amount, standing out during of the unit of time, of the gas during the *slow* ejections of the gas is a variable value.

If in point θ^z of the sediment stratum ($\theta^z < \theta^z_{oc}$) the mole-fraction $c_0(\theta^z,\tau)$ of the carbon dioxide be more than the threshold value , and after this the mole-fraction, will increases up to values , with which is executed correlations [1.] , at moment of time, when will begin be executed correlations [1.], *instantly* will destroyed the upper layer (thickness $(\theta^z_{oc}-\theta^z)$) of the solid porous phase of the sediment stratums.

The destruction of the solid porous phase, containing the gaseous mixture, is accompanied by the *instant* liberation and expansion of the gaseous mixture of the carbon dioxide and the methane (the gas), which forms the gas bubbles stream, which are surfacing to the lake's surfaces.

The *instant* destruction on big area of the solid porous phase of the sediment stratums, containing the gaseous mixture, and expansion of the gaseous mixture, generate the *acoustic field* (boom), which, in some places, can be perceived as the earthquake.

The *Sound field*, who are generating by two different physical processes (the destruction of the solid porous phase, expansion of the gaseous mixture), possesses, at least, two the maximums, who differs in time and which could be sensed as separate strong blasts.

Under influence of the *acoustic field* will be destroyed a another part of the solid porous phase of the sediment stratums (not more 1%), located under point with coordinate θ^z.

The *acoustic field* are causes of the following increase of the mass and volume of the gas in the stream of the gas bubbles , including, the stream of the gas bubbles in the water solution of the carbon dioxide and the methane in the destroyed solid porous phase of the sediment stratums.
Increasing of the mass and volume of the gas in the stream of the gas bubbles occurs by way of the diffusions in the gas bubbles of the carbon dioxide and the methane from the supersaturated water solution of the carbon dioxide and the methane (a gaseous cavitation), which be contained in destroyed parts of the sediment stratums.

During of the *gaseous cavitation*, the surfacing stream of the gas bubbles (the *field bubbles*) does of whistle or of hissing sound (10).
The field bubbles, herewith, can radiate, visual observed in the dark, of the light (11).
The velocities of the surfacing bubbles by diameter 0,1 - 2,0 cm. are equal to 20-30 cm/sec (12,13).
The field of the surfacing gas bubbles carry away the part of the lake's deepest waters, which are charged of the carbon dioxide and methane.

The gas, which are discharging (cavitation) from this part of the lake's deepest water, enlarge the volume of the gaseous ejection.

The gaseous ejection of this sort occurs for hour and less, are accompanied by the ejections of the big amount of the gas from the sediment stratums and they are *instant* on scale of time of the *slowly* current processes to the pressure confined aquifers and the sediment stratums.

The solid particles from destroyed part of the sediment stratums subsequently are falling to the lake's bottom, and are covering his by the even layer.

The *Instantaneous* gas ejections occur relatively seldom, and can be *catastrophic*.

Consequently, gaseous ejections can be:
Null;
Slow;
Instantaneous.

Null gaseous ejections are not *catastrophic*.

The *Instantaneous and Slow* the ejections of the gas depending on amount of the ejected gas can be catastrophic, but can and be not catastrophic.

The column of the carbon dioxide by height 0,2 m., mingling with the air, have the capability are forming the column 15 % (volume) air mixture by height in 1,5 m..
Inhalation of this air mixture mortally for person (21).

Catastrophic ejections are a gaseous ejections, at which height of the column of the gas (carbon dioxide), ejected during day, on surface of the lake exceeds, in recalculation on the normal (1 atm., 278,10K) conditions, 0,2 м..

The *catastrophic* gaseous ejections are mortally dangerous for the person.

The *Instantaneous and Slow* (not *catastrophic*) ejections of the gas from the sediment stratums of the lake can be a reason to deaths of the people and animal in single events.
At the catastrophic Instantaneous and catastrophic Slow ejections of the gas from the sediment stratums of the lake occurs the mass ruin of the people, animal and vegetation on lake and in his vicinity.

The *catastrophic Slow* ejections of the gas do not be accompanied by the appreciable mechanical destructions.

The *catastrophic Instantaneous* ejections of the gas are accompanied by the appreciable mechanical destructions.

The authors of this work, on the base of the mentioned closed system of the equations of the mechanics processes, by what are generated of the *limnological catastrophes,* have developed the computer program "SONATA" for quantitative estimation of the processes, by what are generated of the *limnological catastrophes*, including, the calculation of the change of the mole-fraction of the carbon dioxide and the methane in the water solution in the sediment stratums and in the water-bearing rock , and determination of the periods of the ejections of the gas and of the amount of the being ejected herewith of gaseous CO2 and CH4.

In this work the program **"SONATA"** are used for calculation of the processes, by which are generating of the *limnological catastrophes*, in the lake "Nyos" and in the lake "Monoun".

However, program **"SONATA"** are suitable for calculation of the processes, capable to generate the *limnological catastrophes* in the other places of the earth, as well as for calculation other *catastrophes*, caused gaseous ejections from the water-bearing rock.
At the thickness the sediment stratums 10 m. and at the parameters of the lakes "Nyos" and "Monoun", the resolution ability of the program **"SONATA"** on the time of the gaseous ejections: +/- 10 day.

At calculation are used the original data, by which characterizes the carbon dioxide and the methane of the magmatic origins. The Carbon dioxide and the methane of the biogenic origins in the original data were left aside.

In the original datas of the lake "Nyos" and lake "Monoun" at the program "SONATA" are used the data of the monitoring of the monthly atmospheric precipitations (14) to weather station "BAMENDA", (WMO station code: 64893.1 BAMENDA, coordinates: 6.00N , 10,10E, 1608m), behind period 1929 - 1988.

The station "BAMENDA" are located practically on equal distance against of the lakes "Nyos" and "Monoun".
The Period of the monitoring the monthly atmospheric precipitation, executed by weather station "BAMENDA", covers the time cell most, in contrast with the other stations, which list is provided in work (15).

Distribution of the amount of the annual atmospheric precipitation, is shown on Fig.2., are determined by with use the monitoring the monthly atmospheric precipitation by the weather station "BAMENDA".

The Program "SONATA" were used for calculations of the *six scenarios* of the gaseous ejections in lakes "Nyos" and "Monoun", which are specified in six columns on the right of the **Tables 1..**
Used at calculation the original data, which is not specified in this work, alike for each scenario.

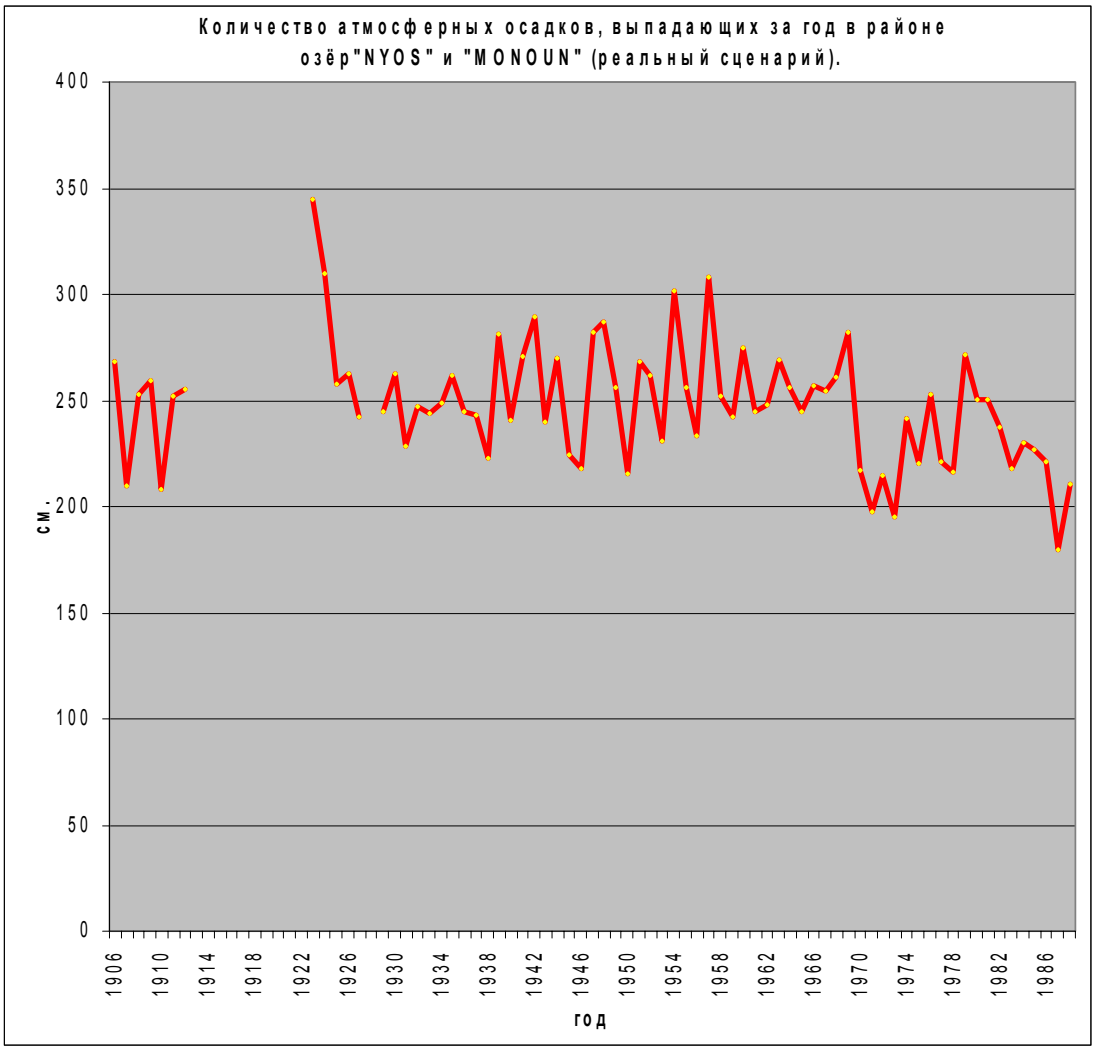

Fig. 2. The amount of the annual atmospheric precipitation in vicinity of the lakes "NYOS " and "MONOUN". (Real scenario)

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(Natalija Solodovnika· Anatolijs Solodovniks)

МЕХАНИКА *ВКЛЮЧЕНИЯ СПУСКОВОГО МЕХАНИЗМА*
***ЛИМНОЛОГИЧЕСКИХ КАТАСТРОФ*, произошедших в КАМЕРУНЕ на озере «MONOUN» в 1984г. и на озере «NYOS» в 1986 г.,**
ВОЗДЕЙСТВИЕМ АТМОСФЕРНЫХ ОСАДКОВ в 1983 г..
02.06.2006

The Table 1.

The Parameters:	**Lake «Nyos»**	**Lake «Monoun»**	**Lake «Nyos» R**	**Lake «Monoun» R**	**Lake «Nyos» A**	**Lake «Monoun» A**
Height of the the water recharge zone of the pressure confined aquifer comparatively sea level, m.	1148,97	1140,84	1148,97	1140,84	***1152,97***	***1144,84***
Height of the water discharge zone of the pressure confined aquifer comparatively sea level, m.	1079,21	1061,85	1079,21	1061,85	1079,21	1061,85
Height of the surface of the lake, comparatively sea level, m.	1090,72	1027,05	1090,72	1027,05	1090,72	1027,05
Depth of the lake, m.	209,00	95,24	209,00	95,24	209,00	95,24
Thickness of the layer of the sediment stratums, m.	10,00	10,00	10,00	10,00	10,00	10,00
Distance, along the vertical line, from the lower surface of the sediment stratums till the pressure zone of the pressure confined aquifer, m.	61,34	89,94	61,34	89,94	61,34	89,94
Distance, along the vertical line, from surface of the lake till the pressure zone of the pressure confined aquifer, m.	280,34	195,18	280,34	195,18	280,34	195,18
Distance, along horizontal line, from of the water recharge zone of the pressure confined aquifer till the water discharge zone of the pressure confined aquifer, m.	12000,00	7500,00	12000,00	7500,00	12000,00	7500,00
Distance, along horizontal line, from of the water recharge zone of the pressure confined aquifer till the lake, m.	6000,00	3000,00	6000,00	3000,00	6000,00	3000,00
$(\mathbf{n'}_{CH4}/\mathbf{n'}_{CO2})$	0,020	0,020	0,020	0,020	0,020	0,020
Sq. area of the surface of the bottom of the maar, km^2	0,435	0,032	0,435	0,032	0,435	0,032
Sq. area of the surface of the lake, km^2	1,580	0,526	1,580	0,526	1,580	0,526
φ_{τ}	0,400	0,400	0,400	0,400	0,400	0,400
$\varphi_{g(\tau,\theta^{z})}$	0,020... ...0,200	0,020... ...0,200	0,020... ...0,200	0,020... ...0,200	0,020... ...0,200	0,020... ...0,200
$\varphi_{f(\tau,\theta^{z})}$	0,400... ...0,580	0,400.. ...0,580	0,400... ...0,580	0,400... ...0,580	0,400... ...0,580	0,400... ...0,580
The Amount of the annual atmospheric precipitation in 1983, cm.	217,90	217,90	***228,80***	***228,80***	217,90	217,90

Наталья Анатольевна Солодовник · Анатолий Борисович Солодовник
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МЕХАНИКА *ВКЛЮЧЕНИЯ СПУСКОВОГО МЕХАНИЗМА*
***ЛИМНОЛОГИЧЕСКИХ КАТАСТРОФ*, произошедших в КАМЕРУНЕ на озере «MONOUN» в 1984г. и на озере «NYOS» в 1986 г.,**
ВОЗДЕЙСТВИЕМ АТМОСФЕРНЫХ ОСАДКОВ в 1983 г..
02.06.2006

Specified in **Table 1.**, the vertical and horizontal distances, characterizing of the geometry of the pressure confined aquifer, defines, by using, the one-to-one mapping of the curve line,which are passing along the natural pressure confined aquifer, and the broken line, consisting of the vertical and horizontal segments of the straight line.

The lengths of segments of the curve line and of segments of the straight line. (the reciprocal correspondence) at the one-to-one mapping are not changed.
The elevations and the thicknesses, specified in **Table 1.**, at the one-to-one mapping are not changed.
The broken line, hereinafter, characterizes the geometry of the pressure confined aquifer.

The *Real scenarios*, with using parameters from the columns **"Lake "Nyos""** and **"Lake "Monoun""** of **Tables 1.**, authors this article consider plausible.

The term plausible is used whereas, not having of the results of measurement, in natural conditions, of the parameters of the lakes "Nyos", "Monoun" and the pressure confined aquifer, authors carried in original data some parameters, got by analysis of the indirect data for the lakes "Nyos" и "Monoun").

In columns ""Lake "Nyos" R and Lake "Monoun" R" **Tables 1.**, the Real scenarios of falling out of the atmospheric precipitations, is replaced by Conditional scenarios , in which parameters "Amount of the annual atmospheric precipitation in 1983." for the lake "Nyos" and for the lake "Monoun" are increased on 5% in contrast with the data of the station "BAMENDA".

Change of scenarios is connected with the need of the identification of the sequences and amount of the atmospheric precipitation as regulator to mole-fraction carbon dioxide and methane in water solution, flowing in the pressure zone of the pressure confined aquifers under the lakes "Nyos" and lake "Monoun".

In columns “Lake "Nyos" A” and ”Lake "Monoun" A” **Tables 1.**, *Real* scenarios is replaced by *Changed* scenarios, in which parameters of topographies "Elevation at sea level of the the water recharge zone of the pressure confined aquifer” of the lakes "Nyos" and "Monoun" are increased per 4 metres.

Changing the scenarios is connected with need of the explanation of the experimentally observed difference in mole-fraction carbon dioxide in lake "Nyos", in lake "Monoun" and in others lakes in the same region.

According to, the graphs on the Fig 3. («Nyos») and Fig 8. («Monoun»), maximum mole-fraction carbon dioxide (the *Real* scenario) in 1983 in the point of the mixing in the pressure zone of the pressure confined aquifer, supplying the water solution of the carbon dioxide to the lakes "Nyos" or "Monoun", was being anomalous high in contrast with maximum mole-fraction of the carbon dioxide in the water solution in same pressure zone at any other year for period 1929-1988:
0,1940 in the pressure zone pressure confined aquifer of the lake "Nyos";
0,0249 in the pressure zone pressure confined aquifer of the lake "Monoun".

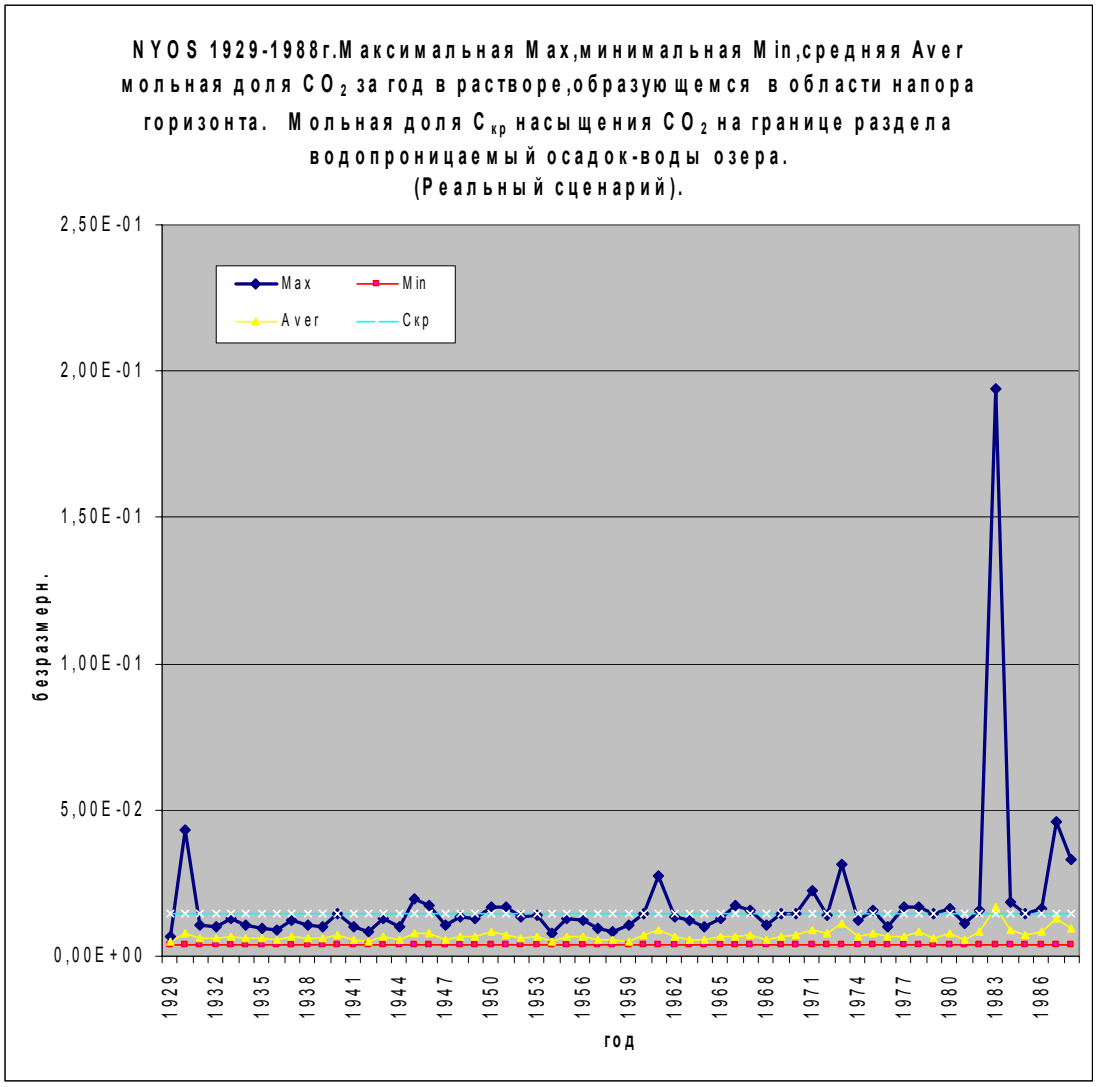

Fig. 3. NYOS 1929-1988. Distribution under years of the maximum Max, of the minimum Min and average Aver of the the mole-fraction of the carbon dioxide in the point of the melange in the the pressure zone of the pressure confined aquifer, but in the same way the mole-fraction of the saturation Скр carbon dioxide on upper surface of the sediment stratums.

(The Real scenario).

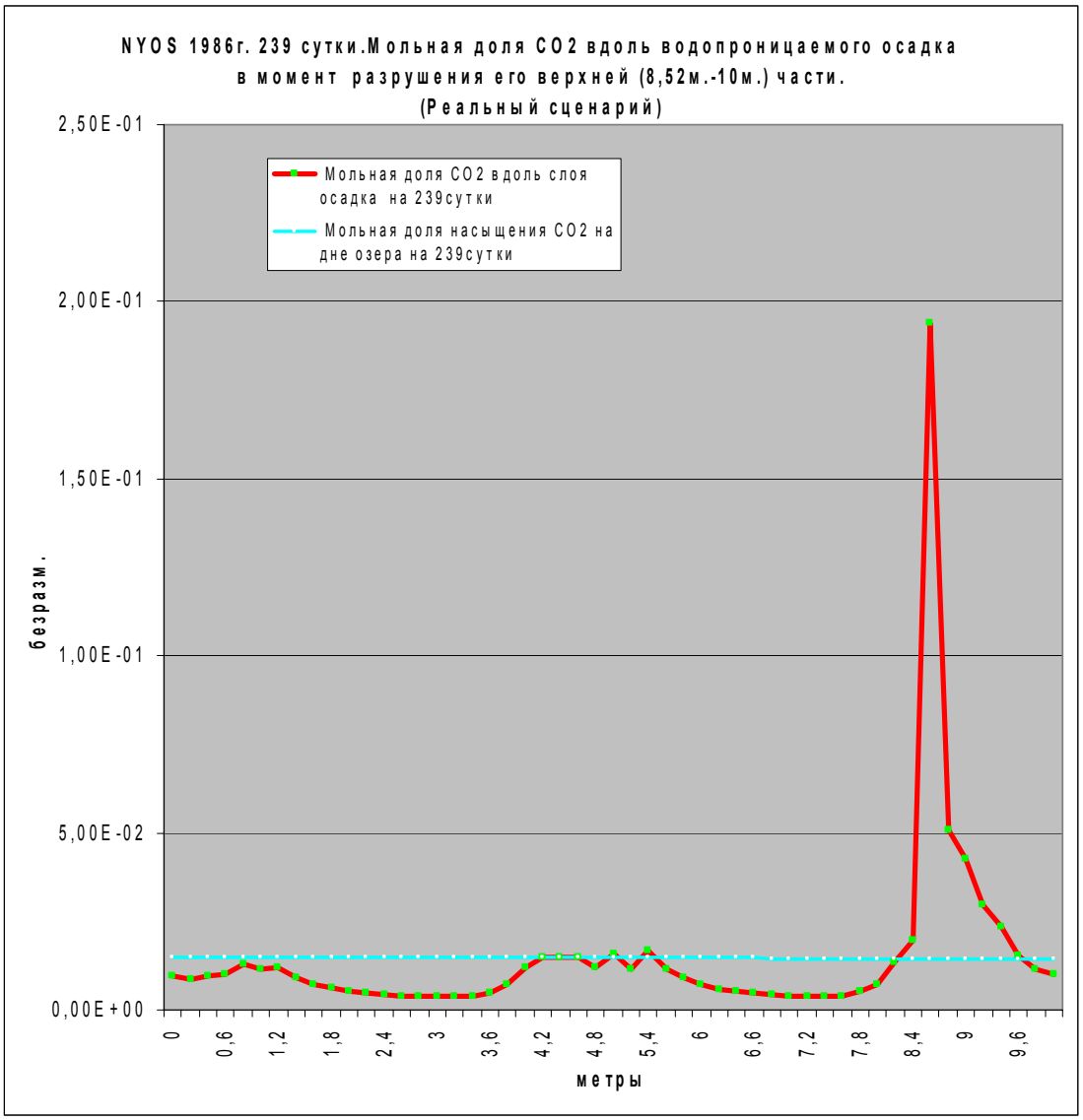

Fig. 4. NYOS 1986. Day 239.The mole-fraction (red line) of the carbon dioxide in the water solution along of the sediment stratums at moment of the destruction his upper (8,52m.-10m.) of a part and the mole-fraction (azure line) of the saturation carbon dioxide.
(Real scenario)

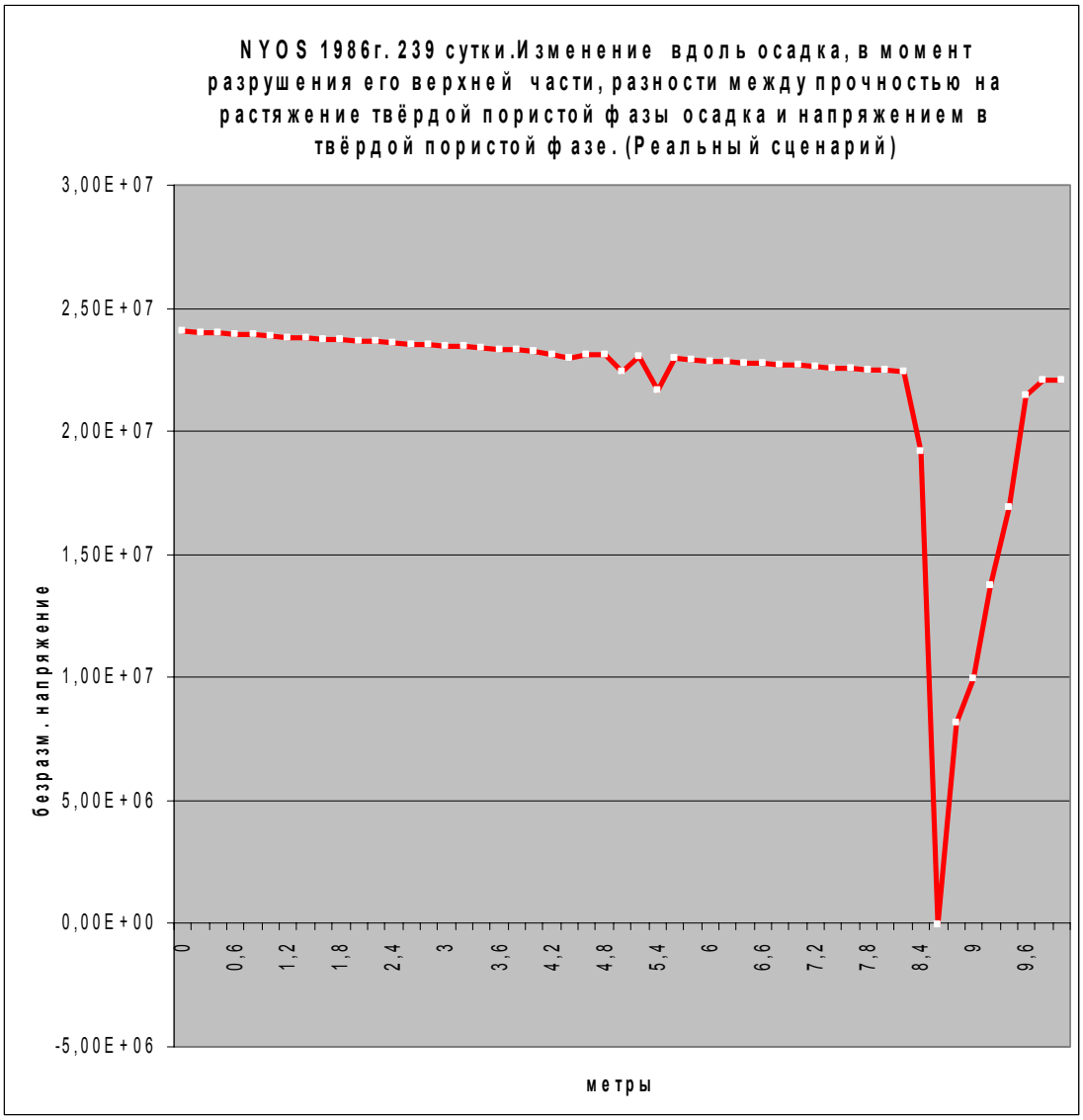

Fig. 5. NYOS 1986. Day 239. The changing, along the sediment stratums (m.), at moment of the destruction of his higher part, the differences between the breaking stress (the non-dimensional value) of the solid porous phase of the sediment stratums and the stress (non-dimensional) in the solid porous phase. (Real scenario)

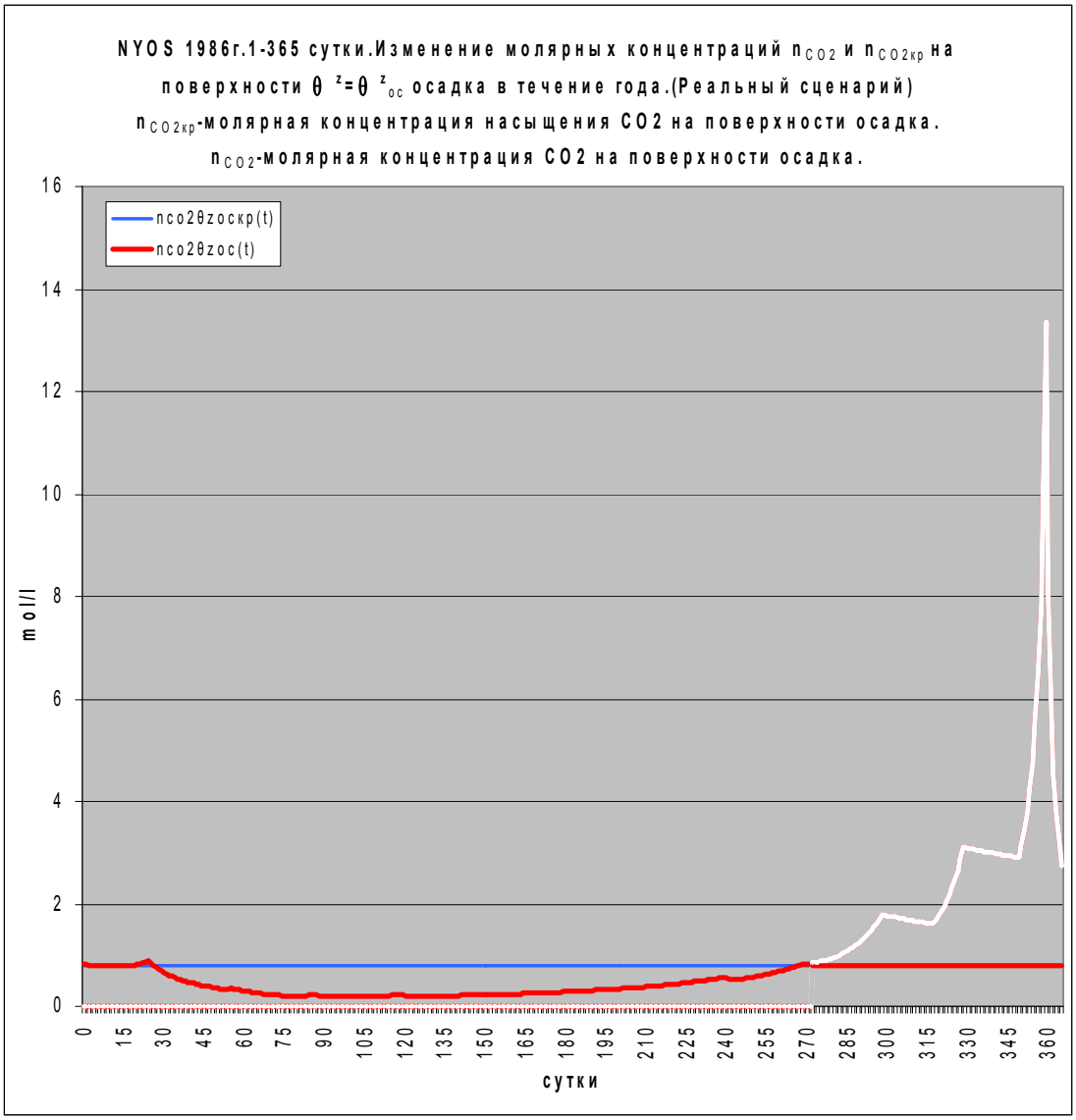

Fig. 6. NYOS 1986. Day 1- Day 365. The Changing of the molar concentration $\mathbf{n}_{CO2}$ and $\mathbf{n}_{CO2кр}$ on the surfaces $\theta^Z=\theta^Z_{oc}$ of the sediment stratums within one year.

$\mathbf{n}_{CO2}$-molar concentration CO_2 on the upper surfaces of the sediment stratums (the red line).

$\mathbf{n}_{CO2кр}$ -molar concentration of the saturation CO_2 on the upper surfaces of the sediment stratums (the blue line).

The Curve of the white colour shows which may be molar concentration $\mathbf{n}_{CO2}$ on the surfaces $\theta^Z=\theta^Z_{oc}$ of the sediment stratums if has not happenned the ***Catastrophic*** gaseous ejections.

(Real scenario)

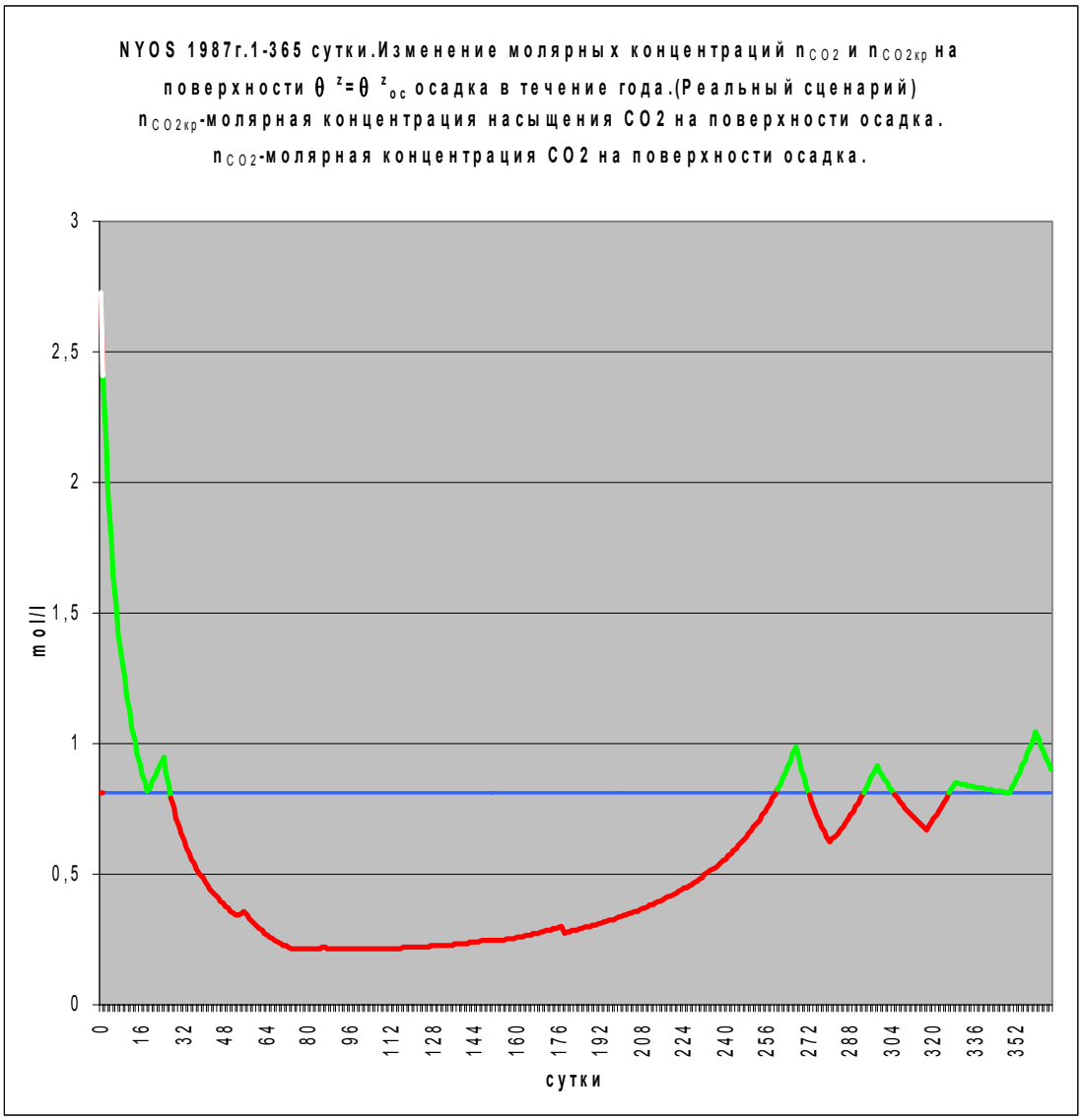

Fig. 7. NYOS 1987. Day 1- Day 365. The Changing of the molar concentration $\mathbf{n}_{CO2}$ and $\mathbf{n}_{CO2кр}$ on the surfaces $\theta^{Z}=\theta^{Z}_{oc}$ of the sediment stratums within one year.

$\mathbf{n}_{CO2}$-molar concentration CO_2 on the upper surfaces of the sediment stratums (the red line- corresponds Null gaseous ejections; green line corresponds Slow gaseous ejections) .

$\mathbf{n}_{CO2кр}$ - molar concentration of the saturation CO_2 on the upper surfaces of the sediment stratums (blue line).

The Curve of the white colour shows which may be molar concentration $\mathbf{n}_{CO2}$ on the surfaces $\theta^{Z}=\theta^{Z}_{oc}$ of the sediment stratums if has not happenned the ***Catastrophic*** gaseous ejections.
(Real scenario)

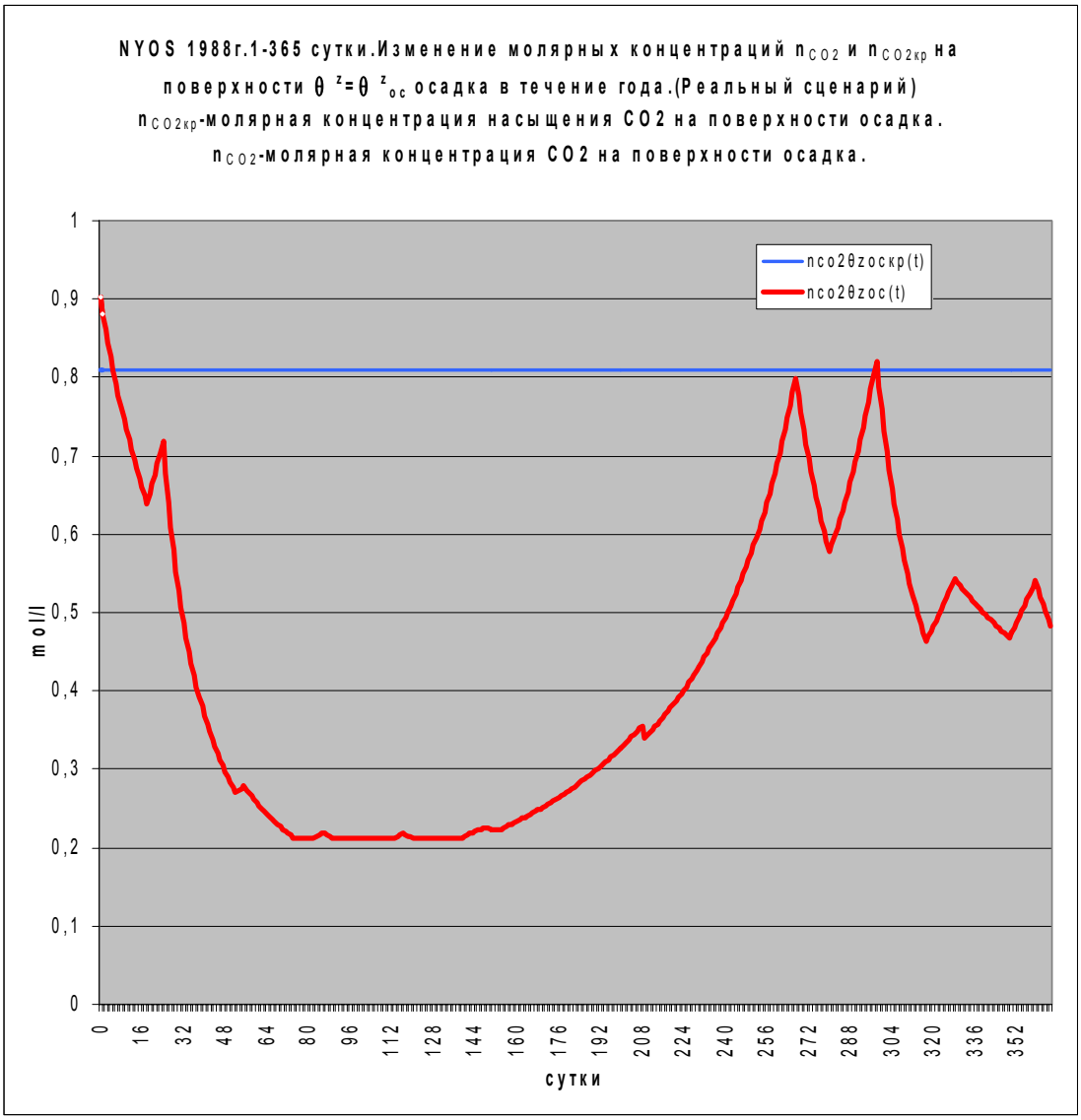

Fig. 7a. NYOS 1988. Day 1- Day 365. The Changing of the molar concentration $\mathbf{n}_{CO2}$ and $\mathbf{n}_{CO2кр}$ on the surfaces $\theta^z=\theta^z_{oc}$ of the sediment stratums within one year.
$\mathbf{n}_{CO2}$-molar concentration CO_2 on the upper surfaces of the sediment stratums (red line) .
$\mathbf{n}_{CO2кр}$ - molar concentration of the saturation CO_2 on the upper surfaces of the sediment stratums (blue line).
(Real scenario)

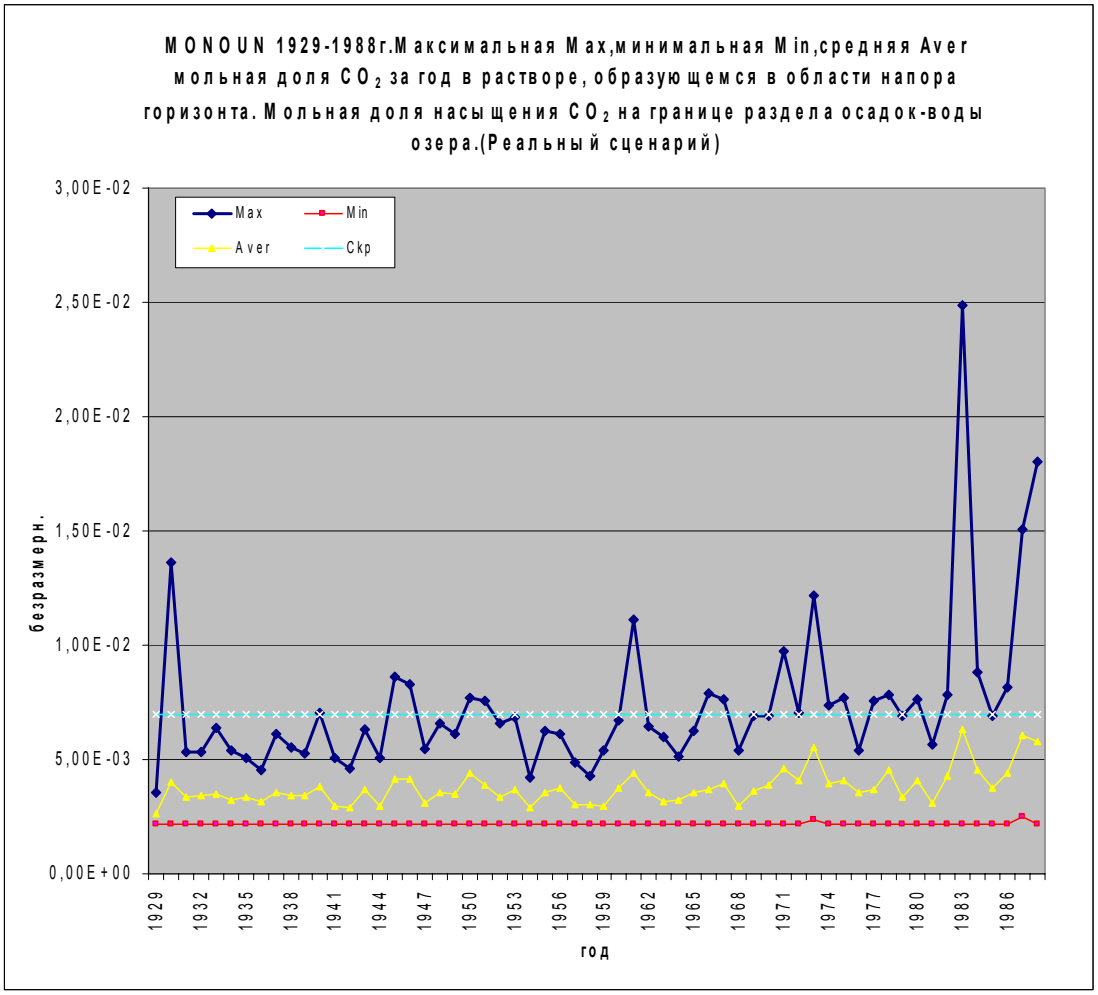

Fig. 8. MONOUN 1929-1988. Distribution under years of the maximum Max, of the minimum Min and average Aver of the the mole-fraction of the carbon dioxide in the point of the melange in the the pressure zone of the pressure confined aquifer, but in the same way the mole-fraction of the saturation Скр carbon dioxide on upper surface of the sediment stratums.
(The Real scenario).

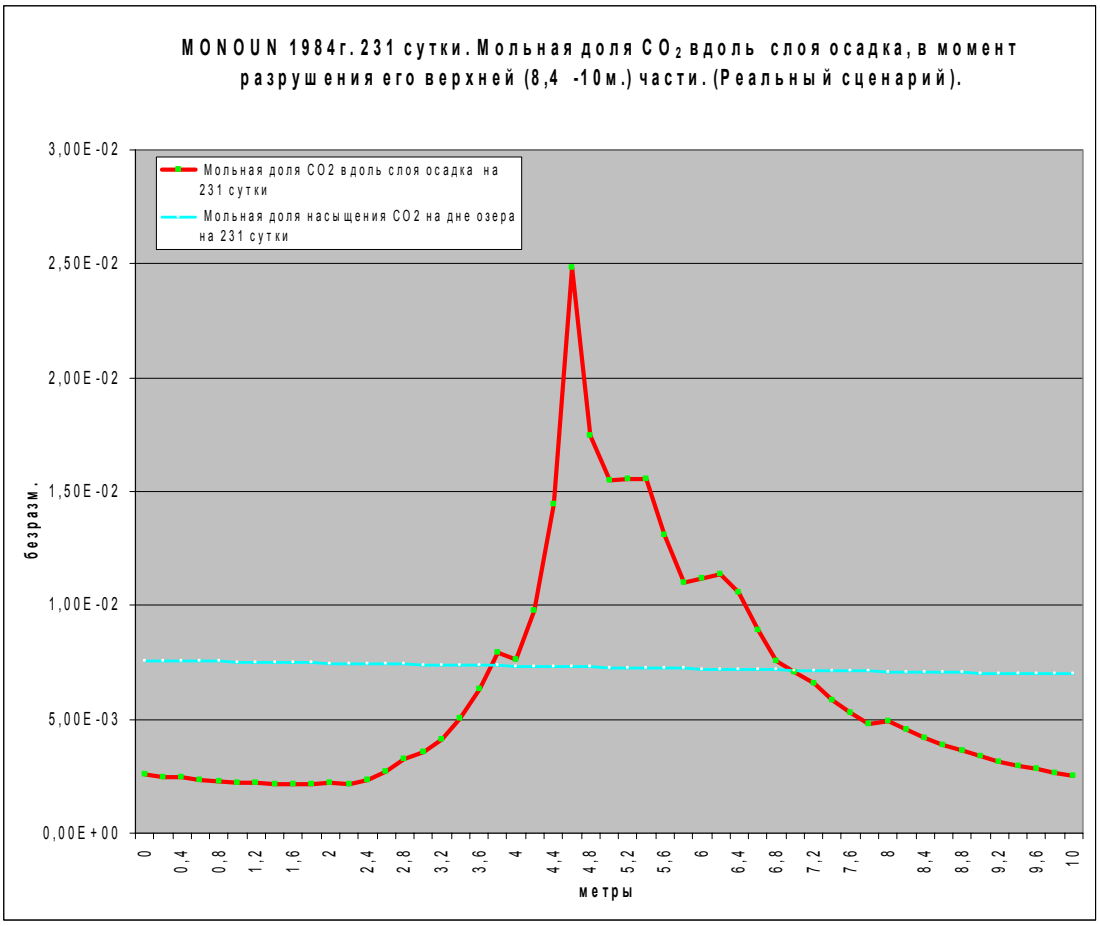

Fig. 9. MONOUN 1984. Day 231.The mole-fraction (red line) of the carbon dioxide in the water solution along of the sediment stratums at moment of the destruction his upper (8,4m.-10m.) of a part and the mole-fraction (azure line) of the saturation carbon dioxide.
(Real scenario)

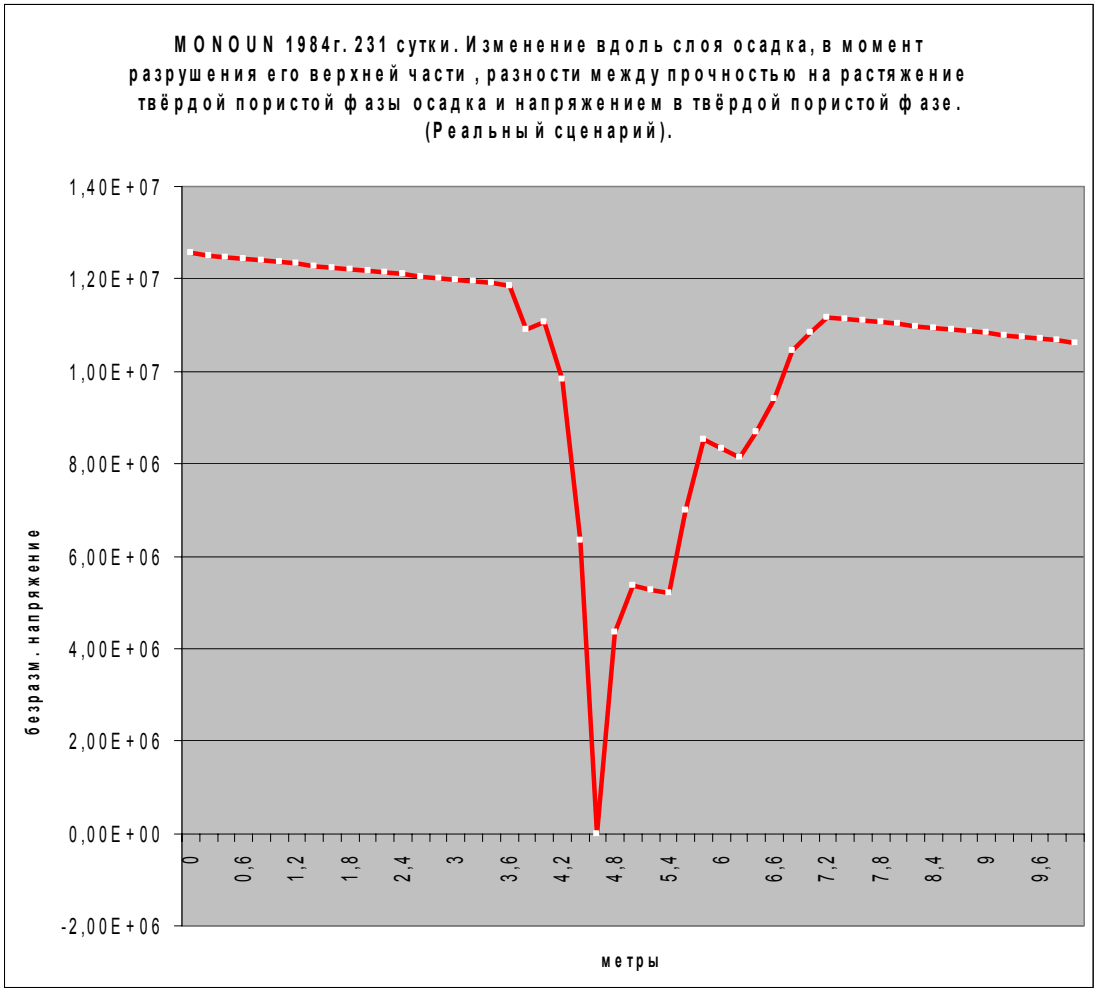

Fig. 10. MONOUN 1984. Day 231. The changing, along the sediment stratums (m.), at moment of the destruction of his higher part, the differences between the breaking stress (the non-dimensional value) of the solid porous phase of the sediment stratums and the stress (non-dimensional) in the solid porous phase. (Real scenario)

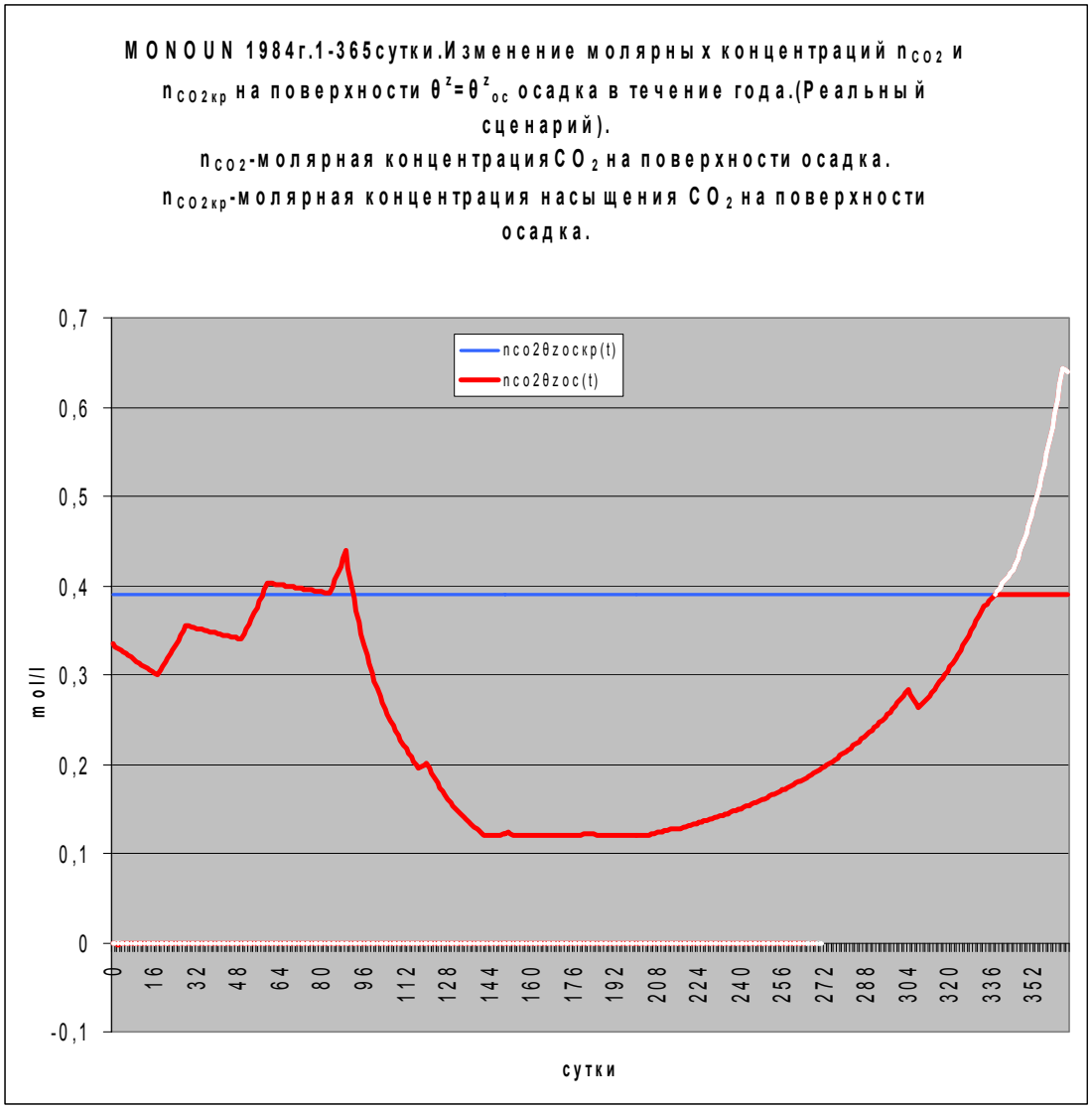

Fig. 11. MONOUN 1984.Day 1- Day 365. The Changing of the molar concentration $\mathbf{n}_{CO2}$ and $\mathbf{n}_{CO2кр}$ on the surfaces $\theta^z=\theta^z_{oc}$ of the sediment stratums within one year.
$\mathbf{n}_{CO2}$- molar concentration CO_2 on the upper surfaces of the sediment stratums (the red line).
$\mathbf{n}_{CO2кр}$--molar concentration of the saturation CO_2 on the upper surfaces of the sediment stratums (the blue line).

The Curve of the white colour shows which may be molar concentration $\mathbf{n}_{CO2}$ on the surfaces $\theta^z=\theta^z_{oc}$ of the sediment stratums if has not happenned the ***Catastrophic*** gaseous ejections.
(Real scenario)

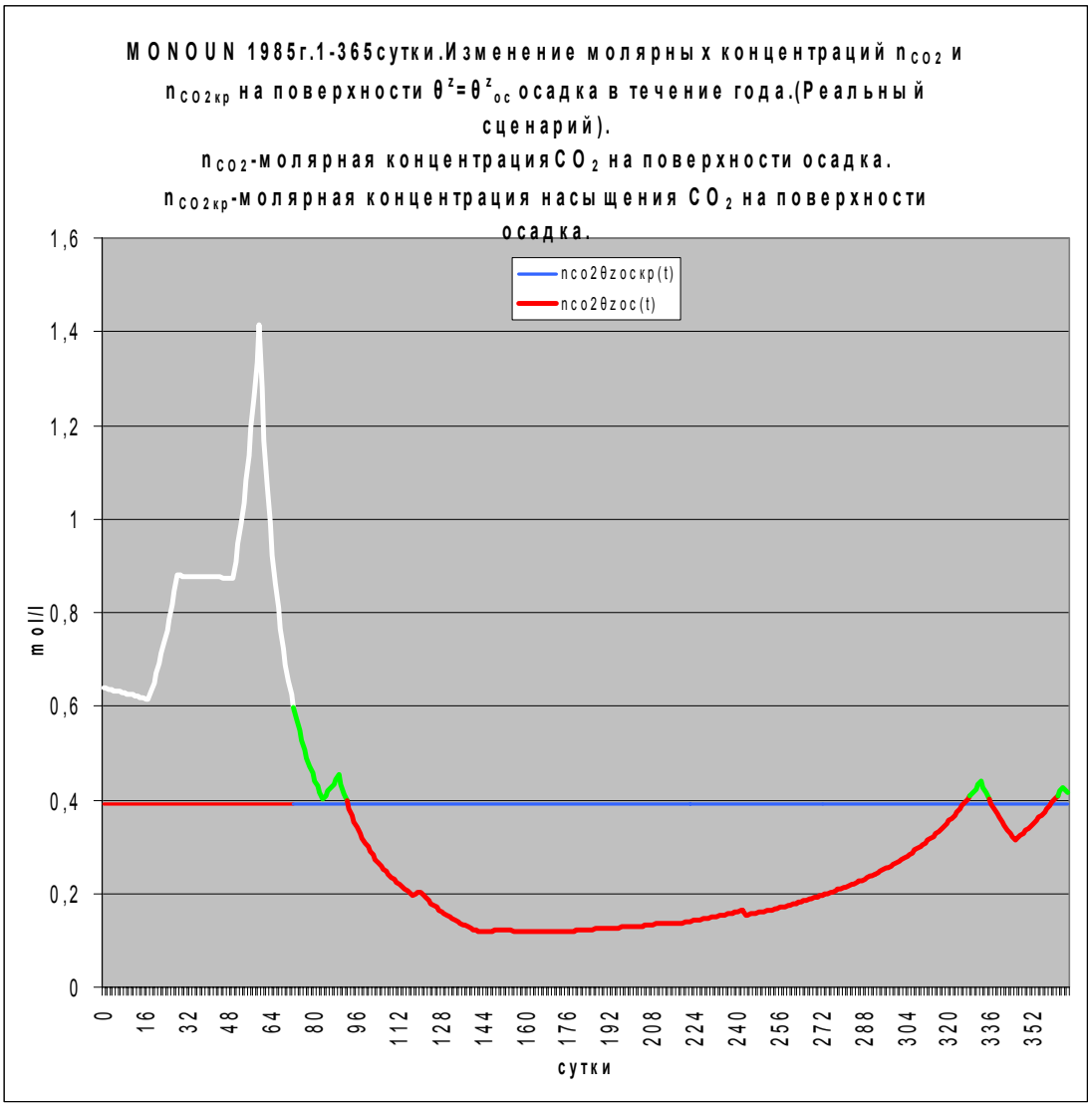

Fig.11a. MONOUN1985. Day1- Day 365. The Changing of the molar concentration $\mathbf{n}_{CO2}$ and $\mathbf{n}_{CO2кр}$ on the surfaces $\theta^z=\theta^z_{oc}$ of the sediment stratums within one year.

$\mathbf{n}_{CO2}$-molar concentration CO_2 on the upper surfaces of the sediment stratums (the red line- corresponds Null gaseous ejections; green line corresponds Slow gaseous ejections) .

$\mathbf{n}_{CO2кр}$ - molar concentration of the saturation CO_2 on the upper surfaces of the sediment stratums (blue line).

The Curve of the white colour shows which may be molar concentration $\mathbf{n}_{CO2}$ on the surfaces $\theta^z=\theta^z_{oc}$ of the sediment stratums if has not happenned the ***Catastrophic*** gaseous ejections.
(Real scenario)

Under influence of the atmospheric precipitation 1983 in the water solution of the pressure confined aquifer of the lakes "Nyos" and "Monoun" in 1983 are appears the said anomalous high mole-fraction of the carbon dioxide.

Hereon of the moving to the sediment stratums of the lakes "Nyos" and "Monoun" of the solution, which are characterized by the mentioned anomalous high mole-fraction of the carbon dioxide, has caused the destruction of the solid porous phase of the sediment stratums in the lake "Monoun" (Fig 9.) on 231 day 1984г. and in the lake "Nyos" (Fig 4.) on 239 day 1986г..

At moment of the destruction of the solid porous phase of the sediment stratums the mole-fraction of the carbon dioxide in the point of the destruction was equals:
0,1940 in the the sediment stratums of the lake "Nyos";
0,0249 in the the sediment stratums of the lake "Monoun".

The growing mole-fraction carbon dioxide in water solution in the sediment stratums of the lake "Monoun" (the Fig 9.) and "Nyos" (the Fig 4.) before anomalous high values, be by the cause of increasing a pressure of the gas in the sediment stratums. Increasing of the pressure of the gas in the sediment stratums is a reason of the origin and growing in solid porous phase the tensile stress.

In the sediment stratums of the lake "Monoun" (the Fig 10.) the tensile stress for day 231 of 1984 has exceed the value to the breaking stress of the solid porous phase, and has caused the destruction of the higher part layer (8,32m.-10m.) of the solid porous phase and with the Instantaneous ejections of the gas (the Fig 11. , Fig 11a.).

Taking into consideration the Fig 9., and the area, concluded on Fig 11. , Fig 11a. between the curve of white colour, and horizontal blue line, height of the column of the gas, which are ejecting on day 231 of 1984 from the surface (0,032 km2) of the bottom of the maar at the depth 95 m, will be in lake "Monoun", in recalculation on normal conditions (1 atm., 278,10K), by the value not less than 13,69 m.

In recalculation to all the surface (0,526 km2) of the lake "Monoun" the average height of the gaseous layer, ejected on day 231 of 1984 from bottom of the maar, will be, in recalculation on normal conditions (1 atm., 278,10K), by the value 0,83 m..
The *Instantaneous* gaseous ejections on the lake "Monoun" on day 231 of 1984 are *Catastrophic*.

Got by calculating way in this article the day of the Instantaneous gaseous ejections (day 231of 1984) and the average height (0,83 m.) of the gaseous layer, ejected in the lake "Monoun", corresponds such (15 august 1984=day 227 of 1984г.; 0-3 m above the ground), which are mentionned in message (16).

In the sediment stratums of the lake "Nyos" (the Fig 5.) by the tensile stress on day 239 of 1986 have exceed of the value to the breaking stress of the solid porous phase.

As a result, in the sediment stratums of the lake "Nyos" on 239 day 1986 (the Fig 5.) be destructed the higher part of the layer (8,52m.-10m.) of the solid porous phase and was the *Instantaneous* ejections of the gas (the Fig 6.).

Taking into consideration the Fig 4., and the area, concluded on Fig 6. and Fig 7. between the curve of white colour, and horizontal red line, height of the column of the gas, which are ejecting on day 239 of 1986 from the surface (0,435 km2) of the bottom of the maar at the depth 209 m, will be in lake "Nyos", in recalculation on normal conditions (1 atm., 278,10K), by the value not less than 30,29 m.

In recalculation to all the surface (1,580 km2) of the lake "Nyos" the average height of the gaseous layer, ejected on day 239 of 1986 from bottom of the maar, will be, in recalculation on normal conditions (1 atm., 278,10K), by the value 8,34 m..
The *Instantaneous* gaseous ejections on the lake "Nyos" on day 239 of 1986 are *Catastrophic*.

Got by calculating way in this article the day of the Instantaneous gaseous ejections (day 239 of 1986) , the height of the column of the gas (30,29 m) and and the average height (8,34 m.) of the gaseous layer, ejected in the lake "Nyos", corresponds such (21 august 1986=day 233 of 1984г.; 80 m above the lake (the point of the maximum on the surfaces of the level of the gaseous ejections); surge height reached (~6 m)), which are mentionned in message (17).

According to calculation, at period of the time before and after the *Instantaneous* gaseous ejections (day 239 of 1986), the tensile stress in the sediment stratums of the lake "Nyos" had values less than value of the breaking stress in solid porous phase of the lake "Nyos".

Thus, at period of time before (1929- day 238 of 1986) and after (day 240 of 1986г.-1988) of the *Instantaneous* gaseous ejections (day 239 of 1986), the ejections of the gas from the sediment stratums of the lake "Nyos" were only by Null and Slow.

According to calculation, the Fig.7., Fig.4. , at period of the time from day 1 till day 27 of 1987 (the January 1-27 of 1987) from the sediment stratums was occurred the Slow ejections of the gas to the water of the lake "Nyos" .
The maximum of the height of the layer of the gas, ejected during day in mentioned period from surface (0,435 km2) of the bottom of the maar, was in the lake "Nyos", in recalculation on normal (1 atm. , 278,10K) of the condition,not more than 0,04 m. Consequently the Slow ejections of the gas from day 1 till day 27 of 1987 not were Catastrophic

Taking account of the resolution ability of the program "SONATA", which relates to the terms of the gaseous ejections in the lake "Nyos", the events since December 30 1986г. till January 02 1987 and since January 20 1987 till January 25 1987, described in (18) can be considered as stages, of the said Slow ejections of the gas from day 1 till day 27 of 1987.

According to calculations, the Fig. 7b, the molar concentration of the carbon dioxide in the water solution in the lake's water on the bottom of the lake "Nyos" December 17 1988 (day 351) was

equal 0,480 mol/l , but December 18 1988 (day 352) the molar concentration was equal 0,487 mol/l.

The mentioned values of the molar concentrations of the carbon dioxide in the water solution in the lake's water on the bottom of the lake "Nyos" are corresponded with such at the lake "Nyos" (17-18 December 1988, Free CO2, 416-483 mmol/kg), described in (19).

According to the calculations (*Real* scenario) (Fig 3., Fig 8.), in the lakes "Nyos" and "Monoun", for the period 1929-1988 were of *Null* and *Slow* (non *Catastrophic*) the ejections of the gas from the sediment stratums of the lakes "Nyos" and "Monoun" .

The *Instantaneous* ejections of the gas had occurred in each of lakes only at one day (on day 231 of 1984 in lake "Monoun", and on day 239 of 1986 in lake "Nyos").

The *Instantaneous* ejections of the gas in each of the lakes "Nyos" and "Monoun" were *Catastrophic*.

According to calculations, if the monthly falling out of the atmospheric precipitations in 1983 in the region of the lake "Nyos" and of the lake "Monoun" will be increased on five percents (the Table 1., Conditional scenario) in contrast with the station data "BAMENDA", then in 1983 the maximum of the mole-fraction of the carbon dioxide in the water solution in the point of the mix in the pressure zone of the pressure confined aquifer, who do of the supply of the water solution of the carbon dioxide in the lake "Nyos" or the lake "Monoun", though will remain the largest during period 1929-1988, Fig.12., Fig. 16., but will become less than the mole-fraction, stated in Real situation , and will equal:
0,1060 mol/l on day 239 of 1986г. in the pressure zone of the pressure confined aquifer of the lake "Nyos" (instead of 0,1940);
0,0213 mol/l on day 231 of 1984г. in the pressure zone of the pressure confined aquifer of the "Monoun" (instead of 0,0249).

These values of the mole-fraction of the carbon dioxide will be not enough great for creating of the pressure of the gas, under which the tensile stress in the solid phase of the sediment stratums are to be more or are to be equal the breaking stress of the solid porous phase of the sediment stratums (the Fig 14.) and (the Fig 18.).

According to calculations (*Conditional* scenario), if in 1983 the monthly falling out of the atmospheric precipitation in the region of the lakes "Nyos" and "Monoun" was on five percents more, in contrast with station data "BAMENDA", then for period 1929-1988 on the lakes "Nyos" and "Monoun" has not occurred nor one the *Instantaneous*, including *Catastrophic*, ejections of the gas from the sediment stratums.
The *Slow* ejections of the gas, in the event of *Conditional* scenario, per period 1929-1988г. only at one day were *Catastrophic*.

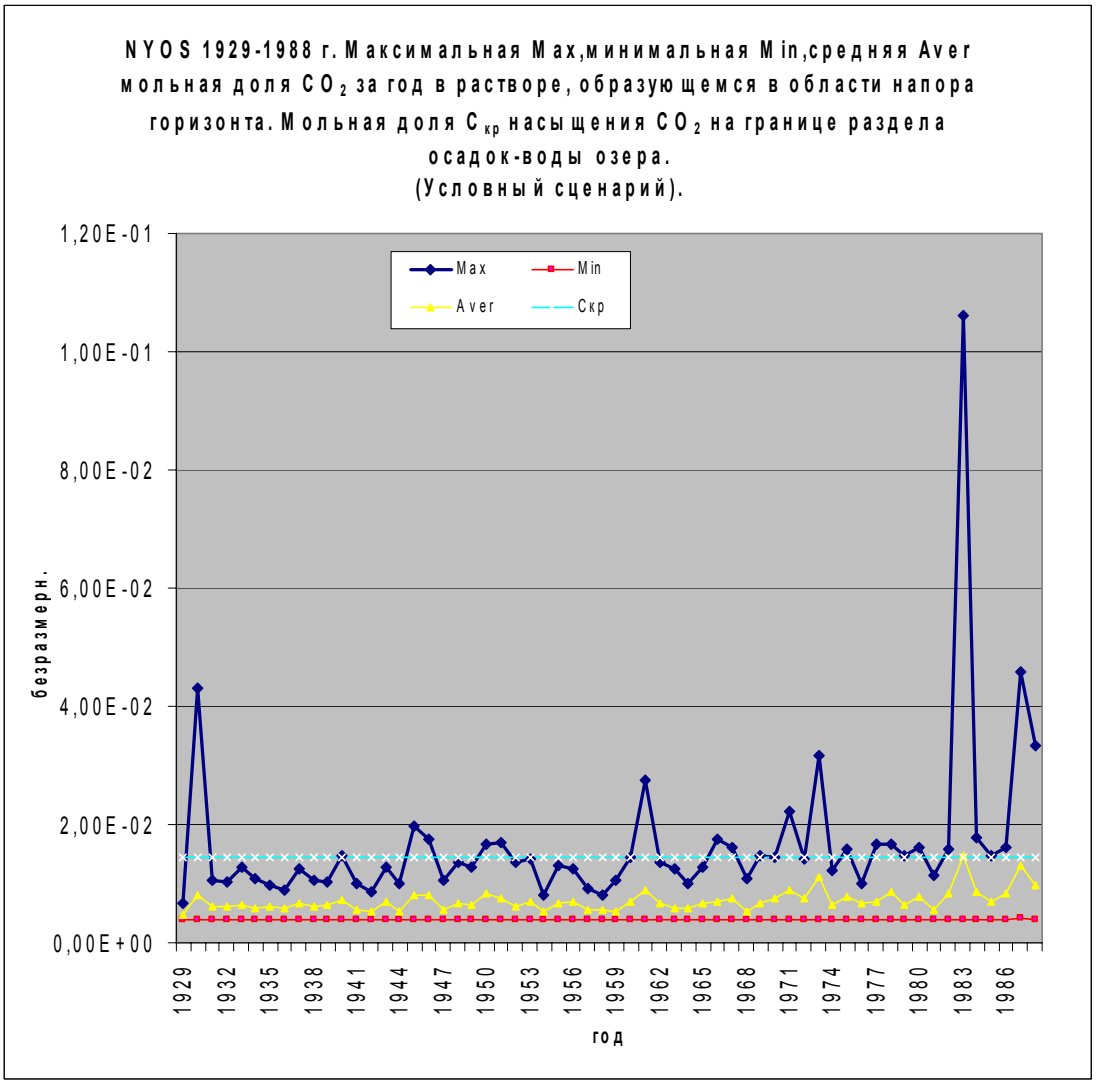

Fig.12. NYOS 1929-1988. Distribution under years of the maximum Max, of the minimum Min and average Aver of the the mole-fraction of the carbon dioxide in the point of the melange in the the pressure zone of the pressure confined aquifer, but in the same way the mole-fraction of the saturation Скр carbon dioxide on upper surface of the sediment stratums.
(The Conditional scenario).

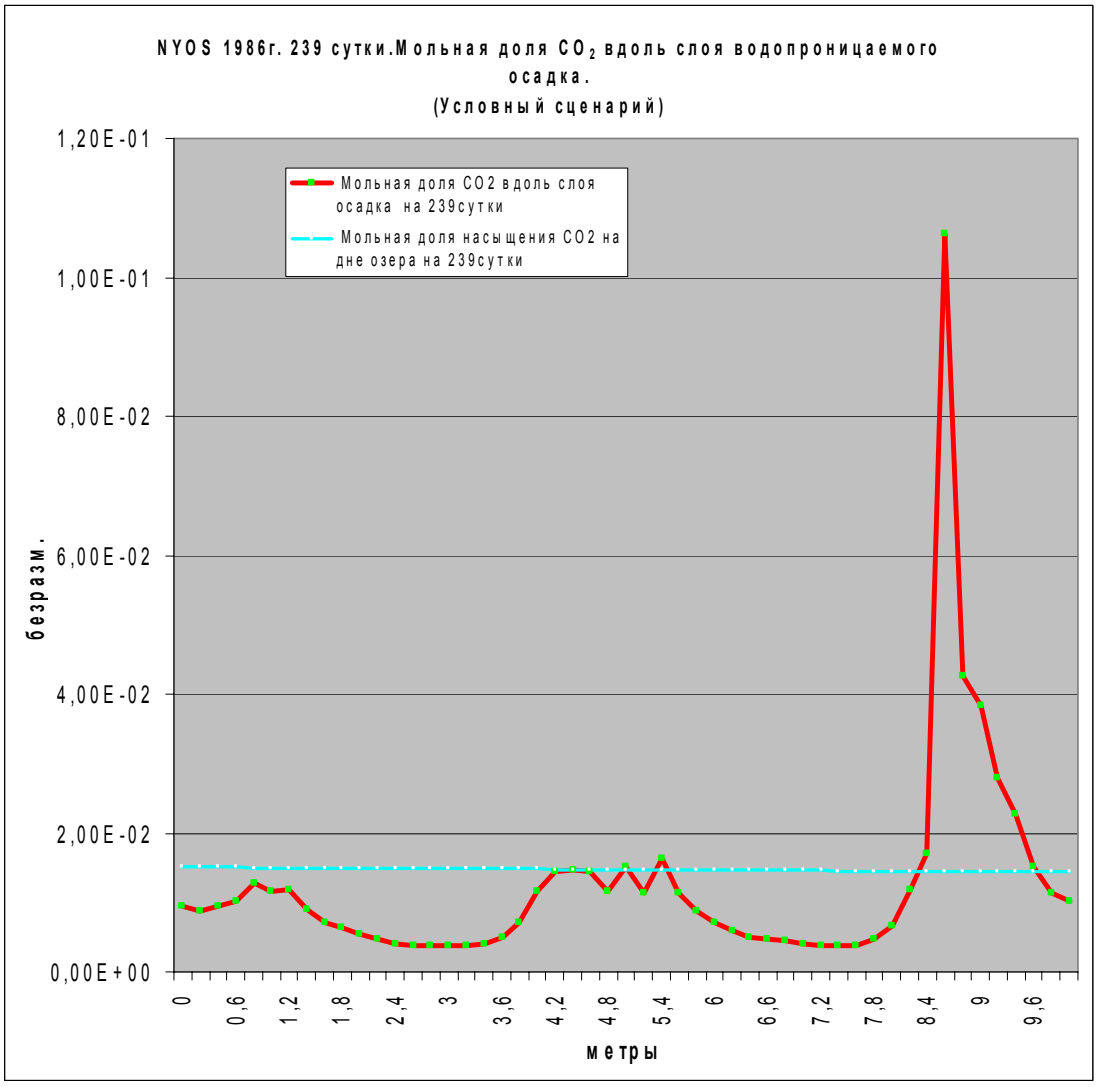

Fig. 13. NYOS 1986. Day 239. The mole-fraction (red line) of the carbon dioxide in the water solution along of the sediment stratums and the mole-fraction (azure line) of the saturation carbon dioxide along of the sediment stratums.
(The Conditional scenario).

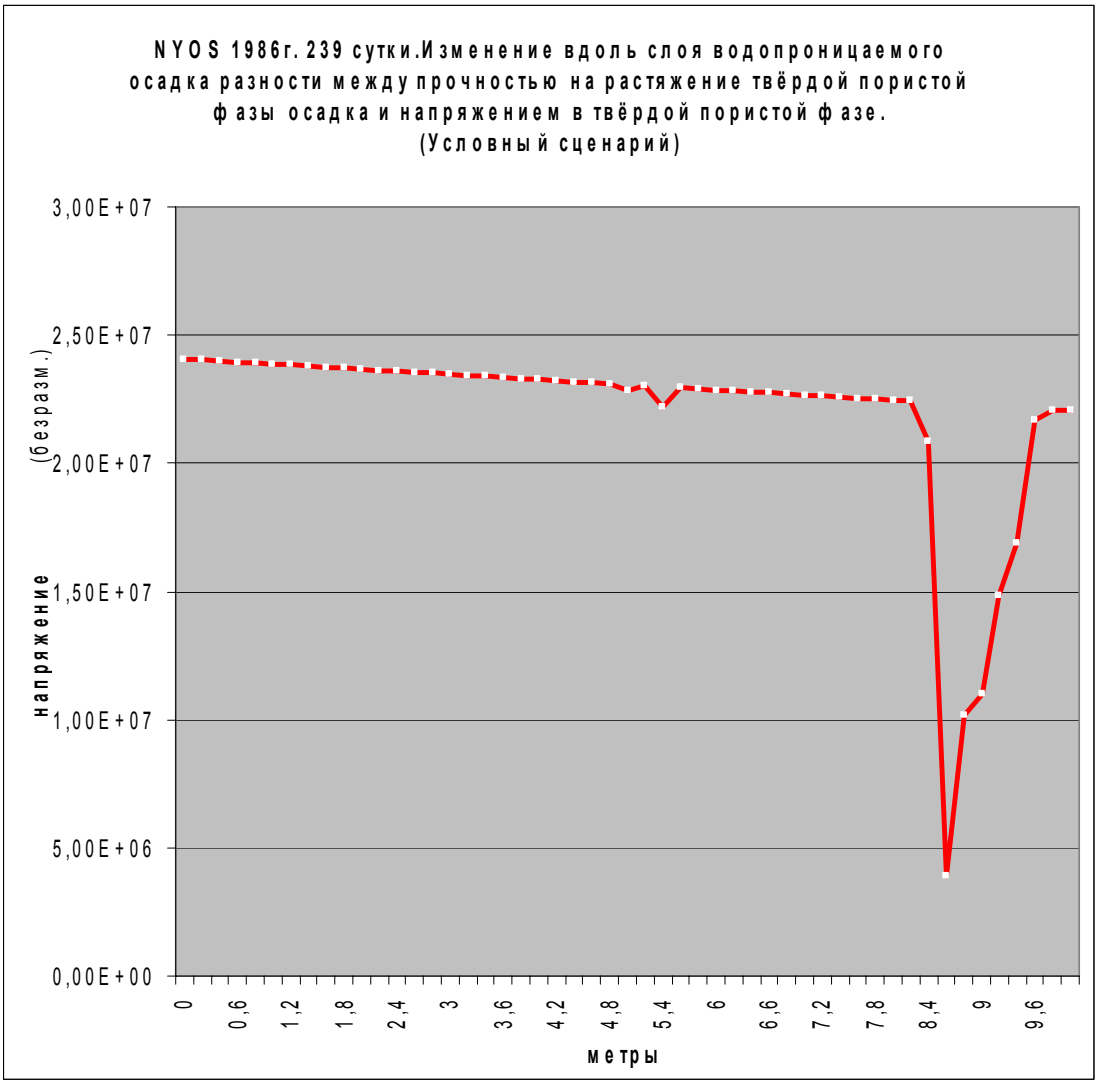

Fig. 14. NYOS 1986. Day 239. The changing, along the sediment stratums (m.), the differences between the breaking stress (the non-dimensional value) of the solid porous phase of the sediment stratums and the stress (non-dimensional) in the solid porous phase.
(The Conditional scenario).

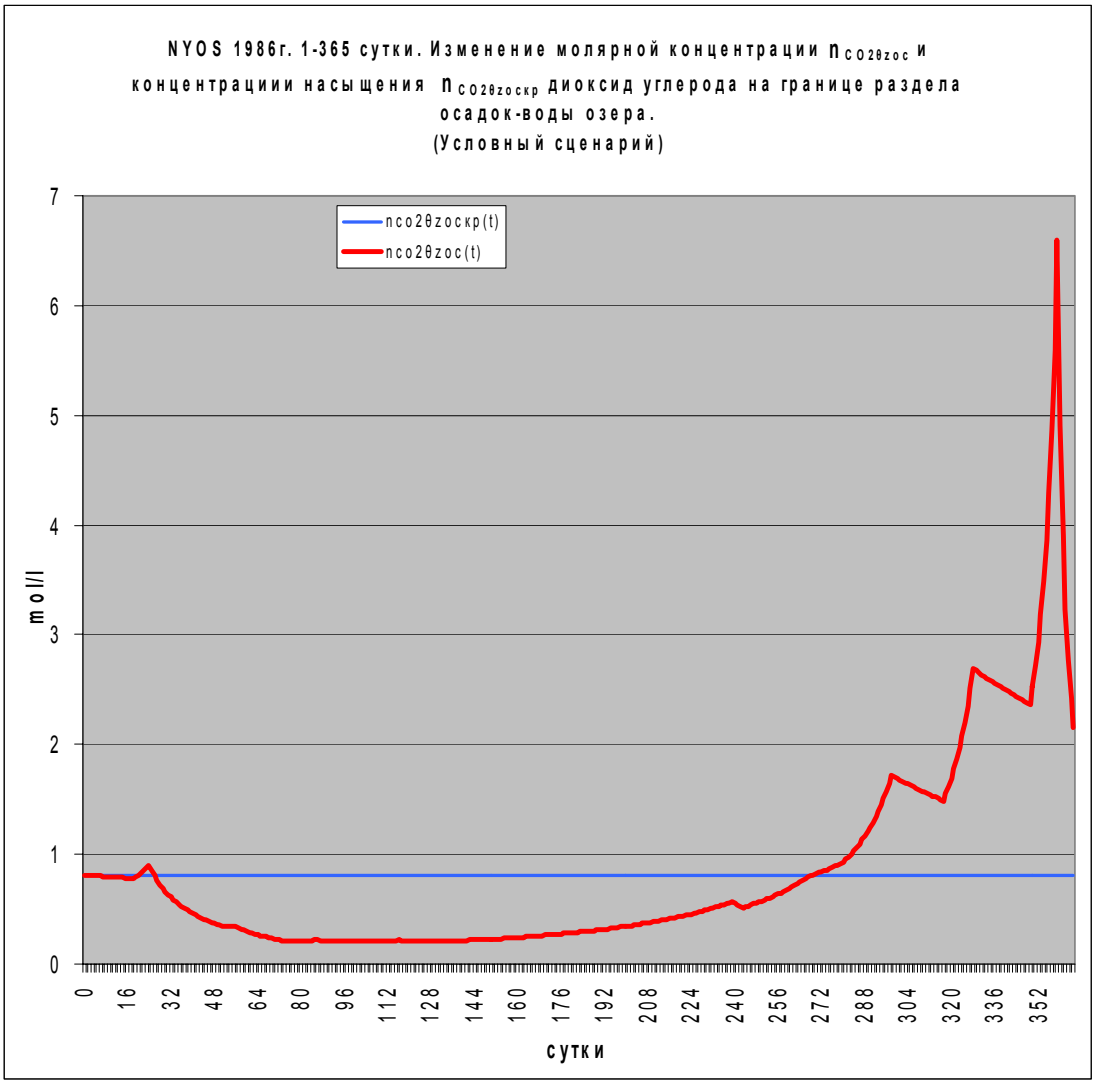

Fig.15. NYOS 1986. Day1-Day 365. The Changing of the molar concentration $\mathbf{n}_{CO2}$ and $\mathbf{n}_{CO2кр}$ on the surfaces $\theta^z=\theta^z_{oc}$ of the sediment stratums within one year.

$\mathbf{n}_{CO2}$-molar concentration CO_2 on the upper surfaces of the sediment stratums (red line) .

$\mathbf{n}_{CO2кр}$ - molar concentration of the saturation CO_2 on the upper surfaces of the sediment stratums (blue line).

(The Conditional scenario).

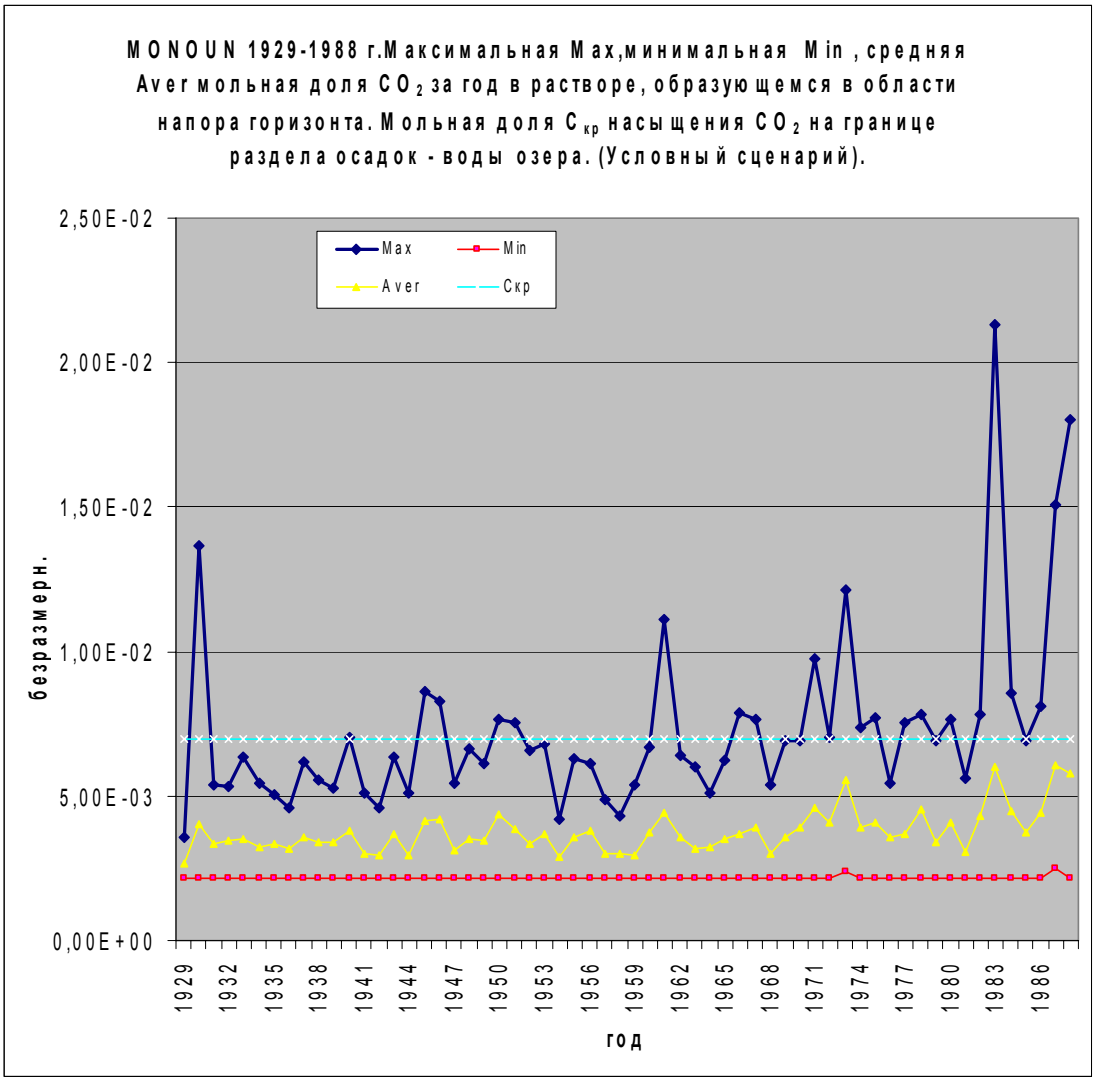

Fig. 16. MONOUN 1929-1988. Distribution under years of the maximum Max, of the minimum Min and average Aver of the the mole-fraction of the carbon dioxide in the point of the melange in the the pressure zone of the pressure confined aquifer, but in the same way the mole-fraction of the saturation Скр carbon dioxide on upper surface of the sediment stratums.
(The Conditional scenario).

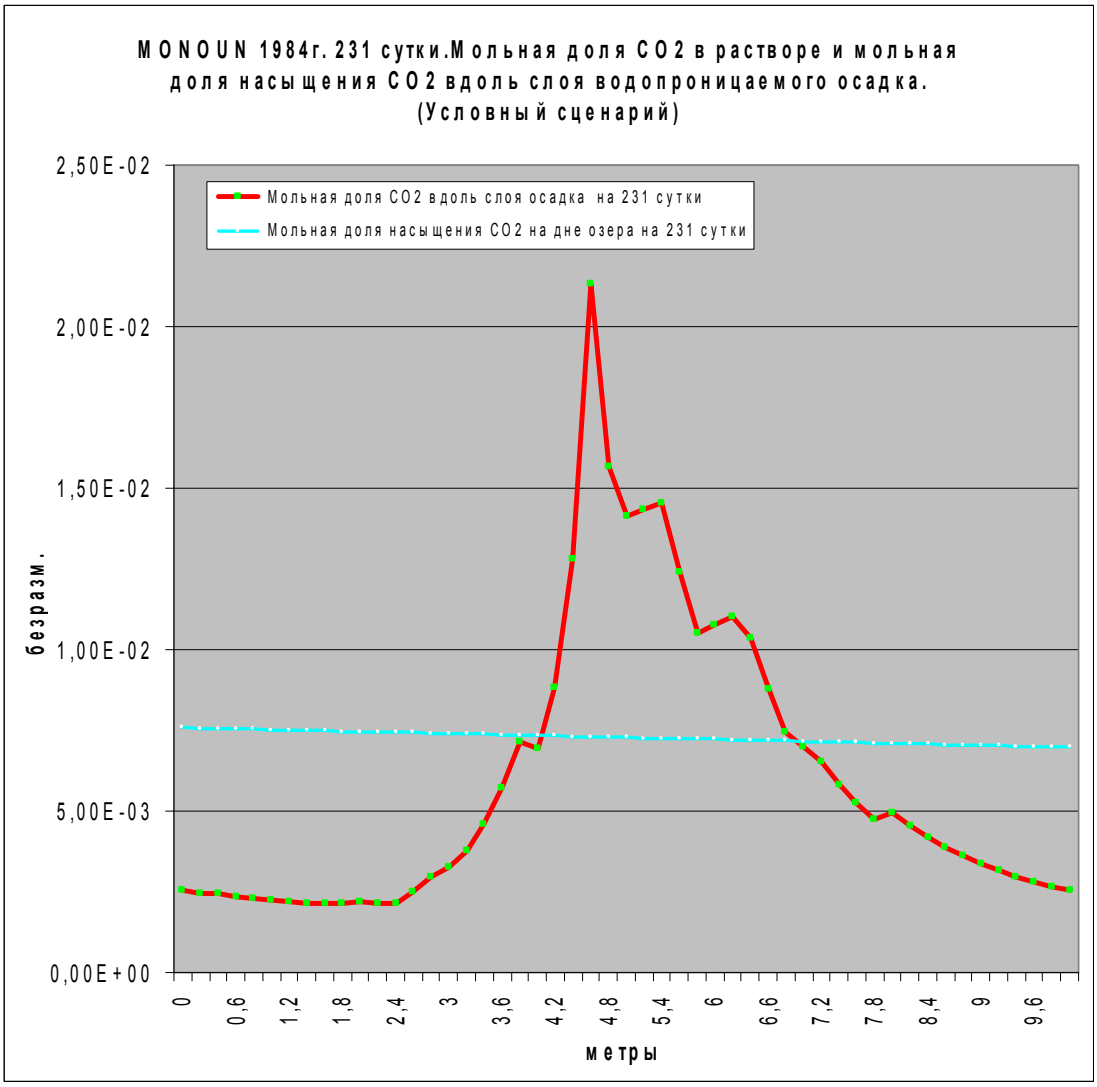

Fig. 17. MONOUN 1984. Day 231. The mole-fraction (red line) of the carbon dioxide in the water solution along of the sediment stratums and the mole-fraction (azure line) of the saturation carbon dioxide along of the sediment stratums.
(The Conditional scenario).

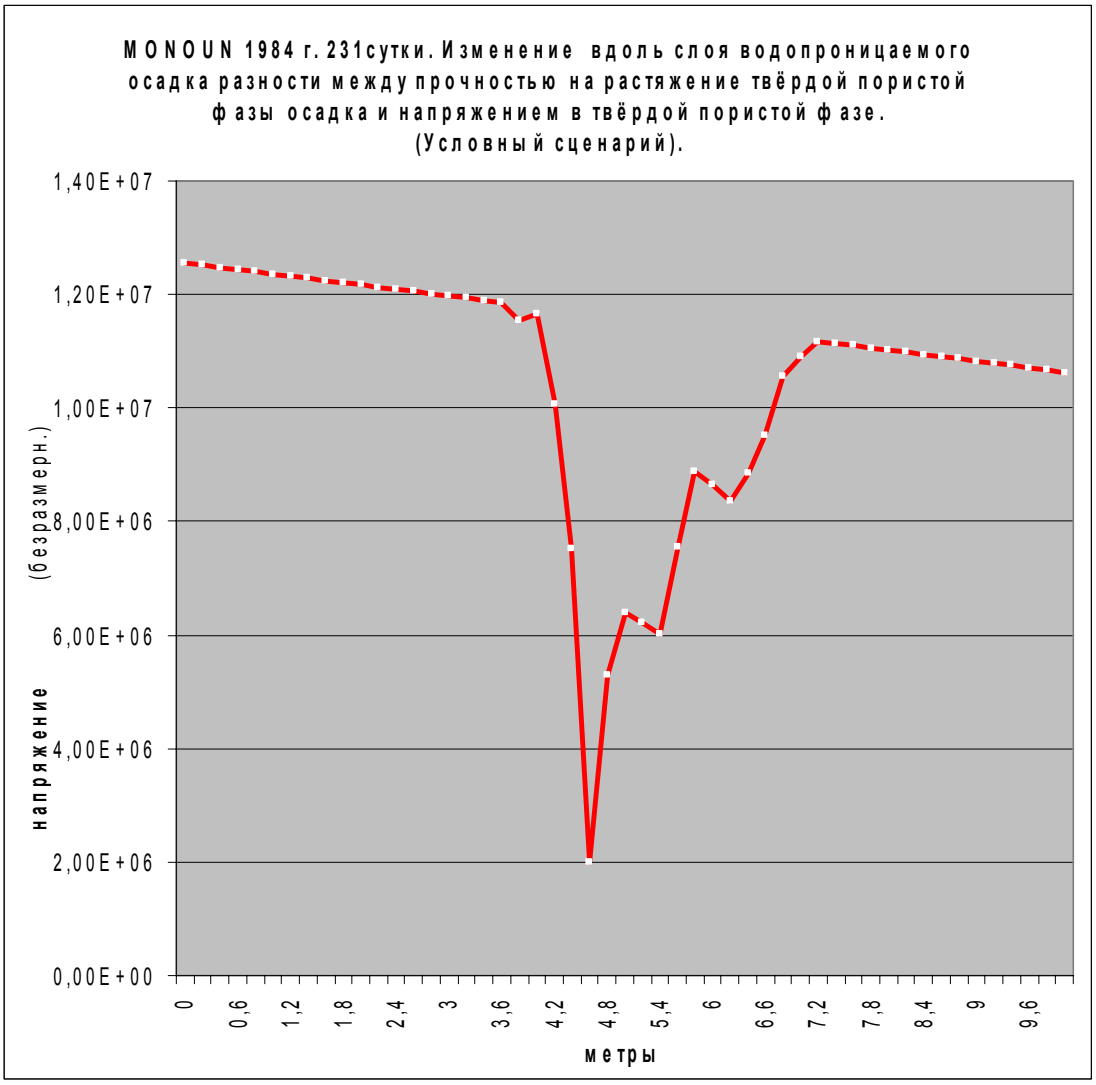

Fig. 18. MONOUN 1984. Day 231. The changing, along the sediment stratums (m.), the differences between the breaking stress (the non-dimensional value) of the solid porous phase of the sediment stratums and the stress (non-dimensional) in the solid porous phase.
(The Conditional scenario).

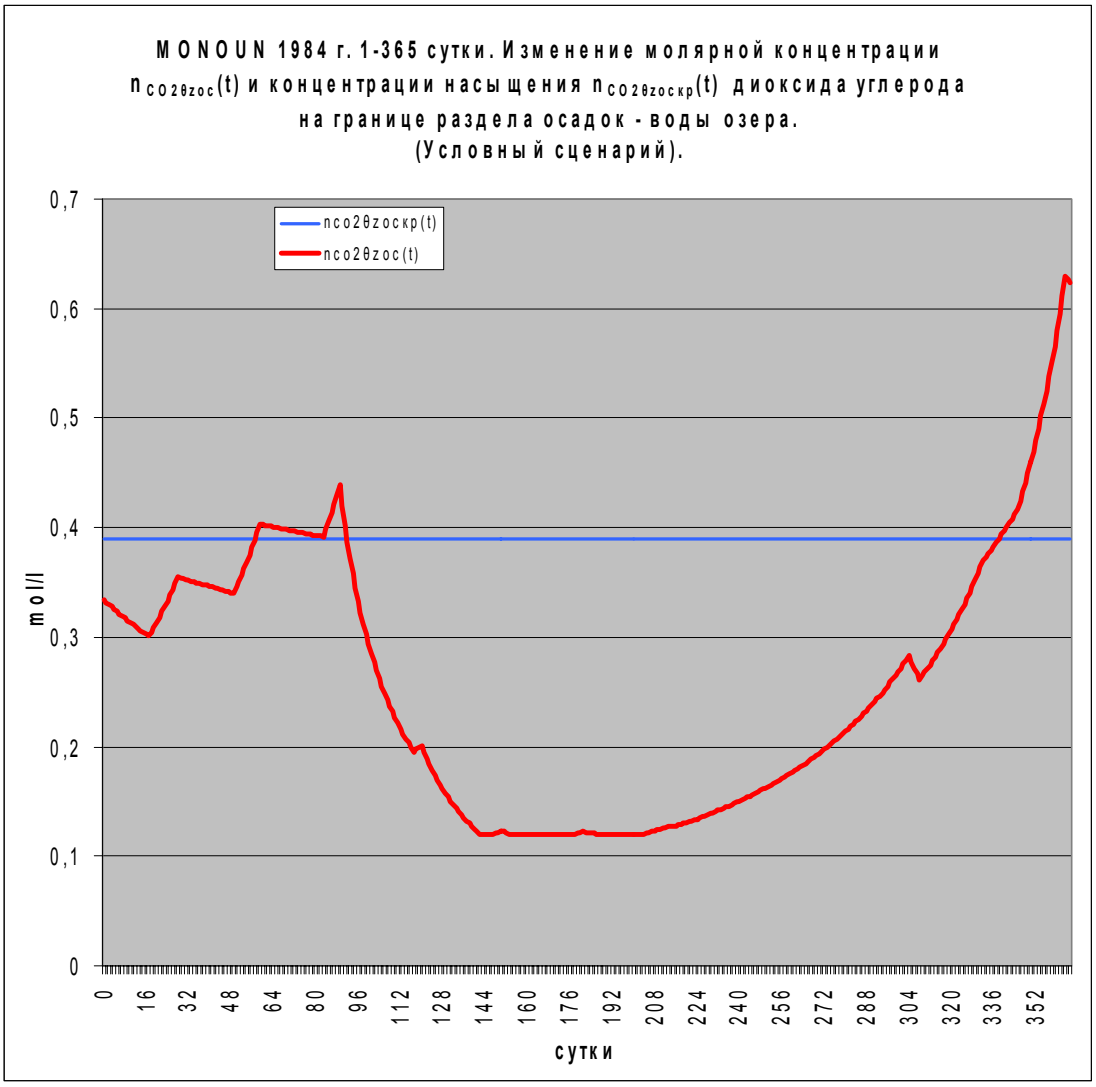

Fig. 19. MONOUN 1984. Day 1- Day 365. The Changing of the molar concentration $\mathbf{n}_{CO2}$ and $\mathbf{n}_{CO2кр}$ on the surfaces $\theta^z=\theta^z_{oc}$ of the sediment stratums within one year.
$\mathbf{n}_{CO2}$-molar concentration CO_2 on the upper surfaces of the sediment stratums (red line) .
$\mathbf{n}_{CO2кр}$ - molar concentration of the saturation CO_2 on the upper surfaces of the sediment stratums (blue line).
(The Conditional scenario).

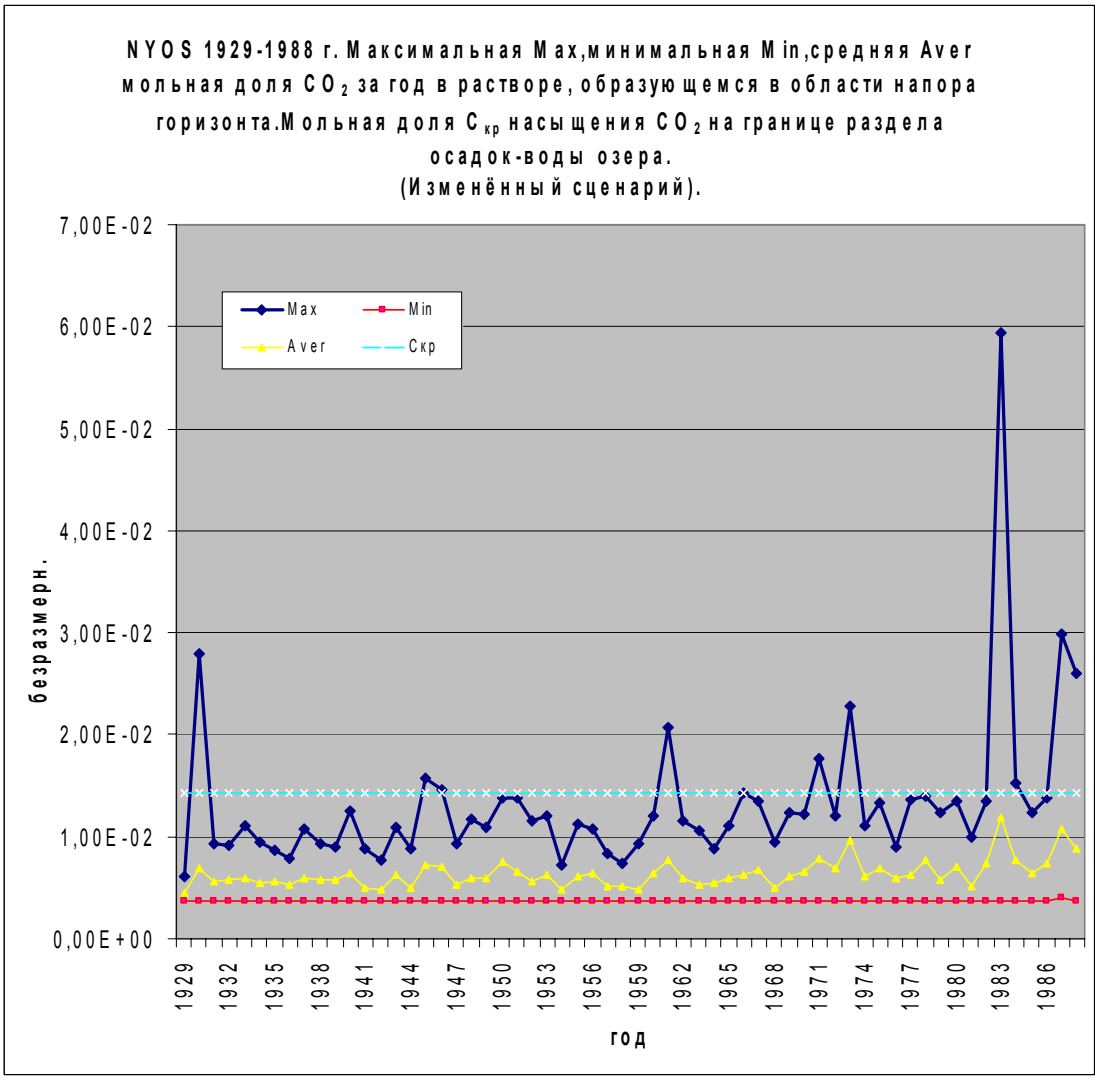

Fig.20. NYOS 1929-1988. Distribution under years of the maximum Max, of the minimum Min and average Aver of the the mole-fraction of the carbon dioxide in the point of the melange in the the pressure zone of the pressure confined aquifer, but in the same way the mole-fraction of the saturation Скр carbon dioxide on upper surface of the sediment stratums.
(*Changed* scenario).

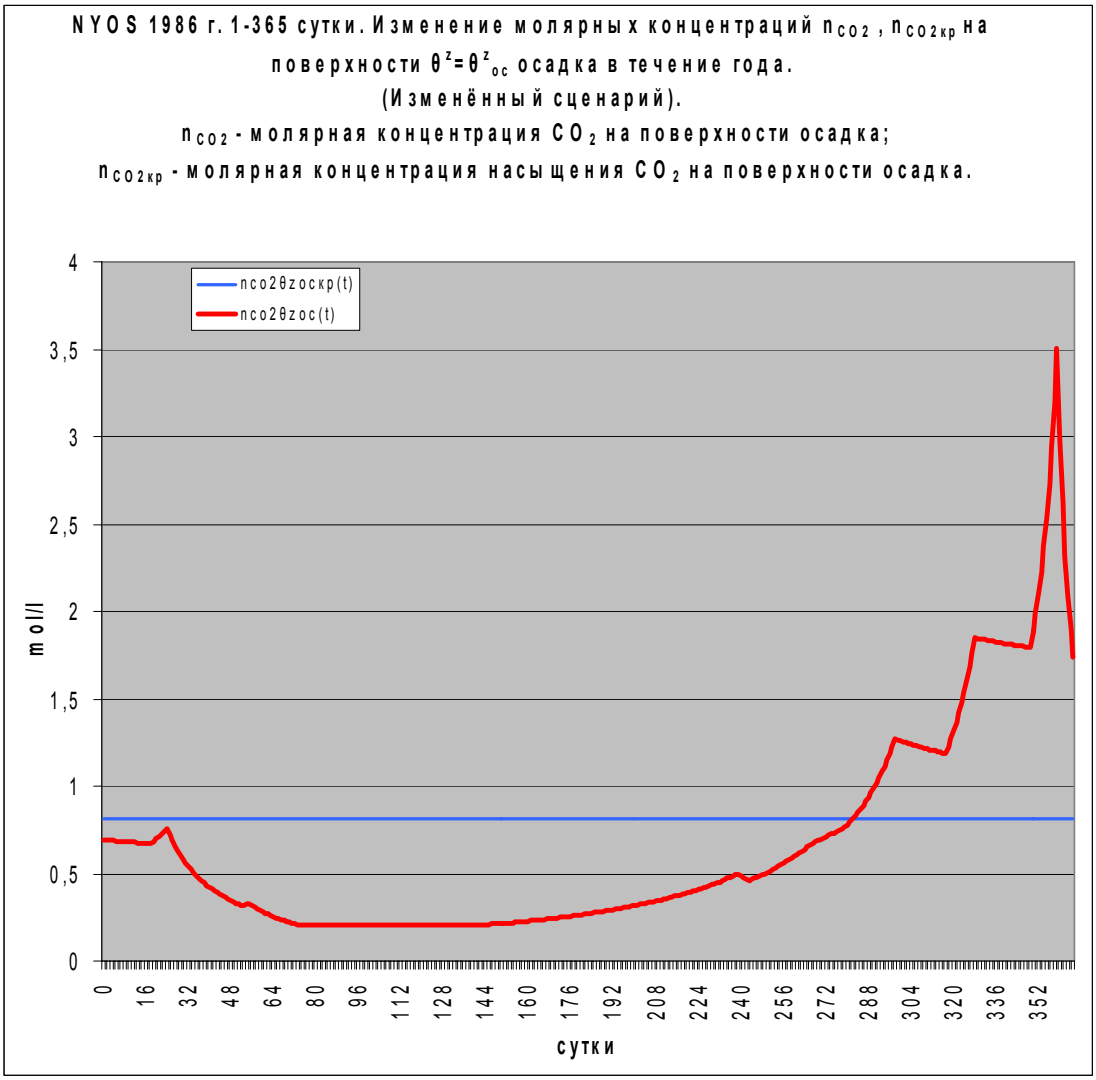

Fig.21. NYOS 1986. Day1-Day 365. The Changing of the molar concentration $\mathbf{n}_{CO2}$ and $\mathbf{n}_{CO2кр}$ on the surfaces $\theta^z=\theta^z_{oc}$ of the sediment stratums within one year.
$\mathbf{n}_{CO2}$-molar concentration CO_2 on the upper surfaces of the sediment stratums (red line) .
$\mathbf{n}_{CO2кр}$ - molar concentration of the saturation CO_2 on the upper surfaces of the sediment stratums (blue line).
(*Changed* scenario).

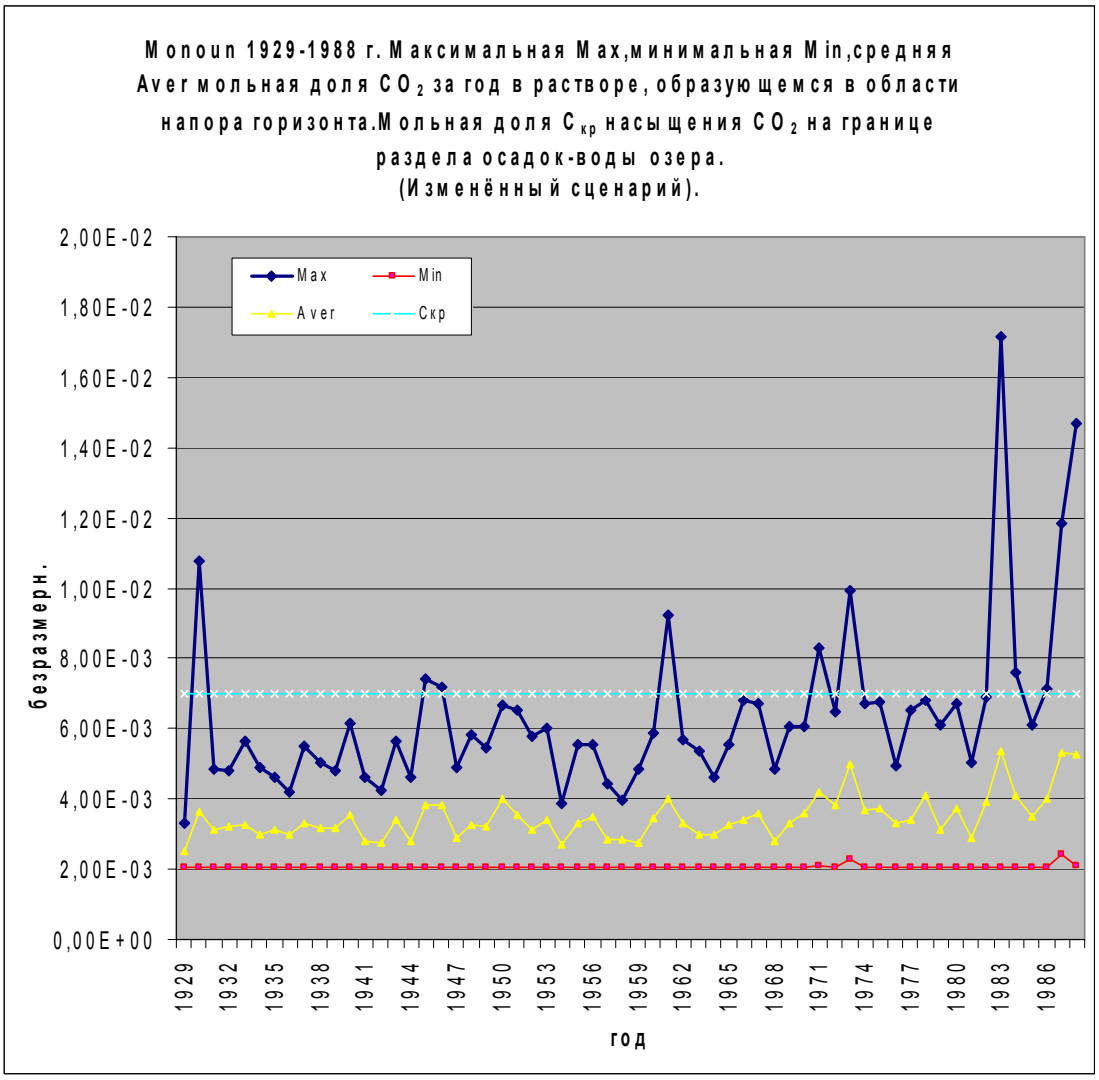

Fig. 22. MONOUN 1929-1988. Distribution under years of the maximum Max, of the minimum Min and average Aver of the the mole-fraction of the carbon dioxide in the point of the melange in the the pressure zone of the pressure confined aquifer, but in the same way the mole-fraction of the saturation Скр carbon dioxide on upper surface of the sediment stratums.
(*Changed* scenario).

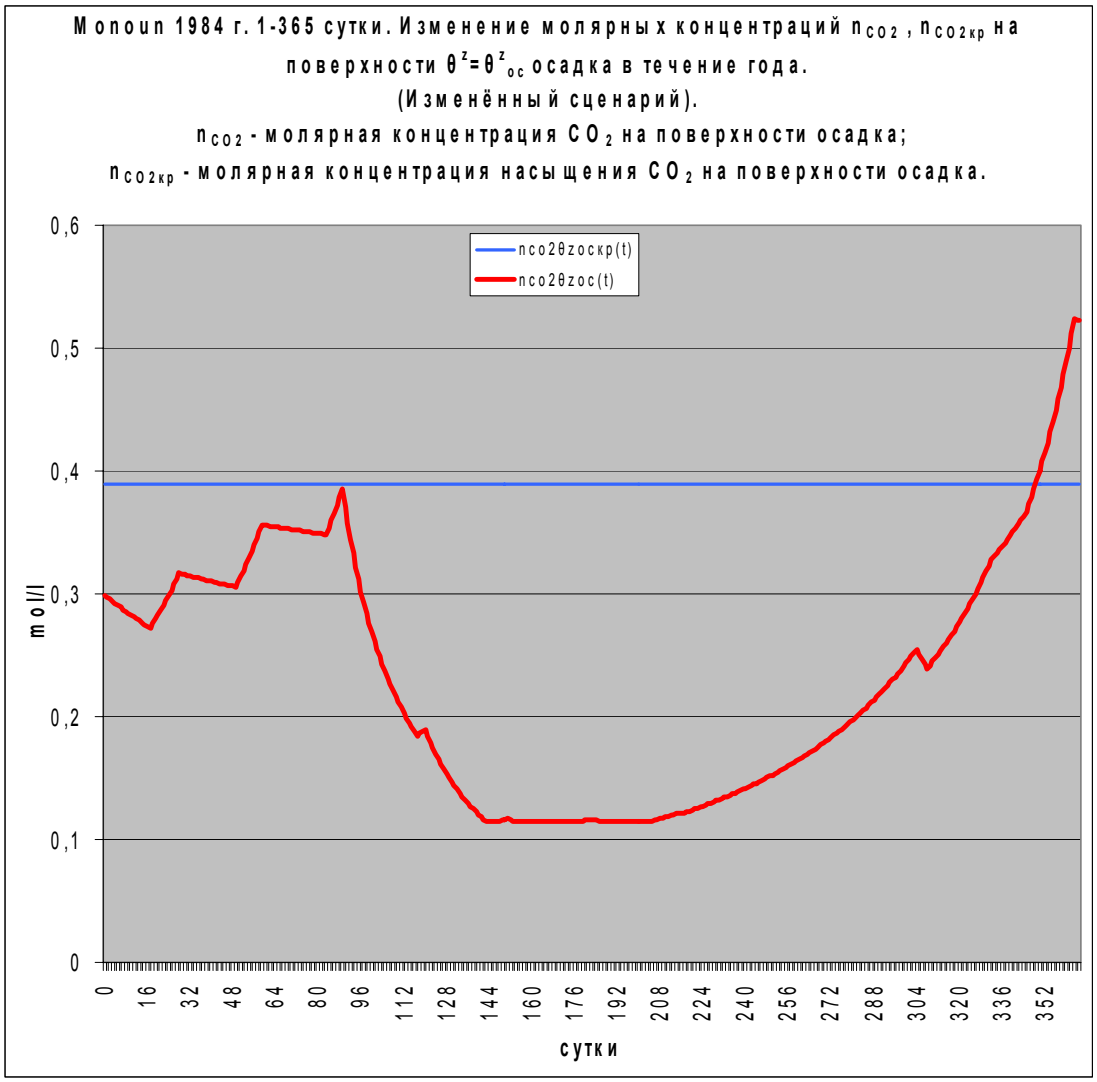

Рис. 23. MONOUN 1984.Day1-Day365. The Changing of the molar concentration $\mathbf{n}_{CO2}$ and $\mathbf{n}_{CO2кр}$ on the surfaces $\theta^z=\theta^z_{oc}$ of the sediment stratums within one year.
$\mathbf{n}_{CO2}$-molar concentration CO_2 on the upper surfaces of the sediment stratums (red line) .
$\mathbf{n}_{CO2кр}$ - molar concentration of the saturation CO_2 on the upper surfaces of the sediment stratums (blue line).
(*Changed* scenario).

Said shows that mole-fractions of the carbon dioxide and methane in the pressure zone of the pressure confined aquifers of the lake "Nyos" and of the lake "Monoun" *regulates* by the atmospheric precipitations, and in 1983 the atmospheric precipitations have raised the mentioned mole-fractions till the anomalous high values and hereunder *was switched on of the trigger mechanism an limnological catastrophes*, in the lakes "Nyos" and "Monoun".
Switched on by the atmospheric precipitations in 1983г., *the trigger mechanism was switched off*, in 1984г. in the lake "Monoun", and in 1986г. in the lake "Nyos", after the *Instantaneous catastrophic ejections* of the gas from the sediment stratums in the lake's water.

According to calculations, if parameters "Elevation at sea level of the the water recharge zone of the pressure confined aquifer " of the lake "Nyos" and of the lake "Monoun" will be increased on 4 metres (the Table 1., *Changed* scenario) in contrast with data of the *Real* situation, then in 1983 the maximum of the mole-fraction of the carbon dioxide in the water solution in the point of the mix in the pressure zone of the pressure confined aquifer, who do of the supply of the water solution of the carbon dioxide in the lake "Nyos" or the lake "Monoun", though will remain the largest during period 1929-1988 Fig.20., Fig. 22., but will become less than the mole-fraction, stated in *Real* situation, and will equal:
0,0594 mol/l in the pressure zone of the pressure confined aquifer of the lake "Nyos" (instead of 0,1940);
0,0172 mol/l in the pressure zone of the pressure confined aquifer of the lake "Monoun" (instead of 0,0249).

These values of the mole-fraction of the carbon dioxide will be not enough great for creating of the pressure of the gas, under which the tensile stress in the solid phase of the sediment stratums are to be more or are to be equal the breaking stress of the solid porous phase of the sediment stratums.

According to calculations (*Changed* scenario), if parameters "Elevation at sea level of the the water recharge zone of the pressure confined aquifer " of the lake "Nyos" and of the lake "Monoun" will be increased on 4 metres (the Table 1., *Changed* scenario) in contrast with data of the *Real* scenario, then per period 1929-1988 on the lakes "Nyos" and "Monoun" has not occurred nor one the *Instantaneous*, including *Catastrophic*, ejections of the gas from the sediment stratums.

Besides, if parameters "Elevation at sea level of the the water recharge zone pressure confined aquifer " of the lake "Nyos" and of the "Monoun" will be increased on 4 metres in contrast with the data of the *Real* situation, then the number of the years per period 1929-1988, in which occur the *Slow* ejections of the gas from the sediment stratums, will shorten on the lake "Nyos" from 31 (the Fig 3., *Real* scenario) till 12 (Fig.20., *Changed* scenario), and on the lake "Monoun" from 26 (the Fig 8., *Real* scenario) till 12 (Fig.22., *Changed* scenario).

By hereunder were shown that differences in the topographies of the terrain in the vicinities of the lake are an essential reason of the significant difference of the values of the mole-fraction of the carbon dioxide in the water solutions, who were supplyed to the lake's waters, as well as at the

amount and at the nature of the *Instantaneous* and *Slow* gas ejections in the lake "Nyos" and the lake "Monoun".

The comparison of the data on Fig. 3., Fig. 8., Fig. 20., Fig. 22. shows, that the mole-fraction of the carbon dioxide in the water solution, forming in the pressure zone of the pressure confined aquifer, are changing depending on the linear sizes of the lake (vertical) or are changing depending on the parameters of the pressure confined aquifer. The parameters of the pressure confined aquifer are defines by the topography of the terrain in the vicinities of the lake.

Said explains the difference of the values of the mole-fraction of the carbon dioxide in the water solution on the bottoms of the lakes "Nyos", "Monoun" and in the another lakes in their vicinities.

On Fig. 6., Fig. 7., Fig. 7a. is shown the continual change of the values of the molar concentration $\mathbf{n}_{CO2}$ of the carbon dioxide in the water solution on the bottom of the lake "Nyos" per period 1986-1988, caused by the continual change of the values of the mole-fraction CO_2 in the water solution in the pressure confined aquifer under the lake.
Said explains the continual changes of the values of the molar concentration $\mathbf{n}_{CO2}$ of the carbon dioxide in the water solution on the bottoms of the lakes "Nyos" and "Monoun".

By Said are proved that *the trigger mechanism* of *the limnological catastrophes* can *to be switched on* by the atmospheric precipitations, which are acting upon creation, of the mole-fractions of the carbon dioxide, with values more than *the threshold value*, of the mole-fractions of the carbon dioxide in the water solution, which are flowing through of the water-bearing rock and through the sediment stratums to the lake's water.
The Limnological catastrophes, whose *trigger mechanism switchs on* the influences of the atmospheric precipitations, were be generated of the *Instantaneous Catastrophic* ejections of the gas mixture CO_2 and CH_4 from the sediment stratums under the bottom of the lake.

The Trigger mechanism will be switched off at disappearance in the water solution, in mentioned the water-bearing rock and the sediment stratums, of the mole-fractions of the carbon dioxide, whose value exceeds of *the threshold value*.

The Degassing the waters of the lakes "Nyos" and "Monoun" (6) does not influence upon the values mole-fractions of the carbon dioxide and the methane in water solution, flowing in the sediment stratums and in the water-bearing rock of the pressure confined aquifer under the bottom of the lake.

Therefore, the *artificial Degassing* of the waters of the lake "Nyos" and of the lake "Monoun" (6), can not prevent from *the limnological catastrophes*, for *which the trigger mechanism was switched on* by the influence of the atmospheric precipitations.

The *Degassing* the waters of the lakes "NYOS" and "MONOUN" can not prevent from *the repetition* in lakes "NYOS" and "MONOUN" *of the limnological catastrophes*, similar to *the catastrophes of 1984 and of 1986*.

The calculations, with using of the program "SONATA", have proven that by the atmospheric precipitations *regulates* of the mole-fractions of the carbon dioxide and the methane in the water solution, flowing in the water-bearing rock of the pressure confined aquifer.

When in the water solution under the influence of the atmospheric precipitations appear the anomalous high mole-fractions of the carbon dioxide and the methane, the *trigger mechanism of the limnological catastrophes* will switchs on by the atmospheric precipitations.

The trigger mechanism, after as he *was be switched on* by the atmospheric precipitation, having caused the *Slow* or *Instantaneous catastrophic ejections of the gas* from the sediment stratums in the lake's water, *will switched off*.

By the surfacing, of the ejected to lake's water, of the gas and by his diffusing on the surface of the lake and in the vicinity of the lake will terminate of the limnological catastrophe, created by the trigger mechanism, who was switched on by the atmospheric precipitations.

The limnological catastrophes, whose *the trigger mechanisms are switched on* by other phenomena (the earthquake and others), occur through the other scenarios.

The artificial Degassing of the waters of the lake "Nyos" and of the lake "Monoun" (6), be able to prevent of of the lake "Nyos" and of the lake "Monoun" (6) from The limnological catastrophes, who can occur through such the other scenario, differing from the scenario of the limnological catastrophes of 1984 and of 1986 in the lake "Nyos" and the lake "Monoun".

The limnological catastrophes on the lakes "MONOUN" and "NYOS" *can occur anytime*, if their *the trigger mechanisms*, *will be Switched on* under influence of the atmospheric precipitations.
Switching on the trigger mechanism, under influence of the atmospheric precipitations, can occur anytime on the lakes "MONOUN" and on the lakes "NYOS".

The Program "SONATA", by using the data of long times of the monitoring of the monthly atmospheric precipitations in the vicinity of the lake "Nyos" and of the lake "Monoun", may forecasts the *Instantaneous* and *Slow* (including *Catastrophic*) ejections of the gas from the sediment stratums:
on lake "Nyos" - for three years before of the forecasted phenomena;
on lake "Monoun" - for one year before of the forecasted phenomena.

CONCLUSION

The calculations , with using the program "SONATA", prove:
Limnological catastrophes on lake "Nyos" (the August 21 1986) and "Monoun" (the August 15 1984) were caused by the *catastrophic* ejections of the gas from the sediment stratums of the lakes.

The catastrophic ejections of the gas from the sediment stratums of the lakes "Nyos" and "Monoun" have happened after occurrence, when , in 1983, *was Switched on* of *the trigger mechanism of the limnological catastrophes* under influence of the atmospheric precipitation.

By the Influence of the atmospheric precipitations in 1983 was caused formation of the anomalous high mole-fractions of the carbon dioxide and the methane in the water solution, which are flowing through of the water-bearing rock under the lake.

The water solution, after arising in him in 1983 the anomalous high mole-fractions of the carbon dioxide and the methane, are moving from the pressure confined aquifer in the sediment stratums under lake.
The Appearance in the sediment stratums under lake of the water solution with anomalous high mole-fractions of the carbon dioxide have enlarged the pressure of the gas before values, under which the solid porous phase the sediment stratums are to destruct.

At period from 1929 till 1988 the anomalous high mole-fractions of the carbon dioxide and the methane in the water solution, with the value, which was enough great for destruction of the solid porous phase of the sediment stratums and origin of *the limnological catastrophes,* were formed in the pressure confined aquifers of the lake "Nyos" and the "Monoun" simultaneously and only once upon a time - in 1983.

The Influence of the topographies of the terrain around of the lake into the differences of the vertical and horizontal parameters of the pressure confined aquifer under the lakes "Nyos" and the "Monoun", is a reason that, for each lake are distinguished the times of the moving the water solution from the pressure confined aquifer in the sediment stratums under the lake, as well as are distinguished the values of the mole-fractions of the carbon dioxide and the methane in the water solutions.

The differences of the time of the moving the water solution, from the pressure confined aquifer in the sediment stratums under the lake, was a reason that, in spite of that that simultaneously in 1983 *be switched on* of *the trigger mechanism* in the pressure confined aquifer , *the limnological catastrophes* in the lake "Nyos" and in the lake "Monoun" have occurred at different times:
On the lake "Nyos" - an August 21 1986,
On the lake "Monoun" - an August 15 1984.

The differences of the linear vertical and horizontal parameters of the pressure confined aquifer under the lake "Nyos" and under the lake "Monoun", defined by the topography and by the geology

of the terrain, is a reason that,that the values of the mole-fractions of the carbon dioxide in the solution on the bottom of the lake "Nyos" and of the lake "Monoun" vastly differ.
Unceasing time history of the value of the atmospheric precipitation in the vicinities of the lake are cause , of the unceasing the change on the bottom of the lake ("Nyos", "Monoun") of the values of the mole-fractions of the carbon dioxide and the methane in the water solution, who will be entered on the bottom of the lake from the pressure confined aquifer, after some times.

Under influence of the atmospheric precipitation *the trigger mechanism of the the limnological catastrophes* in the lake "Nyos" and the "Monoun" , in any time may *to be switched on* and in a certain time hereon *will happen of the limnological catastrophes.*

The artificial *degassing* the waters of the lakes "NYOS" and "MONOUN" (6) does not influence upon atmospheric precipitation and therefore can not prevent from the repetition in lakes "NYOS" and "MONOUN" of the limnological catastrophes, similar to the catastrophes of 1984 and of 1986.

The Forecast instantaneous and slow (including catastrophical) of the gaseous ejections from the sediment stratums of the lakes "Nyos" and the "Monoun", as of long times (1929-2006) of the monitoring the monthly atmospheric precipitation, with by use of the program "SONATA" possible:
to the lake "Nyos" - for three years prior to the forecasted phenomenon;
to the lake "Monoun" - for one year prior to the forecasted phenomenon.

REFERENCES

1. W.Aeschbach-Hertig, M.Hofer, R.Kipfer, D.M.Imboden, and R.Wieler, “Accumulation of mantle gases in permanently stratified volcanic lake (Lake Pavin, France), Geochimica Acta, Vol. 63, No 19/20,pp. 3357-3372,1999.,
2. Scott M.Klara, Sarah Forbes, “ Lake Nyos and Mammoth Mountain: What Do They Tell Us about the Security of Engineered Storage of CO_2 Underground?”, PROGRAM facts , Sequestration, 03/2005.,
3. Giovanni Chiodini, Mariano Valenza, “PROJECT V5. Research on the diffuse degassing in Italy, pp140-155.,
4. Karsten Pruess, Earth Sciences Division, Lawrence Berkeley National Laboratory, Berkley, CA94720,“Numerical Studies of Fluid Leakage from a Geologikal Disposal Reservoir for CO_2 Show Self-Limiting Feedback between Fluid Flow and Heat Transfer, March 22, 2005, 1-8.,
5. Michel Halbwachs, Jean-Christophe Sabroux, Jacques Grangeon, Gaston Kayser, Jean-Claude Tochon-Danguy, Alain Felix, Jean-Christophe Beard, Adelin Villevieille, Gerard Vitter, Patrick Richon, Alfred Wüest and Joseph Hell, ”Degassing the ”Killer Lakes” Nyos and Monoun, Cameroon”, EOS, volume 85, number 30, 27 july 2004, pages 281-288.,
6. George W.Kling, William C.Evans, Greg Tanyileke, Minory Kusakabe, Takeshi Ohba, Yutaka Yoshida, “Degassing Lakes Nyos and Monoun: Defusing certain disaster”, PNAS,October 4, 2005, vol.102, no.40, 14185-14190.,
7. Martin Schmidt, Andreas Lorke, Alfred Wüest, Michel Halbwachs, Gregory Tanyileke, “Development and sensitivity analysis of a model for assessing stratification and safety of Lake Nyos during artificial degassing, Ocean Dynamics (2003)53: 288-301.,
8. Martin Schmidt, Michel Halbwachs, Bernhard Wehrli and Alfred Wüest, “Weak mixing in Lake Kivu: New insights indicate increasing risk of uncontrolled gas eruption”, Geochemistry Geophysics Geosystems G^3, Volume 6, Number 7, 26, July 2005, 1-11.,
9. Р.И.Нигматулин, «Основы механики гетерогенных сред», Москва, «Наука», Главная Редакция Физико-Математической Литературы, 1978, стр.14-51, 64.,

Наталья Анатольевна Солодовник · Анатолий Борисович Солодовник
(Natalija Solodovnika· Anatolijs Solodovniks)

10. Г.Флинн, «Физика Акустической Кавитации в Жидкостях», Физическая Акустика под редакцией У.Мэзона, Том 1 Методы и приборы ультразвуковых исследований, Часть Б, Издательство «МИР», Москва 1967, стр.20.,
11. Г.Флинн, «Физика Акустической Кавитации в Жидкостях», Физическая Акустика под редакцией У.Мэзона, Том 1 Методы и приборы ультразвуковых исследований, Часть Б, Издательство «МИР», Москва 1967, стр.14,93.,
12. Р.Биркгоф, Э. Сарантонелло, «Струи, Следы и Каверны», Издательство «МИР», Москва, 1964, стр,414.,
13. Вопросы Физики Кипения под редакцией И.Т, Аладьева, Издательство «МИР», Москва, 1964: Фритц В., Энде В., «Исследование механизма парообразования с помощью киносъёмки паровых пузырей», стр174.; Клинг Г. «О динамике образования пузырей при насыщении жидкости под давлением», стр.396..,
14. http://bonnet19.cs.qc.edu:7778/pls/rschdata/rd_prcp.show_prcp_data,
15. Edouard K. Penlap, Cristoph Matulla, Hans von Storch, F.Mkankam Kamga, "Downscaling of GCM scenarios to asses precipitation changes in the little rainy season (March – June) in Cameron, CLIMATE RESEARCH, Vol. 26: 85-96, 2004, Published May 25, p.87.,
16. Smithsonian National Museum of Natural History,Global Volcanism Program, Oku Volcanic Field, 08/1985 (SEAN 10:08), Fatal 1984 gas emission may have been caused by sudden release of dissolved CO_2 , not volcanic activity.,
17. Smithsonian National Museum of Natural History,Global Volcanism Program, Oku Volcanic Field, 08/1986 (SEAN 11:08), Toxic gas cloud from Lake Nyos kills more than 1,700 people.,
18. Smithsonian National Museum of Natural History,Global Volcanism Program, Oku Volcanic Field, 12/1986 (SEAN 11:12),Three explosions in 5 minutes; red stain in lake center the next morning; 01/1987 (SEAN 12:01), Rockfalls; Lake Nyos remains clear; samples taken.,
19. Case Teaching Notes for " A killer lake", Thomas Horvath, Page 9.,
20. Н.А.Солодовник, А.Б.Солодовник, «Влияние атмосферных осадков на газовую кавитацию в донном осадке открытого водоёма», Рига, 2004, стр.79-82.
21. В.Шретер и др., «Химия» , Москва, Химия, 1989, стр.316.
22. G.Nelson Eby and William C.Evans, Feature. Taming the killer lakes of Cameroon, *Geology Today*, Vol.22, No.1, January-February 2006.
23. V.Vendrig, J Spouge, A.Daycock and O.Jonsen DNV Consulting, Risk Analysis of the Geological Sequestration of Carbon Dioxide, Report No. R DTI/Pub, 2003.
24. David W. Keith and M.Granger Morgan, Chair's Essay: Industrial Carbon Management: A Review Of The Technology And Its Implications For Climate Policy, ASPEN GLOBAL CHANGE INSTITUTE, Elements of Change 2000.

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(Natalija Solodovnika· Anatolijs Solodovniks)

МЕХАНИКА *ВКЛЮЧЕНИЯ СПУСКОВОГО МЕХАНИЗМА*
***ЛИМНОЛОГИЧЕСКИХ КАТАСТРОФ*, произошедших в КАМЕРУНЕ на озере «MONOUN» в 1984г. и на озере «NYOS» в 1986 г., ВОЗДЕЙСТВИЕМ АТМОСФЕРНЫХ ОСАДКОВ в 1983 г..**
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