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Geophysical and Geochemical fields of Pyramids

SUMMARY

Obtained results of geophysical and geochemical fields of Pyramids and the necessity of their exact physical interpretation make the development of an adequate model of the pyramid very important. This model shall explain the most notable experimental effects: concentration and amplification of intensity (amplitude of vibration displacement) of seismic waves; anomalously high level of seismic-acoustic emission (especially inside the pyramid) and electromagnetic radiation, accompanying this emission, as well as to explain detected spectral peaks for certain geophysical (free oscillations of the Earth) and astrophysical (frequencies of radio pulses from pulsars) processes. The close analogs are the laboratory and geophysical, natural and artificial concentrators of vibrations in form of the pyramid, which earlier were offered (1971 – 1972) for detection of gravitational waves by seismic methods.

In accordance with the main aims of investigation, in this paper will be presented:

- Geophysical fields and signals of Egypt pyramids: instruments, methods and equipments for research; first results; seismic signals and seismic emission fields near the Broken (Southern) pyramid, electromagnetic fields, variations of tilts of pyramids, high frequency, radition background and fluids, analysis of gas samples.

- Seismic-physical structural model of pyramids, experimental testing; comparison of analoges, model choise, discretely periodical structures of Egyptian pyramids: first experiments, response of the Snowfru pyramid on impulsive sounding, Dakshur – red pyramid, vertical impact, Medume – “incorrect” pyramid, internal and external impact, impulse studies at the plateau of Giza pyramids.

- Seismic noise (SN) and seismo-acoustic emission (SAE) of a field of pyramids: elements of structure;, high-frequency part of seismic noise and it analysis of the Broken-line Snowfru/Dahshru pyramids.

- Seismic noise of Snowfru/Dahshru pyramids: gas dust stream influenca; seismically active (nonlinear) medium and wave processes; analysis of seismic noise of the Broken-line Snowfru/Dahshru pyramids, low and high frequency part of seismic noise, spectral peak in the vicinity of 17 Hz as a resultant of several physical mechanisms.

- Seismic noice (SN) and seism acoustic emission (SAE) of a field of pyramids: elements of structure.

- Conclusions.
  (At the end of paper there are 75 used References).

Key words: Geophysical and geochemical fields of pyramids, astrophysical frequencies, seismic noice (SN), seismo-acustic emission (SAE), low and high frequencies, spectral peak.

Chapter 1: Geophysical and Geochemical fields of Pyramids

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§1. Geophysical fields and signals of Egypt pyramids: instruments, methods and equipment for research; first results

1. Preliminary remarks

In accordance with the main aims of investigation (geophysical fields and signals of the most remarkable Egyptian pyramids and surrounding geological structures) the field investigations primarily had the reconnaissance character and were limited by the pyramids' area near Memphis.

Even in the framework of routine geophysics this region is very interesting: after strong earthquakes of the early Middle Ages and continuous calm now the seismic activation is observed. The pyramid area as well as the Greater Cairo is inside the zone of high seismic intensity and activity of faults. Accordingly the first stage of investigation was connected with the pyramids' area of the Giza plateau, which in fact borders upon the Greater Cairo, and the pyramids' area in Dakhshur, which is far removed from the sources of industrial noise, as well as the pyramids in Medum [1]. Simultaneously all research have applied aim – short time earthquake prediction.

The most complete cycle of the seismic investigations was conducted on the pyramid Snofru (Southern). Significant attention was paid to the investigations of non-linear seismic effects and noise, which require the special equipment and high culture of seismic experiment. Technical and methodical basis of such investigations requires the special attention, so the reader could refer to the final report [2]. During all measurements wind and industrial noise were absent, other particularities are described for each particular experiment.

2. The used equipment and instruments.

The following equipment was used for measurements of different geophysical fields of pyramids and surrounding structures.

1. The standard seismometers-velocimeters SV10 and SG10 with the frequency band of 10 to 1000 Hz, transformation coefficient of 16 V/m/sec, and non-standard seismometer NVS, which is the velocimeter with the high transformation coefficient of 160 V/m/sec and the frequency band of 5 to 1000 Hz.
2. Registration system for analogue signals IDL-02-04 (8 channels, dynamic range of 70 db, frequency band Δf = 0 - 25 Hz, solid state memory capacity - 4Mbit).

3. Electronic unit for registration of envelope of the seismic emission (ROSE), which consists of microprocessor, two-channel recorder of digital transformer of analogue signals within the frequency band of 5 to 1000 Hz with subsequent summation and calculation of mean value for the selected time interval (sec, min). The minimal measurable signal is < 10^{-6} V (for displacements 10^{-11} - 10^{-12} m for seismometer-velocimeter NVS), dynamic range is about 120 dB, duration of registration is 1 sec.
4. System of registration IDL-02-04 for registration of high frequency signals (active impact).
5. Dosimeter-radiometer (ANRI-01-02) with the following technical characteristics: power of gamma radiation range, mR/h - 0.010 - 9.999, energy of gamma radiation range, MeV - 0.06 - 1.25, relative error for Cs137 is less than 30%.

6. Tiltmeter non-standard (NN), sensitivity < 1 second of arc (10^{-9}rad).
7. UHF ferrite antenna for registration of electromagnetic radiation (EMR) accompanying the seismoacoustic emission (SAE).

3. Methods.

The main object of the measurements was the seismic processes and fields, as well the seismoacoustic emission. Seismometers NVS were used for registration of seismic signals and fields, such as seismic and seismoacoustic emission and background noise. Recording of seismic fields was carried out by the electronic unit of the system of registration of envelope of the seismic emission (ROSE). Amplitude and energy spectra of seismic noise, recorded on the pyramid, were obtained with the use of the seismometer NVS.

Active impact was limited by weak shocks (excitations) on side faces of pyramids or on separate blocks for determination of velocity characteristics of materials. Method of falling weight and seismometers SG10 and CV10 were used for location of reflecting boundaries and probable hollows. Taking into account the small coefficient of transformation and low level of seismic noise only seismic signals, generated by shocks, and signals, connected with their reflection and propagation, were recorded during active experiments.

Dosimeter-radiometer ANRI-01-02 "SOSNA" was used for measurement of natural radioactivity of blocks and facing plates of pyramids, and entire natural radioactive background was measured on day face.

Tilt-meters were installed on plates of basement of the pyramids in center of faces, leeward, 2 - 3 meters from the ground surface.

4. Seismic signals and seismic emission fields: records, preliminary processing, short comments.

Seismic emission fields were recorded by ROSE equipment on pyramids Snofru in Dakhshur ("Red" and "Broken") and in Medum ("Wrong"), including internal chamber of the latter. Seismoacoustic emission was recorded by one channel and simultaneously signals from UHF antenna were recorded by the other one. By different reasons duration of records was varied from 20 minutes to 3-5 hours.

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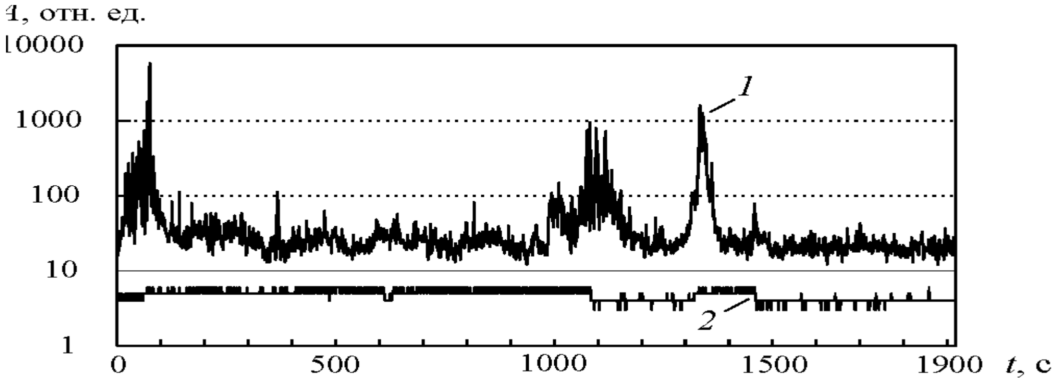
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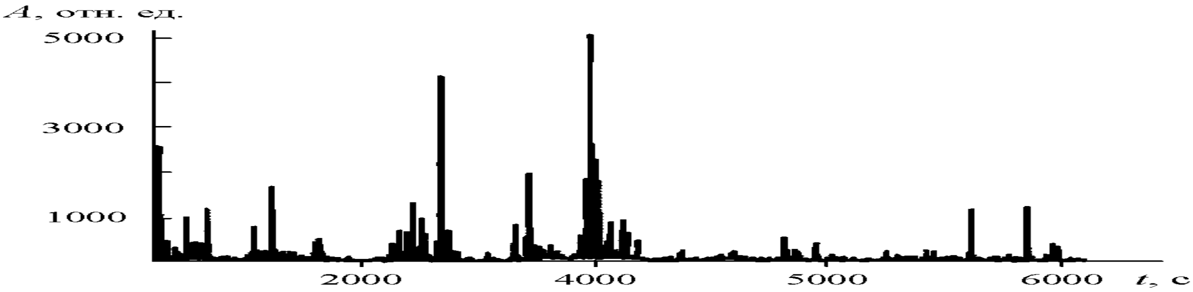
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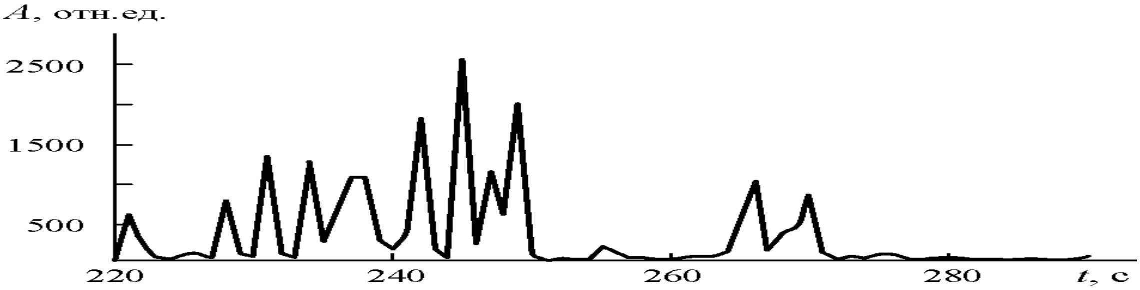
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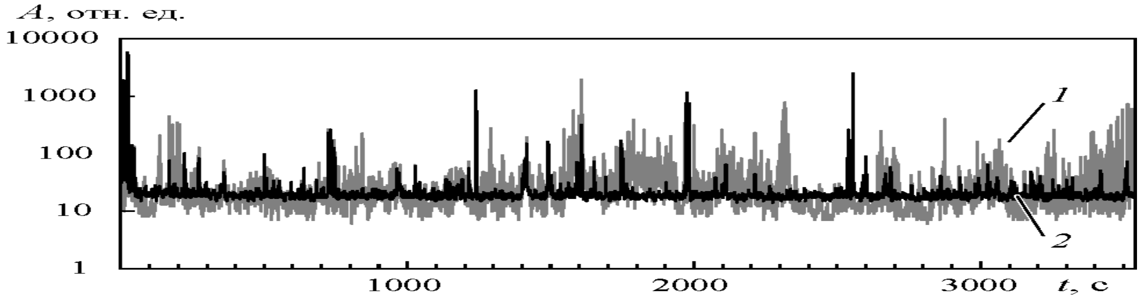

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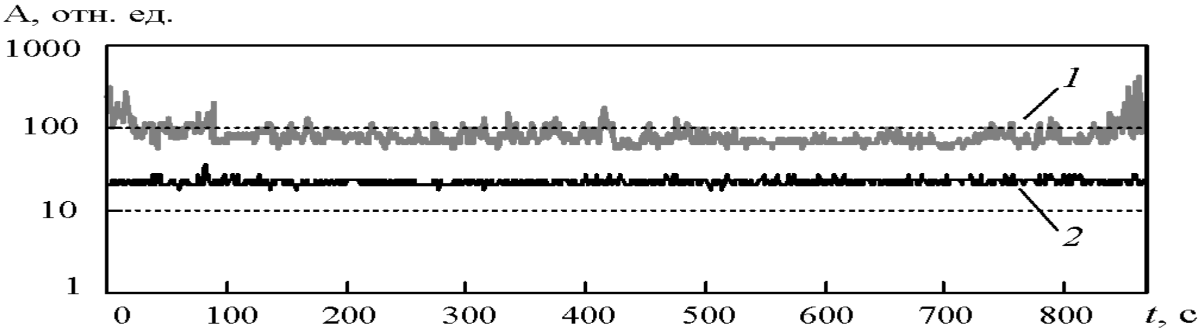

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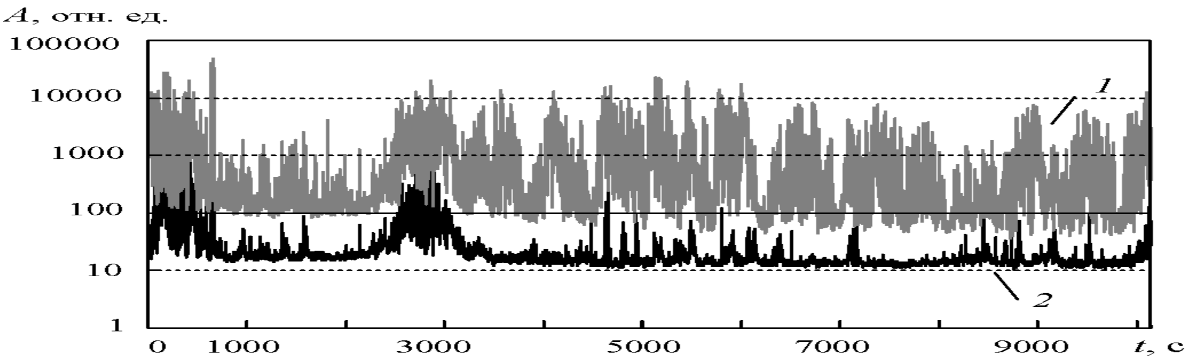

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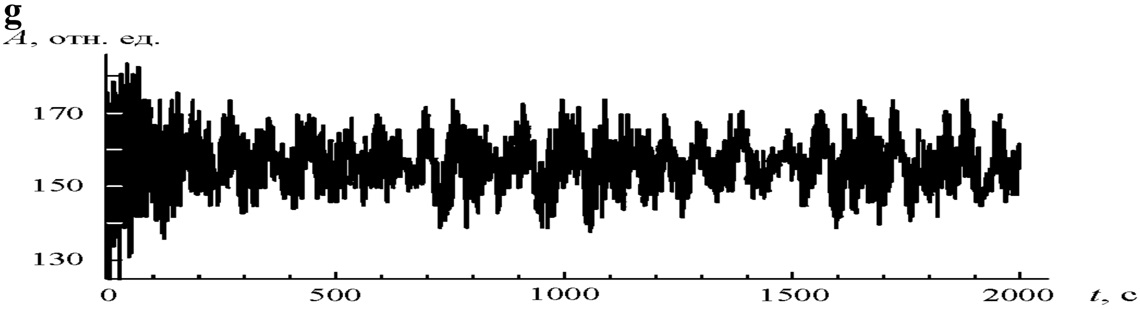

Figure 1. Examples of records of seismic noise envelopes SAE and EMR:

a) The record of fluctuations of seismic emission envelope in Dakhshur on the Southern "Broken" pyramid: seismometer was installed in the center of the western face 5 meters above the ground level, and the record of envelope of the signal from the ferrite antenna. Grey curve in the seismic noise envelope, black curve is the envelope of electromagnetic emission of the pyramid body. X-axis: current time in seconds, Y-axis: amplitude of envelope in microvolts (March 3, 2004).

b) The record of fluctuations of the seismic emission envelope on "Red" or Northern pyramid in Dakhshur: seismometer was installed in the center of the western face near observable microcrack 4 meters above the ground level. . X-axis: current time in seconds, Y-axis: amplitude of envelope in microvolts, March 18, 2004.

c) Fragment of the record (Figure 1b) near point of origin from 220th to 280th seconds.

d) The record of fluctuations of the seismic emission envelope on pyramid in Medum: seismometer was installed in the center of the southern face (grey curve); the other cannel is the record of the envelope of the signal from ferrite antenna (black curve), March 21, 2004.

e) The record of fluctuations of the seismic emission envelope in the chamber of pyramid in Medum (grey curve) and the record of the envelope of the signal from ferrite antenna (black curve), March 21, 2004.

f) Record of envelope of variations of seismic noise and seismic emission on the top of the small pyramid near the "Broken" or Southern (figure 3) in Dakhshur on two channels: standard more low frequency seismometer ($f_n \approx 2$ - 5 Hz) (black curve) and non-standard high sensitive seismometer (5 - 7 times more) (grey curve), March 23, 2004.

g) Fragment of the record of noise (figure 1f), first part (250 seconds) with higher amplitude caused by seismic emission.

5. Registration of seismic emission near the Broken (Southern) pyramid.

Seismic emission was investigated with use of small pyramid. Just before the equipment was turned on 3 shocks were made near the basement of the small pyramid for generation of seismic emission in near-surface structures. The effect was observed during 600 seconds (figure 1f, g)

It is necessary to notice the fact of increasing of the seismic noise on the top of the small pyramid (approximately 10 times) in comparison with the noise level near the basement (compare figures 1a, f), i.e. the effect of focusing. Records of the seismic noise by the high sensitive seismometer were also made near the basement on southern side of the "Broken" pyramid.

6. Active seismic fields and signals.

We understand active seismic fields as shock generation of seismic waves in medium for determination of seismic velocities and distances to geological and structural boundaries in result of reflection of seismic waves from them. Shock generation of seismic pulses allows to conduct the search of some cavities and resonance, structures and objects inside a pyramid body with rough estimation of their dimensions. It is simple to determine dimensions of blocks from near-surface structure of faces or internal chambers. Seismic velocities in pyramids' blocks were determined earlier: *P*-waves velocities in limestone blocks were about 2000 - 2500 m/sec, *S*-waves velocities were about 1300 m/sec (American expedition observed much greater values), in granite *P*-waves velocities were about 4500 m/sec and *S*-waves velocities were about 2500 m/sec.

Shocks on blocks of pyramids' faces generate not only reflections from boundaries, determined by blocks' geometry, but also different reverberations, which probably depend on fixation of blocks. In Dakhshur shocks were made on blocks of faces of pyramids: two vertical (downward and upward) and horizontal. Seismometer SG10 was installed vertically. Figure 2 shows the records of these shocks.

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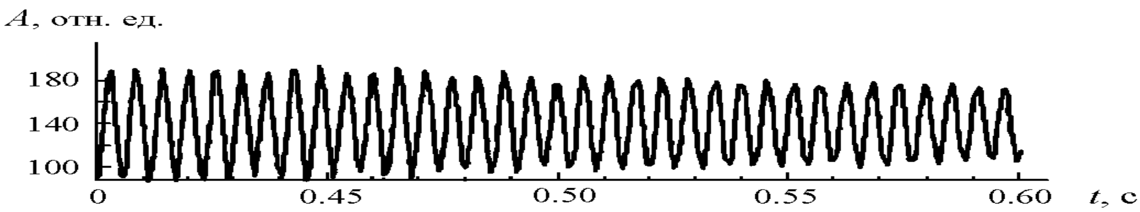

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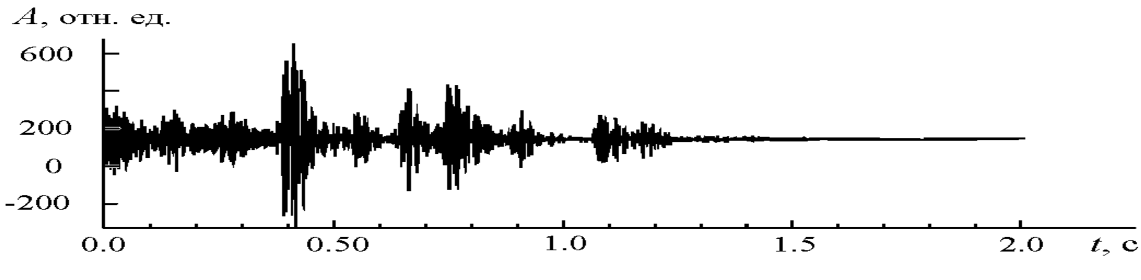

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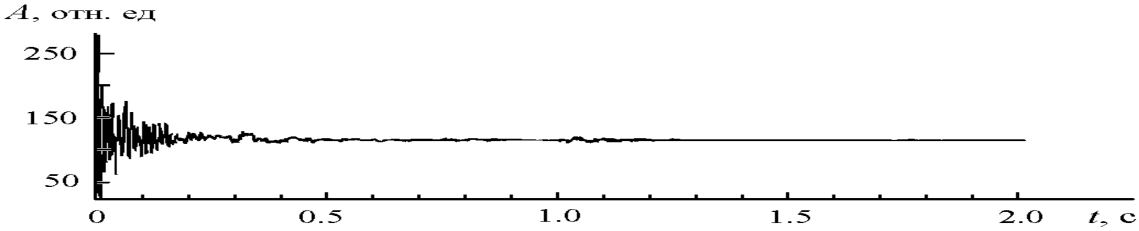
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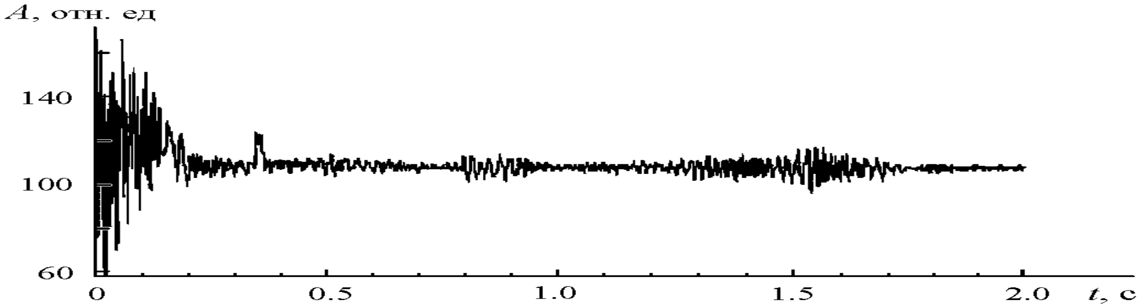
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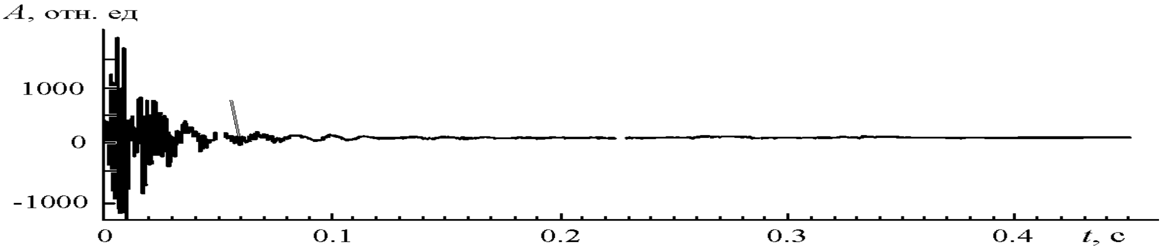
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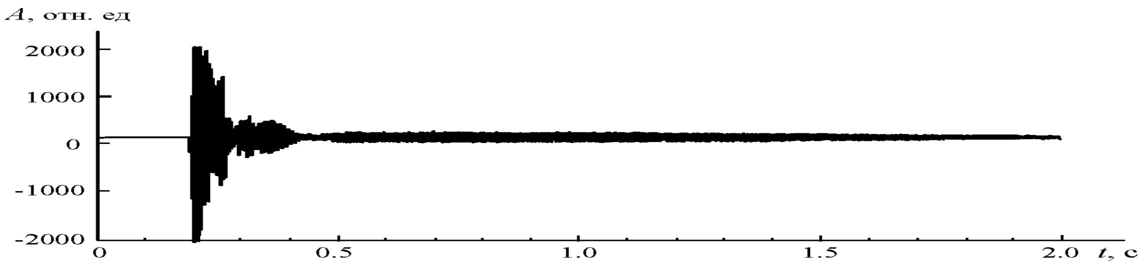
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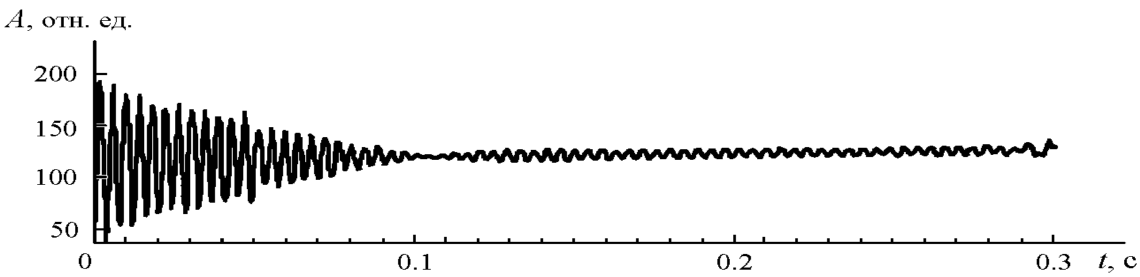
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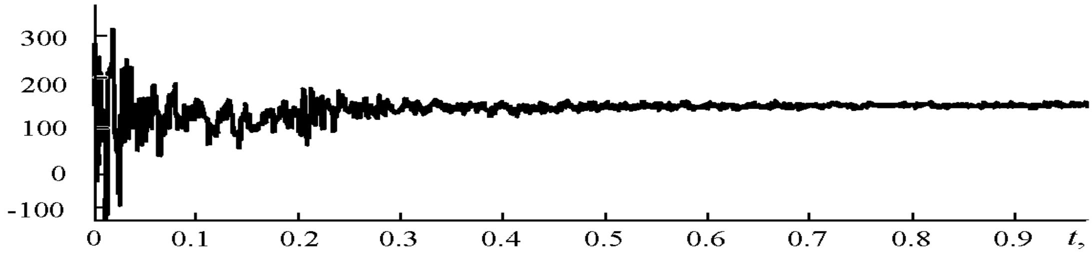

Figure 2. Examples of records of sounding shocks:

a) Record of the vertical downward shock on block of basement of Southern "Red" pyramid in Dakhshur (weight is 10 kg, place of shock - 1 m above the day surface). March 18, 2004. The block is located 3 m above the ground level. Hereinafter: A - amplitude of the signal in relative units, τ - current time in seconds.

b) Fragment of figure 2a. Strong reverberation (ringing) during several seconds is observer, which could be explained by the extremely high Q-factor of the block.

c) Vertical shock similar to the sock in figure 2a on the same block, but in upward direction.

d) Horizontal shock. Block and parameters of the shock are the same.

e) Record of shock on the "Red" pyramid. Complicated reverberations, connected with block structure of the pyramid, are observed.

f) Example of record of shock inside the pyramid in Medum.

g) The record of the vertical shock on north-eastern corner of the pyramid in Medum. Continuous "ringing" with frequency of 465 Hz is observed.

h) The record of the vertical shock (signal with frequency of 241 Hz is observed). Southern face of the pyramid of Menkaur.

i) The record of the horizontal shock at the same place (frequency 231 Hz is observed)

On March 20 one vertical downward shock was made on "Red" (Northern) pyramid in Dakhshur. Its record has also some particularities, figure 2e.

On March 20 the downward shock was made in Medum, figure 2f.

In some cases the quasi-harmonic reverberations, which do not correspond to solid body of blocks, were observed, for example, in case of the shock on north-eastern corner of the pyramid in Medum, figure 2g.

On March 22, 2004 near the Menkaur (Mikerin) pyramid in the top of the small outside pyramid the record of shock on ground near its basement was made. Its autocorrelation function was calculated. In accordance with the practice of processing of seismic data some peaks on shock's record and on its autocorrelation function could be interpreted as seismic reflections from deep (down to 1 km) layers, focused by the pyramid.

Vertical and horizontal shocks were also made on southern face of Menkaur's pyramid on March 22, 2004 (figure 2h, i). Observed frequencies for vertical and horizontal shocks (241 Hz and 231 Hz correspondingly) could be connected with conditions of shocks excitation and probably with geometry of the pyramid. In future it is necessary to estimate values of frequencies in pyramids in case of vertical and horizontal shocks and their connection with geometry (angle of slope of face and blocks, general dimensions, height).

7. Electromagnetic fields

Connection between seismoacoustic emission and electromagnetic radiation (EMR, radio emission) in pyramids was investigated with use of ferrite antenna in kilocycles and megacycles frequency bands. Equipment for record of envelope of seismic emission (second channel) was primarily used for qualitative estimations. Registration was conducted on maximal sensitivity. Direct correlation between envelopes of seismic emission and radio emission was not observed. So the averaging on one-minute interval was used. In result the significant correlation (P = 0,99) was found out. Short-waves radio receiver was used in investigations of SAE and EME, the work with which has shown significant decrease of the signal in the medium waves band and its absolute absence in short waves band inside of pyramid's body. It shows the electromagnetic screening of the signal from radio station.

8. Variations of tilts of pyramids

Measurements of variations of one component of tilt of basement of pyramid were conducted. The tilt meter was installed on 3 - 4 block from the ground level and the component North-South was measured. In connection with significant difficulties of adjustment of the tiltmeter and regulation of its operation range duration of records available for processing was limited by two hours.

On March 21 tilts (in relative units) were measured on the Southern side of the wrong pyramid in Medum. On March 23 tilts on the Southern side of the "Broke" pyramid in Dakhshur were also observed.

9. Radiation background and fluids

Radiation measurements were conducted outside and inside all investigated pyramids. Generally the standard gamma background for limestone and basalt (6 - 9 mkR/h) and for granite and granitoids (20 - 25 mkR/h) was measured. However, inside the pyramid of Hufu (Heops) in the south-eastern corner of the Pharaoh's chamber radiation of 35 - 37 mkR/h was observed on relatively fresh split. May be this difference could be used for dating of the pyramid's construction, because more amount of thoron with short period of half-life in the thorium series (Tn = 55.3 sec, ThC' = 60.5 min, ThC'' - 3.1 min), which then transforms to lead, is delivered on the fresh surface. In comparison with other parts of surface of the chamber the fresh split has no such lead screen. The other fact was also observed: internal part of the pyramid in Medum is made of more radioactive limestone (13 - 15 mkR/h) in comparison with outer part (5 - 7 mkR/h). May be limestone from different regions was used for construction of the pyramid. Location of the place of extraction of the radioactive limestone could give the additional information about the time of construction of internal part of the pyramid. But other explanation is also possible.

Usually inside pyramids in chambers made of limestone radioactive background was 2 times lower and was 2 - 5 mkR/h. This could be used for registration of high energy cosmic rays inside pyramids.

10. Analysis of gas samples

Gas samples were taken from the Pharaoh's chamber of the pyramid of Hufu and from one of the cambers of the "Red" pyramid in Dakhshur. Analysis is conducted for 40 components. Composition of atmosphere in the pyramid of Hufu (Heops) is not differed from the standard one, but in the "Red" (Northern) pyramid the anomaly is observed: total content of hydrocarbons C8 - C12 reaches 9 mg/m^3.

Conclusion

Unique equipment is required for investigation of geophysical fields and signals. Form of signals - seismic pulses shows the presence of internal high frequency resonance in some pyramids. Existence of seismic acoustic emission is typical for all large pyramids and surrounding structures. Seismic acoustic emission is accompanied by electromagnetic radiation.

§2. SEISMIC-PHYSICAL STRUCTURAL MODEL OF PYRAMIDS;

EXPERIMENTAL TESTING

1. Preliminary notes, close analogs

The seismic-physical model of a pyramid as a system with periodic structure is proposed, this model is adequate to observational data. Acoustic analogs are given. It is shown that the existing mathematical methods are employable.

The significant part of results obtained from studies of geophysical fields of Egyptian pyramids and their following physical interpretation necessarily require the choice of an adequate model of pyramids. The model should be consistent with the most clearly expressed effects that were observed, particularly: increase in intensity of seismic waves at the top of the pyramid; anomalously high level of seismic acoustic emission (especially inside the pyramid) and electromagnetic radiation accompanying the emission. The analysis of seismic noise revealed spectral peaks at known geophysical (free oscillations of the Earth) and astrophysical (frequencies of radio impulse transmission from pulsars) periods.

There are known laboratory and geophysical, natural and artificial analogs, whose form is similar to a pyramid [1-11] (Fig. 1). Some of peculiarities found in geophysical fields are well explainable in terms of nonlinear seismology and statistical theory of open systems, as well as astrophysical-geophysical experiments [12-22].

2. Comparison of analogs, model choice

In accordance with the notes above, the choice of the pyramid model and the comparison of analogs should take into account the state and the structure of the pyramid medium and near-surface structures beneath its foot (hundreds of meters, first kilometers). The model taken as a basis should fit the experimental data obtained (Fig.1 D).

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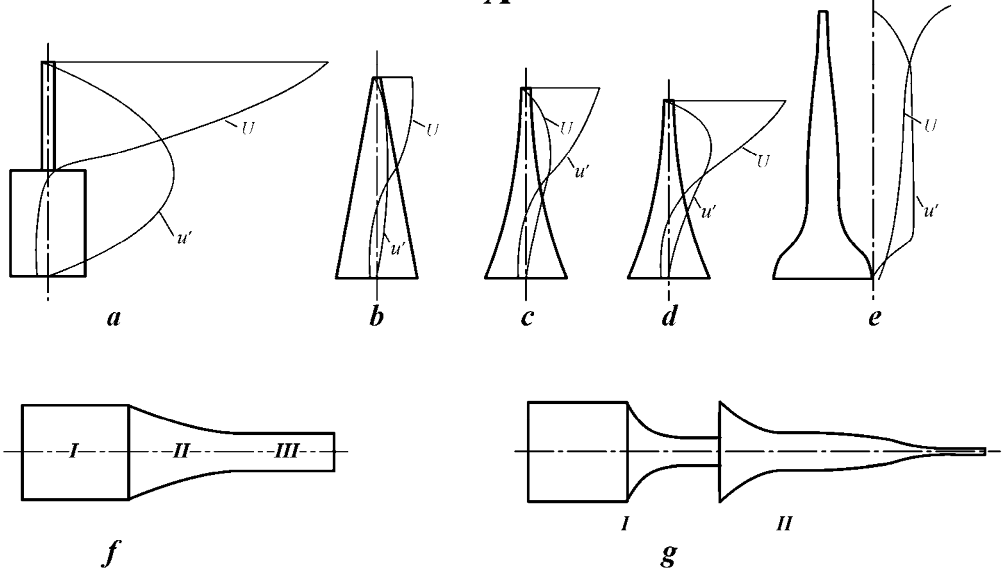
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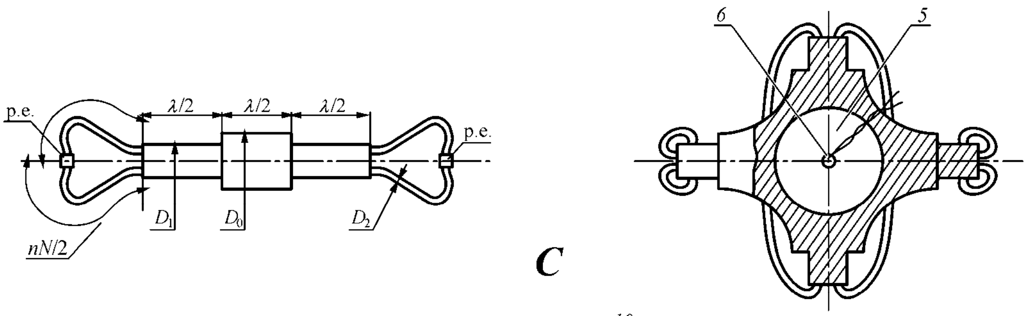
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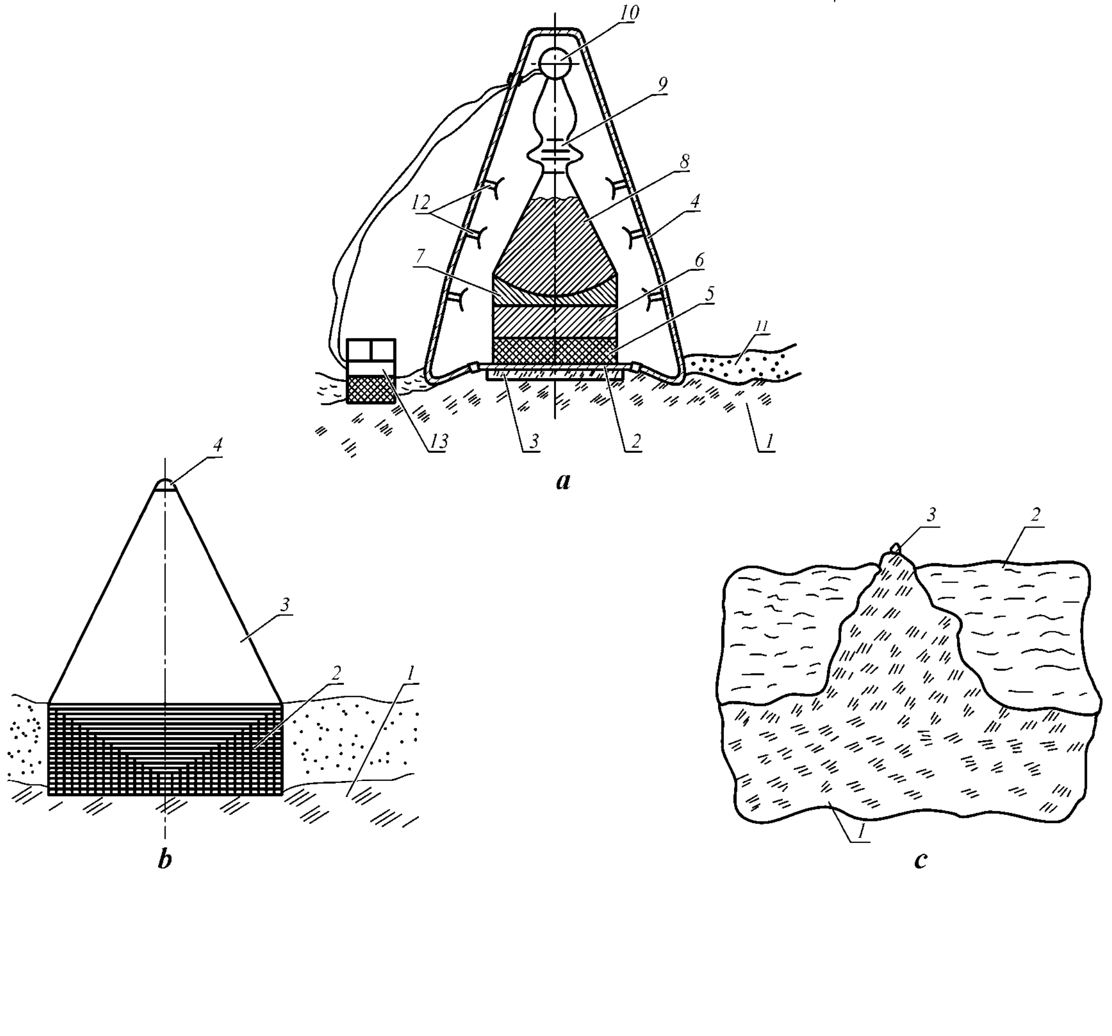
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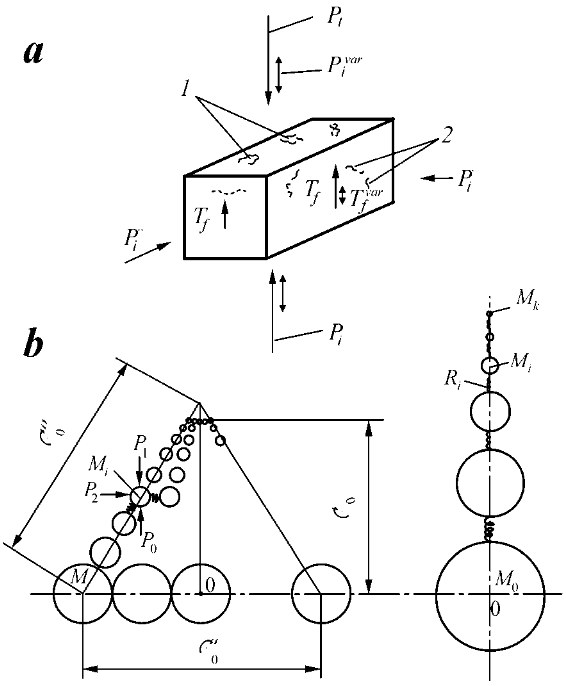


Fig.1 Closest wave analogs of Egyptian pyramids and their discretely periodical structural model.
A – analogs **–** supersonic systems:
1 **–** Layouts of circular simple one-step concentrators of longitudinal oscillations *a* – stepwise; *b* – cone; *c* – exponential; *d* – catenoidal; *e* – Haussian (ampoule). Curves show the distribution of amplitude of oscillation velocity *v* and strain *u'* along the concentrator length; 2 **–** Composite concentrator: *I* – cylinder of large diameter; *II* – segment of bar of a cone or exponential form; *III* – cylinder of small diameter; 3 **–** Two-step concentrator *I* – step concentrator; *II* – ampoule concentrator.
B – analogs **–** gravitational antennas of laboratory scale:
1 **–** Layout of gravitational antenna with two-cascade amplification of signal; the last cascade is the resonance waveguides of the length $n \times \lambda/2$; 2 **–** Spherical gravitational antenna with oscillation converters and complicated beam pattern; 1 **–** piezoceramic receiver; 2 **–** cavity with liquid
C – analogs – gravitational antennas of geophysical (seismic) type:
1 **–** Geophysical gravitational antenna-converter of multi-cascade type:
1. Bedrocks; 2. Plate **–** basement; 3. The bottom part of shell for noise and heat protecting 4; 5. Active piezo-seismic protection; 6 **–** Heat insulator; 7 **–** Acoustic (seismic) lens; 8. Waveguide-converter; 9. Complicated cascade of the converter; 10. Receiving block; 11. Ground; 12. Thermostatic elements; 13. Block of managing and preliminary processing;
2 **–** The simplest geophysical antenna-converter based on the block layout: 1 **–** rock basement; 2 **–** seismic lens; 3 **–** Block waveguide-concentrator; 4 **–** receiving system; 5 **–** ground.
3 **–** Island-antenna: 1 **–** island and adjacent structures; 2 **–** ocean; 3 **–** receiving system.
D – Discretely periodical structural model of the Egyptian pyramid:
a – schematic primary element-block of the pyramid structure: *1* – spots of contact with blocks, *2* – microfissures. P_i – forces from vertical load (weight) of the pyramid; P_i', P_i'' – lateral forces of different sides; $P_i' << P_i$; T_f – lateral forces of friction; P_i^{var} – variable component of vertical force; T_f^{var} – variable component of friction force

b – multi-element idealized linear model of the pyramid: M_i – mass of a separate element; r_3^i – elastic connection in the i-th chain (line) of the whole massive of the pyramid; λ_0', λ_0'', λ_0''' – height, basement (diameter) and generatrix of the model; P_1, P_2, P_3 – external forces acting upon the pyramid;
c – one-dimensional model-chain of the pyramid: M_0, M_1, M_i, M_k – effective masses of the basement, first rows, intermediate level, and top, respectively; R_1, R_i – elastic forces between masses M.

Consider the focusing of seismic energy that was detected and significantly increased the calculated values. According to Fig.1, we have two types of analogs, gravitational antennas of laboratory and geophysical scales (Fig.1 B, C) [23-24] and their origins, concentrators of supersonic oscillations (Fig. 1A) [9-11]. Depending on characteristics and forms of gravitational antennas and supersonic concentrators, we can distinguish groups or systems closest to the pyramids studied. We transfer two important but different characteristics of concentrators upon pyramids and estimate the validity of this procedure. The first characteristic is technological and is related to the tuning in maximum amplitude increase by the composite concentrator or step pyramid; the second characteristic is theoretical constraints on the amplification factor. Amplification factor is $K=\xi_l/\xi_0$, where ξ_0 is the amplitude of displacement on the input element (wide end of the concentrator, the foot of the pyramid); ξ_l is the amplitude on the narrow end, or the top of the pyramid. In the case of the step concentrator $K=N^2$, where $N=R_0/R_l$, R_0, R_l are radii of input and output elements of the length l, respectively, and in the case of the step pyramid, $K=N^2$; $N=a_0/a_l$, a_0, a_l are, respectively the sides of the square foot and top of the pyramid. In the case of exponential concentrator, $K=N$, of catenoidal concentrator, $K = N \Big/ \left|\cos\frac{2\pi l}{\lambda}\right|$; of the cone one, $K < N$ and always $K < 4.6$, moreover, in the case of cone gravitational antennas, $K \sim 1.8$ [23]. Besides, there exist corrections to the material properties and the concentrator form (Two-step concentrator is the most effective (Fig. 1) [11]). Obviously, the pyramid does not satisfy the first criterion, and exceeds the theoretical K, as investigations showed.

We also note the third criterion applicable only for pyramids: the necessity to explain the permanent high internal level of seismic acoustic emission and electromagnetic emission accompanying it. The geometry of the pyramid is so that together with the increase in weight, the square, at which the pressure is distributed, also increases. Hence, in terms of the continuous medium, electromagnetic radiation may be unobservable, contrary to experimental data. Therefore in general case, emission processes contradict the model of the continuous medium.

Thus, the application of the theory of focusing and acoustic waveguide in a continuous medium does not provide the adequate physical model for the description of wave processes in pyramids. Hence we should choose the principally other model.

3. Seismic-physical model of the pyramid

In accordance with experimental data and the block structure of pyramids, we accept the system with periodic structure as a seismic-physical model of pyramid. The methods applicable to analysis of oscillation processes and propagation of waves of various physical origin are well developed and can be also applied in our case [25]. The models were developed from simple ones to more complicated models. At first, we consider the propagation of particles in a one-dimensional grid, consisting of point particles with mass m and equal distances d between them, equal elastic connection and located along a line. The velocity of wave propagation V and wavelength λ are connected as

$$V = V_\infty \frac{|\sin(\pi d/\lambda)|}{\pi d/\lambda},$$

where V_∞ is the velocity at infinite wavelength.

The wave number $a = \frac{1}{\lambda}$ should lie within the limits ($2d$ is minimum wavelength)

$$-\frac{1}{2d} \le a \le \frac{1}{2d},$$

i.e. we consider only waves at $\infty \ge |\lambda| \ge 2d$, and waves at $0 \le \lambda \le 2d$ are excluded.

These regularities are also valid in the case of one-dimensional Born lattice from particles of two types with masses *M* and *m*. In this case, the second branch (degree of freedom) appears in the dependence of frequency ν on *a* due to particles of mass *m*.

Longitudinal oscillations of the chain of connected oscillators at equal distances display additional properties. If coefficients of elasticity are different along directions 0*X*, 0*Y*, 0*Z*, then the oscillator is anisotropic and has 3- eigen-frequencies at corresponding directions. In the case o longitudinal oscillations of a system with interaction only between adjacent oscillators, at large wavelengths, frequency ν is determined by

$$\nu = \nu_0 + ba^2,$$

where the sign of *b*, depending on elastic coefficients of the system, takes into account the change of ν, if $|a|$ increases. In our case (Fig.1D), three coefficients of elasticity P_i, P_i', P_i'' of a pyramid block (mass *M*) are different; moreover, these coefficients vary not only in their values but also in signs depending on the phase of oscillations, because the number of contact spots changes. This means (according to the theory of nonlinear systems) that during a cycle of oscillations, the restoring force of the system may be rigid or soft [26]. The other property is that, there exist two limit values of ν, equal to ν_0 and $\nu_{\max}$. Only waves with frequency ν, $\nu_0 \le \nu \le \nu_{\max}$, may propagate in the system, and waves beyond an interval (ν_0, $\nu_{\max}$) are rapidly damped (band filtration).

Therefore, in the case of pyramids, limit frequencies f_{min}, f_{max} slightly differ for each pyramid, because f_{min} depends on the pyramid geometry, firstly, on its height, and f_{max} depends on sizes and mechanical characteristics of the block material. The most precise approximation in the analytical description of wave processes in the pyramid should be searched in the synthesis of formal methods of quantum acoustics, nonlinear seismology, and regular and stochastic dynamics [14–17; 25–32]. The seismic noise of Egyptian pyramids should be analyzed in terms of nonlinear seismology and other (physically close) wave processes [27-39]. All these models should be incorporated into the formalism of the pyramid wave process, including the most difficult part, the results of the gravitational experiment [40-44]. The new methods relating to Finsler geometry [46-48] may possibly be exhibited in this case. On the other hand, we can employ the verified formalism and representations of description of waves in periodic structures [37].

The structure of the pyramid cannot be actually regarded as a medium with small heterogeneities, because roughly treated blocks contact each other at points rather than the whole surface. Hence we deal with the clearly expressed periodic structure. In its frames, we should create the model for analysis of the anomalously high effect of focusing and propagation of elastic impulse (Fig. 1D). The model with clearly periodic heterogeneities allows us to describe the wave field with the use of the Matje-Hill equations. If the pyramid structure is regarded as a discrete chain, the dispersion law (upon several simplifications) is

$$f(k) = \pm 2\sqrt{\frac{\alpha}{M}}\sin\frac{k\alpha}{2}$$

and the maximum frequency is

$$f_{\max} = 2\sqrt{\frac{\alpha}{M}},$$

where $a = d$, α is the rigidity coefficient of contact spots (α=R in Fig.1d), M is the mass of a block; k is wave number; λ~d .The wave with the positive direction of x axis is described by the linearized equation of Corteveg– de -Vrize using the method of slowly changing profile [37]:

$$\frac{\partial U}{\partial x} = \beta \frac{\partial^3 u}{\partial \tau}, \ \beta = \frac{a^2}{24c_0^3},$$

where $c_0 = a\sqrt{\frac{\alpha}{M}}$ is nondispersional sound velocity at extremely low frequencies.

The pyramid as a geophysical system is actually under the influence of several disturbances, including random (microseismic noise). The behavior of this system can be analyzed using the method of Fokker-Planck-Kolmogorov .Seismic emission processes in pyramid blocks and Coulomb dry friction mutually admit the existence of the regime of seismic auto-generation that can be described using the Van-der-Pole equation. Taking into account the external noise influence, we finally regard the Fokker-Planck-Kolmogorov equation for the disturbed auto-generator as the most valid. Thus, properties of wave processes of Egyptian pyramids are partly similar to that of quantum and nonlinear oscillators. However, besides the effect of focusing, this approach should also fit other data of experiments on impulse impact on pyramids.

4. Discretely periodical structures of Egyptian pyramids: first experiments

Besides the effect of anomalously high focusing, this approach should also explain other experiments with active impulsive impact (stroke) upon the pyramid or directly near its basement[1]. Usually a stone of weight of 15-20 kg was thrown from a height of 1-2 m, or knocks with a porous limestone with a weight of 1-1.5 kg were applied to a block of a pyramid.

Experiment on focusing of seismic waves in the zone of pyramids of the Giza plateau near the pyramid of Menkaur (Mykerinos) showed that the model of the pyramid of a continuous medium is clearly insufficient. This experiment was of applied character; its aim was to determine the distance to fundament (consolidated rocks). The focusing of seismic energy exceeding its theoretical value by 1-2 orders of magnitude and the experience of description of wave processes in periodic and discrete structures lead to a new model (Fig. 1D) [25, 26, 29, 37]. The increase in displacement amplitude Δn and/or transformation coefficient K in a plane seismic wave propagating in vertical direction from bottom to the top (Fig. 1D) depending on the height of the receiver h_i are described by the well-known example from the classical mechanics and are determined by

$$\Delta h_i \sim \frac{\Delta h_0 \cdot k_g}{k_p \sqrt{\frac{\sum\limits_{=0} M}{M_i}}}$$

or

$$\frac{\Delta h_i}{\Delta h_0} \sim K \sim \frac{k_g}{k_p \sqrt{\frac{\sum\limits_{M=M_0}^{M_{i-1}} M}{M_i}}},$$

where $\Delta h_0, \Delta h_i$ are displacements in seismic wave near the foot and at a height h_i;

[1] We should note that all impulsive impacts were of the strength of one “manpower” and were absolutely harmless for monuments.

$k_g;k_p$ are coefficients regarding dissipation and scattering of seismic energy; M_0, M_{i-1}, M_i are masses of the foot, (*i*–1), and *i* layers of pyramid blocks (level of signal recording)

We should also note the other fact. Focusing effect is displayed not only in impulsive regime, impact near the small pyramid in Giza, but in the stationary regime, as well, e.g. during recording of high-frequency seismic noise near the basement of the South side of the Snowfru pyramid and at the top of the small pyramid near it. On the average, the signal on the top exceeded the noise level at the foot by an order of magnitude. On the other hand, the estimate of amplification coefficient K in quasi-static regime revealed its essentially less value (~ 4), that nevertheless exceeded the theoretical value for the simplest concentrator of the cone form (measurements of seismic noise near the foot and at the top of the Menkaur pyramid). Estimate of K depending on the noise level requires the consideration of spectral peaks of pyramid resonances and averaged spectra. The relations between spectral peak amplitudes near the foot and at the top at the resonance range do not coincide with the smoothed spectra. In the latter case, K does not increase several units; in all cases, we noted the suppression of noise beyond the pyramid resonance (K < 1,0). Generally, determination of K is rather difficult problem; because, we should take into account, e.g. the influence of free oscillations of the massive of the whole pyramid on adjacent structures.

5. Response of the Snowfru pyramid on impulsive sounding

The other active seismic experiment was carried out at the Snowfru pyramid (layout of impacts (strokes), Fig. 1D; impact records and comments see in [ ]). It was simple and should display impulse records of simple form in the case of the pyramid regarded as a continuous medium, i.e. all impacts should insignificantly differ independently on their direction (P_1, P_2 , P_3). As seen from [45], impacts on block along directions P_1-P (Fig. 1D), significantly differ in the form of the record. This contradicts to the model of a continuous medium and, at first glance, to the discretely periodical model, but spectra of these impacts explain many facts (Fig. 2a, b). Spectrum of vertical impact along the direction P_1 (Fig.2a) contains a group of three peaks with a frequency of ~127 Hz and small amplitude, main peak at 175 Hz with an amplitude exceeding the amplitude of the group by an order of magnitude, and hardly noticeable peak at 270 Hz. Spectrum of the horizontal impact (P_2) is enriched by peaks in a wide range of frequencies: 65, 78, 89, 97, 103, 110, 116, 137, 270 Hz (Fig.2b). The spectrum of vertical impact (direction P_3) insignificantly exceeds the spectrum of direction P_1 impact with respect to number of peaks: 123, 127, 130, 175, 184, 228, 270 Hz, but their amplitudes and qualities significantly differ (Fig. 2b). It is obviously, that all spectra mainly depend on geometrical parameters of blocks, the degree of their connection, and load of these blocks (Fig.1D). All these facts satisfy the model of the discretely periodic structure of Egyptian pyramids. The geometry of a single block, characteristics of its material, and the form of free oscillations in the first approximation are described with a set of frequencies: three longitudinal (f_1^l, f_2^l, f_3^l), two bending (f_1^b, f_2^b) and one torsion (f_1^t) (Fig. 1d,a). In general case, we define them as the block frequencies f^B that simultaneously are boundary at upper frequency of filtration of elastic signal [25, 37]. Note that the form and the load level of block and its location in the pyramid massive (near the side surface or in the interior) also influence the spectrum. We also should mention the existence of several types of sizes of blocks depended on their location (blocks inside the massive of the Snowfru pyramid are twice shorter).

In terms of the notes above, we consider all spectral peaks obtained from processing of impact records along directions P_1, P_2 , P_3 (Fig.1D). If the longitudinal wave velocity is 1200 m/s, the frequency of 270 Hz, common for all impacts and frequencies of 127 and 175 Hz observed at vertical impacts most probably determine the set of f^l and block sizes of 2.2 and 3.5 m, respectively. Isolated peak at 228 Hz with small amplitude but high quality can be governed by the third characteristic block size (Fig. 2B). Groups of peaks near 127 Hz, weak at impact P_1 and powerful at impact P_3, are possibly of the same origin and are connected (as well as those surrounding the quality peak at 175 Hz)with oscillations of the neighboring blocks, as well as peaks at 123 and 130 Hz close to peak at 127 Hz (Fig.2a,b). Horizontal impact directed inside the pyramid massive excited oscillations of the largest number of blocks (frequencies); part of them can be related to bending oscillations in a horizontal plane (Fig. 2b). In this case, the absent peak at 175 Hz is also related to the bending mode but in vertical plane, and the constant noisy spectral part in the range of 0-65 Hz reflects reverberation processes of the pyramid massive adjacent to the impact zone. On the other hand, peaks in the range of 65–137 Hz roughly correspond to 2-nd, 3-d subharmonics from peaks recorded earlier. At the same time, they correspond to sizes of large blocks and cavities inside the pyramid massive (Fig. 2c). Quality and amplitude of spectral peaks strongly vary depended on the impact direction $P_{1,2,3}$ which firstly reflect the characteristics of block connection with the rest massive, its load and mechanical characteristics.

6. Dakhshur. Red pyramid; vertical impact

Spectral analysis of vertical impact at the center of eastern side at a height of ~5 m revealed the reliable peaks at 8.86, 80.0, 95.0, 127.0, 248.0 Hz (Fig.2d). Assuming the same velocities of longitudinal waves and according to the series of frequencies obtained, we have linear sizes of ~102.0, 7.0, 6.0, 5.0, 2.5 m. Hence, the massive of this pyramid is constructed from the larger blocks, as compared with the Snowfru pyramid and is more homogeneous in sizes. The latter decreases scattering and damping of seismic waves and the upper filtration frequency and allows (accounting the absence of breaks at sides) to observe peak at 5.86 Hz corresponding to the pyramid height (102 m).

7. Medume. «Incorrect» pyramid; internal and external impacts

Three impacts (strokes) were carried out inside the pyramid, in the lower chamber. The first impact was at the chamber floor with the direction P_1 with the use of the "soft" shocker with the power of ~7.5 kgm/s; the second and third impacts of the power of 1.0 kgm/s were oriented at sides along directions P_1 and P_2 (horizontal).

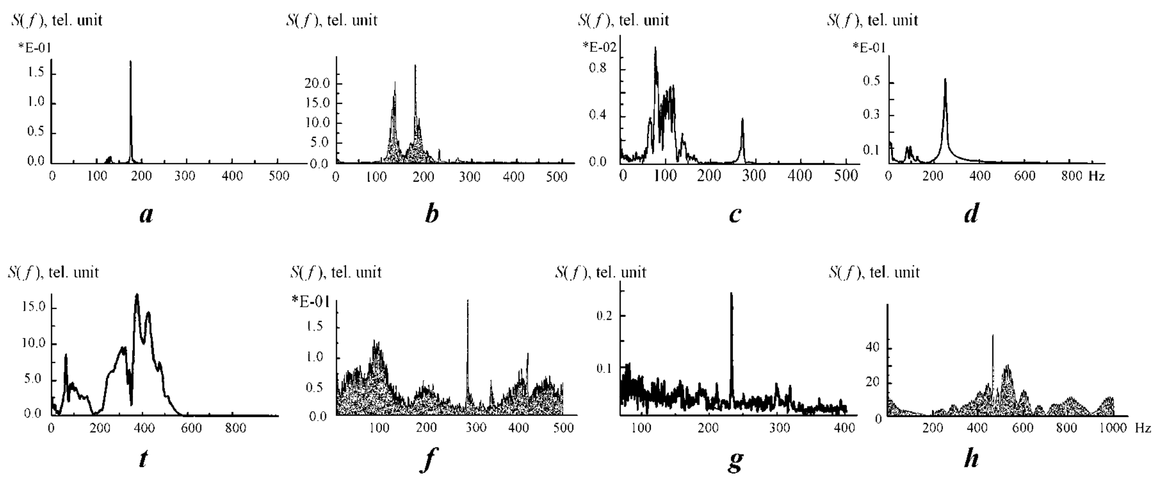


Fig.2 The spectrum images for pulse actions on pyramids.
a. Energy spectrum of the vertical impact from above; south side of the Snowfru pyramid, Dakhshur; direction P_1 (Fig. 1D).
b. Spectrum of vertical impact from below; the same block; direction P_3.
c. Energy spectrum of the horizontal impact at the side surface of the same block; direction P_2.

d. Spectrum of the impact; Red pyramid.
e. Spectrum of impact inside the pyramid in Medume.
f. Spectrum of the vertical impact (Medume).
g. Spectrum of the horizontal impact (Medume).
h. Spectrum of vertical impact on the northeastern corner; Medume.

Spectra of all impacts in the chamber significantly differ from the previous results (Snowfru, Red), which is partly expected. Seismic waves from impulse excited in the pyramid interior are similar to that of the point source and propagate in a volume, in three-dimensional discretely periodic medium, whereas impact (impulse) at the external surface (side) excites seismic energy in a half-space. Therefore, spectra of chamber impacts are characterized with the constant component with definite peculiarities for each type of impulse (Fig. 2e-g). The constant component of the spectrum of vertical impact at the chamber floor determines the spreading of powerful peaks –increases in level, vanishing at ~600 Hz, upper filtration frequency. The chamber is close to near-surface structures loaded by the weight of the whole pyramid, therefore, the contribution of seismic emission processes leads to the increase in the level of constant component of the noise spectra and to the absence of fine structure of peaks (Fig. 2e). Against the background of spread peaks at frequencies of 90.0, 305.0, 374.0, 412.0 Hz, we see the narrow peak at 61.5 Hz resulting from the first reflection from the near-surface structure at a depth of ~10 m and more. Part of spread peaks is possibly related to the structural properties of the pyramid foot and/or cavities beneath it at depths of 1-7 m. Hence, this impact was of the sounding character.

Constant components of spectra of vertical (P_1) and horizontal (P_2) impacts upon the vertical wall of the chamber inside the pyramid are different (Fig.2f,g): P_2 impact is characterized by the trend of this component to high frequencies; the component of vertical P_1 impact (as well as in the case of the sounding impact (Fig. 2e) is disturbed and quasiperiodical. However, if the form of constant component of the sounding impact depends first of all on reflections from the near-surface structures and seismic emission processes in them, the disturbances of the constant component of the vertical impact on the chamber wall, i.e. the pyramid massive, reflect seismic oscillations of this massive, as a whole. With the exception of the increase in the region of 200 Hz (Fig. 2, f), the both vertical impacts display consistent behavior: increase in constant component and/or existence of common peaks. These peaks are spread in the case of sounding impact and qualitative in the case of the impact on the chamber wall (pyramid massive) (Fig. 2f, g). In the spectrum of horizontal impact, a set of expressed peaks is of small amplitude decreasing with the frequency, and only two low-frequency peaks at ~308 and 320 Hz are displayed from vertical impacts. The exception is the high-quality peak of considerable amplitude at 232 Hz (Fig.2, g). The dominant role of this peak with respect to the whole spectrum is probably explained by oscillations of block closest to the impact location. The spectrum as a whole is consistent with the model with discretely periodic structure.

Experiments on the choice of the wave model of pyramid are originally connected with indestructible methods of detection of inner seismic heterogeneities in the pyramid massive, chambers, corridors, channels. The history of construction of the Medume pyramid is rather uncertain, and its inner structure is poorly studied, contrary to other pyramids. Therefore, in order to develop the searching seismic method, the trial sounding horizontal impacts were carried out on the massive of northeastern corner of the pyramid. The cases of anomaly reverberation were observed in the form of quasi-harmonic signal at a frequency of 465 Hz. As the impact P_2 was located near the side edge rather than a half-space, its spectrum is partly of generalized character (Fig.2h) and display characteristics obtained earlier in analysis of other spectra (Fig.2e-g). This peak undoubtedly reflects oscillations of a resonance high-quality system, e.g. block. At the same time, this block also oscillates at 232 Hz (Fig. 2g) at the second harmonic from the anomalously high-quality peak. Horizontal impacts display very different spectra (Fig. 2 g, h). Therefore, the detection of two connected high-quality resonances, coinciding up to the third digit of frequency cannot be explained by the existence of the resonance block somewhere inside the pyramid massive. The most real alternative explanation is the existence of inner cavity or channel. Taking into account that P_2 impact locations are significantly distanced along vertical line, we assume the ratio of height-width of the channel is equal to 2.

8. Impulse studies at the plateau of Giza pyramids

During the studies on focusing and sounding of the fundament depth in the region of Giza pyramids, we obtained the spectrum of the record of the sounding signal recorded at the top of the small pyramid situated near the Menkaur pyramid opposite its south side (Fig. 3a) and spectra of strikes on the south side (Fig. 3b,c). Spectrum in Fig. 3a contains the complicated set of quality peaks of two ranges: low-frequency – 1.3, 3.4, 8.3, 11.7, 18.5 Hz and high-frequency – 41.0, 77.0, 111.0, 129.0 Hz. The powerful sounding signal and the field of seismic emission of the Giza pyramid zone allow the transform of oscillations of the Menkaur pyramid to the small pyramid, and their focusing at the top of the small pyramid contributed to their registration.

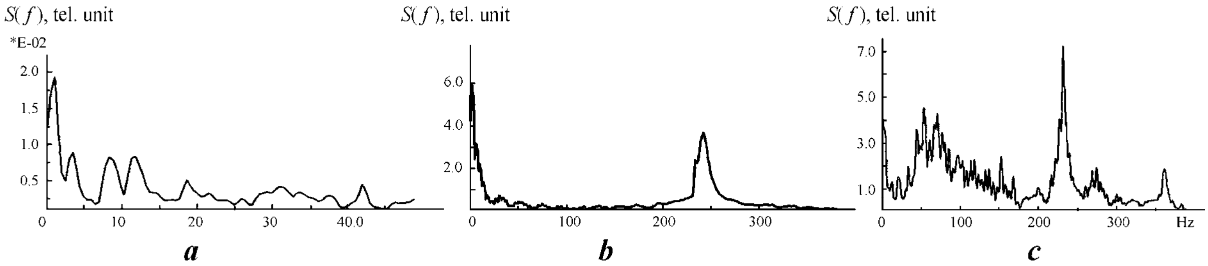


Fig.3. Spectrum images of differed pulses action on plateau Gize pyramids.
a. Spectrum of the sounding signal recorded at the top of the small pyramid near the Menkaur pyramid.
b. Spectrum of the vertical impact (2.0, 241.0 Hz), Menkaur (Mykerinos) pyramid.
c. Spectrum of the horizontal impact, Menkaur pyramid.

Therefore, it is reasonable the combined consideration of the spectrum at small pyramid (Fig. 3a) and spectra of signals recorded near the foot of the south side of the Menkaur pyramid upon the vertical (Fig. 3b) and horizontal (Fig. 3c) impacts on the side block. The spectrum of vertical impact in P_1 direction (Fig. 1D) displays several characteristic peculiarities (Fig. 3b), namely, the significant growth (peak in the range of 230-260 Hz), the smooth weakly disturbed low level without peaks with the powerful low-frequency segment near 2.0 Hz with insignificant peaks and decreasing to 20 Hz.

Some characteristics of the spectrum of the horizontal impact in P_2 direction (Fig. 1D) spectrum are similar to those of other horizontal impacts (Fig. 2c, g), namely, numerous peaks in the range of 300-350 Hz, the increase of constant component with the decrease in frequency, and the predominated peak at 232 Hz. In the whole, the following frequency series can be formed on the basis of this spectrum: 20.5, 33.2, 44.0, 53.7, 70.3, 77.0, 86.0, 96.6, 113.0, 118.0, 132.0, 136.0, 152.0, 168.0, 232.0, 268.5, 274.0, 360.3 Hz.

Comparing the general form of spectra (fig. 3b, c), we note that the spectrum in Fig. 3b is more typical for the continuous medium, whereas the spectrum in Fig. 3c for the discretely-periodical. This difference from the studies in Medume and Dakhshur possibly reflects the new property of the Menkaur pyramid. Several peaks (Fig. 3 a, b) differ in several percents or coincide (77 Hz), which is explainable by similar characteristic sizes of their block structure and/or transmitting-receiving of oscillations from the large pyramid to the small one. All three spectra contain noticeable low-frequency part (Fig.3a-c) that is close to zero frequency with peaks in Hertz range. This contributes to the existence of permanent oscillations of pyramids as connected oscillators, and possibly the system: field of pyramids- near-surface geological structures. For example, upon the falling of a body of ~20 kg from the height of ~3 m, the peak at a frequency of 1.3 Hz was recorded. This peak possibly corresponds to pulsations of this system. If the Giza pyramids are regarded as quarter-wave resonator, then , at the velocity of longitudinal wave in the massive $V_p \leq 2000$ m/s and average height of 110-120 m, we obtain the main frequency of vertical oscillations $f_0 \sim 3.5\text{-}4.0$ Hz, The first subharmonic $f_0/2 \sim 1.7–2$ Hz, and the second harmonic $2 f_0 \sim 7.0\text{-}8.0$ Hz (Fig.3b).

The strongest peak at 232 Hz (Fig.3c) also observed for the Medume pyramid (Fig. 2g) and its second harmonic (Fig. 2h) are more simply explained as a result of impacts on resonance blocks of the sides of Menkaur and Medume pyramids. However, this explanation requires the following conditions: blocks should be taken from the specific zone of the open-cut mine, be in identical load conditions, and their characteristic sizes should coincide with accuracy to several mm. An alternative explanation is, as in the case of the Medume pyramid, the existence of inner cavities or chambers of identical size near the side surface.

In the whole, all characteristics of impulsive seismic study of pyramids given above, are most reasonably interpreted and united in the framework of the discretely-periodic structural model of the pyramid.

9. Conclusions

1. Pyramids, by form and even functionally as giant focusing seismic systems have many close analogs in experimental and technical physics, techniques and nature.

2. Coming from general physical and seismic concepts, we can regard Egyptian pyramids as concentrators and/or systems focusing the seismic wave field, i.e. the unique geophysical instrument.

3. Experiments with impulsive impact on separate pyramid blocks and in their inner chambers revealed radical differences from known analogs (concentrators) almost identical by form and functions.

4. Amplification coefficient of seismic waves of impulsive type reaches a value ≥ 10 in the case of small pyramids, which contradicts the theory of acoustic concentrators.

5. Damping and scattering of seismic impulses in the pyramid massive is inconsistent with properties of continuous or geological medium.

6. According to experiments, the wave model of a pyramid is the discretely periodical focusing structure with band filtration.

7. The formal description of wave processes in the pyramid should be based on equation of Matje, Fokker-Planck, etc. taking into account the seismic acoustic processes in the massive.

8. Response spectra of a pyramid on impulsive impact are of complicated character, display general properties; extremely high-quality lines exist.

9. A possible explanation of quality lines is the existence of unknown inner chambers or channels.

10. The values of quality lines coincide to 0.01 Hz for several pyramids (Medume, Menkaur).

§ 3. SEISMIC NOISE OF SNOWFRU (DAHSHRU) PYRAMID: GAS DUST STREAM ENFLUENCE

1. Preliminary remarks

Seismic noise and signals of the Egyptian pyramids and of adjoining structures served as material for investigations in several directions each being of interest from the point of view of the applied and fundamental sciences. Thus, spectral and spectral-time analyses of the high-frequency noise and of the seismic-acoustic emission and of their envelope have revealed certain periodic behavior (peaks) that correspond to well known geophysical and astrophysical processes and sources. A problem of recording the seismic response of a pyramid to the gas dust stream of pulsar is examined in this part of article.
Simplicity of recording and abundance of information on the seismic noise of the Egyptian pyramids can surprise any geophysicist and seismologist irrespective of the extent of their knowledge of this subject. Since nature and properties of microseisms and of high-frequency noise, seismic-acoustic emission included, are stated adequately in specialized publications (articles, monographs), examination of results will be divided into several parts. Thus, the seismic noise recorded without separation of the envelope, i.e. in a traditional way, is analyzed as two separate blocks. In the spectra; range of 0 to 6 Hz and in the range of 0 to180 Hz (0 Hz should be understood conventionally and characteristics of the geophones used permit efficient recording of noise ranging from 2 Hz and more). All peaks and peculiarities of the geophysical medium in the range of 0 to 6 Hz are analyzed in detail and only several peaks were examined in detailed for the range of 0 to 180 Hz.

Adequate understanding of informative content of the seismic noise is impossible without introduction of a concept of the seismically active medium adapted to conditions of pyramids.

The seismic-acoustic emission and the modulation processes (a new but dynamically developing section of the nonlinear seismology), despite short periods of recording and fragmentary records, have confirmed their status of an efficient instrument of cognition and will be undoubtedly enriched with new.

2. Seismically active (nonlinear) medium and wave processes

The concept of a geological medium as seismically active has appeared and is developing successfully from the moment of formation of the nonlinear seismology as an independent section of physics [1-3]. We know several constructive features of such medium. This is radiation of a portion of accumulated internal potential energy in the form of seismic (acoustic) waves in a wide range of frequencies (seismic-acoustic emission – SAE); parametric amplification of the wave train propagating through a geological medium, which is in a trancritical, close to destruction state; self-synchronization and self-generation of waves in a volume of the medium with defects, forming, for example, an ensemble of renewable bistable elements (cracks) [4]. In accordance with these features level of activity of the medium near the Egyptian pyramids is determined by globally scale factors such as active tectonics of the region (growth of seismicity is observed) and location of pyramids along the edge of the East African fracture and local factors such as load on the medium from the pyramid overweight and from stress fields inside pyramids; regional features of the medium and of the wave fields. The experimental proof of existence of the SAE, or rather, efficiency of the modulation method and features of the revealed periodicity of high-frequency seismic noise proved power of this component in the seismic noise. The proof of existence and estimation of the SAE level of the whole body of the pyramid blocks have become clear immediately from the experimental results: seismic noise inside the body was higher than on the external surface of faces.

In real terms, i.e. for a medium, which is dozens and hundreds kilometers away from pyramids there are two more nonlinear mechanisms in the medium and in the wave field, which were known earlier and which are capable of playing a certain role in this particular case. These are evolution of the seismic spectrum or a nonlinear transformation of waves connected with a viscoelastic rheology of geomaterials, i.e. sand of the desert [3], and a man-caused multifrequency chaotized wave field (operation of the Aswan hydroelectric power plant) [5, 6].

Chaotization of the seismic signal is studied as regards regularities of formation of the active medium and frequency ranges of a possible amplification of weak signals and the mechanism itself has an excellent theoretical and physical basis being a seismic illustration of a regular and stochastic dynamics [7, 8]. In other words, seismic fields of stochastic type man-caused noise formed as follows cover many regions of the planet having local zones of the transport noise. Most powerful sources of vibration either directly [hydroelectric power plants (HEPP), nuclear power plants (NPP), combined heat and power plants (CHPP)] or through power installations and electric energy converters (industrial complexes, industrial zones etc.) generate, as a rule, primary seismic waves at a frequency of 50, 100, 25 Hz (f_0). However, powerful lines in the noise spectrum at the above frequencies (f_0^i) are observed at an insignificant distance from the source (first dozens of kilometers and less). Harmonics and subharmonics begin to appear from the first kilometers of the propagation route from the main frequencies (f_0^i) because of a strong non-linearity of the geological medium and only subharmonics appear with the increase of the distance. Further the spectrum becomes still more complicated. Waves are generated at the sum-difference frequencies with participation of newly formed subharmonics. Experimental investigations of chaotization of seismic vibration signals, which have been conducted since 1987, have revealed difference as compared with other physical systems, for example, a simultaneous doubling and trebling of the period $f_0/6$, that was predicted theoretically earlier [6, 9]. Instability of the amplitude and frequency chaotization peaks in the low-frequency zone of the spectrum (Hertzian range) should be assigned to a more general features of the spectrum of the chaotized seismic wave field. A great number of unstable and poor quality peaks lead at the same time to appearance of a considerable constant component [1–3, 5, 6, 9]. Some of these regularities are observed also in other works on noise with other research tasks, fig. 1a, b [10–12]. A 17 Hz peak, marked by the authors as the resonance peak, is determined by chaotization as $f_0/3$ can be seen in Fig. 1a; and the constant component of the Hertzian range is well presented in fig. 1b.

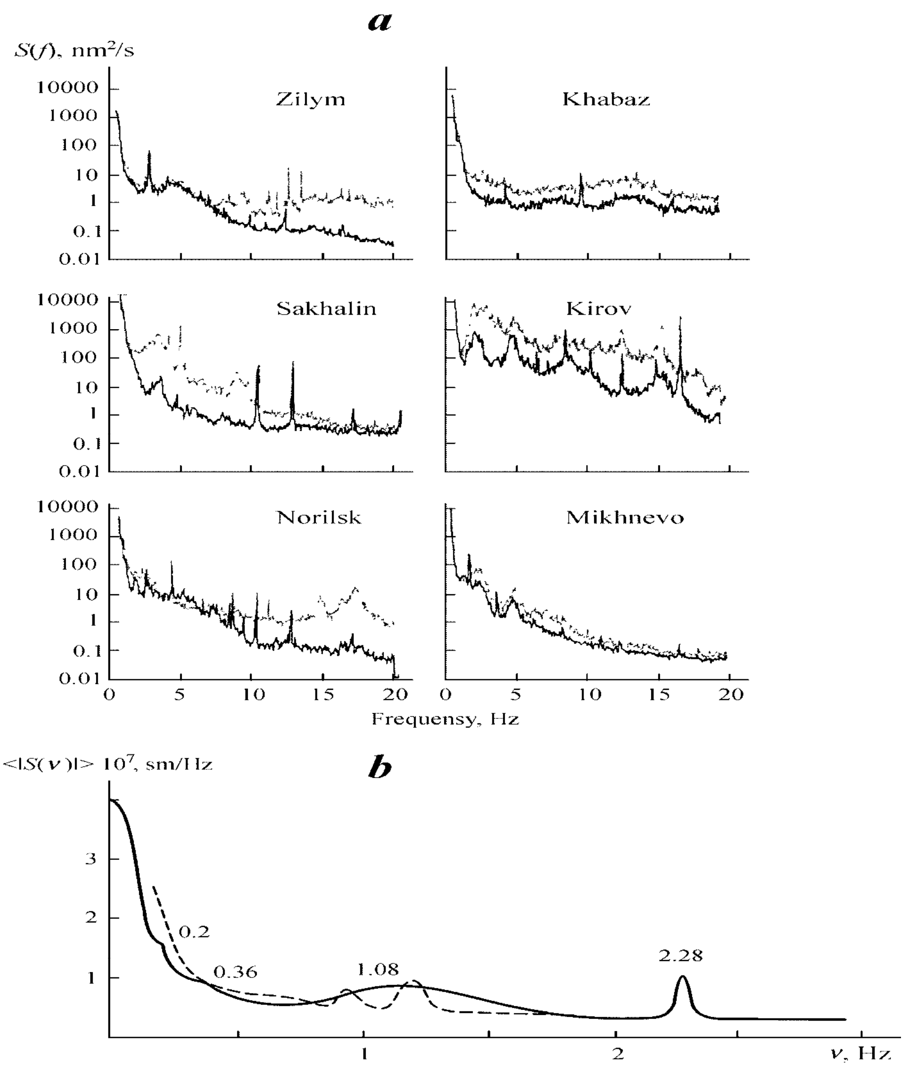


Fig. 1 a, b. Examples of spectral presentation for seismic noises.
a. Examples of spectral density of vertical components of micro seismic oscillations recorded in daytime (light graph) and at night (dark graph): a – Zilim, b – Khabaz, c – Sakhalin, d – Kirov, e – Norilsk, f – Mikhnevo. Attention is drawn not only to variation of amplitude of the 17 Hz peak, but also its shape (nonlinear effect).
b. Observable micro seismic background (solid curve) after accumulation of the background signal at the interferometer outlet
a –0.1–5 Hz range; *b* –0.1–2 Hz range

As may be seen from the above, the chaotized wave field of the geophysical medium can be represented, in a general case, by two sections of the spectrum: low-frequency section with a considerable constant components and poor quality weak peaks of the chaotic frequencies and a high-frequency section with powerful isolated peaks of the initial stage of the seismic chaotization. A weak but a high-quality signal, which occurs in such a medium due to action of an external source (electromagnetic, gravity) will interact with the chaotized wave field. In the low-frequency section this interaction depend weakly on frequency of the signal and the latter will be amplified due to synchronization and pulling of the wave energy of the chaotized component uniformly distributed over this section of the spectrum. Amplification of the signal in the high-frequency section of the spectrum will be determined by the signal frequency mismatch with powerful peaks of initial stage of chaotization. In both cases, however, the chaotized seismic field and non-linear geological structures play the role of the seismic active medium. Efficiency of this medium is determined in many respects by non-linearity parameters, microstructure, emission activity, tectonic processes [1–3, 6, 5]; theoretical treatment of the matter is the subject of many investigations [4, 7, 8, 13–15]; problems of chaos and of self-organization (soliton`s properties) are included in the experimental structure of the nonlinear seismology [16].

Thus, in the analysis of records of the seismic noise of pyramids, one has to have in mind existence of several types of the seismically active medium comprising:

1. Seismic-acoustic emission field of the pyramid body.
2. Seismic-acoustic emission field of the medium near to the pyramid and, first of all, under the pyramid.
3. Seismic emission processes against action of the active tectonic movement of the region, lunar solar tides etc.
4. Chaotized seismic wave field of the region.

3. Analysis of seismic noise of the Broken-line Snowfru pyramid. Dahshru.

Low-frequency part of seismic noise

Let us examine a low-frequency part of the seismic noise spectrum (0–6.5 Hz) recorded on the south face of the broken-line Snowfru pyramid in accordance with a conceptual view of the seismic active medium (Fig. 2). A part of the spectrum that adjoins zero (0-1 Hz) has low amplitude due to characteristics of the geophone leading to suppression of the signal within this range. Data about actually all peaks of the spectrum in Fig. 2 as the major feature are shown in table 1, where f – frequency, T – period, A or ($S(f)$) – amplitude of the peak.

Table 1. Peaks of low-frequency part of the spectrum

N	1	2	3	4	5	6	7	8	9
f, Hz	1.1716	1.6602	2.1484	2.5391	3.0273	3.7109	4.6875	5.1758	6.1523
T, s	0.8533	0.6024	0.4655	0.3938	0.3303	0.2695	0.2133	0.1932	0.1625
A, rel.units	0.55	1.025	1.30	1.68	0.85	1.20	0.41	0.45	0.39

About 25 years ago the noise range in question was paid much attention in connection with theoretical and experimental works on the search of a seismic response of the Earth to a gravitation-wave radiation of pulsars, which is concentrated mainly in this zone [17–19]. Unfortunately, these investigations were based on the Hooke’s conception about the ideal medium, there were no concepts of a regular and stochastic dynamics and the nonlinear seismology and, therefore, by this time these works are purely of a historic interest. However, after a flash of interest towards investigations of seismic noise this direction was recognized as unpromising and further observations of the spectral peaks from pulsars of a higher frequency did not save the situation [20–22]; an implicit taboo for the seismic methods appeared. This partially played a positive role as investigations of the nonlinear seismology began.

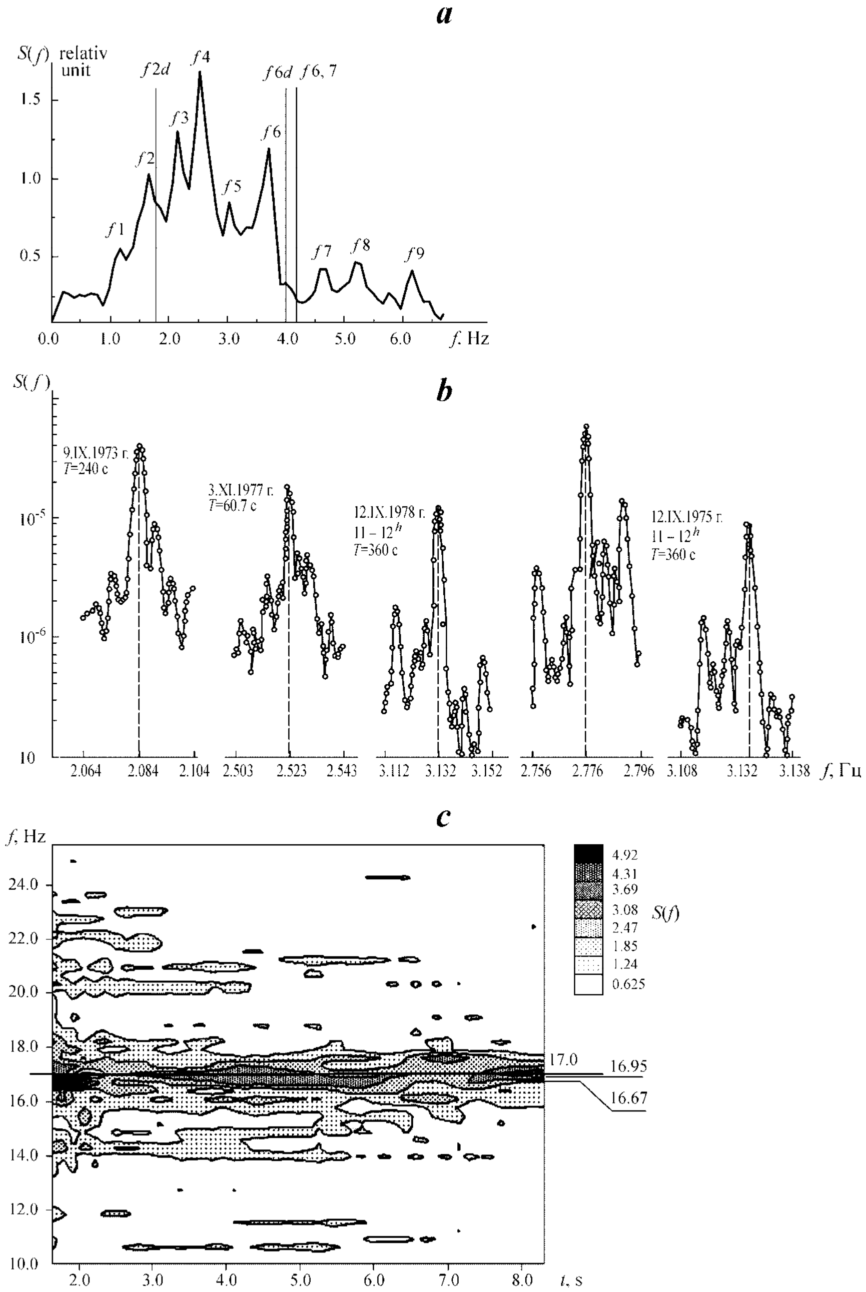


Fig. 2. a, b, c. Comparative analysis for low – frequency seismic noises.

a. Low -frequency section of the Snowfru pyramid seismic noise spectrum. *S*(*f*) – spectral density, *f* – frequency

b. Spectral presentation of microseismic background (noise) in 1-3 Hz range. Quasiharmonic components (N. Pleskach)

c. Spectral-time presentation of variation of seismic noise power on the southern face of the broken-line pyramid in the range of 10-25 Hz. Lines at 16.95 and 16.67 Hz frequency for sending radio-frequency pulses from the pulsar PSR 1913+16 and subharmonic (f_0/3) of seismic signal from the Aswan HEPP respectively.

t – current time in s; *f* – frequency, Hz; analysis with the use of a spectral window 33 %

Starting the work on analysis of the spectrum (Fig. 2) one has to bear in mind the following.

1. The electromagnetic radiation of pulsars, interacting with a complicated structure of upper layers of atmosphere and with magnetic fields, conducting sections in the earth's crust and seismic-acoustic emission and electromagnetic sources of the geological structures and the pyramid body, is able to initiate seismic waves at the pulsar main frequency with the P_0 (s) period through ponderomotive effects.

2. Since the electromagnetic radiation capture cross-section in this case is several orders (~40) greater than the cross-section of gravitational waves from $P_0/2$ period, at the initial stage the growth and formation of the seismic noise spectrum in the nonlinear seismic active medium becomes apparent in appearance and growth of spectral peaks in periods P_{01}, P_{02}, ..., P_{0i}, ..., P_{0n}.

3. There is a strong interrelation between the main tone and the first harmonic at the first undertone (doubling of $P_0/2$ period) in the linear, and more over, in the seismic active medium. In other words, due to such interaction the energy contribution into spectral peaks in P_0 and $P_0/2$ periods is determined by the electromagnetic and gravitational radiation simultaneously.

4. In sections of the spectrum, where difference in periods P_{0i}; $P_{0i\pm1}$ corresponds to the 2-3 place (Fig. 2), synchronization occurs and peaks appear at the new displaced frequencies [5, 15], due to the above mentioned properties of the medium and shape of these peaks does not correspond generally to the resonance shape; it is asymmetric, it has a powerful base and a chopped top; a more long record may reveal structure of such top as a set of partial peaks with time fluctuating amplitudes [23] (Fig.2b).

5. Sections of the spectrum which appeared in a similar way are quasistable and they rearrange under a minor external action of a regional type, for example, the wave field affected by a local earthquake destroyed completely even a classic pattern of chaotization of signal of the hydroelectric power [1], and the tidal deformations may cause rearrangement of the chaotization peak structure.

6. Appearance and a further amplitude predominant peak with synchronization period $T^s_{i_C}$, which is pulling in several waves with $P^s_{0i\pm1,2}$, is determined by some factors: difference in synchronizing partial frequencies (P_{0i}) of a group of the synchronization pulsars, their number n and coherence level; electromagnetic radiation power $W_{\text{e.m.}}$ (for example, flux density at 400 MHz) and a gravitational radiation $W_{\text{G.R.}}$ (period derivative $\dot{P}_0$) of each pulsar [24].

7. Electromagnetic and gravitational effect on the section of the seismic noise spectrum should be estimated not only by coincidence of the seismic peak values with a set of P_0 and $P_0/2$*, but also by the correlation coefficients between smoothed sections of the spectrum and functions $n = n(T_i)$;

$$W_{\text{e.m.}} = W_{\text{e.m.}}(T_i);\ W_{\text{G.R.}} = W_{\text{G.R.}}(T_i),\quad T_i = P_{0i}.$$

As a preliminary, table 2 of pulsars meeting requirements of synchronization of periods P_{0i} and some of their parameters was compiled from data [24], in accordance with everything stated above to analyze peaks of the low-frequency section of the spectrum (Fig. 1). According to experience available on synchronization of seismic vibration signals [5, 16] pulsars whose P_0 periods differ from values of peaks in table 1 by $\Delta t \approx \pm 0.01$ c are introduced into table 2. Thus,

* *It should be noted that the search for peaks* $P_0/2$ in all known experiments is the consequence of the pulsar model with one hot spot, but introduction of a model with two symmetrically located hot spots (there is no prohibition for such a model) maps out to a first approximation the signals with $P_0/2$.

a group of pulsars (number of pulsars n) determined by Δt has been found for every spectral peak (Fig. 1). According to data of tables 1,2 mean values of periods $\overline{P}_0$, difference $\Delta\tau$ between $\overline{P}_0$ and the spectral peak period, integrated density $\Sigma\, W_{e.m.}$ of the electromagnetic radiation flux were determined for each group of pulsars and for some derivatives $\Sigma \dot{P}_0$ ($\dot{P}_0$ - characterizes the gravitational radiation). Thereby an attempt was made to find correlation between spectral peaks of the low-frequency part of the pyramid seismic noise spectrum and a section of the bar chart showing the pulsar period distribution [24]. Results are summarized in table 3.

Table 2. Parameters of pulsars with P_{0i}, periods, which differ in the 2-3 places from values of the spectral peaks shown in table 1.

Spectral peak, s	Pulsar, PSR	Period P_0, s	Flux density $W_{e.m.}$ 400 MHz	Distance, kiloparsec
1	2	3	4	5
	0820+02	0.8648	22	0.9
	0953–52	0.8621	29	3.9
0.8533	1309–55	0.8492	16	5.3
f_1=1.1718 Hz	1358–63	0.8427	34	3.4
	1503–51	0.8407	5	2.3
	1558–50	0.8642	47	5.7
	1648–42	0.8440	98	18
	1941–17	0.8411	6	2.2
	1729–41	0.6279	9	7.6
	1813–26	0.5929	30	5.1
0.6024	1818–04	0.5980	170	1.5
f_2=1.6602 Hz	1844–04	0.5977	75	4.5
	1857–26	0.6122	120	1.5
	1911+11	0.6009	5	2.4
	1919+14	0.6181	17	2.8
0.6024	0403+61	0.5946	30	0.9
	0254–53	0.4477	17	0.6
	0626+24	0.4767	30	2.7
0.4655	1030–58	0.4642	14	13
f_3=2.1484 Hz	1159–58	0.4528	23	5.6
	1323–58	0.4779	120	11
	1353–62	0.4557	???	14
	1436–63	0.4596	21	4.6
	1510–48	0.4548	9	2
	1641–45	0.4550	375	4.9
	1718–02	0.4777	24	2.8
	1718–32	0.4771	60	4.6

	1756–22	0.4609	20	5.5
	2305+55	0.4750	23	1.7
0.3938 f_4=2.5391 Hz	0559–05	0.3959	17	0.4
	1240–64	0.3884	110	14
	1609–47	0.3823	17	6.0
	1642–03	0.3876	440	0.2
	1745–13	0.3941	25	4.0
	1813–36	0.3870	22	3.7
	1839+09	0.3813	22	1.9
	1910+10	0.4093	2	4.0
	1913+10	0.4045	30	7.5
	1937–26	0.4028	8	2.0
	2024+21	0.3981	3	3.6
	2148+63	0.3801	25	4.9
1	2	3	4	5
0.33032 f_5=3.0273 Hz	0449+55	0.3408	40	0.6
	0611+22	0.3349	21	3.5
	1110–65	0.3342	19	8.0
	1600–49	0.3274	44	5.1
	2048–72	0.3413	29	0.6
	2123–67	0.3257	7	1.3
	2310+42	0.3494	55	0.6
0.2695 f_6=3.7109 Hz	0136+57	0.2725	45	2.3
	0905–51	0.2535	35	1.2
	0.950+08	0.2530	500	0.1
	1143–60	0.2733	17	3.1
	1317–53	0.2797	18	3.8
	1451–68	0.2633	350	0.3
	1556–57	0.2570	110	2.3
	1806–53	0.2610	12	1.7
	1914+09	0.2702	15	1.9
	1930+20	0.2682	7	6.2
0.2133 f_7=4.6875 Hz	0743–53	0.2148	23	2.5
	1221–63	0.2164	47	3.2
	1929+10	0.2265	130	0.05
0.19321	0.656+64	0.1955	40	0.2
	1055–52	0.1971	80	1.1
	1556–57	0.1944	20	6.8

f_8=5.1758 Hz	1557–50	0.1925	???	9.0
	1821–19	0.1893	52	8.6
	1915–13	0.1946	50	2.9
0.16254 f_9=6.1523 Hz	0355+54	0.1563	56	1.5
	0740–28	0.1667	195	2.0
	1449–64	0.1794	231	2.6
	1541–52	0.1785	23	1.3
	1804–08	0.1637	53	4.4

Table 3. Comparison of some parameters of the spectral peaks of the pyramid noise and of pulsars in the 0.8–0.1 s period band

N	1	2	3	4	5	6	7	8	9	Note
T, s	0.8533	0.6024	0.4655	0.3938	0.3303	0.2695	0.2133	0.1932	0.1625	
A, rel.units	0.55	1.025	1.30	1.68	0.85	1.20	0.41	0.45	0.39	
$\overline{P}_0$, s					0.3362					
n	8	8	13	12	7	10	3	6	5	
$\Sigma W_{e.m.}$, mH	240	460	720	700	215	1090	200	240	550	
$\Sigma \dot{P}_0$					61.60					
$T-\Sigma \dot{P}_0$					–0.0059					

Unfortunately, table 3 reflects but not all features of groups of pulsars shown in table 2 as radiation sources, which influence upon shape of the noise spectrum (Fig. 2a). Since each group is considered as a cooperative source whose radiation acts upon lithosphere and upon the region of pyramids, the following factors should be taken into account later on: distribution of the pulsar group over the chemosphere; primary coefficients of coherence for radiations whose appearance is possible prior to approach to the Earth, and secondary, most essential that appear in the nonlinear and seismically active geological medium; pulsar remoteness correction for flux of gravitational radiation or the pulsar gas dust stream. Of course an affect of the pulsar gas dust stream is very more strong in compare of gravitational radiation but the frequencies of both process are coincidence.

However, comparison of the seismic noise parameters and of the pulsar groups as presented in table 3 and in Fig. 2a is the evidence of a stable accordance of these parameters and confirm an assumption about an appreciable contribution of the space impact in the low-frequency spectral peaks of the Snowfru pyramid noise. The spectrum general level rises are also distinctive. The most powerful part is in the range of periods of 0-1 s (this tabletop section of the insignificant amplitude is damped dozens of times due to characteristic of the apparatus) and corresponds to the maximum number of the known pulsars. And the pulsar period bar chart as a whole, on assumption of appearance of the 2-nd harmonic of the seismic noise of the periods in the range of 0-1 s and/or radiation in $P_0/2$, is displayed in the second constant part, i.e. on the rise of the spectrum in the frequency range of 1-4 Hz.

The same noise range was studied by the spectral-time analysis (STA) method (Fig. 2b). The STA was not used earlier for the search of the space effect in the seismic noise and, on the other hand, it proved to be an efficient tool in the search of nonlinear effects, of synchronization of seismic signals in particular [5, 15]. A more detailed examination of the STA of seismic noise in the range of 0-8 Hz (Fig. 2b) and its comparison with the earlier obtained STA diagrams of analysis of behavior and evolution with time of the harmonic seismic signals in the nonlinear and/or seismically active medium show many common typical features inherent in processes of chaos and self-organization in the nonlinear seismology [5].

These processes are implemented, first of all, through a mechanism of synchronization and desynchronization. In other words, peaks in the noise spectrum, even most powerful, for example at 2.5 Hz frequency, formed on a B–A′ straight line, exist for a limited period of time from the 2-nd to the 3-rd second of the record (Fig. 2a). Afterwards energy of the peak is distributed in a wide frequency band (from the 3-rd second to 4.5) and then it is pulled from the 5.5 to 6.8 second of the current time to a peak of ~2 Hz (the peak is not shown in the spectrum in Fig. 2a but it is seen in the STA in Fig. 2b). Further, the peak gaining strength constantly, moves along the line A–A′ to higher frequencies and again reaches the frequency of f~2.5 Hz. Taking into consideration data of table 3 the frequency band, where the amplitude-frequency variations and interactions are most intensively observed, corresponds to groups of pulsars with the maximum $\Sigma W_{e.m.}$.

Another element of study of the seismic noise is a comparative analysis of spectral lines at frequencies f_2', =1.8 Hz, f_6'=4 Hz and $f_{6,7}'$=4.2 Hz, which are in the vicinity of powerful peaks (f_2, f_4), but one peak (f_2') is on a spectral rise in the range of 1–4 Hz, and another peak f_6' is at the border of this rise (Fig.2a). The third line $f_{6,7}'$ is 0.2 Hz away from the rise and corresponds to a background level of the spectrum in Fig. 2a. These lines as routes of constant frequencies are designated in the STA (Fig. 2b). The extract is made for the assigned frequencies f_2', f_6', $f_{6,7}'$ is made according to the method of table 2 for groups of pulsars and it is presented in table 4.

Table 4. Comparison of some parameters of the spectral peaks of the pyramid noise and of pulsars

Central period of spectral line, s	Pulsar, PSR	Period P_0, s	Flux density, $W_{e.m.}$ 400 MHz	Distance, kiloparsec
0.5555 f_2'=1.8 Hz	0403–76	0.5452	19	0.8
	0450–18	0.5489	55	1.6
	0808–47	0.5471	46	5.7
	0.919–41	0.5454	63	0.6
	0.904–74	0.5495	11	2.0
	1322–66	0.5430	28	8.2
	1749–28	0.5625	1300	1.0
	1834–10	0.5627	30	10
	1921+17	0.5472	2	4.3
	2016+28	0.5579	290	1.0
0.2500	0540+23	0.2459	30	2.9
	0905–51	0.2535	35	1.2
	0.950+08	0.2530	500	0.1

f'_6 =4.0 Hz	1451–68	0.2633	350	0.3
	1556–44	0.2570	110	2.3
	1806–53	0.2610	12	1.7
	1930+20	0.2682	7	6.2
	0540+23	0.2459	30	2.9
	1719–37	0.2361	25	3.0
0.2381	1754–24	0.2340	–	5.1
$f'_{6,7}$ =4.2 Hz	1922+20	0.2377	4	8.0
	2324+60	0.2336	41	3.4

The following should be noted in comparison of data of tables 2 to 4 and positions of the spectral lines f'_2, f'_6, $f'_{6,7}$ on the spectrum and in the STA (Fig. 2a, b). The line f'_2, which belongs to the maximum of distribution of pulsars by periods, passes through the most powerful part of the spectrum level rise; by the number of pulsars (*n*=10) and by the sum total power $W_{e.m.}$ (1844) is in excess of or is comparable with other groups of pulsars (Table 3). But with the change of parameters of the medium and of the synchronization conditions it may become the basis of a new spectral peak, which is determined by a period such as PSR 1749–28 or PSR 2016+28. Possibility of such observation is tracked in the STA from the 3-rd to the 5-th second of observation. Line f'_6 also belongs to the maximum of distribution of pulsars, but at a more steeply falling border and passes also along the border of the spectral rise (Fig. 2a) with *n*=7 and $\Sigma W_{e.m.}$ =1044. This proposes a possibility of forming a spectral peak with the period of the pulsar PSR 0950+08 due to the same reasons (a stable zone of intensive oscillations from the 7-th second of observation appears in the STA near the line).

Line $f'_{6,7}$ is connected with a slope of a steeply falling maximum of distribution of the pulsars and has already $\Sigma W_{e.m.}$ =230 at *n*=6 beyond a powerful rise of the spectrum level (Fig. 2a) and can, under favorable conditions, generate a weak peak with the pulsar PSR 1929+10 period. This, however, as in the case of f_7, f_8, f_9 will be an unstable formation.

Thus, a zone of unstable synchronization of seismic waves from a small number of sources n begins at frequencies $f_{gr.}$≥4.5 Hz; above 10 Hz the cooperative effects, probably, do not appear and the space impact on the seismic noise may exist only in the form of separate peaks.

4. High-frequency part of seismic noise. General.

By convention the microseisms or seismic noise exceeding 10 Hz frequencies can be considered as high frequency. One of the general features of the seismic noise is almost a square law of drop of power with the rise of frequency, though beginning from 30-40 Hz the curve begins to form a plateau. Actually, spectra of the high-frequency part of noise contain frequently peaks, which as a rule, are of the man-caused origin.

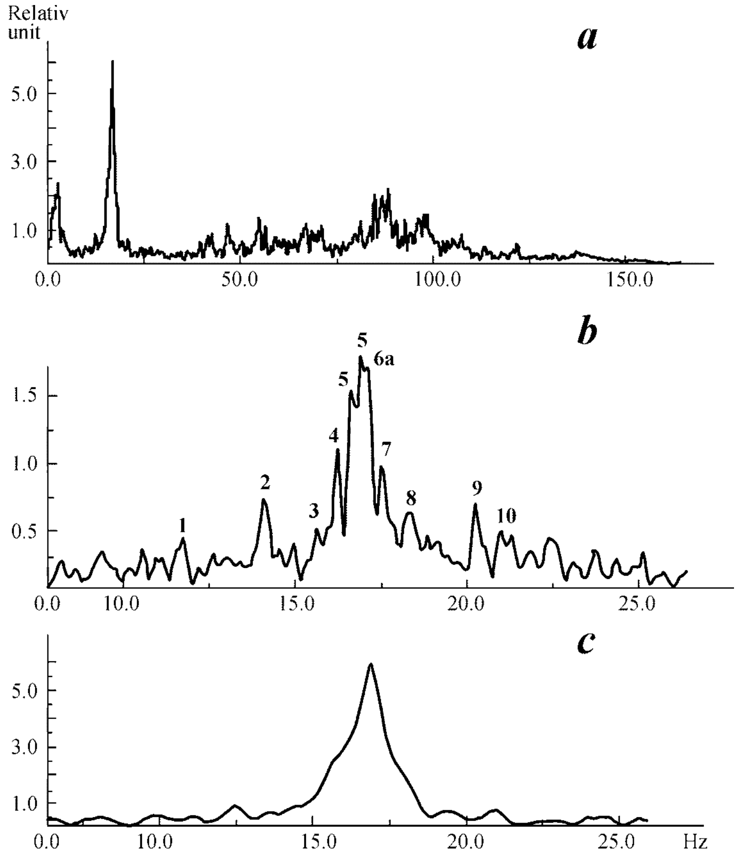


Fig. 3 a ,b ,c. Comparative analysis for high – frequency seismic noises.
a. Spectrum of the Snowfru (broken-line) pyramid seismic noises in the range of 0-150 Hz.
b. Peak at 17 Hz; period (sampling rate) – 2 мs; duration of recording – 4 s; precise value of peak 16.8457 Hz.
c. Peak at 17 Hz; period (sampling rate) – 2 мs; duration of recording – 10 s. Values of peaks 1–10 in Hz: *1* – 11.72, *2* – 14.06, *3* – 15.63, *4* – 16.21, *5* – 16.6, *6* – 16.8945, *7* – 17.48, *8* – 18.26, *9* – 20.21, *10* – 21.

Therefore, peculiarities of the Snowfru pyramid seismic noise spectrum should have comply with a general case, but in reality it turned out that it was not so (Fig. 3a). Peaks and a constant part of the spectrum in the range of 0-8 Hz were discussed in the previous part; the peak neat 17 Hz was observed earlier by some researchers but its dominating value is observed for the first time. Further, from 40 Hz up to 90-100 Hz it is possible to see a growth of a constant component with many peaks and with the maximum in the region of 85-90 Hz, that is the spectrum (Fig.3a) possesses features which can be expected in an industrial center but not in a semi-desert area about 40 km from Cairo and several hundred kilometers from the Aswan hydroelectric power plant which is the most powerful source of the industrial noise. Therefore, existence of a powerful background of seismic emission of the pyramid and of the geological medium under the pyramid should be accepted as the most real explanation of features of the spectrum. As has been shown by measurements, the level of emission inside the structural part of the pyramid exceeds the signal on its external lateral face. Most probably peaks of the spectrum (Fig. 3a) carry information about a natural resonance of the pyramid, about dominating frequencies of the seismic emission process in blocks of the pyramid and about periodicity of seismic emission in the geological structures under the base of the pyramid.

Decoding and study of a set of frequencies that is so complicated from the point of view of structure and mechanisms is a separate scientific task.

5. Spectral peak in the vicinity of 17 Hz is a resultant of several physical mechanisms

Physical processes which exist near the Snowfru pyramid and inside the pyramid is the seismic and seismic-acoustic emission especially inside the pyramid massif; here belongs the field of chaotized varying in time seismic waves caused by industrial sources, including the peak at about 17 Hz frequency as a sub harmonic $f_0/3$ from 50 Hz (Aswan hydroelectric power plant) and the natural resonance of the pyramid as an object described by the Matje and Fokker-Plank equations.

The seismic noise at about 17 Hz frequency has one more feature – existence of a space source which is the pulsar PSR 1913+16 with the period *P*=0.059 with (16.95 Hz), whose radiation acts also upon the geological medium and on the pyramid. By its amplitude this effect is by many orders inferior than previous processes, but from the point of view of stability of the frequency it is incommensurably higher.

The 17-Hz peak was observed by researchers earlier and in some cases it was identified with processes of a developed chaotization of a powerful primary 50-Hz signal from the hydroelectric power plant (Fig. 2b). By now, even by using non-purposeful investigations of microseisms or of seismic noise the abnormal nature of this peak is well seen, as a rule, (Fig. 1a). The noise spectrum, where the peak dominates at a frequency of 17 Hz was obtained from the Snowfru Egyptian pyramid (Fig. 3a). This permits to analyze it more thoroughly. Let us examine this peak obtained from spectra of different type records to this end; at a sampling rate 2 ms and duration of recording 4 s (Fig.3b); and at the sampling rate 5 ms and duration of recording 10 s (Fig. 3c). Let us present the dynamics of state of the wave field at a 17 Hz frequency and in the adjoining frequency ranges (±7 Hz) by the STA diagram (Fig. 3d).

Comparison of spectra (Fig. 3b, c) even with different duration of recording and quantization periods taken into account makes it difficult to explain their difference: at a quantization period 2.5 times shorter the spectrum in Fig. 1b is more smooth and relation between of the peak amplitude with the averaged level of the spectrum near ~±9 Hz makes 12; the spectrum having an exceptionally irregular structure this relation is ~7 and the peak proper at ~17 Hz has a fine structure. To explain these peculiarities it is necessary to accept an important role of the fact that spectra were obtained from recordings made at different times. This is evident from the STA (Fig. 3d): frequency of the maximum value of the peak (without taking into consideration the sections-satellites) varies in the current time within the range from 16.5 Hz to 17.5 Hz and amplitude from 1.8 to 4.9 relative units, i.e. about 3 times. In general, the local dynamics of this section of the wave field of the seismic noise is in the range 16-18 Hz. One of the pyramid resonances and the commercial frequency (and seismic signal) fluctuations from the Aswan hydroelectric power plant ($f_0/3$=16.67 Гц, f_0=50 Hz) may probably be within the same range. And only a weak signal from the PSR 1913+16 has a stable frequency 16.95 Hz. As is evident from the STA (Fig. 3d), the seismic noise signal in the 16.5–17.2 Hz is synchronized and captured to a frequency of ~16.95 Hz occasionally at the current time τ from 1.5–2.5 s, 3–6 s and 7.5–8.5 s, i.e. the weak signal of a space origin is amplified from the pulsar PSR 1913+16 on account of a poor quality regional signal and resonance of the pyramid. The same is confirmed by peaks in Fig. 3b, c: the exact value of the peak differs from frequency of the PSR 1913+16 in the 4-th place, an inclined chopped top, whose two points take values of 16.601 and 17.09 Hz, appears in the same peak upon smoothing. Both values differ from $f_0/3$ and from the pulsar frequency only at the 4-th place. A fine structure of another peak at a frequency of 17 Hz (Fig. 3c) contains sub-peaks at 16.6 Hz (5) and 16.89 Hz (6), which also differ from the man-caused and space peaks at the 4-th place. Thus, there is a good agreement between results of the spectral analysis and the spectral-time analysis.

6. Conclusion.

1. The seismic-acoustic emission of pyramids and of adjoining geological structures forms a considerable part of the seismic noise and is favorable for the search and study of the external regular actions.

2. The seismic noise of Snowfru pyramid is of non-linear nature, and its structure has the high sensitivity to external influences.

3. Different parts of the spectrum of the seismic noise have different physical mechanisms of their formation.

4. Low-frequency part of the spectrum reflects the cooperative processes of influence and interaction of energy of seismic noises of pyramid and medium and external space influence of the majority of known pulsars.

1. 5. Isolated peaks in high-frequency part of the spectrum of seismic noise, and first of all on frequency ~17 Hz, are also determined by several energy mechanisms, and the analysis of such structure of the peak reveals the influence of space gas dust stream of the pulsar PSR 1913+16 and the man-caused component on $f_0\ /\ 3$ (f_0 = 50 Hz). Seismic response on influence of acoustic waves on day surface of the region according to scheme: discrete gas-dust flow from a pulsar - its interaction with ionosphere and subsequent creation of atmospheric acoustic waves, propagating toward the day surface, generation of seismic waves.

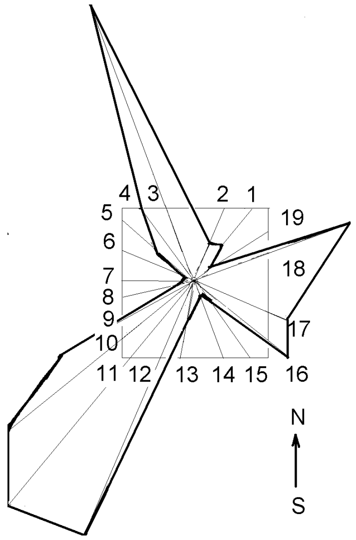
6. Searching for a space influence on the seismic noises must be conducted not only by coincidence of frequency of the spectral peaks of noises with frequency of pulsars but by observing and proving existence of the nonlinear nature of the seismic noises, physical mechanisms of their existence and influence of a space source upon these noises.

7. The Snowfru pyramid must be employed effectively as a geophysical instrument for the pilot and applied researches.

§ 4. Seismic noise (SN) and seism acoustic emission (SAE) of a field of pyramids: elements of structure.

According to preliminary results, SN and SAE pyramids have extremely complex three-dimansional temporal structures and resonances, the understanding of which many features will demand many efforts. On the other hand, geological structures adjoining to pyramids are less complex and actually besides tectonic fields of stress test influence only weights of a massif (body) of pyramids. That is as a first approximation we have a task about the huge stamp working on elastic geological structure. The maximal deformations existing under a massif of a pyramid and an adjoining geological structure, derivate SAE processes which, as well as pressure from loading a massif, should be reduced with removal from a pyramid. One of models of distribution SAE for this case is described within the framework of representation of diffusion of a stream of substance (fluid) or, for example, fields of the stress from a dot source. The diagram of an orientation such diffusion streams in the environment usually determine on structure of distribution, for example, on primary development and a direction of cracks and crack network , or on field measurements of the maintenance of a fluid, fields of deformations etc. In this case task is modified: under experimentally constructed diagram to define dynamics of stress and structural features of environment. Direct analogy of such diagram in this case is radius - azimuthally profile SN and SAE which is methodically optimized at research of fields of fluids. For this measurement SAE were carried out around of pyramids as from a source in the points (pickets) accessible to registration (and not on one radius, as in a case with a fluid). Record of amplitude envelop of SN was conducted on a second interval in frequency a range from 10 up to 400 Hz; duration of measurements has made 3-5 minutes. Therefore in each point of picket received more than 200 values of amplitudes envelop SN and SAE, and their one average value was postponed on radius of the given azimuth in uniform scale. Probably, average values of amplitudes SN and SAE in points of picket reflect both filtering properties of the geological structure, and actually emission features of the environment determined background and induced (from a massif of a pyramid) pressure (stress). Radius-azimuthally noise seismic profiles around of pyramid Kheops (Khufu) in Giza and pyramids in Meidume were constructed on the basis of measurements with use high-frequency seismometer with a pass band of a signal from 10 up to 400 Hz. It approximately corresponds to spectra of noise of this region (Fig.1a, b), where figures around of a contour of pyramids (a square in thin lines) are numbers of pickets of measurements, thick lines - borders of structures (profiles).

a



b

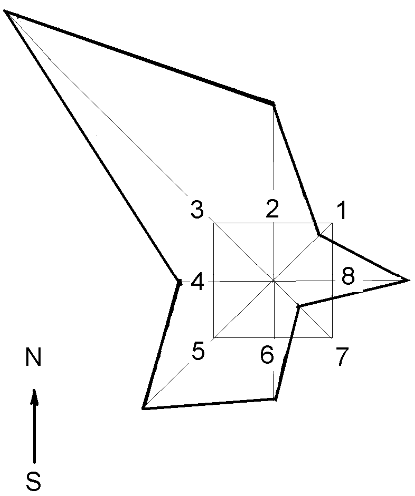


Fig. 1a, b.
An example of profiles structure SN and SAE around of some pyramids of Egypt.

a. Radius -azimuthally seismic structure SN and SAE of pyramids Хеопса in Gize;

b. Radius -azimuthally seismic structure SN and SAE pyramids in Meidume.

From comparison of radius –azimuthally profiles structures for pyramids of a plateau of Giza and Meidume follows the next : each profile of structures SN and SAE has the three petals form, on two maxima - petals as a first approximation unidirectional - north-northeast (Giza) and northeast (Meidume). Petals at a profile structure of Giza of the greater size also are more narrowly directed in comparison with Meidume`s, the profile structure of Giza has tendency to formation of additional petals. Both pyramids stand in regions of the increased seismicity, especially a plateau to Giza, therefore the orientation of the maximal petals of profile structures (Fig. 1a, b) can correspond to a maximum of spatial distribution of background stresses of region. Thus, a pyramid is a huge stamp on elastic surface geological structure and the unique historical and geophysical experiment having lasting value for experts in geomechanics and tectonics. Realization of similar research with natural quasi-dot object, for example, an active volcano is of interest.

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