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**ԲԱՐՁՐ ՏԵԽՆՈԼՈԳԻԱՆԵՐԻ ՏԵՂԵԿԱԳԻՐ**  
**ИЗВЕСТИЯ ВЫСОКИХ ТЕХНОЛОГИЙ**  
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## LANDING RADAR WITH COMMUTATION OF THE MUTUALLY SPACED IRRADIATED SECTIONS OF ITS COVERAGE AREA

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*The task of the radar designing, which serves aircraft landing in airports is considered in the given article. For providing of modern requirements on airport traffic capacity and increasing of the reliability of aircraft landing the scheme of landing radar construction is based on separated from each other receiving and transmitting antenna systems of the radar. The receiving antenna system is a phased array antenna that forms a scanning four-beam directional pattern. It provides the realization of a high-precision monopulse method for determining of the angular coordinates of an aircraft in a pick out section of the radar coverage area. The transmitting antenna system consists of a set of separate radiating units. Each unit sequentially irradiates its section of the radar coverage area by commutating of the transmitter to it. The searching process of aircraft and measuring of its range, speed and angular coordinates in a particular section of the radar coverage area are synchronized with the commutation of the microwave probing signal of the transmitter to the unit, which irradiates this section. The possible circuits of microwave commutators are presented. A variant of constructing of the radar transmitting antenna without commutation of the transmitter microwave probing signal is also discussed. In this case a single transmitting phased array antenna is used, which sequentially irradiates the sections of the radar coverage area.*

**Key words:** landing radar, transmitting antenna, receiving antenna, microwave commutation, radar coverage area.

### ***Introduction***

For the landing of various aircraft, when the high accuracy is required for determining of the range, course (azimuth) and glide path (elevation angle) of the aircrafts, the centimeter waveband radars have been used widely. The angular coverage area of such radars is about  $30^0 \dots 35^0$  by the course and  $10^0 \dots 12^0$  by the glide path. The range of the landing radar is usually not more than 30 km. Outside of this distance, in the range of 30 to 50 km, the centimeter waveband terminal radar is used usually to provide an observation of air situation and to carry out the operational control of the aircrafts. In the distance of more than 50 km the observation radar of the meter waveband is used for continuous monitoring of the general air situation.

At the modern rate of aviation progress the increasing of traffic capacity of landing radar systems and their reliability give rise the increased requirements on system operation speed, accuracy of determining of the coordinates of the aircrafts, their resolution, their tracking to the airport runway and etc. To meet these requirements, the antenna system of the radar can be constructed on the basis of a receiving-transmitting (combined) phased array antenna (PhA). In this case, together with fast electrical, instead of mechanical, scanning of the probing beam in the transmitting mode of the PhA, in its receiving mode it is possible to realize a monopulse method that has an increased accuracy in determining of the aircraft angular coordinates [1, 2].

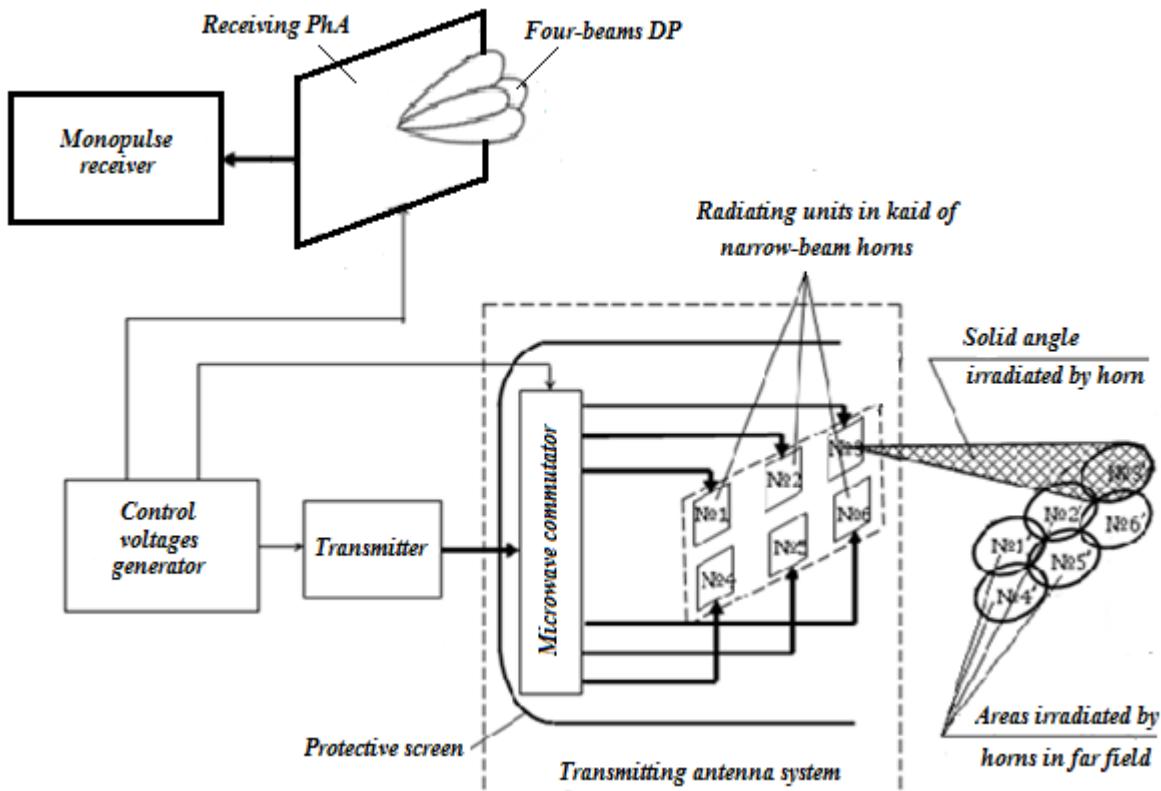
### **Statement of the problem**

The above described combined PhA in the transmitting mode should form a narrow pencil probing beam, and in the receiving mode it should form a four-beams directional pattern (DP). The two mutually spaced beams of this DP, which determine the course of the aircraft, should intersect at the minus 3 dB level in the monopulse null axis and scan in such a related manner in the range of angles  $\pm 17.5^0$ , and in the analogous way the two other beams of this DP should scan in the range of angles  $\pm 6^0$  for determining of the aircraft glide path. At determining of course and glide path of aircraft with an accuracy of less than a tenth of a degree, the width of each of these beams should be less than  $1.5^0$  [3].

Such a combined PhA will contain several thousand emitters, which means that there are a large number of switching elements in circuits of the PhA radiators (for transferring of combined PhA from reception to transmit mode or vice versa), phase shifters, etc. Obviously, the solution of the problem of a significant reduction in the number of any elements in the PhA will lead to its simplification and, as a result, to an increase in the reliability of the radar operation.

### **The landing radar with separate receiving and separate transmitting antenna systems**

The attempt to solve the assigned task is the constructing scheme of landing radar, proposed in [4], in which the transmitting and receiving antenna systems are separated. To understand the following possible ways of constructing of the separate transmitting antenna system the general scheme of the proposed radar is represented in fig. 1.



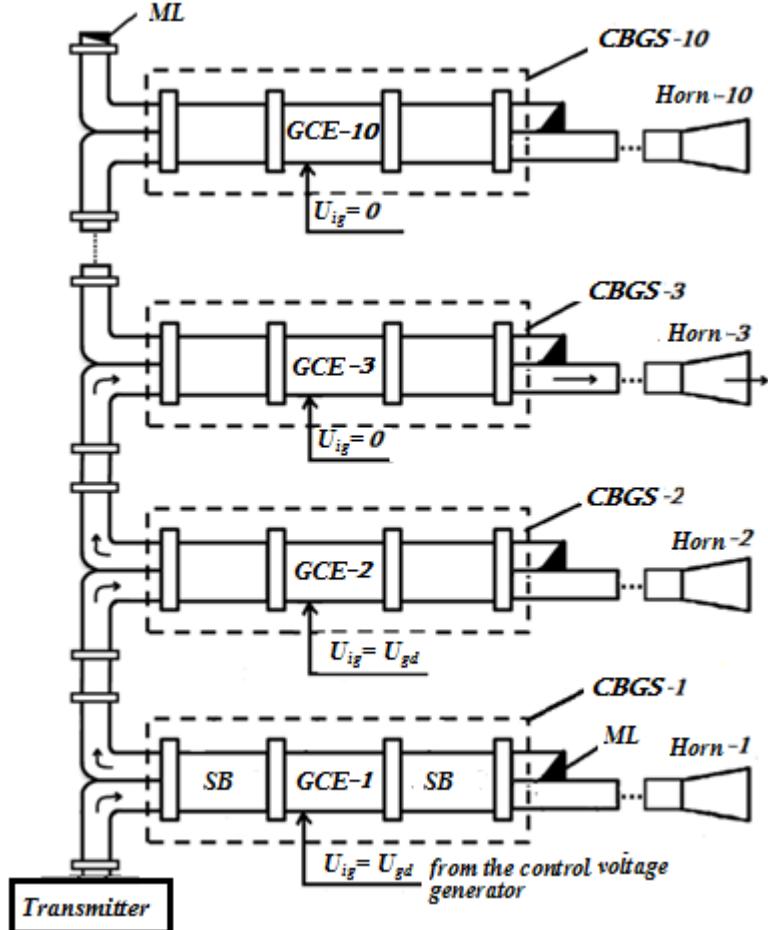
**Figure 1. Block diagram of the lading radar**

The receiving antenna system consists of PhA, which forms a four-beams DP with the possibility of scanning of DP in the coverage angular area of the radar -  $35^0 \times 12^0$ . The widths of each DP beams of the receiving PhA are equal to each other and are amount to  $1^0 \dots 1.5^0$ . The transmitting antenna system consists of a microwave commutator and a two-row kit of identical radiating units in kind of narrow-beam horns - 5 pieces in each row.

For simplification of fig.1 the case with 3 horns on each row is represented. The beam width of each from 10 horns is about  $6^0 \dots 7^0$ . The axes of the horns are disposed relative to each other in

such a way that the irradiated angular solid sectors of the horns are imposed partially on each other. In result of successive excitation of the horns the entire radar coverage area is irradiated. Thus, the total solid angle of irradiation of the transmitting antenna system is equal to the required angular coverage area of the radar.

During the operation of a specific horn, the four-beam DP of the receiving PhA scans within the solid angle, which is irradiated by this horn, for the searching of aircraft and measuring of its coordinates and speed. At commutation of the microwave power to another horn, the receiving PhA transfers synchronously to the scan mode in another solid angle, which corresponds to this horn, and the same performs in this area. The commutation scheme of the microwave probing signal from a magnetron or solid-state transmitter to the irradiating horns is shown on fig. 2.



**Figure 2. The circuits of the microwave commutator with controlled balanced gas-discharge switchers**

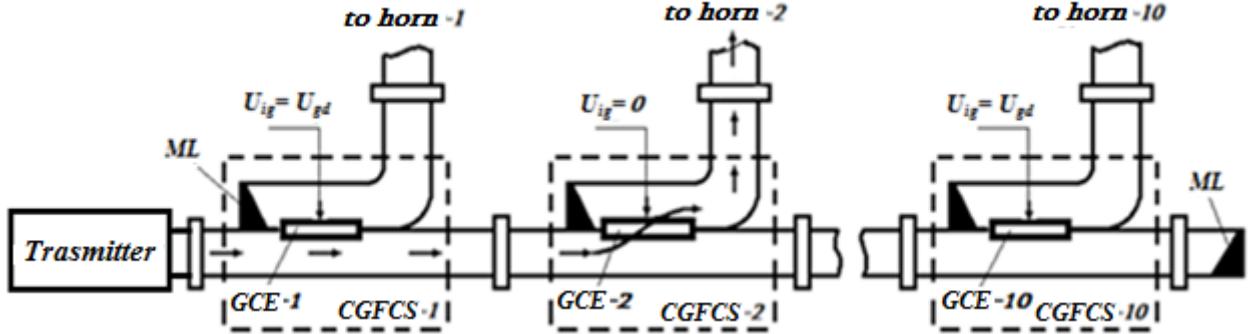
The circuit is based on microwave controlled balanced gas-discharge switchers (CBGS), described in [5]. Each CBGDS contains two waveguide slotted bridges (SB) and the waveguide gas-discharge controlled element (GCE), which is located between bridges. In the circuit, the number of CBGS is equal to the number of radiating horns. The commutated arm of each CBGS is loaded by the horn and an isolated arm is loaded by a matched load (ML).

The GCE reflects the microwave signal to the input of the next CBGS when the supplied on GCE ignition voltage  $U_{ig}$  equals to the gas discharge voltage  $U_{gd}$ , that is  $U_{ig}=U_{gd}$ , and at the absence of the ignition voltage, that is  $U_{ig}=0$ , the microwave signal passes to its horn. By selecting the ignition voltage group (from the control voltage generator in fig. 1) on the GCE of each CBGS, the probing signal of the transmitter passes to one or another horn.

On the fig. 2 the microwave signal from the transmitter passes to the input of horn-3, since the ignition control voltage on GCE-1 and GCE-2, accordingly of CBGS-1 and CBGS -2, not equals to

zero and  $U_{ig} = U_{gd}$ . Their GCE are short-circuited and the signal passes through GCE-3 to the horn-3, as shown by the arrows on fig. 2. Thus, the group of control ignition voltages in this case is  $U_{ig}^{(3)} = \dots = U_{ig}^{(10)} = 0$ , and  $U_{ig}^{(1)} = U_{ig}^{(2)} = U_{gd}$ . If, for example, it is required the commutation to the horn-7, then the group of control ignition voltages will be  $U_{ig}^{(7)} = \dots = U_{ig}^{(10)} = 0$ ; и  $U_{ig}^{(1)} = \dots = U_{ig}^{(6)} = U_{gd}$ .

Below we will consider other possible variants for implementation of some components of the transmitting antenna system. Another version of the microwave commutation circuit is shown in fig. 3. Unlike the commutation scheme described in [4], the given circuit carries out the commutation of the microwave signal by means of controlled gas-discharge switchers with full-connection (CGFCS). They are described in [6] and, in comparison with CBGS, provide higher levels of commutation powers and are more broadband.



**Figure 3. Circuit of microwave commutator with control gas-discharge full-connection switchers**

In such commutators, the GCE is located along the coupling slot of SB. At the supplying of the ignition control voltage to the GCE, that is  $U_{ig} = U_{gd}$  the coupling slot is short-circuited and the power way to the horn-loaded branching arm is closed. Here, as opposed to CBGS, the signal from the transmitter passes to the branching arm of that CGFCS, on the GCE of which the ignition voltage is  $U_{ig} = 0$ . The case of signal commutation from the transmitter to the horn-2 is shown in fig. 3. Therefore, the corresponding group of the ignition control voltages is  $U_{ig}^{(1)} = U_{ig}^{(3)} = \dots = U_{ig}^{(10)} = U_{gd}$  and  $U_{ig}^{(2)} = 0$ . The signal passage is indicated by arrows.

At the landing radar constructing (shown on fig. 1), instead of radiating units in the form of narrow-beam horns with mutually spaced radiation sections of the radar coverage area, the same number of small radiating PhA can be used that do not contain variable phase shifters. In this case the constant phase shifts between the radiators in each PhA should be chosen so that the phased array main beam should irradiate the radar coverage area section of the horn, which is replaced by small PhA. Aperture of radiating PhA should provide a width of a beam near  $6^0 \dots 7^0$ . Calculation of such a PhA, performed in accordance with [7] at an operation wavelength of  $\lambda \approx 3.2$  cm, gives the value of the PhA aperture is about  $27 \times 27$  cm<sup>2</sup> and the number of radiators in it is about 110.

The relevance of arguments of the replacing of horns by PhA is caused by the cost of their implementation. The manufacturing of the PhA may be somewhat more expensive, but the advantage of the using of the PhA should be take into account. It consists in obtaining of lower levels of the radiated side lobes by applying a special amplitude distribution along the PhA curtain.

The choice of the microwave commutator and the radiating units in the transmitting antenna system of the landing radar is caused by the required parameters and the cost of their implementation. At the same time in this case it is necessary to take into account the undeniable fact that the huge number of switching elements are excluded, unlike of the case of the radar with a single combined PhA, where the switching for transfer of radar from the reception mode to the transmission mode and vice versa is required. On the other hand, the commutation of the microwave probing signal of the

transmitter may avoid by using a single transmitting PhA, the beam of which is switching from one section of the radar coverage area to the other section. But the additional variable phase shifters must be inserted into the circuits of the radiators of this PhA for the achieving of switching.

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### ՎԱՅՐԵԶՔԱՅԻՆ ՈԱԴԻՈՏԵՂՈՐՈՉԻՉԻ ԻՐ ԴԻՏԱՐԿՄԱՆ ԳՈՏՈՒ ՃԱՌԱԳԱՅԹԱՎԱՐՎՈՂ ՏԱՐԱՆՁԱՏՎԱԾ ՀԱՏՎԱԾՆԵՐԻ ԿՈՄՈՒՏԱՑԻԱՅՈՎ

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Հողվածում քննարկվում է օդանավակայաններում ինքնաթիռների վայրէջքը սպասարկող ռադիոստերոջիչ կայանի կառուցման խնդիրը: Օդանավակայանների թողունակության և վայրէջքի հուսալիության ժամանակակից պահանջների ապահովման համար վայրէջքային տեղորոշիչի կառուցման սիստեման հիմնված է իրարից տարանջատված ընդունող և հաղորդող անտենային համակարգերի վրա: Ընդունող անտենային համակարգը իրենից ներկայացնում է փոլավորված անտենային ցանց, որը ձևավորում է սկանավորող չորս-ճառագայթանի ուղղվածության դիագրամ: Այն ապահովում է

ռադիոտեղորշի դիտարկման գոտու տրված հատվածում գտնվող օդանավի անկյունային կոորդինատները բարձր ճշգրտությամբ որոշող մոնոիմպուսային մեթոդի իրականացումը: Հաղորդող անտենային համակարգը բաղկացած է առանձին ճառագայթող հանգույցների հավաքածուից: Յուրաքանչյուր հանգույց հաջորդաբար ճառագայթահարում է ռադիոտեղորշի դիտարկման գոտու իր հատվածը՝ կոմուտացվելով հաղորդչին: Ռադիոտեղորշի դիտարկման գոտու տրված հատվածում գտնվող օդանավերի փնտրման և դրանց անկյունային կոորդինատների, հեռավորությունների և արագությունների չափման գործնակացը սինխրոնացված է հաղորդչի ԳԲՀ զոնդավորող ազդանշանի կոմուտացիայի հետ այն հանգույցին, որը ճառագայթահարում է ընտրված հատվածը: Ներկայացված են ԳԲՀ կոմուտատորների հնարավոր սինմաները: Քննարկվում է նաև՝ առանց ԳԲՀ հաղորդչի զոնդավորող ազդանշանի կոմուտացման, ռադիոտեղորշի հաղորդող անտենային համակարգի կառուցման տարրերակը: Այդ դեպքում օգտագործվում է միակ հաղորդող փուլավորված անտենային ցանց, որը հաջորդաբար ճառագայթահարում է ռադիոտեղորշի դիտարկման գոտու հատվածները:

**Բանալի բառեր.** Վայրէջքային ռադիոտեղորշի, հաղորդող անտեննա, ընդունող անտեննա, ԳԲՀ կոմուտատոր, ռադիոտեղորշի դիտարկման գոտի:

## ПОСАДОЧНЫЙ РАДИОЛОКАТОР С КОММУТАЦИЕЙ РАЗНЕСЕННЫХ ОБЛУЧАЕМЫХ УЧАСТКОВ ЗОНЫ ЕГО ОБЗОРА

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В статье рассматривается задача построения радиолокатора, обслуживающего посадку воздушных судов в аэропортах. Для обеспечения современных требований по их пропускной способности и повышению надежности посадки схема построения основана на разделенных друг от друга приемной и передающей антенных систем радиолокатора. Приемная антенная система представляет собой фазированную antennную решетку, формирующую сканирующую четырехлепестковую диаграмму направленности. Она обеспечивает реализацию высокоточного моноимпульсного метода определения угловых координат воздушного судна в заданном участке зоны обзора радиолокатора. Передающая антенная система состоит из набора отдельных излучающих узлов. Каждый узел последовательно облучает свой участок зоны обзора радиолокатора посредством коммутации передатчика к нему. Процесс поиска воздушного судна и измерение его угловых координат, дальности и скорости, находящегося в конкретном участке зоны обзора радиолокатора, синхронизирован с коммутацией СВЧ зондирующего сигнала передатчика к узлу, облучающему этот участок. Представлены возможные схемы СВЧ коммутаторов. Обсуждается также вариант построения передающей антенной системы радиолокатора без коммутации СВЧ зондирующего сигнала передатчика. В этом случае применяется единственная передающая ФАР, последовательно облучающая участки зоны обзора радиолокатора.

**Ключевые слова:** посадочный радиолокатор, передающая антenna, приемная антenna, СВЧ коммутация, зона обзора радиолокатора.

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## DEVELOPMENT OF A MINIATURE DIGITAL UNIT OF A ELECTRODIAPHRAGMOGRAPH

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*This paper is devoted to development of a small-sized microprocessor unit having no analogy and enabling to demonstrate on the monitor the curve resulted from diaphragm movement. By this unit it is possible to measure oscillation period, waves duration, and amplitude. It is possible to obtain the above mentioned biological data from hypodermic sensors, developed by the authors, placed at appropriate points. The paper states forth in details all electrochemical changes occurring in the body which interfere with receiving signals coming from biological sensors and conclusions have been made up on careful choice of sensors.*

**Key words:** *sensor, electrode, biosignal, diaphragm, charge*

### **Introduction**

Lungs located within the rib cage are a pair of spongy organs, which by breathing extract oxygen from the atmosphere and expel carbon dioxide from the bloodstream into the atmosphere. The lungs are covered by a thin tissue layer called the pleura. Human respiration rate and volume depend on oxygen demand of the body. An adult breathes around an average of 500 ml of air usually measured at rest, while sitting, in one normal or relax breathing, that is only 15 percent of the volume change occurs by endless up and down movements of the diaphragm. Presence of ion signals produced by the diaphragm movements is detected by a record produced by electrocardiograph which is evaluated as deviations of the isopotential line and is perceived as noise. In processing all electrocardiograms it is a usual practice to try to struggle against the noise by means of different technical solutions. On the other hand this noise contains important biological data which define functioning of different viscera. The produced ion potentials contain invaluable data. Through the latter one can arrive at a conclusion and assess on deviation of a given organ of a human body functioning from the norm. Among such organs are the diaphragm, stomach, intestines, etc., which perform rhythmical functioning, like the heart of which changes of potentials have been deeply studied, in contrast to the above mentioned organs, therefore the study of principals of work of these organs is a topical issue. The problem is what biological generators are there and where they are located and if there are few, then what is the logical link on which they work. For example, there are the following three sinus, atrioventricular, and His bundles which are also called heart generators. It should be noted that the second (atrioventricular) generator also performs time delay of impulses coming from sinus one, which is necessary for pumping entire blood from atrioventricular to ventricle of the heart. It should be noted that ventricles before atria contain blood up to 75 percent of their volume, for the mitral valve is open and it is closed only the moment ventricle of the obtained positive results of the MM-1 small-seized microprocessor electrocardiograph trials provide a basis for Marat Muradyan, Movses Muradyan, and Stepan Grigoryan - research workers of the chair of Microelectronics and Biomedical Devices of the National Polytechnic University of Armenia - to develop a new device designed to study the mechanism of enabling to record frequency and amplitude

of the diaphragm. To develop such a device it is necessary to convert analog signal into digital one and to consecutively record these data with high accuracy. On the basis of the obtained digital data one can plot curves of oscillations on a graphic display by selecting a respective time quantity. In that case the device will show not an electrocardiogram which repeated approximately after each second, but the number of which the time of one nearly 5 times slower from electrocardiograph. Moreover, for noiseless recording of signals it will be necessary not only to suppress 50Hz industrial noise but also exclude signals of the electrocardiograph to obtain periodically repeated curve without markedly noise which will enable measuring not only repetition period – rhythm but also the oscillation amplitude. To record these data it will be necessary to remember the record of each patient, at the same time to display and remember the recording date with one second accuracy. The device should be able to display, record curves of patients diaphragm's numerous contractions to be able to perform dynamic control. All this require to provide the device with a large volume of memory to keep records of thousands patients. The device should have a graphic display being controlled by contacting symbols on the display. The same principle is applicable during measuring. The device should be portable, weigh not more than 200g, and be mounted in a plastic shockproof case.

The device should be powered by rechargeable batteries, at the time of their discharge the user will receive information, and the recharging of batteries will be carried out without removing the batteries from the device. To control the operation of the device, it is necessary to develop an appropriate software package.

### **Statement of the problem**

The positive results of a carried out series tests of the small-sized electrocardiograph MM-1 developed by the authors provide the basis for the development of a new device that will allow physicians to measure and study the rhythmic changes in ion potentials caused by up and down movements of the diaphragm and which appear in the form of electrical signals coming from sensors installed at appropriate points of the skin. The curvilinear information thus obtained will surely serve for evaluation of the diaphragm operation, and enable measuring the duration and amplitude of rhythmically repeating spikes of the curve and assess the change of the curve shape.

Having the results of the above mentioned measurements and examining changes in accordance with age and sex of healthy people, it will be possible to study and find out their changes related to assessment and treatment of different pulmonary diseases. The study of the results obtained by the clinical trials of the given device will allow us to conduct new, more profound studies of this scientific direction, thus stimulate further development of the electrocardiograph.

### **Results**

To record or study biological information subdermal or intradermal sensors are used, which, in fact, are converters designed to convert inner ion signals to electrical ones. After amplification of the obtained signals and suppression of signals of corresponding frequency range remains those signals which are in the frequency range selected for study. To solve the stated problem it is necessary to study and measure technical data of sensors in use and reveal physical and chemical phenomena occurring in biological object.

### **Study of sensor**

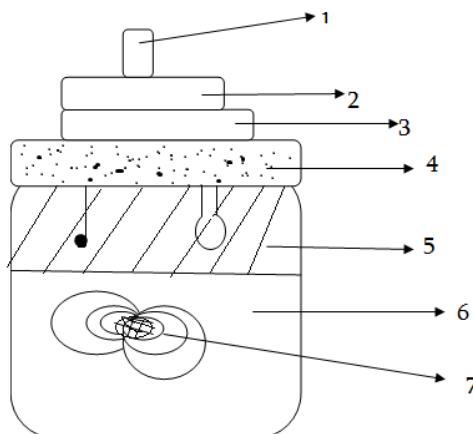
Study of human anatomical and physiological characteristic properties shows that the human organism is a multilevel system consisting of community of interrelated different organs – cells, molecules, ions, chemical elements etc. Separate connections are unlike differ from each other both

qualitatively and chemically. The mentioned differences lay the basis creation of various medical diagnostic methods, where as a diagnostic indices are ultrasonic, optical, x-ray, electromagnetic, magnetic and other physical indices and characteristics for work and survival of a biological object under study. In the framework of the classic electrophysiology on the level of the organs composition are studied such electrical characteristics as sequence of electrical potentials. Bioelectrical measurements are performed by devices developed for medicine and amongst them sensor-electrodes are irreplaceable. Artificial and natural solutions of electrodes as a consequence of influence of inner electrolytes of different composition and different density a electrochemical potential  $\Phi_3$  is developed

$$\Phi_3 = \Phi_{B0} + \Phi_{3X} \quad (1)$$

where  $\Phi_{B0}$  is biological characteristic,  $\Phi_{3X}$  is electrochemical potential on the line

The value of  $\Phi_{3X}$  can changed with time by complex and unforeseen laws. Overlapping of electrical signals may have a negative influence on measurement results, therefore it is necessary in developing biotechnical diagnostic systems to do thorough study of bioelectrical processes at all sensor lines and give a technical justification for a sensors system development in accordance with receiving signals characteristics. Fig. 1 shows one sensor line setting.



**Figure 1. One sensor line setting**

**1-wire, 2-sensor, 3- artificial electrolyte, 4- natural electrolyte, 5- subdermal fat and sweat formation, 6- intradental electrically conductive substances, 7- electrogenerating part.**

### Line potentials

#### Electrode charging in electrode-electrolyte section

In placing of electrode on the skin in electrode-electrolyte section metal cations enter into electrolyte solution due to which a second electrical layer is developed on electrodes. Electrodes' ions interaction with fluid current-conducting layer causes charging in electrode-electrolyte section. As a result of charging the value of  $\Phi_3$  is determined by Nerest's equation depending on chemical activity  $a_Mz$  of the solution

$$\Phi_3 = \Phi^0 + \frac{RT}{Z_F} \lg a_M \quad (2)$$

where  $\Phi^0$  is electrode potential on normal hydrogen electrode,  $R$  is gas factor,  $T$  is absolute temperature,  $Z_F$  is Faraday number.

Between two electrodes placed on the skin a potential difference  $\Phi_{CM}$  occurs which depends on inconsistency between the electrode metals and can be determined by the following equation

$$\Phi_{CM} = \Delta\phi^0 + \frac{RT}{ZF} \lg \frac{a_{M_1}^{z+}}{a_{M_2}^{z+}} \quad (3)$$

where  $\Delta\phi^0$  is a standard potential difference between electrodes,  $a_{M_1}^{z+}$  and  $a_{M_2}^{z+}$  are activities of the first and second electrodes in the electrolyte.

In the absence of external electrical influence we have an electrodynamic equilibrium. Influence of the external electrical field can bring to a dynamic disequilibrium of charges of the second layers of electrodes when the duration will be conditioned by the sum of cycles times and the difference of charges can reach to several hundred

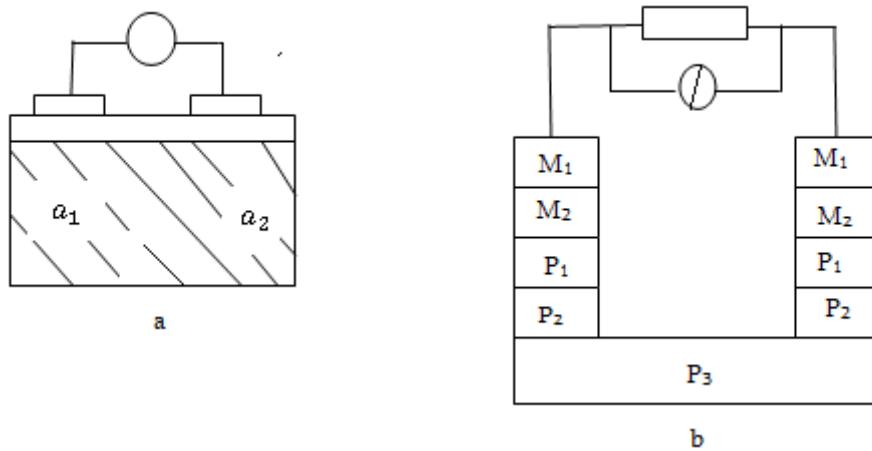
### Diffusion potential

The contact of two electrons possessing different electrochemical properties brings to a situation where the more mobile ions from high concentration fluids travel to fluids of lower concentration, that is a diffusion process begins charging them by positive or negative charge. The diffusion potential is determined by the following equation

$$\Phi_P = \frac{RT}{F} \frac{\lambda_a^\infty - \lambda_K^\infty}{\lambda_a^\infty + \lambda_K^\infty} \ln \frac{a_1}{a_2} \quad (4)$$

where  $\lambda_a^\infty$  and  $\lambda_K^\infty$  is the boundary mobility of anion and cation ions in infinite weakening of concentration, respectively,  $a_1$  and  $a_2$  are ion activity of the line electrolytes between two electrons. Figure 2 shows potentials measuring principal schemes.

The diffusion potential can reach to several hundred millivolts. By selecting symmetric electrodes and ointments of the same electrochemical properties which are equal internal intradental electrolytes the formation of these charges can be neutralized.



**Figure 2. Principal schemes of potential measuring**

**a.** potentials measuring circuit -  $a_1$  and  $a_2$  are indices of current-conducting solutions, **b.** structural diagram of the setting -  $M$  are electrodes and connecting wires,  $P$  are natural and artificial electrolytes.

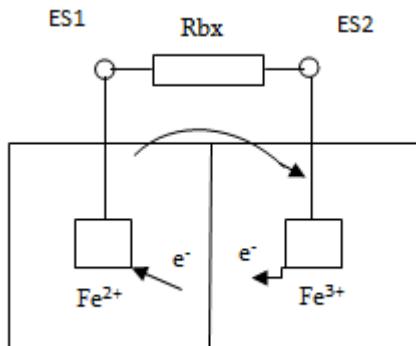
### Potential deviation due to absorption phenomena

Free ions and cations in biological electrolytes can enter into chemical and physical interaction with the electrode and change its potential due to adsorption processes. The change of the potential to negative side can bring organic and inorganic anions, chlorine, bromine, iodine and fatty compounds. Potential change to the positive side can bring cation, amine  $\text{CH}^+$  compounds. Redox reaction is called a process when two reagents interacting with each other from one electrode is conveyed to the other. Discuss this phenomenon referring to a physical model presented on Figure 3. Here in two glassware are filled with the same chemical content but different ferrous iron and ferric iron solutions. This model of the redox reduction pair illustrates a mechanism of a number of processes which run in a living organism, for example, feritin and trasferin. Electrodes in this model are made of platinum. They do not in these solutions therefore ion processes differ from electronic processes.

Ions are forced out from  $\text{Fe}^{3+}$  solution and tend to  $\text{Fe}^{2+}$  solution to produce current in the external circuit, which leads to development of  $\Phi_{0-B}$  potential on  $R_{bx}$  resistance. The potential is determined by the following formula

$$\Phi_{0-B} = \Phi_{0-B}^0 + \frac{RT}{zF} \lg \frac{a_0}{a_b} \quad (6)$$

where  $\Phi_{0-B}$  is the redox reduction potential,  $a_0, a_b$  are acidiferous and reduction activities, respectively. It should be noted that depending on substances potential can reach to several hundred millivolts



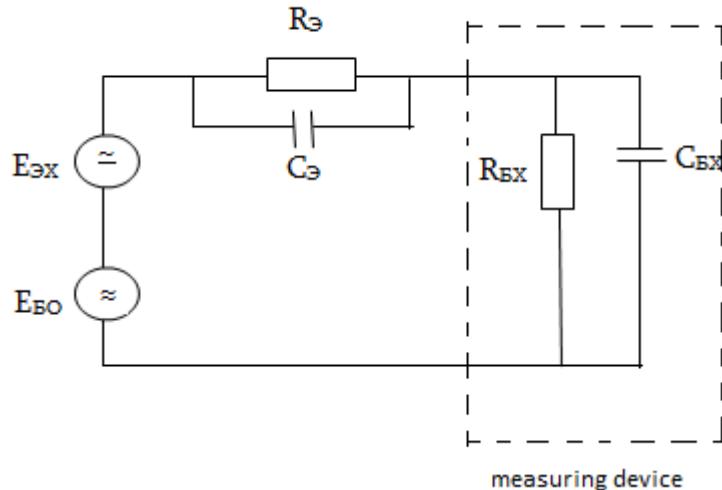
**Figure 3. Electrons movement in case of redox reaction**

Equivalent scheme of a bioobject-electrolyte-electrode-measuring device system can be represented as shown in Figure 4.

$E_{Bo}$  and  $E_{3X}$  are bioelectrical and biochemical potentials, respectively,  $R_3, C_3, R_{Ex}, C_{Ex}$  are indices of the electrode and measuring instrument

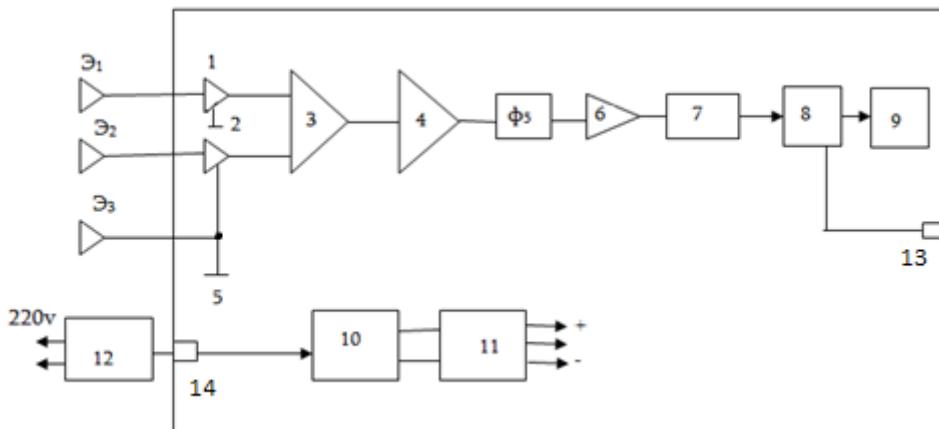
In detailed study of the lead one should also take into account impedance characteristics of the skin, tissues, and organs, especially at the electrode-skin point. biological solutions and electrode contact substance reaction in low and very low frequencies is expressed as active resistance the value of which is inversely proportional to areas of electrodes. In a particular case when microelectrodes are used their capacity  $C_3$  can reach to several microfarads and the resistance to a dozen megaohms. Calculated characteristics  $\Phi_{CM}, R_3, C_3$ , of the electrodes' system and their possible time deviations should be taken into consideration, as in case of coincidence of bioobject and measuring system frequencies differentiation of the real generating biological signal and electrochemical signal becomes very difficult. real Rhythmic changing biological signal and dynamic change of the electrode potential

enable to classify electrodes into two groups – rechargeable electrodes and not rechargeable electrodes.



**Figure 4. Measuring circuit**

Taking into account the above exposition serious problems are encountered in recording the diaphragm movement as the range of the diaphragm frequency nearly 5 times lower from the electrocardiogram range, then all characteristics of electrodes should be taken into account and decrease, if possible, values of changes of obtained signals. It is obvious that Ag-Cl jacketed metal electrodes should be used. The principle block scheme of the device under development can have the view as presented in Figure 5.



**Figure 5. Principle block scheme**

$\Theta_1, \Theta_2, \Theta_3$  Electrode sensors

9. Display

1,2. Voltage adapters

10. Rechargeable accumulator

3,4,6. Voltage amplifiers

11. Voltage regulator

7. Analog-to-digital converter

12. External standard charging device

8. Microprocessor

13. USB

14. Charge switch

### **Conclusions**

Conclusions drawn from the present study are:

Organs of all animals which work in a continuous rhythmic regime surpass repeated biological signals which are in different frequency ranges.

In recording signals of one continuously working organ signals of the other continuously working organ are presented as murmurs for their frequency ranges are different.

Sensors placed on the skin are charged due to electrochemical processes and that charges impede recording of biological signals.

The microprocessor digitized small-sized device developed by the authors enabled with the use of subdermal electrodes for the first time to plot the curve of a diaphragm electrograph in presence of electrocardiogram signals which are considered as noise. To annul these noises research is carried out.

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## ԵԼԵԿՏՐԱՍՏՈԾԱՆԱԳՐԻ ՓՈՔՐԱՉԱՓ ԹՎԱՅՆԱՑՎԱԾ ՍԱՐՔԻ ՄՇԱԿՈՒՄԸ

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Հոդվածը նվիրված է նմանակը չունեցող փոքրաչափ միկրոպրոցեսորային սարքի մշակմանը, որի շնորհիվ հնարավոր կինհի ցուցադրել ստոձանու շարժումներից առաջացած կորագիծը սարքի դիսպլեյի վրա: Սարքի միջոցով կարելի է չափել կորագծի տատանման պարբերությունը, ալիքների տևողությունը և ամպլիտուդան: Մեր կողմից մշակված մեթոդով համապատասխան կետերում տեղադրված ենթամաշկային տվյալներից կարելի է ստանալ բիոլոգիական վերը նշված ինֆորմացիան: Հոդվածում մանրակրիկիտ շարադրված է օրգանիզմում կատարվող էլեկտրաքիմիական գործնականությունը, որոնք խանգարում են տվյալների բիոլոգիական ազդանշանների ստացմանը և տրված են եզրահանգումներ տվյալների ընտրության վերաբերյալ: Տրված է նաև սարքին ներկայացվող պահանջները և մշակվող սարքի բլոկ սխեման:

**Բանալի բառեր.** Տվյալներ, էլեկտրոդներ, բիոազդանշաններ, ստոձանի, լիցք

## РАЗРАБОТКА МАЛОГАБАРИТНОГО ЦИФРОВОГО ЭЛЕКТРОДИАФРАГМОГРАФА

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Работа посвящена разработке малогабаритного, микропроцессорного прибора, не имеющего аналога. Прибор показывает на собственном цветном графическом дисплее работу диафрагмы в реальном масштабе времени. В полуавтоматическом режиме можно измерить ритм дыхания, длительность и амплитуду кривых, полученной информации. Биологическая информация снимается с помощью трех нательных электродов, установленных в определенных точках грудной клетки. В статье подробно рассматриваются электрохимические процессы, происходящие в организме при установке электродов. Дается рекомендация по подбору электродов, а также приводятся блок-схема прибора и технические требования к нему.

**Ключевые слова.** Датчики, электроды, биосигнал, диафрагма, заряд

## DETERMINATION OF THE ANANUN RIVER SILT REGIME CHARACTERISTICS IN THE SITE OF MUSHEGH SMALL HYDRO POWER PLANT HEADWORK

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*The last decade has seen construction of many small hydro power plants on mountain rivers and their tributaries where no hydrometric measurements have been made. The carried out analysis has shown that the efficiency of the majority of small hydro power plants is smaller than the designed one. The reason lies in not reliable calculations of hydrological parameters of streams. Probability of inaccuracy increases during determination of silt flow. Taking into consideration of importance of correct determination of hydrological parameters the paper intends on the example of the operating Mushegh small scale hydro power facility to suggest forecasting techniques for monthly average flow of silt and their annual flow. The obtained results will enable to make corrections in operating regime of the facility.*

**Keywords:** watercourse, silt, operating regime, hydro facility.

### **Introduction**

In the last two years in the Republic of Armenia and Mountainous Karabagh many small scale hydro power plants have been built on not large rivers and their tributaries. Flows of these streams are of clearly defined seasonal character. The ratio of their average monthly minimum and maximum values from time to time exceeds 100. In such conditions for reliable design and effective operation of small scale hydro power plants it is important to correctly evaluate hydrological characteristics of water streams. Yet this problem is often solved with many essential faults. For the absolute majority of active stream of water results of hydrological measurements are wanting. For that reason flows of water streams are determined by calculation or some other techniques [1,2]. In some cases as an analogue one of nearby running rivers is chosen of which hydrological row exists.

In hydrological calculations the probability of inaccuracies increases far more during determination of silt flows. It should be noted that reliable determination of the quantity of silt is very important in terms of calculation of small hydro plants headworks dimensions and safe operation of the entire power system. In addition for small rivers no forecast of silt flow determination often is performed. The problem of that flows removal usually is left on the operating personnel but not always the personnel is enough qualified to solve that problem. Because of hydrological calculations imperfection the majority of presently acting in the Republic of Armenia small hydro power facilities is operated far more below of the designed efficiency. It is well proved that the water stream containing silt and sediments quantities exceeding the permissible level entering in the power house develop intensive wear of turbine blades.

The best part of the above mentioned drawbacks are characteristic of the Mushegh small scale hydro power facility built in Jeruk town, Vayots Dzor province, the Republic of Armenia on the Ananun river which is tributary of the Arpa river.

### **Conflict settings**

Taking into consideration the importance of correct determination of hydrological parameters for both Mushegh small scale hydro power facility and other small scale hydro power plants of the region in the present work by the example of the Mushegh small hydro power facility a prediction technique for determination of silt average monthly quantities is suggested.

### Research results

Water feed to the Mushegh small hydro facility is performed from the Ananun river and Sarnaghbiur springs.

Sarnaghbiur springs all the year round have a relatively uniform yield ( $0.5\text{m}^3/\text{s}$  on an average). To determine the average monthly discharge of the Ananun river a method of an analogue river was employed.

In the first version as an analogue river was taken the nearest Dali tributary. There is a very short period (4 years) of monitoring of that tributary. In this case according to calculations the average annual flow quantity of the Ananun river is  $0.34\text{m}^3/\text{s}$ .

In the second version as an analogue river was taken the Arpa river (Jermuk station) where there is a most presentable row of observations. Calculations have shown that in this case the average annual flow of the Ananun river is  $0.63\text{m}^3/\text{s}$ . As design data of average values of the two versions were taken into consideration. The obtained results are in Table I. Taking into account Sarnaghbiur springs' runoff in the dam site water intake of the Mushegh small hydro power facility the average annual flow quantity is  $0.98\text{m}^3/\text{s}$ .

Let us assuming as a basis of the Ananun small river monthly flows determine their respective silt flow. On the basis of results pf many years studies in the region conditions the following functional relation has been obtained for suspended (floating in the water column) silt flow [3].

$$Q_T = 0,72 Q_w^{0,95}, \quad (1)$$

Where  $Q_w$  is the water flow in  $\text{m}^3/\text{s}$ .

Now let us try on the basis of the above formula to determine the average monthly suspended silt flows of the Ananun small river. As for the flow of bedded or settled on the bottom of a body of water silt it should be noted that for this region in calculation that flow is taken equal to the half of suspended silt flow [3]. The results of silts flows calculations are tabulated in Table2. The analysis of obtained values has shown that for both the fluid and silt flows have clearly defined seasonal character. Particularly, only in April, May, and June flows are larger than for the rest nine months of the year. Let us determine the volume of all silt transported by the stream during one year.

Assuming volume density of suspended silt equal to  $1200-1300\text{kg/m}^3$ , total volume of them transported by the Ananun small river can be during one year can be calculated by the following formula

$$W_{sus} = \frac{0,37 * 365 * 24 * 3600}{1250} = 9300 \text{ m}^3$$

Studies of many years have shown that about 50-60 per cent of suspended silt are particles smaller than  $0,05\text{mm}$ . They are transient and don't deposited even at very slow rates. Therefore, the volume of deposited suspended silt at the Mushegh small hydro power facility headworks will be

$$W_{sed} = 4650 \text{ m}^3$$

Parameter	I	II	III	IV	V	VI	VII	VIII	IX	X	XII	XII	Average annual
Average monthly discharge of the Ananun river (analogue of the Dali river)	0,12	0,12	0,18	1,1	1,56	0,26	0,11	0,09	0,08	0,08	0,09	0,09	0,34
Average monthly discharge of the Ananun river (analogue of the Arpa river)	0,28	0,27	0,29	0,72	2,33	1,53	0,58	0,36	0,32	0,32	0,30	0,29	0,63
Average of the two methods	0,2	0,2	0,23	0,91	1,95	0,9	0,35	0,22	0,2	0,2	0,2	0,19	0,49
Average flows taking into account Sarnaghbiur springs	0,7	0,7	0,73	1,41	2,45	1,4	0,85	0,72	0,7	0,7	0,7	0,69	0,98

**Table 2****Average monthly water discharge and its respective silt in the site of the water intake of the Mushegh small scale hydro power facility**

Parameter	I	II	III	IV	V	VI	VII	VIII	IX	X	XII	XII	Average annual
Design water discharge, $Q_w$ m <sup>3</sup> /s	0,2	0,2	0,23	0,91	1,95	0,9	0,35	0,22	0,2	0,2	0,2	0,19	0,49
Flow of suspended silt, $Q_T$ kg/s	0,16	0,16	0,18	0,66	1,36	0,65	0,27	0,17	0,16	0,16	0,16	0,15	0,37
Flow of bottom sediments, $q_T$ kg/s	0,08	0,08	0,09	0,33	0,68	0,33	0,14	0,09	0,08	0,08	0,08	0,08	0,19

As noted above the quantity of bottom silt is also amount to the half of suspended silt. However, their density ranges within 1900 to 2100 kg/m<sup>3</sup>. Therefore, the volume of bottom silt will be

$$W_{bed} \frac{0,37/2 * 365 * 24 * 3600}{2000} = 3000 \text{ m}^3$$

Thus, during one year the total volume of bottom and suspended silt transported by the Ananun small river and deposited at the Mushegh small hydro power facility headworks will be

$$W_H = W_{sed} + W_{bed} = 4650 + 3000 = 7650 \text{ m}^3$$

By predicted flows of silt the value of obtained annual volume of silt was compared with that calculated by another technique. It is the calculation method for determination of ground volume transported by flood streams [4], and accordingly we get

$$W_{sed} = 19Q_{\max}^{1,4} I^2 \quad (2)$$

where  $W_{sed}$  is the volume of deposited silt (in thousand cubic meters),  $Q_{\max}$  is the maximum calculated value of flood flow (in m<sup>3</sup>/s),  $I$  is river-bed slope in the area under study. For the Ananun small river we have  $Q_{\max} = 3,2$  m<sup>3</sup>/s (5 per cent in case of safety),  $I = 0,25$ . Under the given conditions the volume of accumulated silt according to Eq.(2) amounts to around 6500m<sup>3</sup>. In case of problems similar to the one discussed in this work a close agreement of two values of silt volume calculated by a variety of ways may be deemed to be satisfactory.

### Conclusion

The results obtained in the work enable to predict the annual distribution of silt at the Mushegh small hydro power facility headworks and calculate the accumulated volume. Developments done in this paper can be used in prediction of silt regime for water streams having no hydrological measurements.

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## ԱՆԱՆՈՒՆ ԳԵՏԻ ԶՐԱԲԵՐՈՒԿԱՅԻՆ ՌԵԺԻՄԻ ԲՆՈՒԹԱԳՐԵՐԻ ՈՐՈՇՈՒՄԸ ՄՈՒՇԵԴ ՓՀԵԿ-ի ԳԼԽԱՄԱՍԻ ԳԵՏԱՀԱՏՈՒՅԹՈՒՄ

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Շուշիի գետնողոգիական համալսարան**

Վերջին տասնամյակում շատ փոքր ՀԵԿ-եր են կառուցվել լեռնային գետերի և դրանց վլուակների վրա, որտեղ բացակայում է հոսքի հիդրոմետրիկական չափումները: Վերլուծությունը ցույց է տալիս, որ ՓՀԵԿ-երի հիմնական մասը աշխատում է նախագծայինից զգայի ցածր արդյունավետությամբ: Պատճառը ջրահոսքերի հիդրոլոգիական պարամետրերի մեծությունների ոչ հոսալի հաշվարկումն է: Անճշտությունների հավանականությունը առավել մեծանում է ջրաբերուկների ելքերի որոշման ժամանակ: Հաշվի առնելով հիդրոլոգիական պարամետրերի ճիշտ որոշման կարևորությունը աշխատանքում խնդիր է դրվել շահագործվող Մուշեդ ՓՀԵԿ-ի օրինակով առաջարկել ջրաբերուկների ելքի միջին ամսեկան արժեքների և դրանց տարեկան հոսքի կանխատեսման եղանակներ: Ստացված արդյունքները հնարավորություն կտան ճշգրտումներ մտցնել կառույցի շահագործման ռեժիմում:

**Բանալի բառեր.** ջրահոսք, ջրաբերուկ, ելք, շահագործման ռեժիմ, հիդրոտեխնիկական կառուցվածք:

## **ОПРЕДЕЛЕНИЕ ХАРАКТЕРИСТИК НАНОСНОГО РЕЖИМА р. АНАНУН В СТВОРЕ ГОЛОВНОГО УЗЛА МГЭС МУШЕГ**

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За последние десятилетие были построены многочисленные МГЭС на горных реках и их притоках, где отсутствует гидрометрические параметры потока. Анализ показывает, что большинство МГЭС работают со значительно меньшей производительностью, чем было проектировано. Причиной тому является не учет реальных гидрологических параметров потоков. Вероятность неточностей увеличивается при определении расхода наносов. Учитывая важность определения гидрологических параметров, в работе поставлена задача предложить метод предвидения среднемесячного расхода наносов и их годового стока, на примере эксплуатируемой МГЭС «Мушег». Полученные результаты дадут возможность для внесения коррекций в режим эксплуатации сооружения.

**Ключевые слова:** поток, нанос, расход, режим эксплуатации, гидротехническое сооружение.

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## PROBLEMS OF HYDROMORPHIC SALINE HOLLOW RECLAMATION STATE IMPROVEMENT AND THEIR SOLUTIONS

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*Solutions of hydromorphic saline hollows' problems are directly related to implementation of open circulation of salt-water balance of "irrigation – aeration zone-ground-drainage water" system. This is possible by management of drainage systems operation mode and correct calculation of parameters which will also enable to use a certain volume of drainage flow for irrigation purposes.*

**Key words.** *hydromorphic, salinization, desalting, drainage, saline balance.*

### **Introduction**

In tropical and subtropical mountain regions of streams waters accumulation and discharge are located hydromorphic hollows. Their formation is conditioned by flow of streams of surface and underground waters from regions where uppermost mountain ranges are fed and displaced from regions of middle elevation to lowland areas. The cause of that natural phenomena are atmospheric precipitations which finally are accumulated in intermountain hollows thus forming hydromorphic reclamation mode (waterbearing stratum of strong and weak pressures) [1-7].

### **Research results**

The cause of the above phenomenon are atmospheric precipitations which eventually are accumulated in intermountain hollows forming hydromorphic reclamation regimes in strong artesian and some certain areas (like Ararat valley) as well as subartesian weak pressure aquifers [1-7]. Streams flowing along the downslope transport different chemical elements worn away from rock layers, which eventually turn into sulfate, chlorine and sodic salts in Ararat and many other hollows. Under these conditions three natural negative processes are becoming prevalent [2,3,6,8-11]:

- increasing the mineralization of underground water,
- formation of groundwater low depths according to earth's surface, creating hydromorphic reclamation condition,
- salinization of soil-ground aeration zone.

The mineralization of hydromorphic saline groundwater of hollows is exceeding the permissible levels (0,5-1g/l), totaling from 1 to 8g/l and more. In Ararat Plain decreased from 8 -10g/l [2] and in 2014 does not exceed 3.5 g /l [1].

Ground water depths are ranging from 0-3-3,5m [1-7] which causes an intense surface evaporation at the expense of underground water resources.

The main reasons for hollow salinization are the high mineralization of groundwater and it's close distance from the earth surface, which is accompanied by intense evaporation - accumulating salts in the soil. The above mentioned negative natural processes are accompanied by deterioration of active soil layer reclamation state, and therefore not normal crop development (harvest fall).

An important circumstance is also the groundwater location small depths (0 to 3)m are located on not optimal close distances from crop root system. Therefore, subsoil irrigation takes place with impermissible high mineralization water. In other words, for normal development of crops, plants feeding with groundwater must be avoided.

From the aforesaid it follows, that for the improvement of hydromorphic saline hollows most important measures to be taken are the following:

- regulation of groundwater location,
- chemical reclamation (mainly for strong, and very strong soils),
- soil desalinization,
- to provide conditions for crops normal development.

Solution of the mentioned problems will allow to implement:

- 1) reduction of hydrodynamic pressure impact on the groundwater location,
- 2) neutralization of the basic reaction of sodic saline salts,
- 3) lowering of groundwater location,
- 4) creation of optimal depths for crops,
- 5) exception of subsoil irrigation, if the mineralization of groundwater is higher than the maximum permissible level,
- 6) prevent irrigation water secondary salinization from soil ,
- 7) procurement of irrigation water on the expense of groundwater, which will provide reduction of cost price and evaporation,

To raise soil fertility certain agricultural techniques and land reclamation measures (humus, organic matter, minerals, nutrients, etc.) will be needed.

Researchers of many countries (including Armenia) have tried to find solutions for the problems mentioned in the purpose of reclaiming sodic saline-alkaline soil, in case of plateau soil-hydrogeological different conditions [2-14], grouping this soils into two types:

- weak and medium salinized,
- strong and very strong salinized.

To chemical reclamation is subjected mainly the soils of second class [9-12].

Hydromorphic sodic saline soils are also located in Ararat plain which is surrounded by Ararat, Aragatsotn and Geghama mountain ranges. Problems related to underground water were included in work programs and analyzed by the Ministry of Water Economy of Armenia (1925-1948), then in Hydraulic Engineering and Land Reclamation (1949-1963) and in Water Problems and Hydro-engineering (from 1964 up to date) institutes [2-8, 13-15]. Application of vertical drainage in USSR territory was first implemented in Armenia - in Arazdayan steppe in 1930 (Kostiakov A.N., Agricultural Amelioration., M., Nauka, 1959).

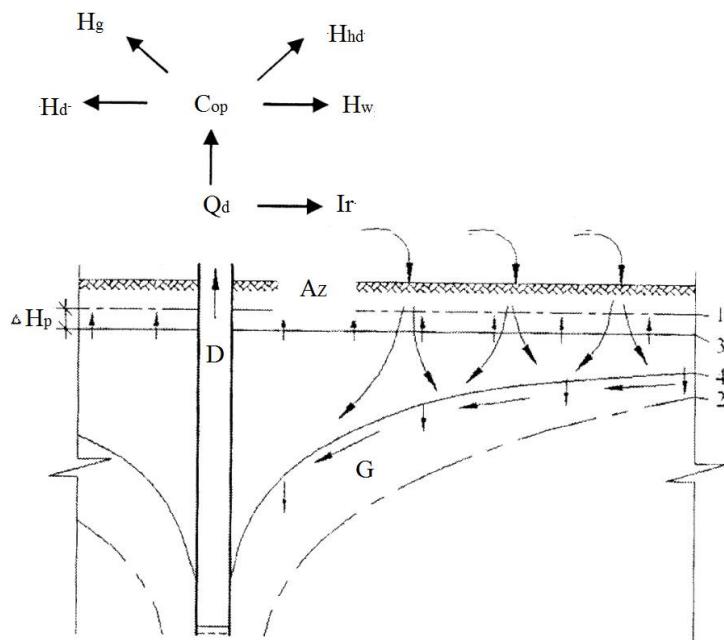
Issues of Ararat hydromorphic hollow sodic saline salt chemical reclamation still in 1942-1957 period were included in work programs of the Soil Science Sector of the Academy of Sciences of Armenia , and from 1958 up till now in programs of the Research Institute of Soil Science, Agrochemistry and Land Reclamation of RA [10.11].

Ecological crises are unavoidable in hydromorphic hollows. To fight against these crises hydraulic facilities, such as drainage systems, have been constructed, which are able to change location of ground waters as needed, decrease the groundwater mineralization, create optimal defined by differences of groundwater ( $H_g$ ) and piezometric line ( $H_p$ ) location, as shown in Figure 1.

$$(\Delta H_p)=H_g-H_p \quad (1)$$

In conditions of Ararat hydromorphic plain the vertical and horizontal drains long-term operation experience confirms that in case of  $\Delta H_p=5-20$  cm, the horizontal drainage operation is economically profitable, while in case of-  $\Delta H_p> 20$  cm - the vertical is more profitable.

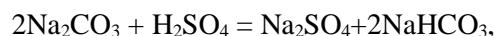
Open or closed horizontal drainage optimum depths are ranging from 3 to 3.5 m with the persuasion radius from 200m to 250 m, and the watershed depth is 3.5-4-4.5 m (by the example of the Ararat Valley). Electric pumps with 60-80 l/s performance of vertical drainage provides reduction of hydrodynamic pressure and groundwater location, in radius  $R = 500 -550$ m and 2.5 m average depth [2-6,13,14].



**Figure 1. Components of drain water usage expressed in percentage norms**

Ir - irrigation water; Cop - openness degree of the salt water balance; Hd - drain; Hg - desalination; H<sub>ag</sub> - desalination of the zone; H<sub>hd</sub> - taking into account hydrodynamic pressure; H<sub>w</sub> - irrigation flow of washing regime; Az - zone of aeration; G - ground water; D - drainage; ΔH<sub>p</sub> - piezometric pressure, cm.

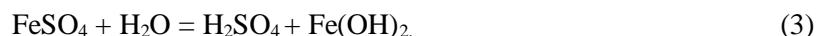
After regulation of groundwater location the implementation of chemical reclamation is becoming the priority task. Reclamation of sodic saline salts with sulfuric acid is accompanied by counteraction of basic and acidic factors, in the result of which the light-lilac water vapor rises from water and soil surfaces is visible to the naked eye. Therefore, the chemical reclamation is accompanied by causing an undesirable ecological environment. However, chemical reclamation is a compulsory necessity for neutralization of some basic and physical-and-chemical reactions. Thus, during chemical reclamation by sulfuric acid the following counteractions take place [10, 11]:



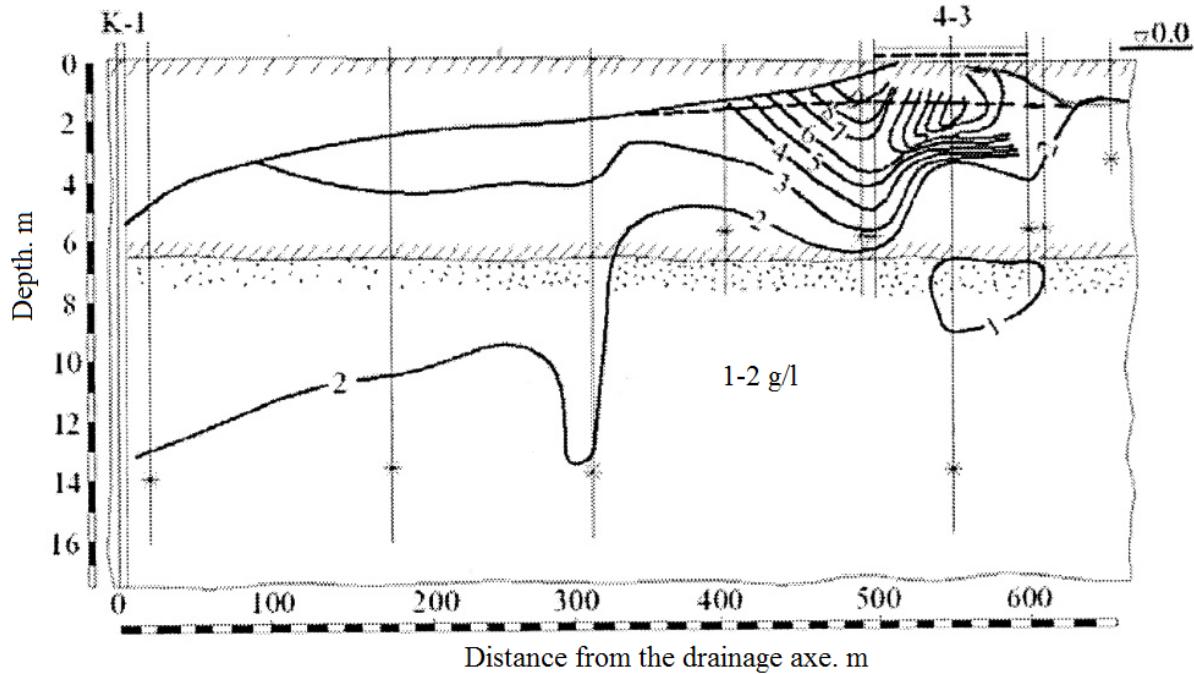
then,



and in case of using  $\text{FeSO}_4$ , due to hydrolysis free sulfuric acid and iron hydroxide are obtained.



The basic reaction in a soil substrate is neutralized due to the chemical influence between sulfuric acid and sodium, calcium and magnesium carbonates and bicarbonates of sulphuric acid. Due to these processes water soluble salts appear, which by thorough wash out are transported into much deeper layers of the ground [4,5,10,11]. This process is accompanied by reduction of hydrodynamic pressure and upward transportation of underground water, removing with it the natural salts formed from the soil and the ameliorant. Therefore, it is necessary to carry out desalting of the deeper layers to avoid a further secondary salinization. (Figures 1 and 2) [4, 5, 8,13,15].



**Figure 2. Isolines of groundwater mineralization according to the depth 3 during the oxidation process**

Chemical reclamation experience of Ararat valley saline soil (with 0,8-1,2% sulfuric acid solution or with  $\text{Fe}_2\text{SO}_4$ ) confirms that the portions of natural salts (from 0,2 to 0,7 percent) in the 0-1 m layer of the ground – increase by around 7 -10 times. It is conditioned by the acid volume (from 40-50 to 80-120 t/ha in case of 80-90 percent  $\text{H}_2\text{SO}_4$ ) [4,8,10,11]. The current situation necessitates to implement thorough washing with irrigation water, the inevitable consequence of which becomes rising of groundwater level up to 0,3-0,5 m according to the ground surface. As a result to 2-3 week's intensive work of drainage, the artificial „pads” of 12-15 g/l mineralization are formed on the free surface of groundwater, (which is a result of a chemical ameliorant) and due to the intensive washing become smaller to 3-5 g/l. Desalination role of drainage is obvious: the initial mineralization of drainage are also reduced from 5-7 g/l to 1,5-1,8 g/l [4,5,8,13,15]. With the aid of thorough washing in the first year of vertical drainage ( $Q_d = 40-60 \text{ l/s}$  capacity) removes from 3 to 2,5 thousand tons of salt, and in the next 2-3 years from 1 to 0,5 and after , 4-5 years 1-0,5, 0,5-0,2 thousand tones (Fig. 2,[4,13]).

It is obvious, that the upper layers of ground are being desalinated, but its deeper masses and ground water detain impermissible quantities of salts for much longer period of time. A question arises „what kind of measures are important to be taken to desalinate the aeration zone and groundwater?”. This is a problem, and its solution requires regulation of drainage flow of water systems by correct choice of their work regime. Therefore, the issue of drain water regulation should include the saline balance in the region and all the processes of implementation.

Results of long-term investigations of Ararat hydromorphic salinized hollows allowed to draw an equation of drainage ( $Q_d$ ) (Figure 1 [8]).

$$Q_d = I_r + C_{op} = I_r + H_d + H_g + H_{hd} + H_w, \quad (4)$$

where  $I_r$ -is the irrigation water,  $C_{op}$ - «irrigation – ( $I_r$ ) - aeration zone ( $A_z$ ) - ground water (Gw) – drainage ( $D_r$ )» (W-A<sub>z</sub>-G-D) the openness portion of system water-salt balance,  $H_d$  - drain norm [9],  $H_g$ -groundwater desalination norm,  $H_{hd}$  - hydrodynamic pressure norm,  $H_{iw}$ -irrigation washing regime norm.

Values of salt water budget equation (4) components of irrigation water-aeration zone-ground-drainage by the example of Ararat plain non-saline and weak and medium saline soils are tabulated below [8]. These data can also be used in case of ground subjected to chemical land reclamation and thorough wash up as non-saline.

**Table 1****Portions of factors characterizing Ararat hydromorphic hollow soil-hydrogeological conditions**

Soil- hydrogeological factors	Portions by soil type non saline soil	Weak and medium saline
Drain norm, according to the irrigation intake volume, Hd, %	5-6,4	22,4-26,2
Groundwater desalination norm, Hg, %	5,2-6,4	18,9-23,1
Removal norm of salts obtained from the hydrodynamic pressure, H <sub>hd</sub> , %	(0,01-0,02)Qd	(0,02-0,05)Qd
Washing regime norm of irrigation, Hiw, %	-	1,25 M <sup>1)</sup>
Openness of salt-water balance, Cop, %	10,2-12,8	41,3 +49,4+0,25M
Irrigation water, I, %	89,8 – 87,2	(~58,7-50,6)-0,25M

1) M – Irrigation norm in non-saline soils.

Lowering of groundwater location through drainage systems of hydromorphic hollows is not the final solution to the problem, as for different crops groups (short, medium and long-root) it is necessary to have different depths [4,6]. In other words, for each group it is necessary to provide optimal groundwater depth, in which case we will have a stable and high yield.

By the results of Ararat Valley (1962-1989) and Gegharkunik Region (2005-2007) surveys have been developed optimal depths for different groups of crops(Hop), conditioned with their full root system(h<sub>f</sub>) and aeration zone capillary water rim zone height from the groundwater [14].

$$H_{op}=1,1h_f+Kh_r \quad (2)$$

where, K - coefficient of capillary water rim, in the case of 1,2,3-short, medium, long root crops respectively (Table 2).

**Table 2****Ground water location shall optimal depths for different groups of crops ( medium and heavy, light and medium clay)**

Crop group according to root length	Total length of root system, h <sub>f</sub> , m	Coefficient of capillary water rim, K	Groundwater location length from hw, Kh <sub>r</sub> , m	Optimal depth of ground water location, Hop, m
Short	0,5-0,6	1	0,40-0,45	0,95-1,05
Medium	0,6-0,9	2	0,80-0,90	1,6-1,80
Long	0,9-1,2	3	1,2-1,35	2,20-2,60

The results of long-term field surveys carried out in (Table 1 and 2) confirm that due to intensive drainage system activity it is possible to solve a number of problems related to hydromorphic saline hollow reclamation improvement, and usage of certain volume of drain water as well (equation, Table 1). The usage portions of water is conditioned by the degree of mineralization.

## Conclusion

The main issue in improving reclamation conditions of a hydromorphic saline hollow is to regulate the ground water location depths. To solve this problem a compulsive necessity through drain flow to implement openness of "irrigation – aeration zone- groundwater and drainage water" system water-salt balance of circulation. The intensive activity of the system allows to regulate groundwater location, preventing soil secondary salinization, providing aeration zone desalinization, normal development of crops, decreasing of groundwater mineralization and usage of certain volume of drainage for irrigation as well.

*The work has been performed within the framework of 15T-2K136 theme.*

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**ՀԻԴՐՈՄՈՐՖ ԱՊԱԿԱԼՎԱԾ ԳՈԳԱՀՈՎԻՏՆԵՐԻ ՄԵԼԻՈՐԱՏԻՎ ՎԻՃԱԿԻ ԲԱՐԵԼԱՎՄԱՆ  
ԽՆԴԻՐՆԵՐԸ ԵՎ ԼՈՒՇՈՒՄՆԵՐԸ**

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Հիդրոմորֆ աղակալված գոգահովիտների խնդիրների լուծումներն ուղղակիորեն առնչվում են «ոռոգման-աերացիայի գոտու-գրունտային-դրենաժային ջրեր» համակարգի աղաջրային հաշվեկշռի ոչ փակ շրջապատճենի իրականացմանը:

Դա հնարավոր է դրենաժային համակարգի աշխատանքի ռեժիմի կառավարման և պարամետրերի ճիշտ հաշվարկների միջոցով, որոնք թույլ կտան նաև դրենահոսքի որոշակի ծավալի օգտագործում ոռոգման նպատակով:

**Բանալի բառեր.**Հիդրոմորֆ, աղակալում, աղազերծում, դրենաժ, աղաջրային հաշվեկշիռ:

## **ЗАДАЧИ УЛУЧШЕНИЯ МЕЛИОРАТИВНОГО СОСТОЯНИЯ ЗАСОЛЕННЫХ ГИДРОМОРНЫХ КОТЛОВИН И ИХ РЕШЕНИЯ**

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Решение задач засоленных гидроморфных котловин связывается непосредственно с осуществлением незамкнутого цикла водно-солевого баланса системы «оросительные-зоны аэрации грунтовые-дренажные воды». Это возможно путем управления режимом работы дренажных систем и правильного определения параметров дренажа, что также предоставит возможность использовать определенный объем дренажного стока с целью орошения.

**Ключевые слова:** гидроморфный, засоление, рассоление, дренаж, водно-солевой баланс.

UDC 556:626:627.5

## ON ROUGHNESS COEFFICIENT IN MOVEMENT OF SEDIMENT CARRYING FLOWS

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*Existing formulas for determination of roughness coefficient relates to deformable, natural channels. Moreover, most of them have been suggested only for particular cases, namely, for mountain streams of small concentration. Recommendations applicable for sediment carrying streams of large concentration practically are not available in the literature, all the more, for mudflows moving on tough, rigid channels, specifically, in case of the limit sediment carrying capacity of the flow.*

**Key words:** water, river, channel, flood, turbulence, reservoir, anti-mudflow.

### **Introduction**

In mountainous and submountain regions a certain part of the land located in a zone of the destructive action of mud-and-stone flows. The area of such zone under anthropogenic impact can undergo essential increased. Restoration of damaged areas in consequence becomes difficult, therefore, all necessary measures should be taken to minimize development of negative processes including mudrock streams causing disruption of relatively stable landscapes surface conditions.

Powerful mudflows are formed, mainly, in erosion cuts representing a whole system of channels in the upper reaches of mountain streams, which, as a result of continuous destruction of rocks and their quick movement down the side of a mountain or hill, are filled with a mass of soft, wet, unconsolidated earth and debris, then affected by weathering, crushing and grinding under the influence of various factors [1].

The slippery mass of mud, formed as a result of such events envelops (in a mixture with crushed rocks) pyroclastic rock and fills the voids between them. The mud mixture prepared in this way in the erosive cuttings is in a connected state - enough rainfall, intense thawing of snow or other causes, triggered a collapse down, grabbing rock fragments, stones, trees, etc. along the way. Morainic and subglacial deposits are often also components of an already prepared mud mixture. If the moraine deposits are saturated with water by 10-20% (by weight), then the formed mud-and-stone flow travels rushing down a steep slope very quickly [2].

In the absence of glaciers, the collapse of subglacial deposits also causes their movement. M

Mud-and-stone flows in such centres occur without heavy rains. Mudrock flows can also be formed on bared surfaces of steep slopes in the upper reaches of mountain streams when a long dry season is followed by excessive rains. As a result, almost the entire surface of the centre is covered with a layer of dust, and since it is waterproof, almost one hundred percent runoff of storm precipitation occurs in the form of a mudrock mass, which entrains a large amount of debris in its movement.

The formed mixture moves along the channel of the watercourse in the form of a cohesive (structural) mud-and-stone flow (if the amount of rainfall is in the range of 10-20% of the weight of the entire mudflow mixture) or a not cohesive stream (the amount of rainfall is 70-80% of the whole mixture weight) or storm rainfall (the amount of storm precipitation is more than 95% of the total mixture [2].) Thus, a structured (cohesive) muddy (mud-and-stone mixture) stream consists of rock

debris, crushed stone, plant residues, and covering them mud components. Such flow contains 80 ÷ 90% (by weight) of solid material and 10 ÷ 20% of water (in a bound state). The density of such a mixture is  $1.8 \div 2.3 \text{ t/m}^3$ , the driving medium is a plastic mud-and-stone conglomerate. Turbulent mudflow is an aqueous medium enriched with a colloidal suspension, it conveys a chippy mass and some large stones, its density varies from 1,1 to  $1.7 \text{ t/m}^3$ , solid inclusions within 10 ÷ 70 percent.

The transporting medium is a water-colloidal mixture. As can be seen from the foregoing, mudrock flows, depending on the density, can be attributed to both Newtonian and non-Newtonian fluids. Therefore, in solving specific practical problems, it is required to use the laws of mechanics of both Newtonian and non-Newtonian fluids. It should also be noted that in the stream of water, where bound mudflows are formed, it is also possible to form inbound mudflows. Where such mudflows are formed, the formation (in this particular basin) of bound mudflows is not necessary [1, 2].

A precise estimate of the resistance of the channel plays an important role in determining the values of the flow velocities. For a purely water flow, this problem can be solved successfully, for the roughness factor  $n$  is set in dependence on the material which constitute the channel bottom and the walls. The values of  $n$  for different types of channels are listed in the tables [3].

For mountain and mudrock flows, the solution of the problem of determining the resistance of the bed and, especially, the roughness coefficient becomes much more complicated. As field and laboratory studies show, the dynamics of sediment carrying flows, the roughness coefficient in this case, even in the developed turbulence, depends not only on the roughness of the channel material, but also on a number of the flow and sediment characteristics.

In [4], a detailed analysis of works of a number of authors (Yu.V. Chernov, R.A. Shestakov, B.A. Topchevskaya, G.V. Zheleznyakova, A.K. Ananyan and others), where indicate the influence of the channel slope, the Froude number and other parameters on the roughness coefficient is indicated has been presented. And in the work of O.M. Ayvazyan [5], it is noted that the coefficient  $n$  depends on the slope or on the Froude number not only in sediment carrying flows, but also when the water flow moves in channels with high and/or reinforced roughness.

When generalizing the experimental data obtained for trays with reinforced roughness, A.A. Alekperov [6] also indicates the presence of the effect of the slope on the roughness coefficient.

Artificial, reinforced roughness is developed in rapid channels with the aim of reducing the kinetic energy of the flow. The heights of the reinforced roughness are also developed in natural channels in which fine particles are washed out under the impact of the flow and the unconsolidated large boulders form a naturally reinforced roughness. As pointed out in the work of M.A. Velikanov [7], in such problems "... we have a case of channels of extreme roughness, generally little explored experimentally, where the resistance increases very rapidly with speed."

**Conflict settings.** A number of formulas are available for determining the roughness coefficient for sediment carrying flows. Existing in the literature dependencies, almost without exception, refer to natural, deformable channels. For artificial structures this problem has not yet been solved and is of a certain practical importance.

**Research results.** Mountain streams and sediment carrying flows slightly differ from each other in terms of qualitative structure of the resistance formation. If roughness heights (boulders) are mainly consolidated along the bottom in mountain beds, then in sediment carrying streams the role of such protrusions is played by large and medium-size particles of moving sediments (especially in man-made structures - channels), whose speed is quite lower than the average velocity of the flow itself. If the average flow velocity is taken equal to the difference of the above two velocities, then in such a case the sediments relative to the flow will be in a relative rest, as if fixed to the bottom.

One of the first formulas for determining the roughness coefficient for mountain sediment carrying flows is the Shtrikler-Chang formula [8]

$$n = Kd_o^{1/6}, \quad (1)$$

where  $K$  is the experimental dimension coefficient. According to the Strikler,  $K = 0.047$ , according to Chang,  $K = 0.052$ ;  $d_o$  is average diameter of bottom sediments or self-paving, m.

Later, the structure of the formula (1.8) was used and confirmed by other researchers. In particular, for different ranges of variation of the ratio  $h/d_o$  ( $h$  is the depth of the flow) V.F.Talmas and A.N.Kroshkin suggested corresponding values for  $K$  and the exponent for  $d_o$  [9, 10].

Later, by using the formula that determines the diameter of the bottom sediments, they propose the following expression for determining the coefficient of roughness of mountain rivers:

$$n = A \cdot (h \cdot i)^m, \quad (2)$$

where  $A$  and  $m$  are determined as a function of  $h/d_o$ .

A form similar to formula (1.9) has a V.M. Makkaveeva's semiempirical formula [11], which he derived from some theoretical considerations using the full-scale measurements on the Rhine River.

Formulas (1) and (2) and similar to them expressions have the following drawbacks: each of them is valid only for a certain interval of hydraulic and granulometric parameters of flow and self-paving of the channel, there do not take into account the influence of the amount of sediment load. For highly saturated streams this parameter is quite essential.

The velocity of the sediment carrying flow is the most important factor determining its dynamics. Unlike single-phase flow, the two-phase one is inhomogeneous. Constantly changing factors impart the movement a more unsteady character. The interaction of sediment and water in the process of movement, the channel characteristics are variable (sometimes very sharply), to which the solid and liquid phases react differently, complicate and make difficult the solution of the problem.

Therefore, the possibility of obtaining reliable theoretical dependences, particularly, for determining the mudflow rate, now is practically impossible. The solution of this problem even in simple cases, when the flow is uniformly steady-state, presents serious difficulties.

As for the experimental field data, they have been accumulated in a sufficient amount for the water flow, whereas for mudflows such data are not very limited, and the accuracy of their measurements is doubtful. Therefore, to determine the velocity of sediment carrying mudflows, the structure of the Chezy formula is often used.

The overwhelming majority of the formulas available for velocity determination rely on the processing of data gathered by field and laboratory measurements of sediment transporting flows. These dependencies give more or less good results for certain intervals of characteristic parameters of the flow, sediments and the channels, limited with initial data. Basically, the proposed formulas refer to the determination of the velocity of mountain streams and mudflows in natural channels, the bottom of which is deformed.

Recommendations for determining the average velocity of sediment transporting high-concentration flows in channels with a non-deformable bottom, and moreover, in the case of the limiting transport capacity of the flow, are actually absent in the literature. By its structure, the existing dependencies can be divided into two groups:

1. Formulas in which the average velocity of a sediment carrying flow is determined depending on the maximum dimensions of the transported particles and on the hydraulic flow parameters.
2. Formulas based on the structure of the Chezy formula, with its appropriate correction and the introduction of parameters that take into account additional resistances, conditioned by the presence of solid particles in the water stream.

We note that according to Thierry's formula [12] and similar to it expressions of the first group, which have not found wide application, it is reasonable to determine the flow velocities corresponding to the movement of solid particles of maximum dimensions. In this case, these formulas give more reliable results.

From the formulas of the second group, we note the empirical and semiempirical dependences of V.M.Makkaveev [11], I.F.Sribnogo [13], and Khan [8], which have the following common limitations:

on the one hand, the characteristic of the resistances of different channels in them is taken into account by constant numbers, while in this channel it can vary quite essentially;

on the other hand, these formulas do not include such important factors as the granulometric characteristics of transported sediments.

In the methodical instructions on the anti-mudflow structures developed by the association "Soyuzavtomatika", researchers M.F.Talmaz and A.N.Kroshkin using the obtained connection (2), suggested the following formula for calculating the average speed of the sediment transport

$$V = K \left( \frac{h}{d_o} \right)^{0.3} \sqrt{qIh}, \quad (3)$$

where K is a coefficient that depends on the concentration of the stream, and is in the interval from 1.4 to 2.9; q is the specific flow rate; h is the depth of the stream; I is the slope of the channel;  $d_o$  is the diameter of the bed-forming soil.

**Conclusion.** The carried out review and analysis of techniques available in the professional literature for calculating the hydraulic characteristics of the flow (sediment carrying capacity, roughness coefficient, average velocity) show that the problem of studying the motion of mud flows is not sufficiently studied. This means that until now the problem of determining the sediment carrying capacity of the flow in different channel, ground and relief conditions remains insufficiently solved. Existing formulas for determining the velocity of sediment transport, mountain streams refer to natural, deformable channels. For rigid channels, such formulas are not available in the literature, especially for flows with high limiting sediment transport (mudflows).

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**Բերվածքատար հոսքերի շարժման դեպքում Խորդուբորդության գործակցի վերաբերյալ**

#### **Վ.Գ. Հայրապետյան**

*Շուշիի փեխնողգիական համալսարան*

Խորդուբորդության գործակցի որոշման գոյություն ունեցող բանաձևերը վերաբերում են դեֆորմացվող, բնական հոներին: Ավելին, դրանցից շատերը առաջարկված են մասնավոր դեպքերի համար՝ փոքր կոնցենտրացիայի լեռնային հոսքերի համար: Գրականությունում առաջարկները, որոնք կիրառելի կինեն մեծ կոնցենտրացիայի բերվածքատար հոսքերին, գործնականորեն բացակայում են, առավել ևս սելավային հոսքերի համար, որոնք շարժվում են կոշտ, չդեֆորմացվող հոներով, մասնավորապես՝ հոսքի սահմանային բերվածքատարողունակության դեպքում:

**Բանալի բառեր.** ջուր, գետ, ջրանցք, հատակ, տուրբոլենտություն, ջրամբար, հակասելավային:

### **О КОЭФФИЦИЕНТЕ ШЕРОХОВАТОСТИ ПРИ ДВИЖЕНИИ НАНОСОНЕСУЩИХ ПОТОКОВ**

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Существующие формулы по определению коэффициента шероховатости относятся к деформируемым, естественным руслам. Более того, большинство из них предложены лишь для частных случаев – для горных потоков малой концентрации. Рекомендации применительно к наносонесущим потокам большой концентрации в литературе практически отсутствуют, тем более для селевых потоков движущихся по жестким, недеформируемым руслам, в частности, в случае предельной наносонесущей способности потока.

**Ключевые слова.** вода, река, канал, дно, турбулентность, резервуар, противоселевое

## CALCULATION OF THE SURFACE POTENTIAL OF NANOSTRUCTURED CARBON FILMS USING MULTIFRACTAL ANALYSIS METHOD

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*In this paper surface potential of diamond-like carbon nanostructured film is studied. Fractal form of the surface of this film is discussed. Fractal parameters and surface potential as a function of them are calculated theoretically. Then obtained results are compared with the results measured by Kelvin probe method. The evolution of the surface topology and related surface potential during the deposition time is studied also. The dependence of multifractal parameters on the deposition duration was revealed.*

**Key words:** Surface potential, nanostructured film, multifractal analysis.

### 1. Introduction

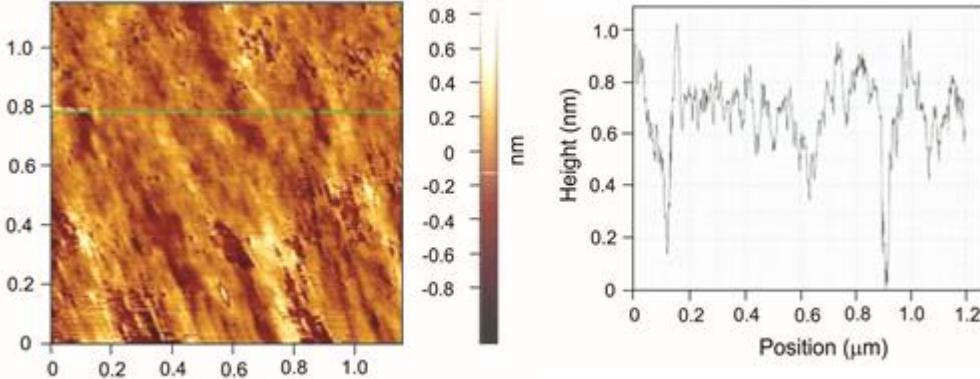
The process of forming the semiconductor layers for modern electronic devices is accompanied by a process of self-organization at the nano and micro levels. A promising approach to describe such self-similar state to the surface is the multifractal analysis [1, 2, 3]. Introduced by Benoit Mandelbrot general pattern of geometric properties of the physical world, which is manifested in the self-similarity of its structure, has found numerous applications in materials science and has provided new opportunities for describing disordered materials microstructures using rigorous quantitative terms, such as fractal dimension. To date, found that to describe the self-similarity of natural materials is not enough just to use one of the fractal dimension, and in the works of different authors [1-7] show that the multifractal formalism provides such an opportunity. One of the important physical parameters of the nanostructured films is surface potential, which we can calculate using the results obtained by multifractal analysis. These results allow us to propose a mathematical expression that gives an opportunity to evaluate the surface potential of the film, due to the presence of fractal structure on its surface. The methodology of multifractal parameterization of structures of materials is based on the fundamental principles of self-similarity, stochastic and fractal broken symmetry structures of natural materials [4, 5, 6]. It uses a set of self-similar measures in Euclidean space, so can more accurately describe the characteristics of the material [7, 8]. The property of self-similarity quantitatively expressed using the concept of fractal dimension. To determine the fractal dimension of the fractal and other parameters, we used obtained atomic force microscopy images for chemical vapor deposited diamond-like carbon nanostructured films.

### 2. Theory

#### 2.1. Multyfractal Analysis

In materials science and allied areas in the majority of cases studied structure is presented in the form of flat images. In the modern computer technology and bitmap processing programs such flat images presented in the so-called digital (digitized) form - a matrix of discrete elements of the same size images - pixels. Each pixel is attributed to three numerical characteristics (coordinates): two of them ( $i, j$ ) define the position of the pixel on the image plane ( $x, y$ ), third characteristic defines its

color  $z(i, j)$ . The color characteristics of pixels are given by integers. Coordinates of the pixels on the plane are numbers of rows and columns of pixels in the matrix (by which the image represented in digital form) and also are set of integers. Thus, using the color characteristics of pixels as the usual number, we can imagine a flat image of the surface topography in three dimensions [3, 7, 15, 16]. Examples of such structures may be three-dimensional digital images of the surface of materials obtained by atomic force microscope (AFM) (Figure 1).



**Figure 1.** AFM image of a sample of DLC grown on Ge substrate (upper panel) and cross sectional profile of thickness across the green line on the image (lower panel).

Generated by the color characteristic or height  $z(i, j)$  measure [7,14,18,20]

$$\lambda_{0ij} = \frac{z(i, j)}{\left( \sum_{ij} (z(i, j)) \right)} \quad (1)$$

on the set of elementary cells - pixels can be directly used for multifractal analysis of images. The sum of two indices for all the pixels on a square matrix  $(i, j)$  can be represented as the sum of one index  $i$ , if renumber the pixels using one index.

Thus, when the partition of space covering, which contains the object being studied, it is possible to generate a measure  $\{\lambda_i\}$ , ( $\sum_{i=1}^N \lambda_i = 1$ ) - some effective distribution does not change its sign value. For anyway constructed (generalized) measure  $P_i$  the generating function is constructed:

$$\Gamma(q, \tau, l) = \sum_{i=1}^N \frac{(p_i)^q}{(l_i)^\tau}, \quad (2)$$

where the summation is only for not empty cells measure  $p_i > 0$ ,  $q$  and  $\tau$  are arbitrary real numbers ( $-\infty \leq q, \tau \leq \infty$ ).

In the case of the singular behavior of measure, taking place in many situations [13],

$$p_i \cong (l_i)^\alpha, l \rightarrow 0, \quad (3)$$

where  $\alpha$  is positive real number, it has been shown [22, 23] that there is a unique function of  $\tau(q)$ , in the limit  $l \rightarrow 0$ , such that  $\Gamma(q, \tau(q), l \rightarrow 0)$  is finite.

For generalized correlation function  $\chi$  and its exponent  $\tau$  we have [1, 7, 16, 19]

$$\chi(q) = \sum_{i=1}^N (p_i)^q \cdot l^{\tau(q)}, l \rightarrow 0 \quad (4)$$

$$\tau(q) = \lim_{l \rightarrow 0} \frac{\ln(\chi(q))}{\ln(l)}. \quad (5)$$

By summing over the cells by expression (4) we can for  $\chi(q)$  go to the integral form [19]

$$\chi(q) = \int d\alpha \cdot p(\alpha) \cdot l^{-f(\alpha)} \cdot l^{q\alpha}, \quad (6)$$

where  $p(\alpha')l^{-f(\alpha')}d\alpha'$  is the probability that a randomly selected  $\alpha$  singularity in the equation (3) for  $p_i$  has a value in the range  $(\alpha', \alpha' + d\alpha')$ , and  $p(\alpha)$  is not singular function. In this way, studied self-similar set is modeled by a set of interpenetrating set of singular  $\alpha$ , each of which has a corresponding fractal dimension  $f(\alpha)$ . In the  $l \rightarrow 0$  limit the integral (6) is determined by some  $\alpha$ , at which  $q\alpha - f(\alpha) = \min$ , obtained from the relationship between the function of  $\tau(q)$  and the spectrum of singularities  $f(\alpha)$  [1, 12, 16, 19]:

$$\tau(q) = q\alpha - f(\alpha), \alpha = \frac{d\tau}{dq}, q = \frac{df}{d\alpha} \quad (7)$$

From the last relations can be seen, the normalization condition is this  $\tau(1) = 0$ . This fact can be expressed explicitly, putting [21]

$$\tau(q) = (q-1)D_q \text{ or } D_q = \frac{\tau(q)}{q-1}, \quad (8)$$

where  $D_q$  is generalized Renyi dimension, at that  $D_0 \geq D_1 \geq D_2$ . Here  $D_0$ ,  $D_1$  and  $D_2$  are fractal ( $q=0$ ), informative ( $q=1$ ) and correlative ( $q=2$ ) dimensions, respectively.

Similar results for  $\tau(q)$ ,  $f(\alpha)$  and  $D_q$  are obtained in works [1, 5, 8, 14, 16], but our work contains mathematical approach differing from their formalism.

In the study of multifractal properties of regular fractal structures acts as *Do* fractal dimension. Strictly speaking, the term "dimension" is only applicable to the  $D_0$ , as the value of  $q = 0$  removes the distinction of cells of different measures, and we have to deal with the media configuration "in its purest form".

## 2.2 Surface Energy Calculation

Excess component of free energy of system, associated with the appearance of the interfaces, can be calculated from the expression [8]

$$dG_S^{ex} = dA_s = \alpha dS, \quad (9)$$

where  $dG_s^{ex}$  is the change in free excess Gibbs energy, due to the emerging of separation boundary,  $dA_s$  is the work on the formation of the section area of the surface  $dS$ ,  $\alpha$  is the specific surface energy of the separation boundary. In this case, the component of the excess chemical potential, associated with the emergence of new geometric shapes on the surface, can be calculated by the classical expression of thermodynamics [8]:

$$\mu_s = \frac{dG_s}{dn} = \frac{\alpha M}{\rho} \cdot \frac{dS}{dV} , \quad (10)$$

where  $\rho$  and  $M$  are density and molecular weight of solid phase,  $dV$  and  $dn$  are changes of the volume and the number of moles of the solid phase, providing change of surface of the section with area  $dS$ .

To formally obtain the desired expression for the surface energy associated with the fractal shape of the surface of the system, it is necessary in the formula (10) enter the expression for the surface area and volume nanoforms. To implement this approach, it is necessary to take advantage of the fundamental dependencies between the parameters, characteristic of fractal approximations:

$$S = N_s \cdot r^{D_{os}} \quad \text{and} \quad V = N_v \cdot r^{D_{0v}} , \quad (11)$$

where  $N_s$  and  $N_v$  are constant proportionality factors depending on the geometry of the system and taking into account the fractal dimension of the described parameters.

Then, forming the differentials for the area and volumes of fractal surfaces in accordance with (10), we obtain the following expression for the surface components of the phase chemical potential:

$$\mu_s = \frac{\alpha M}{\rho} \cdot \frac{N_s D_{0s}}{N_v D_{0v}} \cdot r^{D_{0s}-D_{0v}} , \quad (12)$$

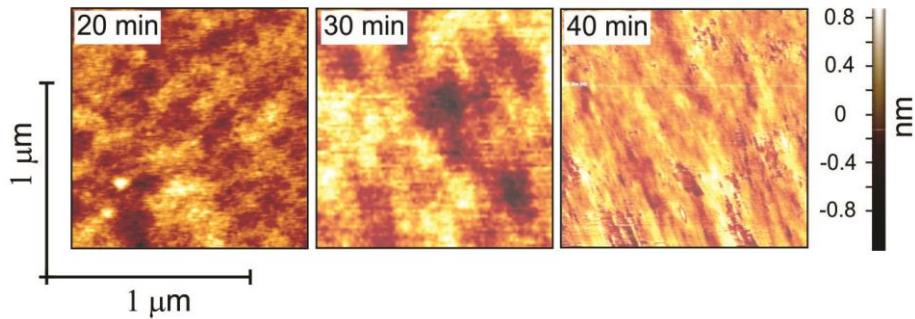
where  $r$  is the characteristic (length) size of the analyzed space.

The obtained expression is used to estimate the magnitude of the surface energy of the thin DLC film deposited on Ge substrate. As the input data to perform calculations AFM image is used.

### 3. Experiment and Numerical Nalculation

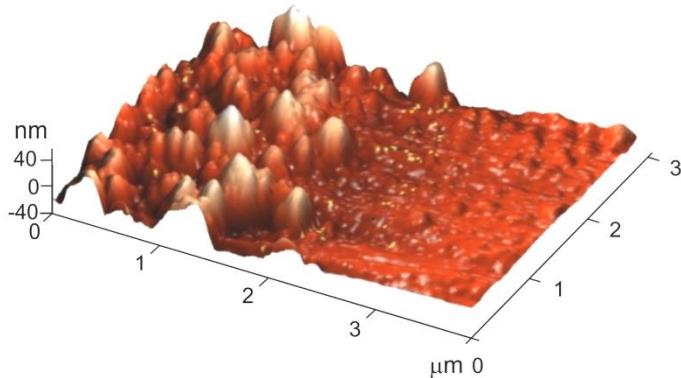
For more concrete investigation, we examined diamond-like carbon (DLC) layers deposited by CVD method on Ge substrate. Films were deposited from dc-plasma excited by the vapor of mixture of carrying gases and hydrocarbon (in our case toluene C7H8) in crossed electric and magnetic fields. In the technological process ion and magnetron sources (or both of them simultaneously) were used [9, 10, 11, 17].

It is possible to study the surface transformation of these nanolayers upon deposition time by examining them with AFM system Solver Nano-NT-MDT (Fig.2a,b,c). Also, it is possible to sketch out their boundary line (Fig. 3a,b) which enables one to draw an idea of peculiarities of formation these layers.



**Figure 2 : AFM images of DLC samples with different CVD deposition time.**

During the initial stage of layer formation, grained structures, granules, which combine and form granules of the same type but bigger and so on. The granules are shown on Fig. 3. Since when these



**Figure 3. The border line between Ge substrate and DLC film.**

granules begin to overlap each other a layer is formed. On the shaped layer, another fragmented layer is formed and so on. As the measurements reveal the topmost fragmented islet-like layers have thickness of 0.34 nm, which indicates that an atomic layer of carbon exists there. These results, as well as the cross-sectional and statistical analysis allow us to state that our layers can be subjected to fractal analysis. Applying already considered to be classical mathematical formalism of multifractal analysis together with computational programs the fractal parameters are deduced which makes possible to present some specific physical properties, in particular the surface energy of the layer, as a function of these parameters. Accordingly, the Regne's fractal coefficient decreases with the deposition time, which is the result of fact that the surface becomes more even and ordered. A software was developed by us to calculate Regne coefficients for surface and the bulk. Thus, for 10 min, 20 min, 30 min and 40 min deposition time Regne's fractal coefficients of  $D_{0S}$  we respectively obtained the following values: 2.75, 2.62, 2.54 and 2.5 and or  $D_{0S}$ : 2.9, 2.88, 2.86, 2.86. Introducing these values into equation 12 we obtained the following relations for surface energy:

$$\mu_{S1} : \mu_{S2} : \mu_{S3} : \mu_{S4} = 1:1.49:2.15:2.32$$

On the other hand, similar relation for surface potential can be obtained also by using data measured by Kelvin probe method. The Kelvin probe technique relies on the detection of an electric field between a sample material and probe material. The electric field can be varied by the voltage that is applied to the sample relative to the probe. Although the Kelvin probe technique only measures

a work function difference, it is possible to obtain an absolute work function by first calibrating the probe against a reference material (with known work function) and then using the same probe to measure a desired sample. The Kelvin probe technique is used to obtain work function maps of a surface with extremely high spatial resolution, by using a sharp tip for the probe.

$$\mu_{S1} : \mu_{S2} : \mu_{S3} : \mu_{S4} = 100 : 150 : 225 : 240$$

The results of the calculations obtained by the method of multifractal analysis and measurements are very similar.

### Conclusions

- DLC film as a self-organized system can be analyzed by the method of multifractal analysis.
- In the process of forming of the DLC film some different fractal regularity are maintained.
- Range parameter decreases with increasing deposition time.
- Investigation made by multifractal analysis method gives similar results with experimental data.

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**ՆԱՆՈԿԱՌՈՒՑՎԱԾՔԱՅԻՆ ԱՇԽԱԾՆԱՅԻՆ ԹԱՐԱՆԹՆԵՐԻ ՄԱԿԵՐԵՎՈՒԹԱՅԻՆ  
ՊՈՏԵՆՑԻԱԼԻ ՀԱՇՎԱՐԿԸ ՄՈՒԼՏԻՖՐԱԿՏԱԼ ԱՆԱԼԻԶԻ ՄԵԹՈԴՈՎ**

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Սույն աշխատանքում ուսումնասիրված է ալմատանման աճխածնային նանոկառուցվածքային թաղանթի մակերևույթային պոտենցիալը: Քննարկված է այդպիսի թաղանթի մակերևույթի ֆրակտուլ ձև: Տեսականորեն հաշվարկված են ֆրակտուլ պարամետրերը և մակերևույթային պոտենցիալը՝ որպես վեցիններից ֆունկցիա: Այնուհետ ստացված արդյունքները համեմատված են Կելվինի գոնդի մեթոդով չափումների արդյունքների հետ: Ուսումնասիրված է թաղանթի մակերևույթի տոպոլոգիայի և մակերևույթային պոտենցիալի էվոլյուցիան նստեցման ժամանակի ընթացքում: Արտածված է ֆրակտուլ պարամետրերի կախվածությունը նստեցման ժամանակից:

**Բանալի բառեր.** Մակերևույթային պոտենցիալ, նանոկառուցվածքային թաղանթ, մուլտիֆրակտուլ անալիզ

**РАСЧЕТ ПОВЕРХНОСТНОГО ПОТЕНЦИАЛА НАНОСТРУКТУРИРОВАННЫХ  
УГЛЕРОДНЫХ ПЛЕНОК МЕТОДОМ МУЛЬТИФРАКТАЛЬНОГО АНАЛИЗА**

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В данной работе исследован поверхностный потенциал алмазоподобной углеродной наноструктурированной пленки. Обсуждается фрактальная форма поверхности этой пленки. Теоретически рассчитаны фрактальные параметры и поверхностный потенциал как функция от них. Затем полученные результаты сравниваются с результатами, измеренными методом зонда Кельвина. Изучается эволюция поверхностной топологии и связанного с ней потенциала поверхности в течение времени осаждения. Выявлена зависимость мультифрактальных параметров от продолжительности осаждения.

**Ключевые слова:** Поверхностный потенциал, наноструктурированная пленка, мультифрактальный анализ.

## AN EFFECTIVE METHOD OF MULTI-STORY INDUSTRIAL BUILDINGS MOUNTING IN SEISMIC REGIONS

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*Decrease of seismic risks in construction of multistorey industrial buildings is provided by strength and stability of mounted structures and parts of a building. This is achieved by creation on the level of floors and covering of rigid disks, consisting of monolithic reinforced concrete longitudinal beams and filled in butt joints of precast reinforced concrete plates.*

*This paper presents an effective method of mounting of reinforced concrete constructions where monolithic crossbars are made in suspended block-forms, serving as temporary mounting joints between columns.*

*Methods of predicting of optimal reserves of inventory concrete forms and their efficient allocation amongst objects of construction are given.*

*Suggested approaches accelerate the rate of objects' construction, reduce prime cost of jobs and seismic risks in the process of mounting constructions of multistorey industrial buildings.*

**Key words:** seismic area, mounting, strength and stability, block-form, monolithic beam, hard disk, formwork stock

Seismic stability of multistorey industrial buildings under construction is achieved at the level of floors and coverings of rigid disks made of precast monolithic structures – monolithic beams and filled butt joints of precast reinforced concrete plates [5,7,8].

During hardening of concrete of monolithic constructions strength and stability of erected framings of a building are provided by temporary metallic mounting stays installed between columns in longitudinal direction.

Monolithic work and installation of temporary metallic ties, to some extent, decrease rate of structures mounting and raise the cost construction-and-assembling operations.

A new method has been developed designed to mounting multistorey industrial buildings in a single technological process using monolithic reinforced concrete beams in suspended metallic block-forms. The latter during hardening the concrete strength in monolithic constructions of horizontal discs are employed as temporary metallic ties between columns as shown in Fig.1.

Application of this method in construction of shoe factories in Stepanakert city, Artsakh Republic, and in the Near Abroad countries, enabled to shorten mounting time of multistorey industrial buildings up to 1,5 times and decrease the cost of monolithic constructions up to 15 percent [4,2].

Taking into account high turnover of metal forms arose practicability of their use in other construction sites during partial or complete retirement of the forms in the period of downtime.

Solution of this problem is described mathematically by the below linear relationship.

To find indices of inventory formworks  $V_{ij\mu}$ , at from i-th construction site to j-th construction site during  $\mu$  period of time, with reduced cost per unit on equal to  $\gamma_{ij}$ , with these parameters we have



**Figure 1. Metallic suspended block-form for monolithic reinforced concrete beams of multistorey industrial buildings**  
**a) top view, b) bottom view**

$$\sum_{\mu=1}^m \sum_{i=1}^n \sum_{j=1}^n \gamma_{ij} v_{ij\mu} \rightarrow \min,$$

for the following limitations

$$\sum_{\mu=1}^m \sum_{j=1}^n v_{ij\mu} = \sum_{\mu=1}^m f_{i\mu}^{(1)},$$

it means that the index of the inventory framework relocated from  $i$ -th construction site at the moment  $\mu$  should be less than or equal to the demand for that framework at the  $j$ -th construction site, or

$$\cdot \sum_{\mu=1}^m \sum_{i=1}^n v_{ij\mu} \leq \sum_{\mu=1}^m f_{i\mu}^{(2)}.$$

that is the index of the framework relocated at  $j$ -th construction site at the moment  $\mu$  should be less than or equal to the demand of that framework.

$v_{ij\mu}^{(3)} \geq 0$  which means that the framework index can not be a negative value.

To determine physical meaning of  $f_{i\mu}^{(1)}$  and  $f_{i\mu}^{(2)}$  values options for formworks stocking are considered in Fig.2.,

In the first time period  $\mu = t_1 - t_0$  the demand is satisfied by two sets of formworks  $F^1 = 2$ .

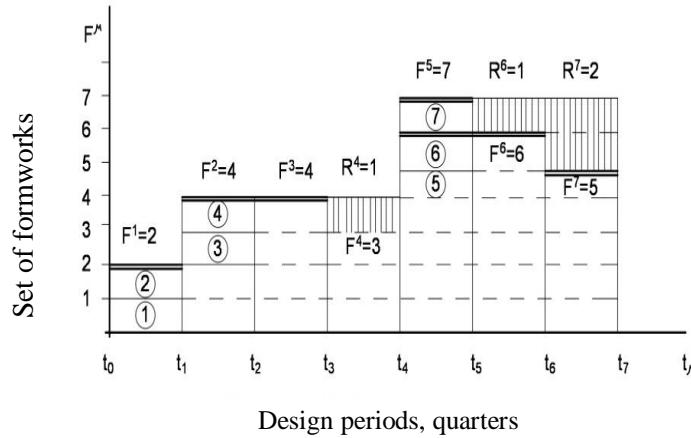
In the second and third time period is a need for four sets of formwork or  $F^2 = F^3 = 4$ .

In the fourth period the demand in formworks is three sets, or a set of formworks  $F^4 - F^3 = 1$ . In number is in downtime, and formworks numbering  $R^4 = 1$  are stocking.

Similarly continuing calculations the number of formworks stock for the example under consideration we have  $R^4 + R^6 + R^7 = 4$ .

It is obvious that the distribution function of formworks reserves will depend on their availability in the construction site and methods of objects construction organization.

In such a case, the analytical expression of the function of total stock of formworks  $F_{Kj}^\mu$  can be represented as [3]



**Figure 2. Schedule of formworks stocking, first option**

$$F_{Kj}^{\mu} = \sum_{\mu \geq I}^{\mu} (F_{Kj}^{\mu-1} - F_{Kj}^{\mu}) \Psi(t - t_{\mu})$$

where  $\Psi(t)$  is the Heaviside's function used in mathematical statistics to describe the empirical function of distribution [1]

$$\Psi(t - t_{\mu}) = \begin{cases} 1 & \text{if } t \geq t_{\mu}, \\ 0 & \text{if } t < t_{\mu}. \end{cases}$$

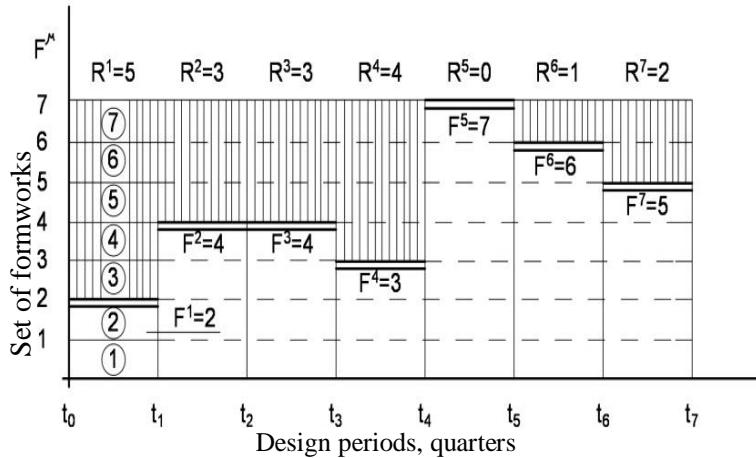
Generally, the maximum reserve of inventory formworks' set  $\max R_{Kj}^{\mu}$  use taking into consideration turnover of the set in N times can be represented as

$$\max R_{Kj}^{\mu} = N \left[ \max F_{Kj}^{\mu} \times t^{\mu} - \sum_{\mu=I}^{\mu} F_{Kj}^{\mu} (t^{\mu} - t^{\mu-1}) \right].$$

The analysis of the above dependency shows that the quantity of stocked formworks  $\max R_{Kj}^{\mu}$  increases as the first maximum of the function approaches to the y-axis, that is in case when the order of formworks sets in  $F^5 = 7$  number will be executed before the beginning of an object construction (Fig.3). At that the turnover of formworks grows in 1.4 times [6] (Table 1).

**Table 1**

Option I				Option II			
№ set	Turnover of sets			№ set	Turnover of sets		
	required	reserve	total		required	reserve	total
1	$1 \times 7 \times 14 = 98$	-	98	1	$1 \times 7 \times 14 = 98$	-	98
2	$1 \times 7 \times 14 = 98$	-	98	2	$1 \times 7 \times 14 = 98$	-	98
3	$1 \times 6 \times 14 = 84$	-	84	3	$1 \times 6 \times 14 = 84$	$1 \times 1 \times 14 = 14$	98
4	$1 \times 5 \times 14 = 70$	$1 \times 1 \times 14 = 14$	84	4	$1 \times 5 \times 14 = 70$	$1 \times 2 \times 14 = 28$	98
5	$1 \times 3 \times 14 = 42$	-	42	5	$1 \times 3 \times 14 = 42$	$1 \times 4 \times 14 = 56$	98
6	$1 \times 2 \times 14 = 28$	$1 \times 1 \times 14 = 14$	42	6	$1 \times 2 \times 14 = 28$	$1 \times 5 \times 14 = 70$	98
7	$1 \times 1 \times 14 = 14$	$1 \times 2 \times 14 = 28$	42	7	$1 \times 1 \times 14 = 14$	$1 \times 6 \times 14 = 84$	98
Sum total	434	56	490	Sum total	434	252	686



**Figure 3. Schedule of formwork sets stocking, the first largest maximum of function  $F_{Kj}^{\mu}$ , option 2**

### Conclusions

1. An efficient mounting method of multi-storey industrial buildings' designs in suspension metal block-forms which during the hardening of monolithic structures of horizontal disks are used as temporary belts between columns has been developed. At the same time constructions assembling is reduced to 1.5 times.
2. The analytical dependence and plots of stocking of inventory formworks and their rational allocation to other construction objects have been presented. In this case, turnover of inventory formworks is increased by 1.4 times, and the cost of monolithic works reduced to 15%.
3. The proposed approach enables to reduce seismic risks in the process of erecting of structures of multi-storey industrial buildings.

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<sup>1</sup>Մուկվայի ազգային հետազոտական պետական շինարարական համալսարան

<sup>2</sup>Շուշիի փեխնողիական համալսարան

Կառուցվող բազմահարկ արդյունաբերական շենքերի սեյսմիկ ռիսկերի նվազեցումը կախված է կոնստրուկցիաների և շենքի մասերի ամրությունից և կայունության մակարդակից:

Դա ապահովվում է միջհարկային ծածկերում երկայնական ուղղությամբ կոշտ սկավառակների ստեղծմանը, միաձոյլ երկաթբետոնե պարզունակներից և միաձուլված հանգույցներում հավաքովի երկաթբետոնե սալերից:

Բերվում է երկաթբետոնե կոնստրուկցիաների մոնտաժման արդյունավետ եղանակ, որի դեպքում միաձոյլ պարզունակները պատրաստվում են կախովի կաղապարներում, որոնք օգտագործվում են, որպես ժամանակավոր կապերի սյուների ամրացման համար: Տրվում է գույքային կաղապարների օպտիմալ պաշարների կանխատեսումը և նրանց ռացիոնալ բաշխումը շինարարության օբյեկտներում: Ներկայացված մոտեցումները արագացնում են բազմահարկ արդյունաբերական շենքերի մոնտաժման պրոցեսը, ինքնարժեքը և սեյսմիկ ռիսկերը:

**Բանալի բառեր.** սեյսմիկ գոտիներ, մոնտաժ, կոնստրուկցիաների ամրություն և կայունություն, միաձոյլ պարզունակ բլոկ-ֆորմա, կոշտ սկավառակ, կաղապարների պաշարներ, բաշխում, արդյունավետություն:

## ЭФФЕКТИВНЫЙ МЕТОД МОНТАЖА МНОГОЭТАЖНЫХ ПРОМЫШЛЕННЫХ ЗДАНИЙ В СЕЙСМИЧЕСКИХ РАЙОНАХ

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Снижение сейсмических рисков при строительстве многоэтажных промышленных зданий обеспечивается прочностью и устойчивостью монтируемых конструкций и частей здания. Это достигается созданием на уровне перекрытий и покрытия жестких дисков, состоящие из монолитных железобетонных продольных ригелей и замоноличенных в стыках сборными железобетонными плитами.

Приводится эффективный метод монтажа железобетонных конструкций, при котором монолитные ригели выполняются в подвесных блок-формах, служащие временными монтажными связями между колоннами.

Даны методы прогнозирования оптимальных запасов инвентарных опалубок и их рационального распределения по об'ектам строительства.

Предлагаемые подходы ускоряют темпы строительства об'ектов, снижают себестоимость работ и сейсмические риски в процессе монтажа конструкции многоэтажных промышленных зданий.

**Ключевые слова:** сейсмические районы, монтаж, прочность и устойчивость конструкций, монолитный ригель, блок-форма, жесткий диск, резервы опалубок, распределение, эффективность.

## ROCK CUT VERSIONS OF ARMENIAN CHURCHES AND MYTHOLOGICAL AND SOCIAL GROUNDS OF THE ORIGIN OF THEIR ARCHITECTURAL COMPOSITION

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*The Armenian central dome churches with cruciform plan, as complete architectural setups, emerged in the seventh century or perhaps earlier and did not change their initial construction for nearly 1,500 years. The reason is the national spiritual philosophy and the mythology of the Indo-European civilization, carrier of which as an important component of culture to this day is the Armenian people. From the architectural point of view, rock carved versions of this type of churches are convincing and irreproachable, with the semantic characteristics of the mythological tree of life, the bowels of the earth-earth-sky trinity, black and white world-creating and world-destroying forces in the form of dragons and the cross as a symbol of light.*

**Key words:** Armenian central domed cruciform churches, national and Indo-European mystical philosophy, tree of life, sacred trinity

**The scientific objective:** Architecture of sacred structures and in particular architecture of temples is anchored in social classification and politics, faith and its dogmas. Depending on the faith of a particular people and changes in that faith in a historic period, as well as serious change in the demographic composition inside the state or radical change of ethnosculture, architecture of temples and sacred structures has been changed respectively. For example, architecture of Pharaos, Ptolemy and then substituting the latter Muslim Egypt has undergone fundamental changes despite the fact that the main ethnic composition of population remained unchanged. We can see changes in the architecture of sacred structures also in case of monuments of Etrusk, Roman, Christian Italian, Persian Ariarbarzan or Ariarmen [Nersisyan2011], Cyrus [Xenophon of Athens 1970], Zoroastrian [[Nersisyan2011; Shahinyan 2012; Agatangeos 1987] and Muslim period. In Armenia, we can see vast changes in architecture of sacred structures and temples of 4<sup>th</sup>-3<sup>rd</sup> millennia, Kingdom of Van (Urartu), Hellenistic and Christian periods. And this is despite the fact that, starting from 6th century B.C. up to Late Middle Ages, the ethnic, native population and the principles of royal administration and social and class order have not undergone any fundamental changes. Only religious views and the religion itself have changed [Shahinyan 2010, Marr 1922, Dyakonov1989, Movsisyan2002,].

Thus, objective number one: what kind of natural and anthropogenic factors have influenced the architectural formation of sacred structures and in particular churches.

Objective two: what is the reason for the longevity of the style and composition of sacred structures and particularly Armenian churches over considerable time periods, more than 1,600 years.

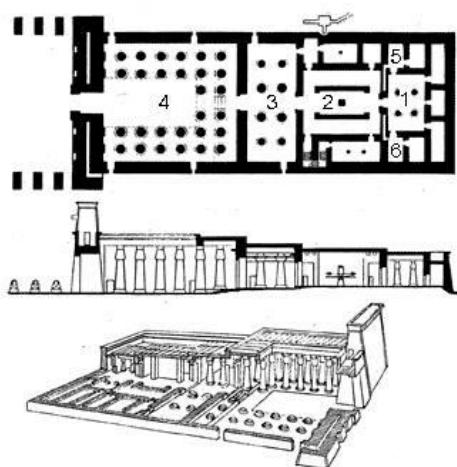
**Research:** Armenian churches have been continuously written about since the 5<sup>th</sup> century, during the entire period of Christianity, and starting from the 19<sup>th</sup> century, numerous scientists have been involved in issues of church architecture and a great amount of materials were published about the results of scientific researches.

Among the vast amount of scientific viewpoints published about basilica, Toros Toramanyan's scientific hypothesis on architecture of basilica type temple structures is favorably distinguished. According to Toramanyan, architecture of basilic churches is a result of thousands years of development of temple construction and the main impact on its formation have been the social

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relationships in empires having clearly differentiated hierarchic class structure. To support this viewpoint, he gives the example of plans of Ancient and Middle Egyptian Kingdoms, Hellenistic and Greco-Roman temples [Toramanyan1945].. From his explanation the functionality of temples is clearly emphasized which is anchored in the empire's hierarchic, religious-civil class structure and functions and rights of each of its strata.

The other principle that has served a basis for formation of the architecture of center domed cruciform planned churches is based on the mythological worldview of Armenians since ancient times about the creation and structure of the Universe and the Earth. Reasonable figures available in Armenian petroglyphs, rugs, decorative art of medieval manuscripts and in mold frames of khachkars (cross stones), and the constructive structures of the composition of mausoleums with circular semispherical stone-hill and stone-box burial chambers built in 4<sup>th</sup>-3<sup>rd</sup> millennia B.C. become meaningful only within the ancient mythological notions of Armenians about the Tree of Life, Dragons, the quadrate structure of the Earth, the Fruit of the Tree of Life, and the structure of Universe.



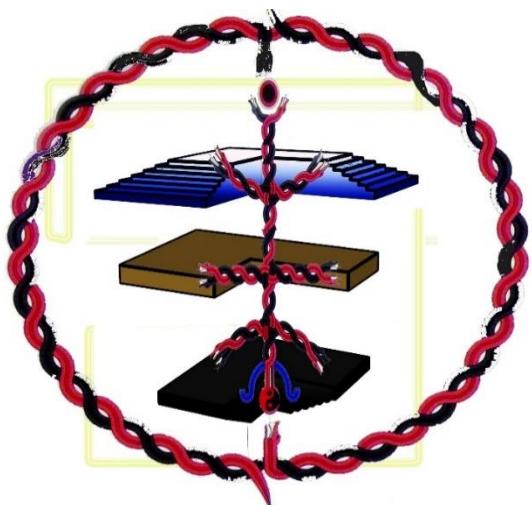
**Figure 1.The plan of Egyptian Temple. 1. Area the Pharaoh-priest 2. The area for Priest and Pharaoh's family 3. Priest 4. The aristocracy and military elite 5-6. Treasury**

Architecture of center domed churches, as a classical model and as structures radically different from other compositions were recorded by Toros Toramanyan. Later on, in the 20<sup>th</sup> century, scientific researches and publications were provided by Strzhigovski, Tokarski, Jaconson, Yaralov, Mnatsakanyan, Chubanishvili, Safaryan, Taghayshvili, Khalpakhchyan and others. Vahagn Grigoryan published in 1982 a monography "Early medieval central domed small monuments of Armenia", where he brings together all works previously done and performs a typological classification, as well as Telman Gevorgian's "The proportions in Armenian Architecture", which studies the numerical relations and proportions of constructive structures of churches based on units of measurement used in ancient and medieval Armenia: dzogh ("rod"), krknaqayl ("double step") girk ("embrace"), votn ("foot"), tiz ("span"), etc. [Gevorgian2012]

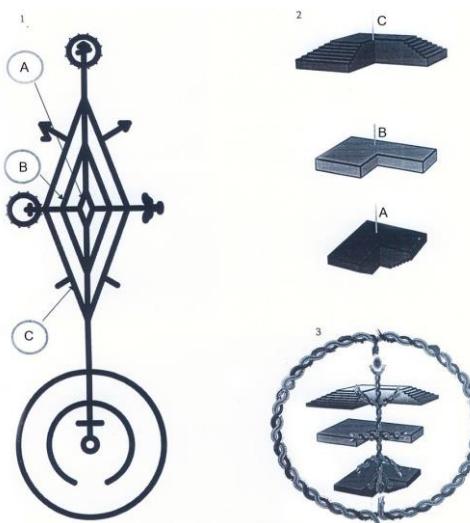
However, the works of all these scientists are based on the tectonic peculiarities of the structure which eventually leads to analysis and description of achievements of engineering technologies of structures and cannot have national features, while studies of the composition do not indicate any traditional, ethnocultural bases of origin and establishment of the form and style. Therefore, it is difficult to ground with this methodology the purely Armenian origin of this type of churches.

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In case of decoding of the esoteric meanings of the all the following is comprehended: the traditional constructive trinity of churches, church windows, doors, defensive towers framed with depictions of two cosmic mythological elements (), Black Water, and Purple Sea that separate the regulated universe of evil and good and protect it from endless chaos) boundaries of the field occupied by depiction of Tree of Life appearing in the form of khachkars and cross images, etc. Numerous examples of application of the symbol of the sacred act of creation in small size architectural monuments (Odzun) and in stylization of church entrances; application of the Sun – the fruit of the symbol of the Tree of Life in the form of a new symbol of Holy Cross adapted to and meaningful in Christianity; application of the symbol with rectangular drawing of the Earth in petroglyphs, esoterics, pictograms, and planning under the domes of churches that characterize the Earth's sphere.



**Figure 2 Tree of Life and Dragons**



**Figure3 1: Mythological construction of Universe 2:A. Underground B. Earth C. Sky 3: Universe**

Furthermore, the portrayals of man, goat, bull, eagle that characterize the four sides of the Earth and, simultaneously, the four elements – soil, fire, water, and ether, as well as, characterizing the sphere of bowels of the earth, three, five or seven platforms of square drawing and developing gradually upward and placed one on the other in the base of churches or in compositions serving as a pedestal for khachkars and monuments.

Social bases for architecture of basilicas and temples: Architecture of basilicas has more often been anchored in social structure and respectively on public demand. The functionality of the structure was a public demand, which had been formed on the bases of exercising the rights of people inside the church or temple according to the class structure of the society during pre-Christian and Christian periods. This point of view is shared by part of the 20th century researchers of the Armenian architecture, while it was most convincingly presented and well-grounded by Toros Toramanyan.

Toramanyan believes that the cult of deceased has appeared among the tribes that had mastered agriculture and metalwork; in the architecture of the mausoleums dedicated to them legends associated with faith and worship were already outlined. In the church architecture, starting from the ancient times, the concept of the eternity of life and rebirth was valued since the idea of immortality and heavenly life still holds an important place in people's mentality. From the plan structure of temples, three functional components are clearly distinguished: sanctuary, functional areas for priests and prayer hall.

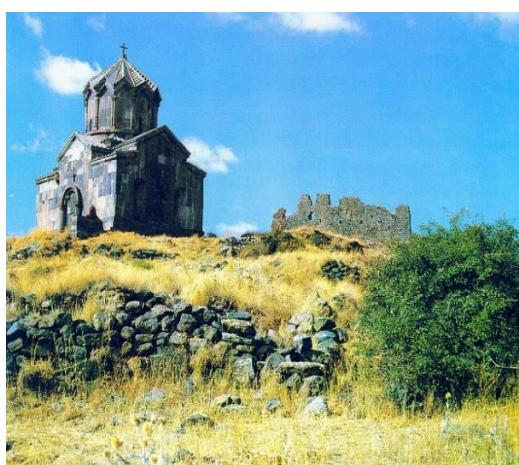
## ARCHITECTURE AND CONSTRUCTION

It is natural that the prayer hall is the largest both in ancient temples and in churches, while the sanctuary that contains a sculpture to God and the treasury with different items gifted to a particular god by believers were inaccessible for the public at large.

**Mythological bases of the compositions of Armenian churches:** In the ancient Armenian mythological notions, the Earth has a square drawing; there are references on this in medieval books. Bowels of the earth consists of a number of layers; mainly seven layers are brought up, where the lowest layer is followed by the Black Water. The sky looks spherical, where the top of the Tree of Life reaches. Every day the Sun is born from a bud of the Tree of Life and is protected by the White Dragon which also protects the Earth and the Sky from external sinister forces or from chaos. Every night the Black Water of Bowels of the earth or the Black Dragon steals and takes the Sun away. The Black Dragon also has a protective function though: it protects the world in the Bowel of the earth or the mythological Dark World and people living there. The Black Dragon is also the protector and the bearer of waters and gives birth to lots of springs from his wounds after he dies.

Thus, according Armenian and in some case common mythology preserved among the Indo-European tribes, the Universe has a form of Sphere or consists of two spheres. In the surface of the cross section of the sphere the surface of the Earth is placed with square drawing, with its landscape arising upward, and below that plane there is the Dark World or Bowels of the earth. Thus, the Universe is three-storied: Bowels of the Earth, Earth, and Sky.

**Results of the research:** Thus, an important situation is outlined both for temples and churches built on the ground and for the rock cut ones: the architecture of part of mausoleums, antique Egyptian and Greco-Roman temples as well as basilicas is anchored in the concept of the eternity of life or immortality or the rebirth. While from the functional standpoint, the sections of temples where the “presence of God” is ensured and the small cell where treasures offered to God are kept as well as areas prescribed for the functions of the priest and pastor class were inaccessible for believers. The prayer hall for believers did not have any direct linkage with the sanctuary section from the functional point of view, while in some cases it was not linked with the temple at all. We can see this phenomenon in Egyptian (Temple of Ra), Sumer (Zikkurats), Urartian (Ayanis in Van, “Sussi” or Arevi in Erebuni), Assyrian, Mesopotamian, and Hellenistic temples. Architecture of these temples is mostly dedicated to a particular god, and only the chosen people from the class of priests and pastors were entitled to enter the temple and the room where the gifts dedicated to that god were put. The prayer hall was located mainly outside the temple and it could be a facility with columned roofing, such as in the case of Ayanis Temple or simply an area adjacent to the temple.



**Figure 4 The Areni and Amberd center domed cruciform planned churches: Stone Tree of Life**

This phenomenon can be seen even more vividly seen in the case of holy temples placed on the top of pyramids in Aztec, Olmec, Ink, Maya cultures, where the faithful people were nestled in the area outside the temple and the pyramid. Thus, it is quite difficult to find the spiritual bases of the architecture of basilica and national features in the principles of functional differentiation of constructive components of composition given that the concept of immortality or rebirth is universal. Therefore, starting from the ancient temple construction up to the basilica, architecture is based on the entreaty from a particularly worshipped God or gods about eternal life or immortality. This means basilic church is basically a result of an international thinking, and only on case of availability of a few details of national culture we can perform classifications for distinguishing it as Italian, Greek, German, Georgian, Armenian, etc.

The situation appears to be different when architecture of central-domed cruciform planned Armenian churches are viewed under the light of Armenian ethnoculture and myths preserved by other Indo-European peoples, where we can see that in the architecture of sacred structures myths about the Tree of Life, World-Destroying and World-Creating Dragons, Life Seed or Cosmic Egg, square structure of the world, the three-storied universe, and the fruit of the Tree of Life, i.e. the Sun, are still alive at least in the Indian mythology and Vedas. We can observe this phenomenon in case of the architecture of earth-hill and stone-box mausoleums both in the Armenian Highland and in Iran, in the ancient civilizations of the Mediterranean Sea basin and in the Irish Newgrange. All these contain all or part of mythological components: cromlechs arranged along the external circle of mausoleums of 4<sup>th</sup> to 3<sup>rd</sup> millennia B.C. in the Armenian Highland or the enormous fined stones arranged along the circle of the mausoleum in the basin of River Boyne in Newgrange, Ireland, which probably embody the Dragons. The planning structure or the plan of the burial chamber or burial area with square or cruciform drawing as well as the deceased contracted and placed like an embryo in the maternal womb that can often be seen, which portray the mythological seed from which the Tree of Life will grow and yield fruits.

All world-creating elements the architecture of central-domed cruciform planned Armenian churches as well as all world-creating elements have preserved in the mythology of Indo-European peoples.

### **Conclusions**

In the bases of the architecture of sacred places and temples lies the need to create necessary functional volumes and space for worship of gods or God. Basilic churches with their medieval planning and planning principles are directly linked with the architecture of sacred places of the Old World, where the sanctuary is separated (the stage and the altar or niche where the image or a sculpture of a saint or Christ is placed), with the priests' rooms and the prayer hall to the right and to the left of the stage. Developments of the architecture of basilica in different countries, because of creative approaches and social order and demand, have formed this diversity of styles such as gothic, baroque, etc. And to resolve issues of tectonics, engineering solutions and technologies have been found such as use of half-arch supporting column to strengthen the external walls to prevent the ceiling from collapsing in French and English churches in the period of Renaissance.

The architecture of the Armenian central-domed cruciform church was immediately formed in the 5<sup>th</sup> century and has never undergone any compositional change to date since the constructive structural details are directly anchored in the ancient mythological model of the structure of the Universe. Occurrence of the rock cut versions of the central-domed church in the Armenian Highland and other places was due to the intention to hide from enemies or the unorthodox. However, for rock cut central-domed churches it was a mandatory requirement to have "yerdik" (a round or square opening through which smoke goes out and the light penetrates) in the central part of the dome of the ceiling, in the place of attaching the cross, wherefrom the light was falling on the believers.

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**ՀԱՅԿԱԿԱՆ ԿԵՆՏՐՈՆԱԳՄԲԵԹ ԵԿԵՂԵՑԻՆԵՐԻ ՃԱՐՏԱՐԱՊԵՏՈՒԹՅԱՆ ԵՎ ՆՐԱՆՑ  
ՍՏՈՐԳԵՏՆՅԱ ՏԱՐԵՐԱԿՆԵՐԻ ԱՌԱՍՊԵԼԱԲԱՆԱԿԱՆ ՀԻՄՔԵՐԸ**

**Ս.Մ. Շահինյան**

*Ճարդարապետության և շինարարության Հայաստանի ազգային համալսարան*

Հայկական կենտրոնագմբեթ խաչաձև հատակագծով եկեղեցիները որպես ամբողջական ճարտարապետական հորինվածք ի հայտ եկան յոթերորդ դարում, կամ հավանաբար ավելի վաղ և այլս չփոխեցին նախնական կոնստրուկցիան գրեթե 1500տարի: Պատճառը ազգային հոգևոր փիլիսոփայությունն ու հնդեվրոպական քաղաքակրթության առասպելաբանությունն են, որը որպես մշակույթ մի կարևոր բաղադրիչ առ այսօր կրողն է հայ ժողովուրդը: Հայ հնագույն հոգևոր և մշակույթային այս յուրահատուկ ժառանգության հետազոտությունն ու մեկնաբանությունն ավելի քան կանոր է, քանի որ համոզված ենք, որ այն հայ մշակույթի և ճարտարապետության ակունքները հասկանալու բանալին է: Այս եկեղեցիների հորինվածքի հիմքում ընկած է առասպելաբանական կենաց ծառը, Ընդերք-Երկիր-Երկինք եռամիասնությունը, սև ու սպիտակ աշխարհահաստեղծ և աշխարհակործան ուժերը վիշապների տեսքով, և խաչը, որպես լուսի սիմվոլ:

**Բանալի բառեր:** Հայկական կենտրոնագմբեթ խաչաձև հատակագծով եկեղեցիներ, ազգային ու հնդեվրոպական միստիկ փիլիսոփայություն, կենաց ծառ, սուրբ եռամիասնություն

**МИФОЛОГИЧЕСКИЕ ОСНОВЫ ПРОЕКТИРОВАНИЕ АРМЯНСКИХ  
ЦЕНТРАЛЬНОКУПОЛЬНЫХ ЦЕРКВЕЙ И ВОПРОСЫ ИХ ПОДЗЕМНЫХ АНАЛОГОВ**

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Центральнокупольные Армянские церкви появились в 7-ом веке как законченный архитектурный замысел и композиция и больше не менялись в течения почти 1500 лет. Автор предполагает, что причина долговечности этой архитектурной композиции является мифологическая концепция вселенной, который формировался в 3-ем тысячелетия у народов Армянского Нагорья. Этот духовная начала также было пресуще предков народов индоевропейского языкового семейства, но в наши дни носителем этой культуры в основном является армянский народ. Доказательства этой теории являются также подземные аналоги центральнокупольных церквей. Каждый отдельный элемент архитектурной композиции символизирует Древо Жизни, Подземелья-Земля-Небо триаду, а также двух Драконов на которых держится равновесия в нашей вселении.

**Ключевые слова:** центральнокупольные Армянские церкви, Национальная и индоевропейская мистическая философия, Древо Жизни, Святая троица

## SPIRAL PETROGLYPHS OF THE USO MOUNTAIN IN VAYOTS DZOR REGION OF ARMENIA: SEMANTICS AND HISTORICAL AND GEOGRAPHICAL CONTEXT

**V.V. Stepkin**

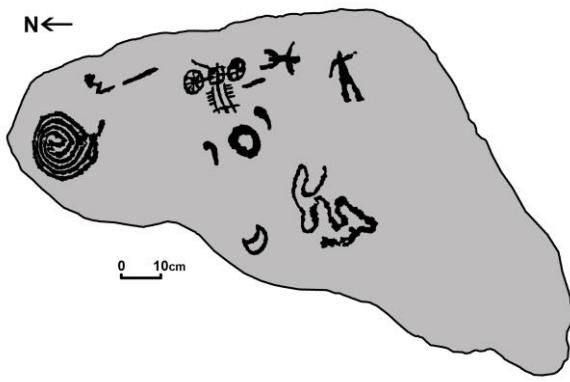
*Russian Geographic Society, Voronezh, Russia*

*This paper is devoted to petroglyphs, a field which is insufficiently explored. Petroglyphs are not direct however contain scientifically accepted proof and base to answer questions related to ancient history, way of living and thinking of people, level of civilization and many other questions. The author base on the results of his own field study and works and viewpoints of other researchers makes conclusions. The wheel found in Lchashen on the shores of Lake Sevan, Armenia by 3000 BC, and chariots and carts of various design expressed in petroglyphs directly show the high level of advanced metallurgy. Referring to other scientific sources, including Rigvand, one of the reasons for tribes disintegration and emigration, Aryan invasions to India, the author sees the mobility of earliest people due to the wheel invention and the techniques of iron and steel manufacturing.*

**Key words:** spiral petroglyph, Mt. Huso, cart, chariot, beginning of metallurgy, Armenia

Petroglyphs of the Armenian uplands have a claim on attention of researchers of rock art around the world. Analysis of wonderful primitive paintings cut in rock enables us to delve not so much into everyday home life and primitive housekeeping of remote ancestors of modern man as penetrate into the world of their ideas, insight and beliefs. In August 2016 the author examined petroglyphs carved on the USO (Huso) hillside 12 km to the north-west of the town of Jermuk of the Vayots Dzor region of Armenia. They were carved on basalt boulders, compactly scattered on a small sloping area, through which runs the water gully illustrated in photos №1 to №6. The area lies at height of 3043 m above sea level – is an alpine meadows zone. During examination of a monument nearby seasonal parking was observed bites for grazing flock of sheep.

The examined petroglyphs were represented by different types. The purpose of this paper is to analyze one of these petroglyphs – a spiral one with accompanying images. It should be noted that this type of petroglyphs is widespread not only in mountains of the Caucasus but also in the mountain systems of Italy [Demirkhanyan-Frolov, 1987, p. 62].



**Figure 1. Cosmogonic myth on petroglyphs of mountain Uso. Painting of the composition with Petroglyph No. 4, reflecting the law of the ordered space rotation**



**Photo 1. Plateau with petroglyphs on the mountain slope of Uso**

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Let us turn into the description of symbols considered in the work and for the sake of convenience giving them sequential numbers. The petroglyph number one is carved on a thin surface layer on a smooth stone using destruction technology without creating a relief image shown in photo №7. Its diameter is about 22 cm. The carving is spiraling counterclockwise tends to its location in the center of the stone on which there is no other petroglyphs. The number of turns of the spiral at various intervals of projections from the center ranges from three to four.

The same technique was used in making the Petroglyph №8. Next to it again there is no other image. The diameter of this Petroglyph is 14 cm. The image is spiralling counterclockwise and tends to the northern edge of the boulder. The number of the spiral turns at various intervals from the centre of projections ranges three to four.



**Photo 2. Lumps of basalt on the slope of the of Uso**



**Photo 3. Petroglyph with the image of the Bezoar goat against the background of the water gully4**

Petroglyph №3, shown in photo №9, was made differently. Because of the deepening in the stone body the turning counterclockwise spiral groove is of relief character and in its centre an image similar to snake head is seen. The diameter of the embossed image carved on the souther-eastern edge of the boulder is 10 cm. There is no other petroglyphs on the rock there. The number of spiral turns over different parts from the centre of projections ranges from four to five.

The Polygliph №4 (photo №10) also is of relief character. However unlike the petroglyph №3 here the image is not a usual one but is of double spirals wound counterclockwise. The diameter of this petroglyph is 21 cm and is carved out on the northern part of the boulder. Unlike the images we have just discussed this petroglyph is not a single, it is a part of composition of which will be discussed later using the photo №11.



**Photo 4. The explorers of the expedition play backgammon on the plateau of petroglyphs**



**Photo 5. S.M. Shahinyan examines the "tree of life" petroglyph**

Based on the above considered carving technique it is not difficult they were made in different times. The problem related to determination of the absolutely exact date of their emergence is the most difficult one. Petroglyphs of the Armenian highlands have been dated by researchers [Piotrowski, 1949; Martirosian, 1971, p.64; Demirkhanyan-Frolov, 1987; Petrosyan, 1987; Tokhatyan 2011, p.171] are ranged the Mesolithic to the Middle Ages. Sometimes here on the same surface of the rock can be seen an image left by the masters of different ages [Demirkhanyan-Frolov, 1987, p. 62].

While studying petroglyphs we have been faced by a question "What is in front of us, the naturalistic reflection of real environment or a certain sign system?" Let us agree with the opinion of those researchers who believe that petroglyphs of Armenia can not be considered solely in the context of "sketching from nature made by ancient artists." First of all, accentuated and limitedness of subjects carved on stones tell about it. For instance, in the Geghama mountain region where petroglyphs are spread there are around hundred duplicates of carved objects. At that around 50 signs repeatedly observed in Syunik, Aragats, Metsamor, and Armavir regions [Martirosyan, 1971, pp 64] are amenable to semantic interpretation and analysis. If count the total number of carved on rocks various images, then it will turn out that their 40 to 50 per cent depict mountain bezoar goats Lat. *Capra hircusaegagrus* [Shahinyan, 2010, pp 25]. Species determination as far back as was done by Vereshchagin N.K., on the material of Gobustan petroglyphs [Vereshchagin, 1981, pp 54].



**Photo 6. V. V. Stepkin at large stones with petroglyphs**



**Photo 7. Spiral-like Petroglyph No. 1 on the Uso mountainside**

Image of bezoar goats are still to be found in the area of Uso mount, as shown in photos №3, №12. Analysis of similar images found in the Armenian highlands shows the possibility to relate them to different historical periods. This phenomenon can be explained partly by the fact that petroglyphic mountain goats image styles hardly changed over time. The correlation of this thesis can be seen in other regions of Eurasia. Thus, for example, researchers involved in the analysis of images of these animals on the rocks of Uzbekistan using special computer programs have arrived at a similar conclusion [Takaki et al., 2011, pp 189].

The time factor of understanding the semantics of mountain goats image is important, but not crucial. Even in societies where primary occupation was farming and cattle-breeding over a long period of time remains of hunting religious ceremonies transfer economical basis of that stage of the society development when hunting was the main source of living [Piotrowski 1949]. Petroglyphs depicting archery are found on the slope of the USO mount.

It is noteworthy that the major zone of petroglyphs distribution in Armenia coincides with the zone of high-altitude alpine meadows (2300-3600 m), used until now as pastures. Exactly here worship to forces of nature found reflection on rock surfaces. The image of a mountain goat in this

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context is comparable to that of a bull of pasture plains, symbolizing the idea of wealth, power, fertility, associated with the cult of vegetation [Danilenko, 1999, pp15, 49].

Succulent vegetation of high-altitude Alpine meadows can not be imagined without an abundance of moisture. In all places artists of primitive era depicted water in the form of a wavy line, echoing the manner of creeping snake that at a later time found reflection in written language systems [Jensen, 1958]. Petroglyph representing water is also found in the study region of USO mountain (photo №13). It has numerous analogues in the mountains of Armenia [Martirosyan, 1971, pp 70].

"Snake, dragon, a symbol represented in almost all mythologies, on the one hand is associated with fertility, the earth, the female reproductive power, water, rain, and domestic hearth, fire (especially the heavenly one), and also the male impregnating power - on the other" [ Ivanov, 1991, p. 468]. In this context, we can talk about the snake as a reflection of dynamic interrelations of various natural elements: earth, water, air, fire (sun). Hence, we see widespread images of snake-dragons as symbology of the Neolith and Eneolith of Eurasia "steadily moving in a circle, and at the same time - now soars in the heavenly heights, now descends to the sphere of the earth and the underworld.



**Photo 8. Spiral-like Petroglyph No. 2 on the Uso mountainside**



**Photo 9. Spiral-like Petroglyph No. 3 on the Uso mountainside**

One would think that just in this connection graphic reproduction showed up in the course of time which for the primitive farmer was equivalent to the run of water over the earth and heaven, and in the same time equivalent to the flow of solar heat and light [Danilenko, 1999, p. 20]. In this case spontaneous-time history perfectly reflected in the spiral petroglyphs of USO mountain. At their heart folded in coils lies a snake, of which the head is particularly well seen in petroglyph №3. In this context an image of a snake is not only deeply symbolic but also naturalistic, bearing in mind that snakes rolled up their bodies in this way.

Analyzing the petroglyphs of the Armenian highlands, it is necessary to take into account that "in the zone of Alpine high-altitude meadows the objects of rock culture were created by casual people and not episodic. Petrographic culture emerged and developed in close connection with the whole culture of the Ancient world. Maps of the constellations, lunar calendars and "art galleries in the open air" were created by that most educated people of the time: scientis-priests, artists and craftsmen carving in stone "[Petrosyan, 1987].

In this context, let us try to look at the petrographic composition which is accompanied by Petroglyph №4 in the form of a double helix (Photo №11, Fig. №1). In the centre, carved on a stone composition there is a circle to which from the East moves a cart harnessed by two horses. To the North from the centre a double spiral is carved and to the South there is a snake over which there are two human figures, one is horizontal and the other –vertical. To the west of the central circle yet there is another one with the sectorial fragmentation which is not explicitly read. It can be assumed that it is the Moon over which a circle is carved – the symbol of the Sun - the eternal flow of time reflected in

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the change of seasons and the daily cycle. The cart moving from East, in the context of the solar symbolism - drawn by two horses, is "the chariot of Surya." Attention is drawn to the center of the chariot - a square divided by a cross into four parts, which may be interpreted as a symbol of the earth or the horizontal section of the median level of the world tree. "The interpretation of the world tree horizontally gives the quaternary division of the universe - the four sides of the world cardinal points. The centre is added to this as the fifth member of the ..." [Tatyana Elizarenkova, 1995, pp 476], which in the present case sredokrestiem. In this context, the two-wheel cart is the day and night sun. The sun in the daytime illuminates the vault of heaven, and at night, according to mythological representations, descends to the underworld, or moves across the vault of heaven in the opposite direction, turning to the audience its dark side. Dualism daily change may also be displayed in the number of horses. (It should be noted that a solar symbols are found on other stones of USO mountain, photo №14). Attention is drawn to the opposition in the image of a snake on the north and south sides of the stone. In the north, two snakes curled up in a spiral - the binary symbolism (day-night, light-dark, heat-cold, top-bottom, sky-earth, etc.) of the ordered space [Tatyana Elizarenkova, 1995, pp 477]. In the south, in the snake's body movement there is not harmony - the concept of chaos. At the top of the composition a man is lying and standing - death and life, an essential feature of human existence. This interpretation is stamped on the rock scene is well within the world of ideas of the ancient Aryans, reflected in the Rig-Veda and finding "their typological parallels in primitive representations of other peoples" [Tatyana Elizarenkova, 1995, pp 479]. "World Model aria Rig-Veda is space-oriented. With it everything is related, and to it all is involved. The life of a man is connected with the space with the help of Rita (rtd-) - gyre law of the universe, which is universal» [Tatyana Elizarenkova, 1995, pp 453]. Attention is concentrated on synchronism of functioning of this law, as reflected in the cosmogonic myth of the universe creation. According to it every important moment in the life of an aria was considered as a repetition of this initial process [Kuiper, 1986, pp 28.].



**Photo 10. Spiral-like Petroglyph No. 4 on the Uso mountainside**



**Photo 11. Composition of images on a stone, including Petroglyph number 4**

The origin of the universe is the prototype of the cyclic renewable renewal of life.

At that in reconstruction of the original version of the Rig-Veda cosmogonic myth two stages are distinguished: "existence of primordial world of nonsegmented unity and creation of dual world by Indra god - individualized forms from non-differentiated chaos" [Елизаренкова, 1995, с.453]. To understand the mythical deeds of Indra the following is cited from a labor of Keiper dedicated to Vedic mythology. "Indra's demiurgic act consists of two different parts, having relation to the original hill and the tree of life, respectively. The hill which is still floating on the primordial waters, should be split to the ground and opened. However, it concluded a significant resistance force. In the myth, the resistance force is personified by dragon, and Indra should, like St. George and other mythological characters, kill the dragon. It should not be forget, however, that this dragon, also called Vritra,

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represents only one particular aspect of the primordial hill - resistance that Indra has to overcome, to split up the hill. In this fight, Indra wins. He kills the dragon, and out of the hill, open it by his force, sees life in two forms - water and fire. In the myth of creation the water is represented by four rivers running down from the top of the hill in four different directions, and the fire – by the sun rising from the hill or from the water. Hill is now no longer floats. It found support (as the texts say), and begins to grow in all directions, until it reaches the size of the earth. At the same time, it remains the center of the universe and the nail that secures land to its place. As for the second part of deeds done by Indra regarding the tree of life, then Indra here is functioning as a pillar supporting the sky, lying until then on the earth. In this way he creates the duality of heaven and earth. From a mythological point of view, it is not a single event, since opposition of the sky to the earth is only one particular aspect of a comprehensive dualism. Further, when the sun rises to the sky, is born the opposition of light to darkness, in parallel to opposition of life to death "[Kuiper, 1986, pp 29-30].

In this context the petroglyphs under study receive an additional interpretation. Let us first look at the "chariot of Surya." From its center, enclosed in a square four rivers flow in opposite directions - escaped from the primordial hill. This idea found its further reflection in Hinduism, where the four rivers flow from Mount Meru, forming a horizontal cross of the earthly world and correlating four elements, four phases of the cyclical development, four ages (*yugas*).



**Photo 12. Composition of petroglyphs with the image of the Bezoar goat on the Uso mountainside**



**Photo 13. Petroglyph in the form of a wave-like coiled body of a snake**

It is noteworthy in this context that the number of turns of spirals considered here, which in most cases can be read in the context of the last unfinished fourth epoch. About to unfold during the creation of the earth and its day and night the sun can also be read in the Ri- Veda [Tatyana Elizarenkova, 1995, pp 480]. In our case, as has already been noted, it is two wheel of the cart.

Let us now turn to the interpretation of the second part of Indra's deed, which established the harmony between heaven and earth, in the context of our petroglyphs. As we already mentioned, in the south of the "chariot Surya" is a man as if lying with his arms and legs stretched out. If we raise him to a vertical position, then we will see nothing but a growing "tree of life" [Shahinyan, 2010, p.4]. At the same time, his upper part is a crown resembling the Greek or Cyrillic letter psi -Ψ, and the lower part of the tree are the roots, the inverted equivalent of the letter psi. Roots are formed as a result of the synthesis of the male and female principles, leading to the germination of seed from the earth, the earthly creation. The crown is the result of a heavenly creation, in the center of which is the sun. The image of the figure with arms raised to the sky is a symbol of life, harmony of micro and macrocosmos, the connecting link of which is man. (It is significant in this context that the Cyrillic spelling of the letter "ж", which is called "live").

Next to this figure, another one is depicted on the stone, but this time in an upright position. The human image on it as if makes a step forward: legs apart, hands swinging. In the context of the above interpretation, it can be assumed that it is the Vishnu step described in the Vedic tradition, connected in the Rig Veda with the killing of the demon dragon Vritra by Indra [Keiper, 1986, pp 104, 107]. Taking a step, Vishnu starts the forward movement through the universe. As the first step he is structures the terrestrial space, by the second step - the atmospheric, and by the third - the sky. Is not this the triple number of turns of the double spiral on that stone? The purpose of Vishnu's steps, recorded in the Rig Veda, can be summarized in one word "life". At the very moment of the dual world creation, he rose from the center like an axis between the wheels, connecting heaven and earth [Keiper, 1986, pp 102-103, 110].

It is important to note that presence in Vedic mythology the dichotomy of the creation of the upper and lower world "organizes phenomena in accordance with the directions of the countries of the world, the upper world is represented by the north and the east, and the lower one by the west and the south" [Keiper, 1986, p.42]. At that the sun is considered as the representative of the upper world, and the moon is a lower one. On the petroglyphic composition we are considering, the same pattern is observed. This allows us to say that since the application of the image to the stone, it has not changed its spatial orientation.



**Photo 14. Solar symbol on the Uso mountainside**

No less interesting is the very mountain location of the stone in the context of the plot struck on it. "There are clear indications of the connection of Vishnu with the mountains: he" dwells "or" stands "on the mountains; He is the ruler of the mountains. Actually, the mythological significance of mountain (or mountains!) in the mythology of Vritra is connected with the original hill "[Kuiper, 1986, p.111].

In the context of the foregoing, the mass image of mountain goats on the rocks of the Armenian plateau is also perceived in a somewhat different perspective. This animal has two key features for selecting it as a specific symbol. Firstly, its habitat range is high in the mountains, and secondly, there are two large horns bent back, representing, as it were, the beginnings of the double spiral. The reality of this association among the creators of petroglyphs is shown by such images of mountain goats, where the horns are strongly twisted in the form of spirals, which can be seen in some rock carvings [Shahinyan, 2010, p.76].

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It can be assumed that with time the meaning of the mountain goat petroglyph sending us back to the time of creation from the original hill in the dynamics of the dualistic space, could be lost. After that, the image of this animal could be reproduced only by analogy, like it was often found in folk embroideries, with respect to other mythological subjects [Rybakov, 1994, pp 471-527]. But when did the master's hand perform this rock panel? Despite all the complexity of dating, we have certain chronological reference points. The first of these is connected with the presence of Indo-Europeans in the Armenian Highlands. In accordance with the hypothesis of T.V. Gamkrelidze and V.V. Ivanov, the territory of the original ancestral home of Indo-Europeans coincided with Eastern Anatolia, the South Caucasus and Northern Mesopotamia (V-IV millennium A.D ).

Hence in the first half of the III millennium BC. Indo-Iranian tribes appeared in the north of Iran, and then - through Afghanistan - the first waves of Indo-Aryan tribes moved east to north-western India. In the area of modern Punjab, through the Hindu Kush passes, the warlike tribes who called themselves arias (arya) came about in the middle of the II millennium BC. [Gamkrelidze, Ivanov, 1984; Elizarenkov, 1995, pp 426, 429].

The second chronological reference point is related to the time when among Indo-Europeans wheeled vehicles appeared. It should be noted that "all the numerous terms pertaining to wheeled transport trace back to the pre-Indo-European epoch, that is, wheeled transport, according to linguistics data, was already known to the Indo-European people before the disintegration and the beginning of their migration. If we assume the date for a pre-Indo-European community of V-IV millennium BC, then the wheeled transport should have appeared already at this time. It was the invention of wheeled vehicles that allowed mass movements to take place, which caused the collapse of Indo-European unity "[Safronov, 1989, C.157-158].

Currently, scientists, comparing the data of linguistics with archaeological material, all dates of the ancient monuments with wagons refer to the IV-III millennium BC. [Safronov, 1989, p.159, 165]. This enables to arrive at a conclusion that the composition of petroglyphs under study did not appear earlier than this time. It should be noted that the archaeological material of the North-Eastern Armenia obtained during the excavations dates the presence of wagons in the 23-21 centuries. BC, referring to the last stage of the evolution of Kuro-Araksian culture in Transcaucasia [Safronov, 1989, c.177].

From the methodological point of view, determining the age of appearance of wheeled vehicles, it should be noted that "the production of wheeled wagons implies a certain level of metallurgy, which was necessary for making of solid woodworking tools" [Gamkrelidze, Ivanov, 1984, p.717].

That is, we can talk about the appearance of petroglyphs of wheeled vehicles in the Armenian Highlands in the period not before the Eneolithic era. The most probable time for the application of these images to the cliffs dates back to the 3rd millennium BC. This conclusion is well correlated with the dating of other petroglyphs of the Armenian highland of a cosmological nature dating back to the 27th to 25th centuries. BC. [Tohatian, 2011, pp 172]. That is, we can talk about the appearance of petroglyphs of wheeled vehicles in the Armenian Highlands in the period not before the Eneolithic era. The most probable time for the application of these images to the cliffs dates back to the 3rd millennium BC. This conclusion is well correlated with the dating of other petroglyphs of the Armenian highland of a cosmological nature dating back to the 27th to 25th centuries. BC. [Tohatian, 2011, pp 172].

It can be assumed that the cosmological plot under examination was not simply connected with the reflection of the mythological concept of the world order, but also with a certain ritual that helps the forces of harmony in the images of Indra and Vishnu in the struggle against death and darkness [Keiper, 1986, p. 50]. After all in the world "everything repeats itself as it was in immemorial prescription, and following the law of rita, a person reproduces the cyclical nature of cosmic

phenomena in the cycle of the ritual, thereby maintaining order in space and in human society and creating conditions for the normal and successful life of his tribe" Elizarenkov, 1995, pp 457].

### **Conclusions**

Noteworthy in this context is the twisting of spirals on the stones of the mountain Uso slope against the movement of the sun, counterclockwise. "What was, it will be; and what was done, it will be done, and there is nothing new under the sun "(Ecclesiastes 1: 9). Thus, the spiral petroglyphs of the Jermuk Mountains that we have discussed symbolize the universal law of the rotation of the universe reflected in myths, brought to life by the cosmological act of creation. Their creators in the Bronze Age were the tribes of the Indo-European cultural tradition, the mythological representations of which were later reflected in the Rig Veda.

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## Վ.Վ. Ստեղին

Դուսական աշխարհագրական ընկերակցություն

Հոդվածը նվիրված է համեմատաբար քիչ հետազոտված բնագավառի՝ ժայռապատկերներին: Ժայռապատկերները կողմնակի, բայց գիտականորեն ընդունելի ապացույցներ են պարունակում հնագույն պատմության, մարդկանց կենցաղի, մոտածողության, քաղաքակրթության մակարդակի և բազմաթիվ այլ հարցերին պատասխանելու համար: Հեղինակը հենվելով իր կողմից հրականացրած դաշտային աշխատանքների արդյունքների և այլ գիտնականների աշխատանքների ու տեսանկետների վրա կատարում է եզրակացություններ: Հայատանում Ք.ձ.ա. 3-րդ հազարամյակում հայտնված անհվլ և նրա հիման վրա սայլերի հորինվածքների տեսականին, որոնց տիպերը արտացոլված են ժայռապատկերներում, ուղղակիորեն մատնացուց են անում զարգացած մետալուրգիայի բարձր մակարդակը: Վկայակոչելով այլ գիտական աղբյուրներ, այդ թվում և Ոհզմեռան, Հայկական բարձրավանդակում ապրած ցեղերի տրոհման, արտագաղթի և դեախ Հղկաստան արիական արշավանքների պատճառներից մեկը հեղինակը տեսնում է անհվի և մետալուրգիական տեխնոլոգիաների նվաճման արդյունքում քարի դարի մարդկանց ձեռք բերած շարժումակության մեջ:

**Բանալի բառեր.** պարուրածն ժայռապատկերներ, Հուսո լեռ, ձիակառք, մետալուրգիայի սկիզբ, Հայաստան

## СПИРАЛЕВИДНЫЕ ПЕТРОГЛИФЫ ГОРЫ УСО В ВАЙОЦДЗОРСКОЙ ОБЛАСТИ АРМЕНИИ: СЕМАНТИКА И ИСТОРИКО-ГЕОГРАФИЧЕСКИЙ КОНТЕКСТ

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Статья посвящена сравнительно малоизученным скальным изображениям-пртроглифам, которые являются косвенными, но с научной точки зрения весьма приемлемыми доказательствами для изучения древней истории людей, об их образе жизни, мышлении, обычаях и уровне цивилизации. Опираясь на результаты как собственных полевых исследований, также и на исследований других исследователей, автор делает следующее заключение. В 3-м тысячелетии колесо и созданные различные типы телег на его основе, изображенные на петроглифах, прямо указывают на высокий уровень развития металлургии в Армении. Ссылаясь на другие научные данные, в том числе Ригведа, одной из причин распада, миграции, походов арийцев в Индию, Автор считает приобретенную высокую подвижность людей каменного века, благодаря колесу и развитию металлургических технологий.

**Ключевые слова:** Спиралевидные петроглифы, г. Усо, колесница, начало металлургии, Армения

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## EDUCATIONAL TECHNOLOGY IN HIGHER VOCATIONAL EDUCATION

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*The article deals with the educational technologies in higher vocational education. It provides an analysis of existing educational technologies and highlights the most promising. It makes emphasis on dual and project method technologies which are the most appropriate for higher vocational education.*

**Key words:** *student-centred education, module-rating technology, dual technology, project-based learning.*

In the modern system of higher vocational education the choice or development of technology for teaching of a particular discipline which is made by teacher based on his personal beliefs and constitutes his individual style of pedagogical activity. There are many educational technologies aimed at implementing the goals of the education system. The leading among them is the technology of *student-centred education*, which primary focus on the individual. *Student-centred education* is of great interest to many educators and psychologists (O. B. Episheva, N. N. Surtseva, G. K. Selevko). Although the term *learning technology* is not common in traditional pedagogy, however it is actively used at present. For example, *education technology* is seen as a systematic method of creation, application and definition of the process of teaching and learning, taking into account technical and human resources and their interactions, aiming at optimizing forms of education. On the one hand, technology is the totality of methods and means of processing, representation, modification and presentation of educational information, but from the other side it is a science of how the impact of the teacher on the students in the learning process with the necessary technical or informational tools. In the technology of teaching the content, methods and means of learning are interrelated and interdependent. And the main criterion of evaluation of educational technology are its efficiency, effectiveness and practical value.

*Educational technologies* according to G. K. Selevko, should meet the requirements of scientific, technological, sufficient completeness and reality of its implementation. These requirements are considered from the position of the subject and object of training and education.

The main criteria are the adaptability of the system (complexity, integrity) scientificity (conceptual role, developing character); structure (hierarchy, consistency, algorithmicity, continuity, variability), procedural (controllability, instrumentality, diagnosticity, prognosticability, efficiency, optimality, repeatability).[4,p.22].

The concept of *educational technology* has appeared in 20-s of XX century and had other names: pedagogical technology, education technology, learning technology. This was due to the technological revolution in the field of physics, chemistry, energetics, biology, mathematics, computer science and other sciences, which, of course, is reflected in the education system. However, the concept of educational technology has a broader meaning than the concept of educational technology, because in addition to teaching, includes social, socio-political, administrative, cultural, psycho-pedagogical, medico-pedagogical, economic and other related aspects.

Pedagogy traditionally covers training and education, and technological approach in pedagogy formed on the basis of new educational technologies, which provides «accurate instrumental control of the educational process and guaranteed achievement of the set educational goals». [4, p.30].

*Educational technologies*, involving the design of learning activities, in contrast to the methodic lesson plans for teachers leading to high stability success with any number of students. In modern conditions, when the computerization of the teaching process has become a necessity, instructional design (pedagogical) is the only requirement for its effective implementation. There is no unambiguous interpretation of the concept of educational technology in science. The opinions were divided. According to academician G.K.Selevko, the head of the Center for development and selfdevelopment of the International Academy of Sciences of pedagogical education, there are four positions:

**1) Educational technology as the production and use of the facilities, hardware and software for the learning process**

Representatives of this position (B. T. Likhachev, S. A. Smirnov) consider the educational technology as a combination of psychological-pedagogical systems, forms, methods, teaching techniques, educational means and pedagogical ethics. By their view, «pedagogical technology - a set of psycho-pedagogical attitudes that define a special set and layout of forms, methods, teaching techniques, educational tools of teaching process» [B. T. Likhachev]; «educational technology is a new type of training» [S. A. Smirnov].

**2) Educational technologies is a communication process or method of implementation of educational tasks**

Representatives of this position ( B. Skinner, S. Gibson, M. Gillette, T. Sakamoto) applied behavioral science and systems analysis to improve learning. They believe that educational technology is a process of communication (method, model, technique exercises), which is based on certain algorithm, a program, a system of interaction of educational process participants.

**3) Educational technology is a vast field of knowledge, based on data from the social, managerial and natural sciences**

The representatives of the third position (V. V. Guzeyev, R. Kaufman, M. Eraut, Pidkasisty P. I., S. H. Wedemeyer) consider educational technology as a vast area of knowledge concerning data on the social, managerial and natural sciences.

**4) Educational technology is a multidimensional process**

Representatives of this position, consider educational technology as a multidimensional process (V. I. Bogolyubov, M. V. Klarin, V. V. Davydov, G. K. Selevko, E. V. Korotaeva, V. E., Steinberg, P. D. Mitchell, R. Thomas). In particular, G. K. Selevko notes that «the pedagogical technology is a operation system of all components of the pedagogical process, built on scientific basis, programmed in time and space and leadded to the planned results». [4, c.39].

From the above we can assume that educational technology is a new attainment level in education and its main purpose that it allow to transfer the learning process to the stage of preliminary planning with the subsequent reproduction. Educational technologies are aimed at achieving the goals through personal development, goal setting and objective quality control of assimilation of learning material, contribute to the realization of educational functions and the personality-oriented paradigm of learning.

At the same time, they contribute to the realization of individual educational trajectories of students of technical colleges, as they help themselves to set goals independently and to find ways to address them. Educational technologies are now widely applied in the education system of different countries and they are many. Among them, the most popular module-rating technology of training , credit-modular technology of education, control and correcting training, technology of individual educational trajectories and etc. However, in our opinion, the most promising technology for vocational education is dual education technology, which involves a theoretical and practical knowledge, simultaneously. This technology is widely used in Europe and Canada, some regions of

Russia, and was first applied in the vocational school after Yeznik Mosyan in the cultural capital of Nagorno Karabakh, Shushi.

According to the dual technology the education is based on the integration of SFA's<sup>1</sup> program, the main advantage of which is the absence of a gap between theory and practice. In the dual task training students in the early stages of training to acquire certain expertise and skills for the optimal choice, as in the diploma indicates multiple qualifications simultaneously. During the training develop such personal qualities as ability to work in a team, responsibility for the charged work area. The advantages of the dual system lie in the fact that students contemplate a new future profession in the process and take a reasonable decision on correctness of choice of profession. And among other things, future engineers can provide some additional income and work experience, which is extremely necessary for employment in modern conditions.

Of course, each country has its own specific features of introduction of the dual system in vocational education. For example, in Germany, which is one of the leader in the system of European education, you can get dual training among such giants as Volkswagen, REWE, SIEMENS, BMW, etc. Enterprises are interested in the dual system of vocational education, because they get an opportunity to prepare qualified young personnel.

Another promising technology for higher vocational education is a *method of projects*. *Project method* as a pedagogical technique involves the combination of research, problem-based methods, which are quintessential creative. The teacher in the framework of the project plays the role of developer, facilitator, expert, tutor. At the same time, the project method is a set of teaching and learning techniques that allow to solve a particular problem is the result of independent actions of pupils with obligatory presentation of results. The technology of the method of projects is the development of cognitive skills of students, abilities to independently design their knowledge, skills to navigate in the information space, development of critical thinking. Method of projects is focused primarily on independent student activity - an individual, a group, which they perform during a certain period of time. Students on this technology, acting individually or in a group, have to «go balls to the wall» and apply their knowledge when solving problems. For students of technical colleges *method of projects* is the possibility of maximum disclosure of its creative potential, because the methods of management of projects involves several stages: planning, searching, generalization, presentation and protection. And since the project activity is aimed at cooperation of teachers and students, in some way is a form of assessment in lifelong learning process. *Method of projects* helps to improve the quality of education, efficiency of educational process. This technology can be used in almost any discipline of a technical college because it offers the organization the learning process in the form of establishing and implementing a set of projects.

To summarize, I would like to note that all educational technologies bring together a number of signs, the implementation of which in practice shows a significant difference in the educational process on the basis of pedagogical technology from educational process organization on the basis of the class- and-lesson system. Such signs include the changing nature of teacher's activity, changing the nature of the activities of students (from an object turned into a subject of educational process), the increase in the proportion of school time to extracurricular independent work, providing students the choice to learn at a pace appropriate to their individual abilities and inclinations, granting the right of way of learning, the learning of an individual educational trajectory.

Aiming the optimization of forms of education, pedagogical technology of activization of informative activity of students on the one hand. On the other hand, they are focused on the design activity of the teacher, giving educators themselves to design a tailor-made pedagogical technology that promotes self-development, transformation, flexible adaptation to the specific conditions of learning, leading to greater success of students and therefore the teacher. New pedagogical technologies allow us to predict outcomes and manage the teaching processes; to analyze and systematize the scientific basis for practical experience and its use; to solve the complex educational

and socio-educational problems; to provide a supportive environment for personal development; optimal use of available resources; to choose the most effective and to develop new models to address emerging socio-pedagogical problems.

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## **ԿՐԹԱԿԱՆ ՏԵԽՆՈԼՈԳԻԱՆԵՐԸ ՄԱՍՆԱԳԻՏԱԿԱՆ ՏԵԽՆԻԿԱԿԱՆ ԿՐԹԱԿԱՆ ՀԱՄԱԿԱՐԳՈՒՄ**

### **Ա.Պ. Գասպարյան**

*Շուշիի պետական համալսարան*

Հոդվածը նվիրված է բարձրագույն մասնագիտական գեխնիկական կրթական համակարգի կրթական գեխնոլոգիաներին: Այսինքն դրվում է առկա մանկավարժական գեխնոլոգիաների վերլուծությունը երկակի գեխնոլոգիաների և նախագծերի գեխնոլոգիաների մեթոդի շեշտադրումով, որոնք առավել ընդունելի են մասնագիտական գեխնիկական կրթական համակարգում:

**Բանալի բառեր.** Կրթական գեխնոլոգիա, մանկավարժական գեխնոլոգիա, մոդուլավարկանիշային գեխնոլոգիա, երկակի գեխնոլոգիա, նախագծերի եղանակ:

## **ОБРАЗОВАТЕЛЬНЫЕ ТЕХНОЛОГИИ В СИСТЕМЕ ВЫСШЕГО ПРОФЕССИОНАЛЬНО-ТЕХНИЧЕСКОГО ОБРАЗОВАНИЯ**

### **С.П. Гаспарян**

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Статья посвящена образовательным технологиям в системе высшего профессионально-технического образования. В ней дается анализ существующих педагогических технологий и делается акцент на дуальной технологии и технологии метода проектов, которые наиболее приемлемы в системе профессионально-технического образования.

**Ключевые слова:** образовательная технология, педагогическая технология, модульно-рейтинговая технология, дуальная технология, метод проектов.

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## SOME METHODS OF TEACHING OF TECHNICAL ENGLISH

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*The paper deals with some means and methods of how to overcome the students' inner psychological obstacles, help the lecturers to improve the educational process when working with the student and teach special language. It introduces different theories, covering inner psychological obstacles of students and the ways of overcoming them, thus improving the educational process of teaching foreign languages.*

**Key words:** *psychological obstacle, terms, technical English, professional vocabulary, communication, volition, lack of confidence, willingness, anxiety, agriculture, architecture.*

### **Introduction**

It was and still it is a big problem for the foreign language educators to find an appropriate approach how to teach English more productively and how to help students to overcome their inner psychological obstacles when learning a foreign language. In fact, it is a very serious problem for not only foreign language educators but also university students. One of the solutions for this problem is that students should be involved in different groups according to their language level: beginners (elementary), pre-intermediate, intermediate, upper and advanced. But when we deal with students from different schools of our republic the problem can seem more serious than we imagine. One of the reasons of the poor English or rather the lack of intelligence is connected with the traditional way of teaching English at schools especially in the villages. In towns the teachers are eager to carry modern methods of teaching English, to use means and devices to make the lessons interesting and motivating, to use the internet, cooperative learning methods, group working, online lessons of every kind, thus the level of knowledge is higher, but in villages the picture is different. In town schools speech is more developed, communication is held every time in classrooms, students can speak more fluently than in village schools where teachers actually cannot communicate sufficiently themselves, have lack of vocabulary and knowledge. Sure there are exceptions as well, i.e. there are schools in villages where teaching English as FL is satisfactory. Unfortunately, after moving from one school to another or to the college, some students face serious problems either being in quite a different environment or experiencing new methods of studying English. The thing is that very often changing English the teacher can be "fatal" for the students. Some students are used to their former teachers at schools, as they have been learning since the first grade, where the methods and style of teaching/learning are quite different. There are also other effective factors such as attitude, motivation, anxiety and beliefs, etc., about foreign language learning that are considered to be important factors which might influence foreign language learning process.

In recent years some research was carried out in different schools to reveal the problems of foreign language teaching and learning. The aims are the same: to find effective methods, to create confidence and strong will for the students to learn English. For this purpose foreign language educators should raise the awareness of the importance of English and strengthen the volitional strategies of the students when they work with them. From the results we understood that there are several important factors that are necessary for the students: confidence, will, ability, tolerance. The results at high school are higher than those of secondary schools. It is quite logical that the level of

foreign language knowledge at high schools is comparatively higher. The reason is actually hidden in the final decision of students where to go and what to do after school. It is also important to know about the factors which can influence their decisions. These two factors: awareness of the importance of English and volitional control-together play an important role in learning English. The sooner the students understand the significance of English, the easier will be for them to choose their future profession.

Shushi technological university is also involved in this process. The teaching stuff is eager to find ways and carry methods on to put teaching process on high levels. Different approaches are being worked out to highlight the main barrier for students in learning English which is that they had a general belief that they are not good at learning foreign languages. Others had already decided where to get education and had a clear orientation, will and proper abilities, but in this case learning English is pushed out. Shushi technological university gives such opportunities to continue students' further education in other universities, in Europe or the USA where a good knowledge of English is quite necessary and required.

### **Conflict setting**

Research proved that the traditional approach is not productive. We must go to holding new and effective methods, to integrate methods which will help students to gain confidence and get rid of anxiety, sometimes to be allowed to choose an appropriate program or the so-called "self study programme". To teach technical and professionally oriented English it is more effective to teach a foreign language by using flashcards, dialogues, watching films, taking online lessons concerning their profile.

Agronomists here need to be taught agricultural terms, special vocabulary which will later help them to study special literature on the item. The same can be said about the architects. Special texts are chosen for them to enhance technical vocabulary, modern technologies and utilities, equipment help the students to strengthen their volitional control, attention, confidence and will. It is a big task that here we do not have live communication outside the university, that's why we must do a lot of group working, pair work and do a lot of practical exercises to develop our students' speech. The lecturers must use all modern interactive and cooperative methods to be useful for their students.

Many faculties in Shushi technological university are opened newly to support the state with experienced and highly qualified specialists. Architectural and civil engineering faculties are also aimed at this: to prepare a real working stuff for town reconstructing, and not only these faculties. University graduates will get chance to experience their profession in Artsakh and Armenia. Our country is first of all an agricultural country and learning special English will be much more demanded for later qualifications and academic research.

**Agronomy** (Ancient Greek ἀγρός *agrós* 'field' + νόμος *nómōs* 'law') is the science and technology of producing and using plants for food, fuel, fiber, and land reclamation. Agronomy has come to encompass work in the areas of plant genetics, plant physiology, meteorology, and soil science. It is the application of a combination of sciences like biology, chemistry, economics, ecology, earth science, and genetics. Agronomists of today are involved with many issues, including producing food, creating healthier food, managing the environmental impact of agriculture, and extracting energy from plants [2]. Agronomists often specialize in areas such as crop rotation, irrigation and drainage, plant breeding, plant physiology, soil classification, soil fertility, weed control, insect and pest control.

Agroecology is the study of ecological processes that operate in agricultural production systems. The prefix agro- refers to *agriculture*. Bringing ecological principles to bear in agroecosystems can suggest novel management approaches that would not otherwise be considered. The term is often used imprecisely and may refer to "a science, a movement, or a practice" [2]. Agroecologists study a variety of agroecosystems, and the field of agroecology is not associated with any one particular method of farming, whether it be organic, integrated, or conventional,

intensive or extensive, although it has much more common thinking and principles with some of farming systems [3]. In Artsakh and Armenia such kind of specialists (agronomists and agroecologists) will be much more useful for developing the economy as they tend to work in the field of agronomy. Teaching special English to the students of these faculties is certainly very difficult first of all for their lack of technical vocabulary. Students have not come across these very vocabulary and texts at school and here in the university it is a problem to learn. But the problem, of course, is not impossible to solve.



**Figure 1. Artsakhi vegetable harvesting**

First of all the whole of vocabulary is given with transcriptions and translations. It is a kind of individual work for them. Later they are asked to learn these words by heart. A group work is held with them in asking the vocabulary. Then the special terms are explained in details to be memorized. Texts are read and told by students who have willingness to speak, to communicate, and as a result of this some students can talk and take part in discussions which is done every time the text is covered. Surely not all students have desire to study specially oriented English, but we work to motivate them. Low motivation is another obstacle. Students who have difficulty with foreign language learning are often described as underachievers or learners with low motivation. As we see, first and foremost one should help the students learning English to develop strong motivation. The Internet is sometimes used to show videos, pictures and information proper to the issue. An individual work is immediately given at home besides their vocabulary and texts either to present reports or show slides speaking about the theme given.

After the war our towns and villages need to be reconstructed soon. And huge work is being done towards this. Government and foreign investors spend much money on reconstructing buildings, or building new constructions. This is where architects are required, and this faculty is trying to prepare real specialists in this sphere of activity.

**Architecture** (Latin *architectura*, from the Greek ἀρχιτέκτον *arkhitekton* "architect", from ἄρχει- "chief" and τέκτων "builder") is both the process and the product of planning, designing, and constructing buildings and other physical structures. Architectural works, in the material form of buildings, are often perceived as cultural symbols and as works of art. Historical civilizations are often identified with their surviving architectural achievements.

Architecture has to do with planning and designing form, space and ambience to reflect functional, technical, social, environmental and aesthetic considerations. It requires the creative manipulation and coordination of materials and technology, and of light and shadow. The practice of architecture also encompasses the pragmatic aspects of realizing buildings and structures, including scheduling, cost estimation and construction administration. Documentation produced by architects, typically drawings, plans and technical specifications, defines the structure and/or behavior of a building or other kind of system that is to be or has been constructed.

The word "architecture" has also been adopted to describe other designed systems, especially in information technology.

Here the students work much to learn technical English, special terms and texts on architecture, architectural design and constructing. History of architecture is taught, and also modern trends of nowadays architecture is shown to students. Texts are read and translated in classrooms, special vocabulary is given to study and learn by heart, and at home students learn telling and preparing reports when given on different topics. The Internet is used to show examples of modern constructions, different architectures (middle ages, ancient times, European architecture etc.), seeing these pictures and videos students can learn much about design and decoration, material and structure. What is notable in this classroom that the students learn interactive methods of learning, cooperative learning, discussions with the aim of developing oral speech and communication skills. These methods of teaching are also supported by many researchers. It is indisputable that English plays a very important role as a world language. This fact will undoubtedly help them to regulate themselves in managing a foreign language anxiety. Some students understand that being weak at English they need to study further, but they admit that "knowing is one thing, doing is another thing". By studying the behavior of different students we ourselves clear up that even if they do their best, it is still a problem for them to overcome the difficulties in learning English. In any case we realize that volition is controlled by learners intentions in realizing their goals and keeping their motivation [1].

Thus, according to our research we reveal that the students should consider two prominent factors: awareness of the importance of English and volition control. Promoting volitional strategies and assisting their students the educators help them to overcome their inner obstacles in learning English.

### **Research results**

The results of our research are the following: the traditional approach is not productive. We must go to holding new and effective methods, to integrate methods which will help students to gain confidence and get rid of anxiety, sometimes to be allowed to choose an appropriate program or the so-called "self study program". To teach technical and professionally oriented English it is more effective to teach a foreign language by using flashcards, dialogues, watching films, taking online lessons concerning their profile.

### **Conclusion**

We may conclude from the paper that there are several methods and approaches to help us to overcome the psychological obstacles during the teaching of English as foreign language, especially Technical English. These methods can help the students to study better and as a result they can support the productive and effective language teaching. In this paper we tried to point out some methods of teaching English at technological faculties of Shushi technological university. Here we discussed carrying new and effective methods at technological faculties, the example is shown in two faculties-agricultural and architectural, but the methods can be carried every time they are needed and whenever necessary. And here also some factors are mentioned which are required to learn English.

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## ՏԵԽՆԻԿԱԿԱՆ ԱՆԳԼԵՐԵՆԻ ՈՒՍՈՒՑՄԱՆ ՄԻ ՔԱՂԻ ՄԵԹՈԴ

### **Կ.Ե. Փաթյան**

*Շուշիի գրեթեական համալսարան*

Հոդվածում ներկայացված են օտար լեզվի դասավանդման և ուսումնառության գործընթացում սովորողների հոգեբանական խոչընդոտների /օրինակ՝ ցածր մոտիվացիան, կամային հատկությունները և այլն/ հաղթահարման որոշ ուժիներ և մի քանի մոտեցումներ, որոնք նպաստում են ուսուցման գործընթացի արդյունավետ կազմակերպմանը և ուսումնական նյութի յուրացմանը:

**Բանափի բառեր.** հոգեբանական խոչընդոտ, եզրույթ, տեխնիկական անգլերեն, մասնագիտական բառապաշար, հաղորդակցություն, կամք, վստահության բացակայություն, պատրաստակամություն, շփոթվածություն, գյուղատնտեսություն, ճարտարապետություն:

## НЕКОТОРЫЕ МЕТОДЫ ПРЕПОДАВАНИЯ ТЕХНИЧЕСКОГО АНГЛИЙСКОГО ЯЗЫКА

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В статье представлены некоторые способы и методы преодоления психологических барьеров студентов /низкий уровень мотивации, волевые особенности и т.д./ в процессе изучения иностранного языка и разные теории, способствующие преподаванию иностранного языка и лучшему усвоению учебного материала.

**Ключевые слова:** психологическое препятствие, термин, технический английский, специальный словарный запас, коммуникация, воля, отсутствие доверия, готовность, неловкость, агрономия, архитектура.

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*Articles can be submitted in Armenian, English or Russian up to 14 p.  
(titled “Economic” up to 24 p).*

*Sheet format A4, margins up , down, left , right 18 mm.*

*The fonts: Armenian – Unicode /GHEA Grapalat/, Russian, English – Times New Roman.*

*The space between the lines – 1,15*

1. The title of the article is given in the article's submitted language , in capital letters, in Armenian 11, Russian and English 12 bold font size at the right bottom of the page.
2. Universal Decimal Classification consisting of 6 symbols at least is given in the left corner of the next page.
3. A line down , in the middle , the article's submitted language , the title, capital letters, in Armenian 12, Russian and English 14 bold font size.
4. Two lines down, from the left, in the article's submitted language, the review of the author's name and surname, initial affiliation, in Armenian 11, Russian and English 12 bold font size
5. Aline , from the left, in the article's submitted language, ( Italic) is given the name of the organization , in Armenian 9, Russian and English 10 font size.
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7. Two lines down, in the article's submitted language, in the middle, (Italic), is written summery of the article., 10-20 lines, in Armenian 9, Russian and English 10 font size
8. Two lines down is given the main text of the article, in Armenian 10, Russian and English 11 font size. The paragraphs begin from new line, 10 mm from the depths. The expound of the theme are guaranteed of the following scheme: “Introduction”, “conflict settings”, “Research results”, “Conclusion”. In case of need can also be other section with corresponding titles.
9. The formulas are presented in separated lines, in the middle and are numbered on the right, in brackets. The formula , as well as math's symbols and expressions are given in the text in Microsoft Equation, Italic 10 font size.
10. There can be found pictures, diagrams , graphs and tables in texts. The pictures and diagrams are numbered by transit numbering by sign “Figure”. The description of pictures, diagrams , the names of pictures , diagrams graphs and the signs of description are given below. They can be placed vertical or horizontal in Armenian 9,Russian and English 10 bold font. Tables are numbered by “Table” transit numbering. The names of tables , sign description are given above. They could be placed vertical or horizontal. If the table can't be placed on a single page, it must be transferred to the other page and mentioned as condonation. In table column must not be left free lines, there must be put dash or write “ not” (“determined”).
11. Pictures , diagrams graphs in electronic version are colored as a rule.
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## **Հոդվածների հեղինակային օրինակների ձևակերպման համար ներկայացվող պահանջներ**

Հոդվածները կարելի է ներկայացնել հայերենով, ոռութենով և անգլերենով՝ մինչև 14 էջի (“Էկոնոմիկա” խորագրով՝ մինչև 24 էջի) սահմաններում. Էջի փորմագր՝ A4, լուսանցքները՝ վերևսկից, ներքևսկից, աջից և ձախից՝ 18 մմ. Տառապեսակը հայերեն՝ Unicode /GHEA Grapalat/, ոռութեն և անգլերեն՝ Times New Roman.

Միջդժողովական հեղինակների համար ներկայացվող պահանջներ:

1. Էջի վերին աջ անկյունում, հոդվածի ներկայացման լեզվով, գլխատառերով՝ հայերեն՝ 11, ոռութեն և անգլերեն՝ 12 **bold** տառաչափով տրվում է հոդվածի խորագիրը:
2. Հաջորդ տողի Էջի ծախ անկյունում տրվում է <S>-ն՝ առնվազն վեցանիշ թվով:
3. Դրանից մեկ տող ներքև, մեջտեղում, հոդվածի ներկայացման լեզվով գլխատառերով դրվում է վերնագիրը՝ հայերեն՝ 12 **bold**, ոռութեն և անգլերեն՝ 14 **bold** տառաչափով:
4. Երկու տող ներքև, ծախից, հոդվածի ներկայացման լեզվով, հեղինակի (հեղինակների, որոնց թիվը, որպես կանոն, չի կարող գերազանցել 4-ը) Անվան, Հայրանվան սկզբնատառերը և Ազգանունը՝ հայերեն՝ 11, ոռութեն և անգլերեն՝ 12 **bold** տառաչափով:
5. Մեկ տող ներքև, ծախից, հոդվածի ներկայացման լեզվով, շեղատառերով (*Italic*) տրվում է կազմակերպության (կազմակերպությունների) անվանումը՝ հայերեն՝ 9, ոռութեն և անգլերեն՝ 10 տառաչափով:
6. Անջատելով տեքստը հորիզոնական հոծ գծով՝ Էջի ծախ անկյունից, հոդվածի ներկայացման լեզվով, տրվում են Բանալի բառերը (5-8 բառ)՝ հայերեն՝ 10, ոռութեն և անգլերեն՝ 11 տառաչափով:
7. Երկու տող ներքև, հոդվածի ներկայացման լեզվով, մեջտեղում, շեղատառերով (*Italic*), գրվում է հոդվածի համառոտագիրը՝ 10-20 տող՝ հայերեն՝ 9, ոռութեն և անգլերեն՝ 10 տառաչափով:
8. Երկու տող ներքև ներկայացվում է հոդվածի հիմնական տեքստը՝ հայերեն՝ 10, ոռութեն և անգլերեն՝ 11 տառաչափով: «Պարբերությունները սկսվում են նոր տողից՝ 10 մմ խորքից: Երաշխավորվում է նյութի շարադրման հետևյալ սխեման. **«Ներածություն»**, **«Խնդրի դրվածք»**, **«Հեղազուրության արդյունքները»**, **«Եղակացություն»**: Անհրաժեշտության դեպքում կարող են լինել նաև այլ բաժիններ՝ համապատական վերնագրերով:
9. Բանաձևերը ներկայացվում են առանձին տողով, մեջտեղում և համարակալվում են աջ մասում, փակագեթերի մեջ: Բանաձևերը, ինչպես նաև տեքստում տեղադրվող մաթեմատիկական սիմվոլներն ու արտահայտությունները տրվում են Microsoft Equation-ով, Italic՝ 10 տառաչափով:
10. Տեքստում կարող են լինել նկարներ, գծապատկերներ, գծագրեր և այլուակներ: Նկարները և գծապատկերները համարակալվում են միջանցիկ համարակալմամբ՝ **«Նկ.»**՝ նմուշառմամբ: Նկարների, գծապատկերների, գծագրերի անվանումները, նշանակումների բացատրությունները տրվում են ներքում: Դրանք կարելի է տեղադրել ուղղաձիգ կամ հորիզոնական դիրքով՝ հայերեն՝ 9, ոռութեն և անգլերեն՝ 10 **bold** տառաչափով: Այլուակները համարակալվում են միջանցիկ համարակալմամբ՝ **«Աղ.»**՝ նմուշառմամբ: Այլուակների անվանումները, նշանակումների բացատրությունները տրվում են վերևում: Դրանք կարելի է տեղադրել ուղղաձիգ կամ հորիզոնական դիրքով: Եթե մեկ թերթի վրա այլուակը չի տեղադրվում, պետք է շարունակել մյուս թերթի վրա՝ նշելով, որ շարունակություն է: Այլուակի սյունյակներում ազատ տեղեր չպետք է մնան. պետք է դնել գծիկ կամ գրել «չկ» («չի որոշված»):
11. Նկարները, գծապատկերները, գծագրերը կենսորոնային տարրերակով, որպես օրենք, տրվում են գունավոր տարրերակով:
12. Հոդվածի վերջում, երկու տող ներքև, ծախից՝ 10 մմ խորքից տպագրվում է **«Գրականություն»**՝ հայերեն՝ 11, ոռութեն և անգլերեն՝ 12 **bold** տառաչափով: Մեկ տող ներքև ներկայացվում է գրականության ցանկը՝ համարակալված ըստ հեղումների հերթականության: Ցանկում աղյունները պետք է նշվեն [...] տեսքով և ընդգրկեն՝ հեղինակի/ների/ ազգանունը և անվան /Հայրանունի/ առաջին տառը /երը/, նյութերի լրիվ անվանումը, հրատարակության տվյալները /տեղը, հրատարակչությունը, քաղաքը, տարեթիվը, հատորը, էջերը/: Տեղեկատվական պաշտոնական, այդ թվում՝ կենսորոնային աղյունների, համակարգչային ծրագրերի, հաշվետվությունների, հրահանգների, հեղինակային հրավունքի արտոնագրերի, պատեսաների դեպքում ներկայացվում են լրիվ տվյալները: Աղյունները բերվում են բնօրինակի լեզվով: Միևնույն ժամանակ, հայերեն և ոռութեն աղյուրները ներկայացվում են նաև լատինատառ շարվածքով:
13. Առանձին էջերի վրա տրվում է հոդվածի գլխամասի և համառոտագրի թարգմանությունը (բացի հոդվածի ներկայացման լեզվի)՝ հայերեն, ոռութեն (Резюме) և անգլերեն լեզվուներով (Summary):
14. Հոդվածները պետք է ուղարկեն info@bulletin.am էլ. հասցեով:
15. Տեքստի խմբագրված և սրբագրված տարրերակը համաձայնեցվում է հեղինակ(ներ)ի հետ:
16. Առանձին թղթի վրա տրվում է հեղինակների մասին տվյալները (Ազգանուն, Անուն, Հայրանուն (ամբողջական), լուսանկարը, գիտական աստիճանը, գիտական կոչումը, հասցեն, հետախոսը, կազմակերպությունը, զբաղեցրած պաշտոնը, կենսորոնային հասցեն):

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*Статьи можно представить на армянском, русском и английском языках объемом до 14 страниц (статьи под рубрикой "Экономика" до 24 страниц)*

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6. Отделив текст горизонтальной выделенной линией, слева даются ключевые слова (5-8 слов) по шрифту: армянский - 10, русский и английский - 11.
7. Две строки ниже, на языке статьи, по центру курсивом (*Italic*) дается аннотация (10-20 строк) по шрифту: армянский - 9, русский и английский - 10.
8. Две строки ниже, дается основной текст статьи по шрифту: армянский - 10, русский и английский - 11. Абзацы начинаются с новой строки с отступом 10 мм. Рекомендуется следующая схема изложения материала: "Введение", "Постановка задачи", "Результаты исследования", "Заключение". В случае необходимости могут быть также другие разделы с соответствующими названиями.
9. Формулы располагаются отдельной строкой по центру и нумеруются в правой части в скобках. Формулы, а также математические символы и выражения приводятся по "MicrosoftEquation", курсивом (*Italic*) по шрифту - 10.
10. В тексте могут быть рисунки, графики, чертежи и таблицы. Рисунки и графики нумеруются по порядку - "Рис.". Названия рисунков, графиков, чертежей, объяснения обозначений приводятся снизу. Их можно расположить в вертикальном или горизонтальном положении по шрифту: армянский - 9 **bold**, русский и английский - 10 **bold**. Таблицы нумеруются по порядку - "Таб.". Названия таблиц, объяснения обозначений приводятся сверху. Их можно расположить в вертикальном или горизонтальном положении. Если таблица не помещается на одной странице, нужно продолжить ее на следующей странице, отметив, что это продолжение данной таблицы. В таблице не должно быть свободных столбцов, в этом случае нужно поставить черточку или написать "нет" ("не определено").
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