UDK 53.02

THEORY AND METHOD OF ENERGY-WAVE FIELD ANALYSIS FOR THE STUDY OF EARTH RESOURCES

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The article deals with the basic theory and method of energy analysis of wave fields (MEA-WF), the method for scientific research of material systems on dynamics is different from Newton, Lagrange, Euler, Hamilton methods of dynamic systems analysis based on the aggregation of laws: save, edit, transfer and packaging of energy in the physical space as and function of deterministic probability (FDP). FDP models inelastic physical space, allowing to gain new knowledge about the physical causes of the formation of the structure and parameters of micro- and macro- material systems.

Keywords: physical point, the physical space, energy, energy-analysis, motion, FDP -quantum, underground resources

Introduction. To the questions of subjective adequacy logic of thought objective logic of things straight or indirect number of studies in physics and mathematics are dedicated. But yet greater amount of scientific publications in different science spheres have clean mathematical maintenance in the research.

Active development of computing facilities and algorithms of treatment of experimental and prognozis information is carried out in the great number of functions of the kind: $F = f(s,t)$ or $F = f(\alpha,s,t)$, where F it is the under investigation function, $s-t$ is space-time Gausse metrology system (space and time are the independent set values), α – physical parameters, frequently frequency.

A problem consists in that subjective and objective adequacy sharply goes down in the solution of problems in which investigations of objective reality are maintained with the use of inverse functions of the kind: $(s,t) = f^{-1}(F)$ or $(\alpha,s,t) = f^{-1}(F)$. Such physical and mathematical functions (models) are not very numerous and, as a rule, relate to the fundamental theories. Modern mathematical methods are in research of inverse functions, they became a general research instruments. It is explained that the derived exactness of approach to experimental information with the modern algorithmic instruments in use turns out with the small error [1] and high refinement from noise. This explains the large stream of scientific publications is with mathematical maintenance.

In theoretical geophysics such publications belong to «point seismic prospecting», and in practical seismic prospecting – to attributive interpretation of the acoustic wave fields. As a result, the exploration rose on a very small, with a general level not exceeding 50% (39% in Ukraine [19]). In the tasks of clarification of geological models, developed deposits of oil and gas successe from the use of programmatic packages (Paradigm Geophysical: Focus, SEISX, Voxel Geo. Petrel, Silicon Graphics Inc PROMAX and other) on the basis of mathematical methods of the integral approach.

The existent methods of the problem solution In the works [2,3] authors design continuum, place it in the Newton space and provide it with thermoelastic properties.

The mathematical aspect of this paper keeps indoors for the functions of the kind: $F = f(s,t)$ or $F = f(\alpha,s,t)$.

Use of the theory for the correct solution of the problems in which research for the above mentioned functions of the kind $(s,t) = f^{-1}(F)$ or $(\alpha,s,t) = f^{-1}(F)$ are executed satisfying the terms of Hadamard, will be very difficult even not possibly approaching of free 15 parameters.

Task of the article: 1) to develop energy informative methodology of the solution of inverse problems of analysis of motion of material systems on the basis of generalization of laws of dynamics: maintenance, change, transfer and packing of energy, jointly determining it motion and system; 2) to give a physical mathematical ground information technologies of analysis of the wave fields and mathematical instrument for their realization.

§ 1 Theory of energy informative analysis of motion of the material systems

Basic determinations.

A physical point (PP) (system of PP - SPP) is the area of one quality of motion formed energy.

Qualities of motion – forward - $\vec{D}$, parabolic - $\overset{\subset}{D}$, hyperbolical - $\overset{\cup}{D}$, elliptic - $\overset{\infty}{D}$, stochastic - $\tilde{D}$.

Physical space of Euclid ($\Re_E$) it is homogeneous (identical physical parameters) изотропное self-reactance space of PP.

Physical space of Gauss ($\Re_G$) it is inhomogeneous (determined with the stochastic distributing of physical parameters) anisotropic self-reactance space of PP.

Basic property of spaces $\Re_G$ and $\Re_E$ – identical energy of PP in SPP equates spaces.

The offered conception of solution of general problem is outspoken in the paper [4]. Conception of the energy informative analysis (MEA) method of motion of the financial systems, differs from existing generalization power laws: maintainance, change, transfer and packing of energy, as maintenance of motion of physical point (PP) or system of physical points (SPP), operating jointly and determining properties and space-time structure, as forms of motion, that allows to decide two basic problems of cognition:

Gnosiological – to get new knowledge about objective reality on the basis of general model of qualities of motions for PP (SPP) of the type $E = f(E)$, where E - general energy which is examined out of space-time (property of discreteness is a fact of maximal non-linearity).

Methodological – to remove of methods distinction of direct and inverse dynamic solutions in space-time (property of continuity) by determination of physical values by differentiation of energy in space-time and in other generalized co-ordinates and values, for example: $dE/dt = N$ – power, $dE/ds = F$ – force, $dE/d(\dot{s}^2) = m$ – mass, $dE/d\xi$ – new power state (ξ-quantum of energy) and so on, preserving mathematical methods [1] and physical transparency in researches of parameters of the different systems and their motion.

In mathematical basis of MEA a theorem is based on a Gauss line on the surface [6] investigated in works [7,9,10,11,12,13,14,15] in the dynamics of seismic prospecting.

It is known [5]: curvatures of line on the surface is presented by the equation

$$k^2 - 2Hk + K = 0 \ , \qquad (1)$$

where parameters, $H = (k_1 + k_2)/2$, $K = k_1 k_2$, $k_1 = 1/R_1$, $k_2 = 1/R_2$, K - Gauss curvature; H - middle curvature; k_1, k_2 - main curvatures; R_1, R_2 - main radiuses of curvature, and k - an operator of curvature of surface is in the point M_0.

Geometrical theorem of MEA [6]. If curvatures of line in the point of surface are presented by equation (1), and Gauss curvature of line is evenly up-diffused between the unlimited amount of points, forming a line on surface, relation eventual to initial middle curvature of line on the surface is

$$\xi = e^{\varphi^2} , \qquad (2)$$

where $\varphi = K/(4H^2)$ - phase of distributing of curvatures on a line,

and main curvatures in the closed system of simple statements satisfy the system of correlations

$$\begin{cases} a_{\sim} + a_{-} = \xi = 1 \\ a_{\sim} - a_{-} = \psi_1 \end{cases} \quad (3); \qquad \begin{cases} a_{\sim} + a_{-} = \xi = 1 \\ a_{\sim} \cdot a_{-} = \psi_2 \end{cases} \quad (4); \qquad \begin{cases} a_{\sim} + a_{-} = \xi = 1 \\ a_{\sim} / a_{-} = \psi_3 \end{cases} , \ (5)$$

where $a_{\sim} = \dfrac{k_1}{2H_к}$; $a_{-} = \dfrac{k_2}{2H_к}$; $\xi = \dfrac{2H_n}{2H_к}$ - normalized curvatures; ψ_i - arbitrary functions ($\vec{D}$, $\overset{\subset}{D}$, $\overset{\cup}{D}$, $\overset{\infty}{D}$, $\tilde{D}$) of curvatures changing; H_n, $H_к$ - initial and final averaged line curvatures.

This theorem allowed to generalize bases of algebra and physics with following maintenance.

Authentication of algebra, physicists and geometries in MEA [15].

In basis of authentication of algebra (integers), physics (energies), geometries (curvatures of line on surface) in MEA analogical to (3) - (5) systems of functional equations, as systems of correlations of the real whole numbers and energies E, K, U PP (SPP) are

$$\begin{cases} a_{\sim} + a_{-} = \xi \\ a_{\sim} - a_{-} = \psi_1 \end{cases} \quad (6), \qquad \begin{cases} a_{\sim} + a_{-} = \xi \\ a_{\sim} \cdot a_{-} = \psi_2 \end{cases} \quad (7), \qquad \begin{cases} a_{\sim} + a_{-} = \xi \\ a_{\sim} / a_{-} = \psi_3 \end{cases} , \ (8)$$

where $a_{\sim} = K/E_0$; $a_{-} = U/E_0$; $\xi = E/E_0 = 1$ are the normalized types of kinetic, potential and general energy accordingly; ψ_i - arbitrary functions of energy methamorphizm of quality and quantitative transformation of one type of energy into other $\vec{D}$, $\overset{\subset}{D}$, $\overset{\cup}{D}$, $\overset{\infty}{D}$, $\tilde{D}$ motions).

Systems of equalizations (6) - (8) have physical interpretation [7,15], accordingly, as the laws of energy conservation, transmission, packing.

Mathematical generalization of the systems of equations (3) - (8) in physical interpretation is examined by equation, analogical to equation (1), named equation of energetic invariant of dynamics PP (SPP)

$$\varepsilon^2 - \xi \cdot \varepsilon + \xi^2 \cdot \psi_0^2 = 0 \ , \qquad (9)$$

where $\varepsilon = \xi\left(0{,}5 \pm \sqrt{0{,}25 - \psi_0^2}\right)$ it is an operator of energy (it can be as complex for $\psi_0 > 0{,}5$, as well as the real number for $0 \le \psi_0 \le 0{,}5$, depending on the value of power phase ψ_0),

$$\begin{cases} \psi_0^2 = \dfrac{a_{\sim} a_{-}}{\xi^2} = \dfrac{1}{4}\left(1 - \dfrac{\psi_1^2}{\xi^2}\right) = \dfrac{\psi_2}{\xi^2} = \dfrac{\psi_3}{\left(1+\psi_3\right)^2} \end{cases} . \tag{10}$$

For seismic traces $\psi_0 \approx 270\pi$, i.e. operator of energy is complex number and exists exact relations

$$\begin{cases} \varepsilon_1 + \varepsilon_2 = \xi\left(0,5 + \sqrt{0,25 - \psi_0^2}\right) + \xi\left(0,5 - \sqrt{0,25 - \psi_0^2}\right) = a_{-} + a_{\sim} = \xi \\ \varepsilon_1 \varepsilon_2 = \xi\left(0,5 + \sqrt{0,25 - \psi_0^2}\right)\xi\left(0,5 - \sqrt{0,25 - \psi_0^2}\right) = a_{-} a_{\sim} = \xi^2 \psi_0^2 \end{cases} . \tag{11}$$

It is proven in paper [15] by energy informative analysis of vibrations of undamped physical oscillator, as PP.

§ 2 Energy informative analysis of motion of elementary objects is in the problems of seismic prospecting

For the tasks of seismic prospecting, in particular for interpretation of dynamic parameters of impulse, vibrations of earthly surface, P-waves and their rays in a geological environment MEA gives the model of transmission of the set energy by a single impulse in time and space, named as energy-quantum.

By submitting equation (9) as a transmission function, but with elastic physical parameters, and collecting of such functions endless great number, ranged consistently, the system of PP (see **Fig. 1**) will turn out as ray model in spaces $\mathfrak{R}_E$ and $\mathfrak{R}_G$, along which the single impulse is passed with energy ξ. It appears in this case, that such energy informative model of trajectory distribution of impulse forms of absolutely unelastic homogeneous physical space, in which on the output of limited line with the endless number of PP an impulse appears with energy $\sqrt{KU}$, what is shown in [15].

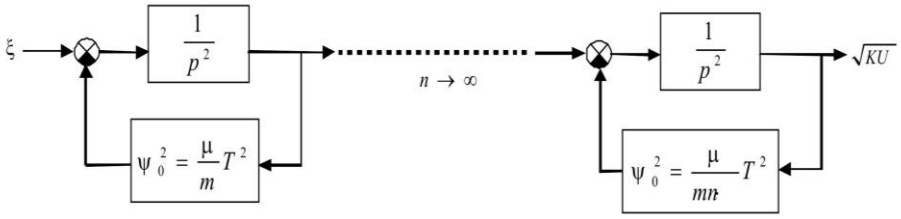

Fig. 1 - Block diagram of the power transmission system of homogeneous linear PP having the same mass, elasticity, natural period of oscillation T, which creates a physical space with a zero elasticity, where p is a complex number [6,15].

Such model of passing to energy in spaces of Euclid and Gausse looks like

$$\frac{E_{вих}}{E_{вх}} = \frac{\sqrt{KU}}{\xi} = e^{-\psi_0^2} , \quad \psi_0^2 = \frac{KU}{\xi^2} . \tag{15}$$

A model (15) has the name of the function of determined probability – DFP [6,7,9,10,14] of the power state PP on a line.

The first derivate of DFP in time, as shown in [15] for a physical undamped oscillator $\dfrac{KU}{\xi^2} = \dfrac{1}{4}\sin^2\left(2\omega_0 t\right)$ with an eigenfrequency ω_0, presents a one period wave: DFP – quantum of the view

$$\frac{dE(t)_{вих}}{dt} = -0,5 E_{вх} \omega_0 e^{-\omega_0^2 t^2} \cdot \sin\left(4\omega_0 t\right), \text{ W}, \quad \omega_0 = \frac{\sqrt{KU}}{\xi T} , \text{ c}^{-1} . \tag{16}$$

DFP-quantum is represented in a graphic view on Fig.2. with a period 1 мс and by parameters: $f = 255$ Hz. $\omega_0 = 2\pi f = 1600$, rad c^{-1}.

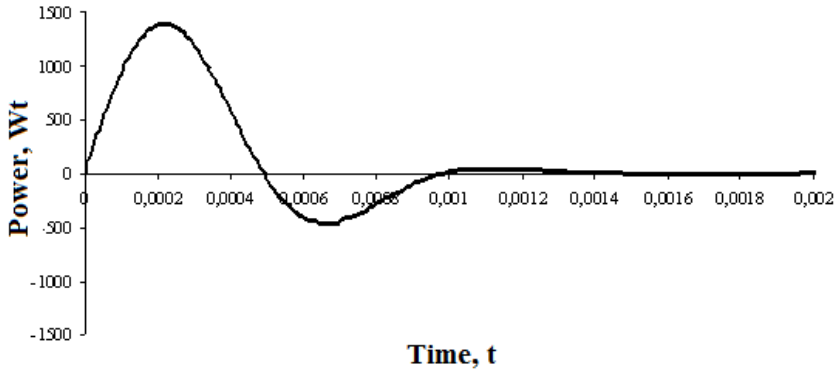

Fig. 2 - Model DFP-quantum $\eta(t) = 0{,}5 \cdot 2 \cdot 1600 \cdot e^{-1600^2 \cdot t^2} \cdot \sin(4 \cdot 1600 \cdot t)$

A DFP-quantum differences from known in seismic prospecting impulses Rikker, Lamb, Berlague, bell impulse, Brekhovskich, Puzyrev, that:

1) conditioned by the united action of conservation, change, transfer and packing laws of energy at motion in an environment;
2) amplitude, damping frequency and eigenfrequency of vibrations of PP, are simply linked and defined only by energy of P-wave, as parameters of earthly surface and seismic receiver are unchanged and known;
3) frequency is complex and consists of frequencies: Fourier, Proni, damping, that is sown in [12], which are determined from the registered vibrations of earthly surface and equations of MEA (7);
4) it is constituting oneself wave motion of environment, complex frequency of which is simply defined by energetic parameters of this environment and energy of a disturbing single impulse, and the integral of impulse for the period is equal DFP.

In-psper [15] on an example undamped physical oscillator methamorfizm of general elliptic motion is $\overset{\infty}{D}$ in new qualities of motion: forward – $\vec{D}$, parabolic – $\overset{\subset}{D}$, hyperbolical – $\overset{\cup}{D}$, on segments depending on potential energy, that is an important informative moment in the dynamics of energy-quantum at distribution in geological medium. When it is determined, geostatic energy changes with a depth.

Therefore space $\mathfrak{R}_G$ in MEA is a general physical space in which every PP at energy level equivalent alongside.

The results of application of MEA are presented in [17] for distribution of P-waves in 138 geological and 87 physical elements. So, on **Fig**.3, attitude of potential energy toward kinetic is shown in every geological element.

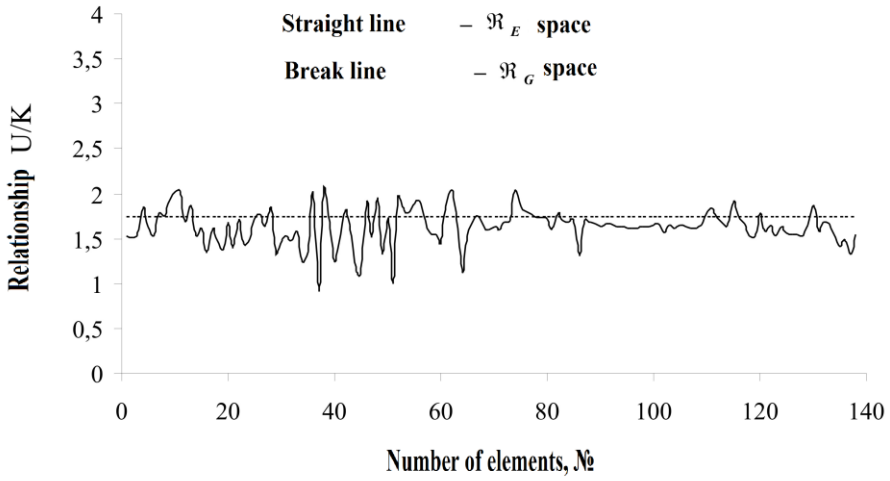

Fig. 3 - Relation of potential energy to kinetic $k = U / K$ in geological elements.

On the basis of equation of energy invariants (14) for $\mathfrak{R}_E$ and $\mathfrak{R}_G$ spaces equation for determination of Poisson coefficient is

$$\sigma = \frac{\left(A^2\sqrt{3} - 2\right) \pm \left[\sqrt{3A^4 - 20\sqrt{3}A^2 + 36}\right]}{8}, \qquad (17)$$

where $\frac{V_p}{V_{p0}} = A$ is the relation of velocity of direct wave in $\mathfrak{R}_G$ space to velocity of P- wave in $\mathfrak{R}_E$ space.

On **Fig. 4** the results of the use of equation (17) are presented, classic wave equation (CWE) jointly with experimental information for determination of Poisson coefficient. As obvious from a picture adequacy of equation (17) to experimental information is higher than in classic wave equalization.

On **Fig.** 5 structural-parametric (Fig. 5) interpretation of the wave field of migrated cube of 3D seismic prospecting of common deep point is presented in a physical parameter differential dynamic viscidity (fig. 5 a) of geo informative system (GIS) [12] by comparison of information GIS (gas logging) and information of mining holes bored on this cut.

Dynamic viscosity (difference between dynamic viscosities in $\mathfrak{R}_E$ and $\mathfrak{R}_G$ spaces) determined in every space from equation

$$\eta = \frac{S}{w_p} = \underbrace{\frac{\int_0^{\Delta t} L dt}{w_p}}_{\text{MEA presentation}} = \underbrace{\frac{\int_0^{\Delta t} (K-U)\, dt}{w_p} = \frac{3\rho}{2k}\sqrt{\frac{\lambda+2\mu}{\rho} - \frac{\omega^2}{k^2}}}_{\text{parametric presentation}}, \qquad (18)$$

where S it is a function of action, Joule sec;

L it is Langrangian, Joule;

w_p it is a volume of P-wave in geological medium, м^3;

$\rho, (\lambda + 2\mu), \omega, k$ are density and Lame modules; frequency of energy-quantum; wave-number, of Proni frequency for the P- wave accordingly.

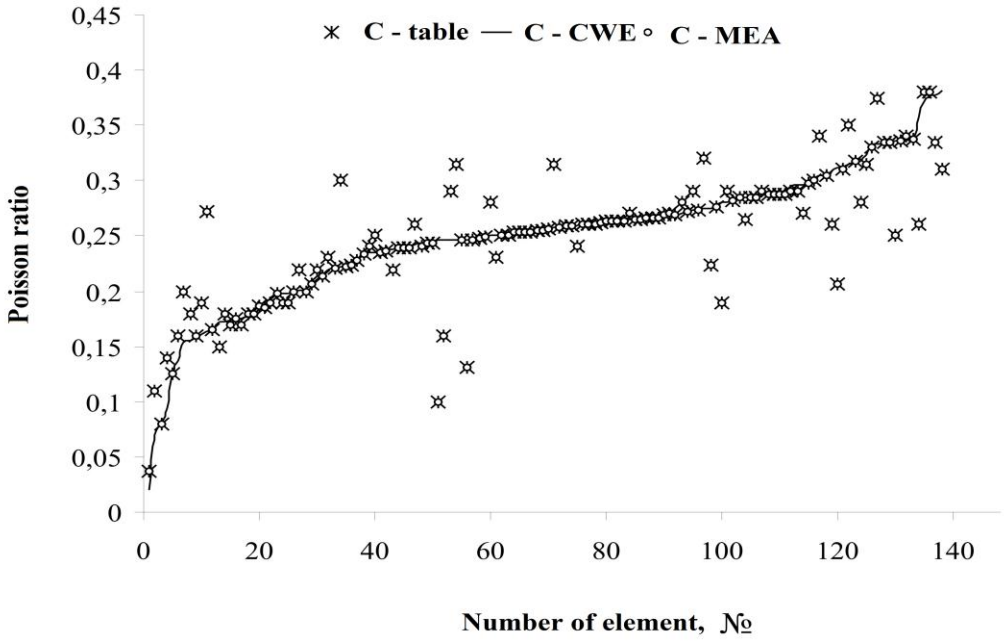

Fig. 4 Descriptions of Poisson ratio of geological elements: C - table or tabular values, C - MEA – from equation (17), C - CWE – from CWE with the use of longitudinal and transversal waves of acoustic waves. An error by mean value for CWE is equal 1.07%, for MEA – 0%.

On **Fig**.6 descriptions of porosity and sand content of geological medium are shown. Porosity and sandy are obtained by methods geophysical informative study (GIS) of boreholes. Porosity is separately obtained by the energy informative method of vibration analysis of earthly surface, given in [13,15]. Basis of the method is the comparison of densities in $\mathfrak{R}_E$ and $\mathfrak{R}_G$ spaces, where for physical Euclid space and densities on an earthly surface are set.

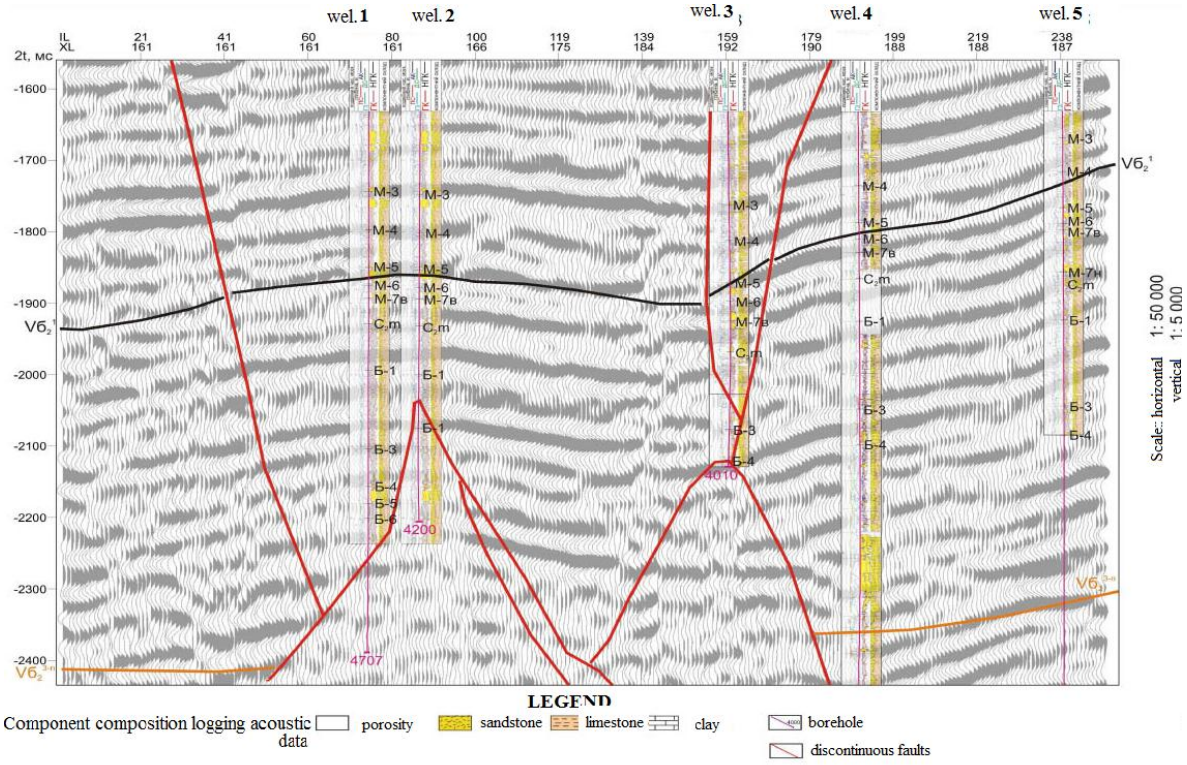

Fig. 5 a) – Seismic geological the SG-1 migrated cube 3D of seismic wave field with CDP and GIS data № 1-5.

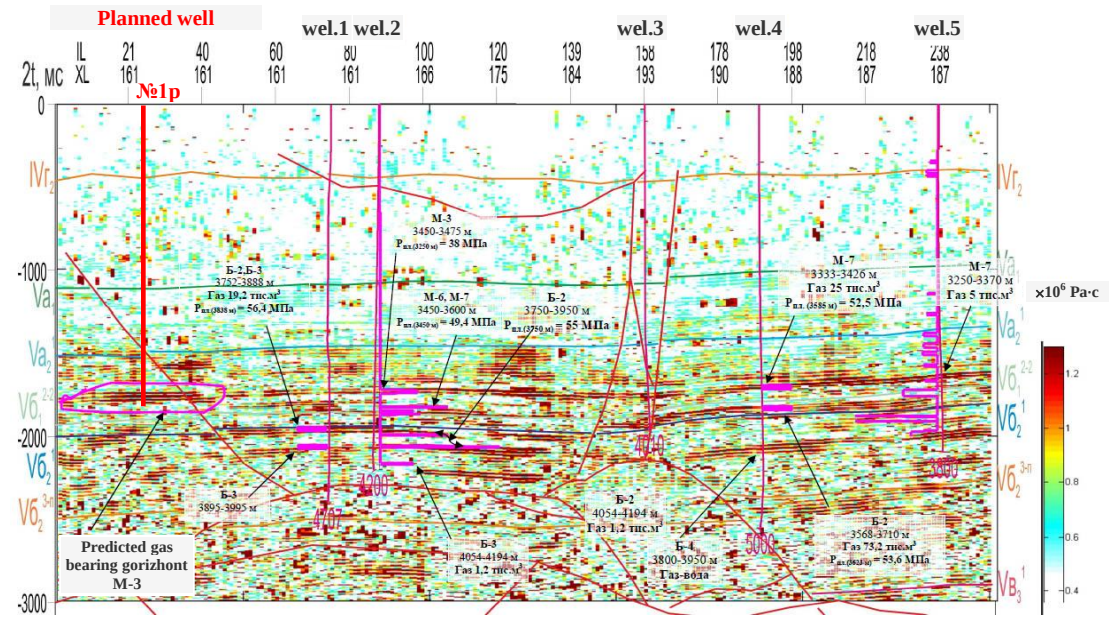

Fig. 5 b) - Seismic geological the SG-1 migrated 3D seismic cube CDP, interpreting the - differential dynamic viscosity, to a gas borehole logging. № 1-2, 4-5.

■ - Indications of gas on logs.

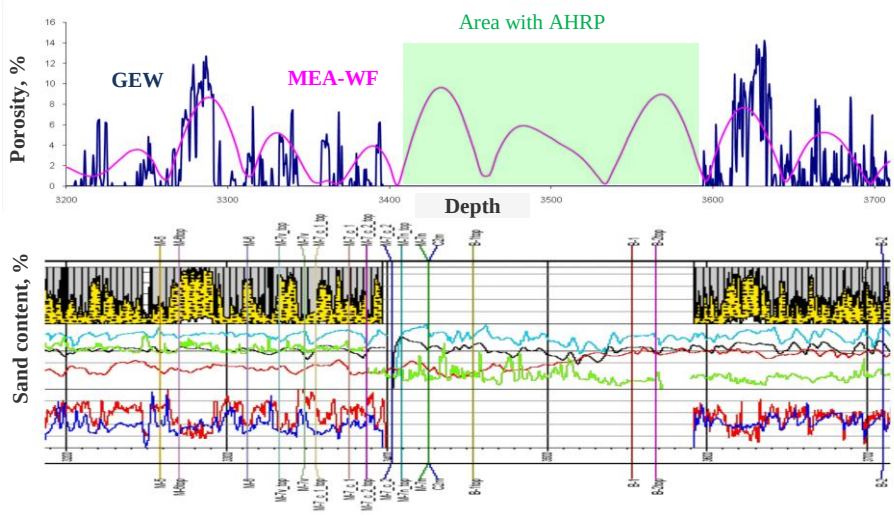

Fig. 6 - Base-gross porosity and subsurface along a vertical axis at the drilled hole number 4:
AHRP - area with an abnormally high reservoir pressures;
GEW - geophysical exploration wells;
MEA -WF - a method of energy analysis of the wave field.

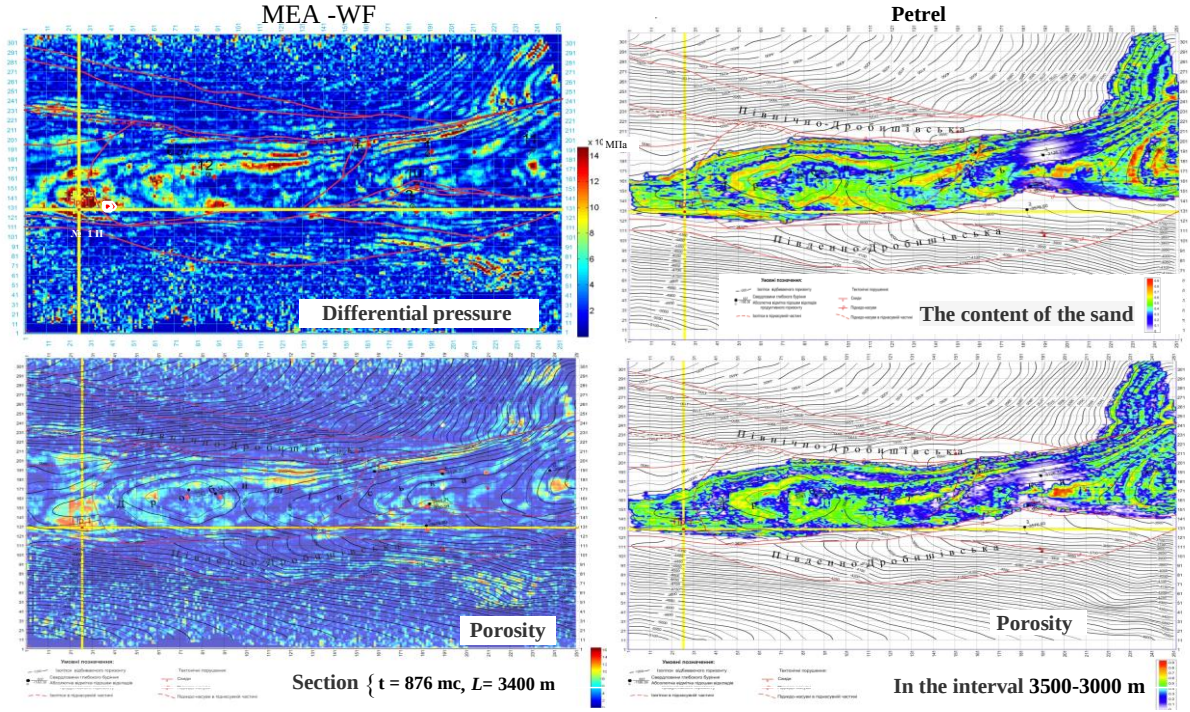

Fig. 7 - Characteristics of the distribution of the physical parameters of the HS defined in the software systems MEA and Petrel. The circle shows the projective exploration well number 1 (Fig. 5).

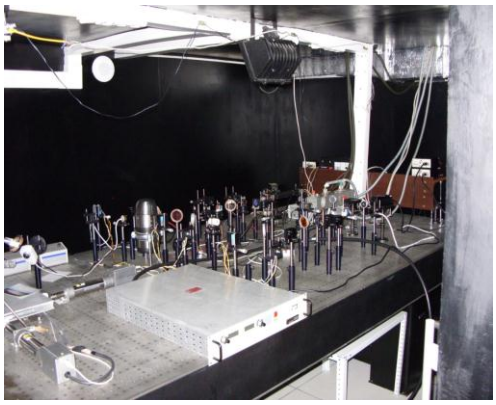

Fig. 8 - Laboratory equipment MEA-HEWF (Method of Energy Analysis Heat Energy Wave Field) ТЭВП [20]

The results of MEA are presented on the Fig.8 and Fig. 9. Researches of MEA-HEWF technology were carried out on the well studied deposits in the different parts of the world and different mining-and-geological terms.

The positive results of approbation of technology on known deposits allowed more confidently to pass the search of the forecast deposits of oil and gas in Tomsk, Omsk areas, in the Krasnoyarsk edge, on Far East of Russia, in Lebanon, Syria, China, more than 50 forecast deposits are exposed confirmed by boring on one oil (Kamovskoe) and two gas deposits (Boguchanskoe, Abakanskoe) in the Krasnoyarsk edge.

On a fig.9 the results of satellite image treatment of the Omsk area are presented (Russia). Opened deposits (yellow) are expressly traced, named, and deposits, exposed by technology of MEA-HEWF (red) are shown.

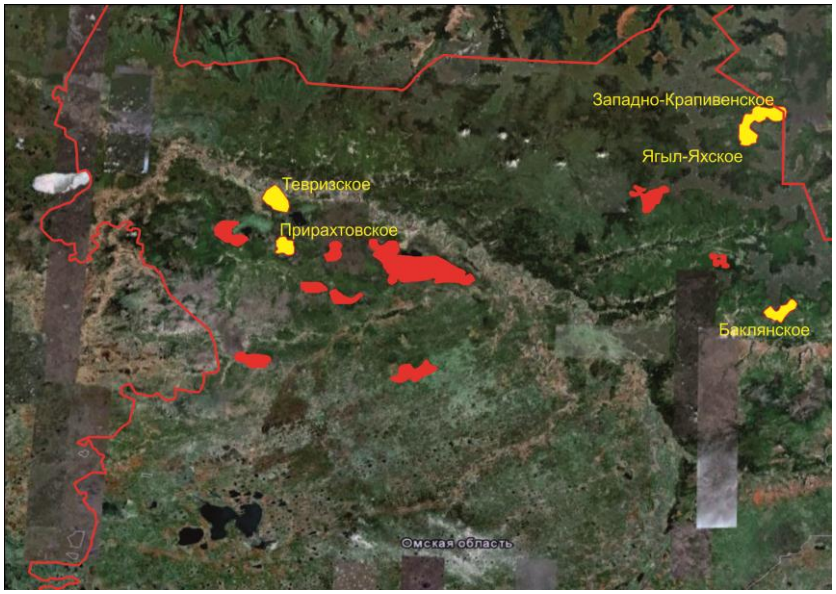

Fig. 9 Results of the satellite image treatment of the part of Omsk area territory in Russia by technologies MEA-HEWF.

Two opened deposits of Yagyl-yakhskoe and Zapadno-krapivenskoe on results of quantum-optical filtration of anomaly HEWF from these deposits met in one. Afterwards, by the employees of «ОАО Tomsknipineft'» in the process of additional prospecting of Zapadno-krapivenskogo deposit the fact of confluence of these deposits was set. This case illustrates that technologies of MEA-HEWF are able not only to expose the deposits of hydrocarbons but also show the features of their geological structure peculiarities.

Conclusions.

Developed method of energy informative analysis (MEA) of motion of the material systems on the basis of generalization of laws of conservation, change, transmission and packing of energy (3), (4), (5), (6), (7), (8) resulted in single equation of motion analysis of physical point (PP), uniting; curvatures of surface (1) of point; power invariant (9), as general physics of point; complex structure (12) of volume point. Equation (9) is named – the equation of power invariant PP.

1. Integral of DFP (determined probability function) -quantum determines the power state of PP or S PP (system physical points) as point with certain amplitude in dimensionless co-ordinates, and there is SFP, where all frequencies (Fourier, Proni, damping, complex) are determined from, that is described in works [11,12].
2. Differentiation of DFP (15) is a motion in space, allows to study forces and other physical values, and also properties of geological medium, exposed by the short impulse of different nature, that is specified in works [14,16].
3. Differentiation of DFP (15) gives time-history, allows to study the change of the energy state of PP or S PP (16).
4. A wave process [15] specified from a temporal DFP-quantum, registered on an earthly surface in a point, spreading into depth of half-space, gives interpretation of seismic cuts with a discrepancy 3-5 ms, taking into account change of the Young modulus in the geological medium with a depth [18].
5. On the basis of MEA of undamped oscillator dynamics the mathematical algorithm of wave transition is shown [15] obtained from correlation $\xi = K + U$ to DFP and DFP-quantum [12].

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