ADAMS-WILLIAMSON'S EQUATION WITHIN THE LIMITATION OF NON-CLASSICAL LINEARIZED THEORY

G.G.Kuliev, A.D.Askerov

Geology Institute, Azerbaijan National Academy of Sciences
29A H.Javid Avenue, Baku AZ 1143, Azerbaijan

In the frame of non-classical linearization approach using for determination of the Earth depth density increase, considering along with the physical and geometrical nonlinearity of the deformation and density processes of the geo-environment, the formula pattern – Adams-Williamson's is obtained.

Introduction

For creation of more real models of the Earth and for well-grounded processing and interpretation of the seismic (tomographic, seismologic, etc.) information it's necessary to use alongside with the earth linear physical-mechanical properties and small deformation, the nonlinear physical-mechanical properties, large deformation, geometric and force parameters of the deformed earth.

The non-classical linearized theory on the deformed solid body has already ventured to solve the analogical objectives in tectonophysics. Therefore, it's expedient to draw the given theory onto the determination of the earth innerior structure parameters. Taking into account all necessary parameters within the limit of Parameter Earth Model (PEM) are distinguished by using formula speed of large elastic wave and the formula of density depth increase, in this article by using these formulas the Adam Williamson's equation is obtained. It was demonstrated how the nonlinearity deformation and intensity considerably influence on earth depth density increase. Quantitative corrections to generally a accepted values of density increase obtained within of deformation theories are different and depending on earth physical-mechanical properties reaching the substantial sizes they can bring to compression and de-compression.

Density distribution, debayev's temperature, Grewnayzen parameter, grating part of the heat conductivity coefficient, earth specific entropy, adiabatic temperature, melting temperature and their gradients, contrast entropy and heating effect during the cycle skip, dip of the curved phase equilibrium and the thermal crystallization for mantle and core are the main Earth inner structure parameters in parametrical models (Jarkov, 1983; Magnitskiy, 1965; Ringvud, 1982; Artyushkov, 1993). While the determination it's necessary to know preliminarily the moveout density on entrails depth. Therefore, it's important to determine more exactly this parameter in real conditions. In modern models for definition there used the Adams-Williamson's Equation (Jarkov, 1983).

$$\Delta\rho = \frac{\rho g}{\Phi}\Delta\ell, \qquad (1)$$

where, ρ – structure density in examined depth, g – gravitational acceleration corresponding to given depth, $\Delta\rho$ – moveout density, $\Delta\ell$ – moveout depth, $\Phi = \frac{K_0}{\rho}$ – seismic parameter, $K_0 = \lambda + \frac{2}{3}\mu$ – bulk modulus; λ, μ – elastic module of the second order.

Seismic parameter Φ – helps to open the density formation mechanism and its increase. From other hand it shows the possibilities of usage of information on determination of elastic waves speed. In practice in geophysical researches usually elastic waves speed is determined by the assistance of processing of seismic information on the basis of the linear theory of elasticity in homogeneous isotope earth model approximation in the cases of small deformation. In the frame of classical linearity theory it's accepted that intensity levels don't exceed the limit of linearity elasticity, the deformation is small (lengthening between the two points is considerably less than unity; relative deformation is 1-

2%); the angles of two linear elements during the deformation are nearly remained unchangeable). In scientific literature this situation got the name the first variant of small elastic deformation theory. If to take into account the additional demand to these terms –the submission of relations between the components of stress tensor and deformation to Hook's Law then it's the second variant of small deformation theory. Violation of these terms leads to large (final) deformation theory that is the nonlinearity theory. In the frame of elastic linearity theory

$$\Phi = V_p^2 - \frac{4}{3}V_s^2 \quad (2)$$

$$\rho V_p^2 = \lambda + 2\mu,\ \rho V_s^2 = \mu \quad (3)$$

Here, V_p, V_s - accordingly, the velocities of elastic primary and secondary (P and S) waves. In this case (1) is true only within the limit of reliability (3). To enlarge the limit of applicability (1) it's also necessary to take into account the nonlinearity process of deformation and earth intensity while defining the velosities of elastic waves and make corresponding changes in (1) and (3). No more so, the results of the experiments (Klarca, 1969; Bayuk etc., 1982) show that the physical characteristics within the changing thermobaric conditions are remained unfixed (as accepted in linearity theories), but on nonlinearity ones they are changed in considerable intervals. Under these terms the usage of (1) is able to cause significant misrepresent (distort) in scientific notion on Earth inner structure in general, and in qualitative changes of separate parameters too. And that's why, in given article proceeding from the provisions of non-classical linearization theory, for definition of density depth increase was obtained the equation as Adams-Williamson's with due regard for geometrical and physical earth non-linearity deformation and intensity.

About the Earth Density

One of the fundamental parameters of Earth inner structure is the medium density of the Earth entrails. It characterizes the mass quantity in unit volume and is usually experimentally determined by the atmosphere pressure and the room temperature. In the frame of phenomenological approach the unit volume is also significant, and because of it in isotropy and anisotropy model limitations the medium density is accepted stable (unchangeable). Each rock (earth material) alongside with other physical, petrophysical ones has got its own definite density.

With the change of thermobaric conditions the density and as the other medium (rock) physical properties are also undergo changes. Till definite thermobaric level changes (till the phase skip) despite the meaning variations of above mentioned parameters, nevertheless, the tested rocks keep their own denominations (names). For example, granite by the atmosphere pressure and under the pressure of 2 (Гпа), it's called just the same - the granite. However, in numerical sense the physical and density properties, corresponding to these pressures, significant diverge are observed experimentally, in other words, the necessary terms of invariability are broken. Accumulated great deal of experimental results (Klarca, 1969; Bayuk etc., 1982) demonstrates that the changes of the medium physical-mechanical and density properties with the thermobaric alterations have nonlinearity character. The pointed variations are connected with the deformation process and its nonlinearity has geometrical (link between deformations and transference) and physical (link between intensity (pressure) and deformations) nature. That's why only the linearity theories have opportunity to take into account the changes in such fundamental parameters that in classical theory limitation they are considered to unchangeable.

By unit volume invariability, the density variability within the considered volume happens by increasing (compression – density increase) or decreasing (decompression) the mass quantity. Within unchangeable mass quantity, the density variety occurs by changing the size of the unit volume. By their increase the decompression process, but by their decrease- the process of compression will be described (density increase). It's observed that the medium physical-mechanical and density properties within the changing thermobaric conditions stay unfixed, but can vary in considerable intervals. Such condition brings (leads) to ambiguity in solving the aims of inertia in seismic researches. The data of various earths (rock) is found in interval varieties. Such invariability is connected firstly with nonlinearity process of deformation and preliminary earth intensity. The density changes are realized when the stress - state drops out the boundaries that ground, the base of classical linearity theory.

About the Parametrical Earth models (PEM)

The real models of the Earth inner structure and the so called modern models of PEM leads (brings) to good agreement with the data on field geophysical measurements (Abasov etc, 1992). It's noted that in PEM limitation the density distribution in the Earth depth 670 kilometers is submitted to (1) and the deviation of real data from the results of this equation don't exceed 0,2%. Despite the good correspondence with the data of measurement, (1) doesn't permit to reveal fully the density variety mechanism on depth. Seismic parameter Φ is defined through the velocities of elastic compressional V_p and shear V_s waves according to (2) by (3). In practice the velocities of elastic waves are determined in real Earth where the conditions are considerably complicated than those are required during the withdrawal of (3). Great deal of lab experiments show (Klarca, 1969; Bayuk etc., 1982) that the volume of these kinematics (traveltime characteristics) parameters of elastic waves alongside with physical-mechanical properties significantly depend on nonlinearity physical-mechanical, force and structural parameters of the deformed system. These states are stipulated to use nonlinearity theory. The aim of drawing in the nonlinearity theory, from one hand is to clarify the classical model parameters, and from other hand, to determine the other additional informative parameters on physical-mechanical, force and geometrical properties.

One of the main dignities of PEM alongside with adequate of their theoretical results with the results of measurements, are simplicity of their significant states and theoretical description. On this regard, attracting nonlinearity theory for determination of the Earth inner structure somehow complicates the model construction and diminishes their simplicity. For keeping the simplicity of the theory and clearness of achieved results there were suggested numerous hybrid approaches based on classical theories states and on additional empiric results (lab and field results). In separate cases, especially when the learned processes can stand the visual measurements (engineering geology and geophysics) or even if can stand the direct results evaluation indirect measurements (seismic exploration, seismic tomography and so on), such approaches allow to get not bad practical results, though in theoretical sense they are not accurate. The main practical shortcomings of such approaches are the impossibility to transfer these Law conformities and dependence in concrete cases on other analogical ones. Every time it's needed to carry out lab and field experiments.

In different branches of physics, including the solid (compact) medium in mechanics are met the analogical situations. In comparison with geology these branches mathematically are more formalized, so they give considerable opportunity to advance in working out the fundamental, as well as the practical problems. Significant role in this point belongs to the disturbance theory.

Nearly in all modern Earth models the theoretical principle for determination of its inner structure parameters the density theory is used, and this theory plays great role in investigations of structural geology, tectonics, geodynamics, geophysics and so on. The process of nonlinearity deformation within the disturbance theory is introduced in the forms of stage consistency of indeformed natural, deformed elementary and deformed actual states. The last two stages can embrace as small as well as large deformations, in other words, they can be described as linearity and nonlinearity theories. The density linearity theory is the zero approximation to density nonlinearity theory. In this case linearization is held in small environs of the elementary deformed state. And what is more, in practical applications mainly the second variant of small deformation. Without using additional information from other branches of science, in tectonophysics drawing in the mechanic linearity theory on deformed solid body is theoretically possible to determine only the medium linearity physical-mechanical properties and the primary density (which remains unchangeable during the deformation process). In the frame of this theory the medium petrophysical properties are also determined through the elastic linearity parameters. As an example the (3) can be given. This case embraces the stages of natural and elementary (and this is within the small deformations) deformed states and by outer (external) loading the body reverts to its natural state. Determined just within these states the constant Liam characterizes the earth linearity physical-mechanical properties (in geology they adequately determine lithology) and according to them the rocks (earth materials) have got names. Therefore, it presents scientific and practical interest in synthesis of properties of linearity physical-mechanical parameters and medium density, when the levels of deformation and intensity are related to the actual state level by the nonlinearity deformation and there's no opportunity to carry out direct quantitative evaluation. To achieve this aim it's suggested to proceed from the non-classical linearization theory.

The non-classical linearized theory of density

Alongside with the classical linearization in small environs of the elementary state, non-classical linearization in small environs of arbitrary (at will) point of actual state is found its large applicability (Biot, 1965; Guz, 1986). And within this approach there appear the linearity approximation in nonlinearity theory. This is the specific first approximation. The specification of it is that this approximation doesn't start from the final point of elementary stage but starts from the small environs of the arbitrary (at will) point of the actual state. In the case of homogenous elementary intensive stage the main equations on movement of non-classical linearization theory by their outward shapes are identical with those that in classical theory. This identity is formal. Firstly, the constant coefficients in these equations are formed by linearity and nonlinearity physical-mechanical properties, force, geometrical parameters and medium density, describing all previous process of deformation and disturbance in small environs of examined point. Secondly, these equations are obtained concerning on disturbances. At the same time the equation of the classical theory is obtained concerning the transference of the elementary state, and the coefficients characterize only the linearity physical-mechanical properties of the earth and density. Hence, the non-classical and classical linearization theories describe considerably different from each other processes. So far as only the first was obtained by more successive and strict linearization, but when determining the parameters of the Earth inner structure the preference is given to non-classical approach, the more so, it's enough simple in use.

The non-classical linearization approach allowed theoretically to predict about the existence of whole planetary folds, lateral faults in the earth's interior, possibility of formation and development of sedimentary basins only by means of the inner energetic, destruction of the earth's interior structure by exfoliation and so on (Kuliev etc., 1989; Kuliev etc., 1991; Abasov etc., 1992; Kuliev etc., 1995; Kuliev etc., 1996a; Kuliev etc., 1996b; Kuliev, 1998a; Kuliev etc., 1998; Kuliev and Jabbarov, 1998; Kuliev, 1998b; Kuliev, 1998c; Kuliev, 1998d; Kuliev, 2000; Kuliev and Jabbarov, 2000; Kuliev and Djevanshir, 2000; Abasov etc, 2000; Kuliev, 2005). Within the frame of the given approach the conception of non-stability in geodynamics is presented according to that all the processes and phenomena are examined not in traditional geology, but as in a new geophysical medium. It's introduced that the traditional geological medium within the geological time is already under the impact of cosmogenous, exogenous (at the same time, the technogenous) and endogenous physical fields of various nature and the learned processes and phenomena happen in this background, that is the learned processes are examined in the form of disturbance relatively to the background (elementary) state parameters. This state is reflected in the linearization method, in the structure of main equations and edge conditions and in the methods by which the researched objectives are going to be solved (Guz, 1986; Kuliev, 2005).

The most general formula for the definition of kinematic and dynamic characteristics of reflected and refracted elastic waves in triaxial stressed medium within the three-dimensional linearized elastodynamics with involving of different elastic potentialities for compressive anisotropic medium in the case of small and large deformations is got in (Kuliev and Jabbarov, 1998). It's accepted that the directions of the elastic symmetry of the anisotropy medium, main intensity and the wave front transmission differ from each other. The elastic wave speed is defined as

$$2\rho V_\alpha^2 = \omega_{3333} + \omega_{3113} + \\ +\left(\omega_{1111} + \omega_{1331} - \omega_{3333} - \omega_{3113}\right)\sin^2\theta_\alpha \pm \Omega_\alpha;$$

$$\Omega_\alpha = \Big\{\big[(\omega_{1111}-\omega_{1331})\times\sin^2\theta_\alpha - (\omega_{3333}-\omega_{3113})\cos^2\theta_\alpha\big]^2 + 4(\omega_{1333}+\omega_{3113})^2\sin^2\theta_\alpha\cos^2\theta_\alpha\Big\}^{\frac{1}{2}}$$

$$\rho V_{SH}^2 = \omega_{1221}\sin^2\theta + \omega_{3223}\cos^2\theta, \qquad (4)$$

Where the symbol "+" in front of Ω corresponds to quasi-compressional P wave and in this case $V_\alpha = V_p$; but the symbol " $-$ " in quasi-shear SV wave and then $V_\alpha = V_{sv}$; ω_{ijnm} – the tensor components of the fourth level characterizing the medium linearity and non-linearity physical- mechanical properties and the elementary intensive state, they're defined by concretization of the structure of the elastic potentialities; θ_α – the angle of incidence, quasi-compressional wave P and quasi-shear wave; index α is chosen as following: $\alpha = 0$ for incidence quasi-P waves in the first medium; $\alpha = 1$ for reflected quasi-P waves in the first medium; $\alpha = 2$ for passing quasi -P waves of the second medium; $\alpha = 3$ for incidence quasi-SV waves of the first medium; $\alpha = 4$ for passing quasi-SV waves of the second medium; the word "quasi" means that the waves are distributed in previously intensive isotropic and anisotropic mediums. When the intensity is absent, they pass on to usual waves.

For concluding the equation like Adams Williamson with due regards the medium intensity and non-linearity process deformation let's consider the case $\theta = 0$ within the comprehensive compression. Then,

$$\rho V_s^2 = \rho V_{sv}^2 = \rho V_{sh}^2 = \omega_{3223} \text{ and } \rho V_p^2 = \omega_{3333}. \qquad (5)$$

According to the (5), for the definition of the seismic parameter Φ, under the (2), we found

$$\Phi = \rho^{-1}\left(\omega_{3333} - \frac{4}{3}\omega_{3223}\right). \qquad (6)$$

In this case the equation of Adams-Williamson has such an affect

$$\Delta\rho = \frac{\rho^2 g}{\omega_{3333} - \frac{4}{3}\omega_{3223}}\Delta\ell, \qquad (7)$$

which is main in learning density increase of the earth material with the increase of the depth with advance consideration of the medium intensity, physical and mechanical non-linearity deformation. Analogically can be learned the non-compressed models of the elastic with the application of the approach generalized on continuous loading of elastic-plastic models and quasi-statistical approach of viscoelastic medium models (Guz, 1986).

In the considered problem the geodynamic aspect is characterized with the specificity of the deformation process realization in various geological mediums, geological conditions under the influence of different force/power factors of cosmogenous, exogenous and endogenous nature. The specific role plays the deformation ability of various earth materials from different lithological and stratigrahpic groups. In connection with it, in geodynamic problems it's necessary in appropriate accordance to model the law on earth's material deformation. Here by analogy of the deformed solid body mechanics is considered that by sufficient level of accuracy these laws can be established by the help of elastic potentialities for compressed and non-compressed mediums.

In the limit of such approach while defining the component $\omega_{ij\alpha\beta}$ there are allocated three different variants depending on deformation size in elementary state, that is, in the state before the wave processes appear:

a) large (final) elementary deformation theory

$$\omega_{ij\alpha\beta} = \lambda_j\lambda_\alpha\big[\delta_{ij}\delta_{\alpha\beta}A_{i\beta} + (1-\delta_{ij})(\delta_{i\alpha}\delta_{j\beta} + \delta_{i\beta}\delta_{j\alpha})\mu_{ij}\big] + \delta_{i\beta}\delta_{j\alpha}S_{\beta\beta}^0, \qquad (8)$$

b) the first variant of small elementary deformation theory (shift and lengthening are small in comparison with unit)

$$\omega_{ij\alpha\beta} = \lambda_j\lambda_\alpha\big[\delta_{ij}\delta_{\alpha\beta}A_{i\beta} + (1-\delta_{ij})(\delta_{i\alpha}\delta_{j\beta} + \delta_{i\beta}\delta_{j\alpha})\mu_{ij}\big] + \delta_{i\beta}\delta_{j\alpha}\sigma_{\beta\beta}^0, \qquad (9)$$

c) the second variant of the small elementary deformation (in additional to the first variant of the small elementary deformations is considered that the tensor intensity and deformation components are submitted to Hook Law).

$$\omega_{ij\alpha\beta} = \delta_{ij}\delta_{\alpha\beta}A_{i\beta} + \\ + (1-\delta_{ij})(\delta_{i\alpha}\delta_{j\beta} + \delta_{i\beta}\delta_{j\alpha})\mu_{ij} + \\ + \delta_{i\beta}\delta_{j\alpha}\sigma^0_{\beta\beta} . \qquad (10)$$

In (8)-(10): λ_i (i=1,2,3) - lengthening coefficient lengthways of the coordinate axis x_i; δ_{ij} - Cronerker's symbols; $S^0_{\beta\beta}$ - co-variants containing Lagrange intensity tensor concerning the basic vectors of the elementary state; $\sigma^0_{\beta\beta}$ - coefficient of the usual intensity tensor. The sizes $A_{i\beta}$, μ_{ij} and $S^0_{\beta\beta}$ (or $\sigma^0_{\beta\beta}$) are existed for each variant (8)-(10) under certain form. Especially, in the case of hyper-elastic isotopic materials, that is, in hypothesis about the existence of an elastic potentiality Φ^0, they are defined by

$$A_{i\beta} = \left(\Sigma_{ij}\Sigma_{\beta\beta} + 2\delta_{i\beta}B_{ii}\right)\Phi^0 ; \\ \mu_{ij} = B_{ij}\Phi^0 ; S^0_{\beta\beta} = \Sigma_{\beta\beta}\Phi^0 ; \\ \Phi^0 = \Phi\left(A^0_1, A^0_2, A^0_3\right), \qquad (11)$$

where the following differential expressions are entered

$$\Sigma_{ii} = \frac{\partial}{\partial A^0_1} + 2\varepsilon^0_{ii}\frac{\partial}{\partial A^0_2} + 3\left(\varepsilon^0_{ii}\right)^2\frac{\partial}{\partial A^0_3} ; \\ B_{ij} = \frac{\partial}{\partial A^0_2} + \frac{3}{2}\left(\varepsilon^0_{ii} + \varepsilon^0_{jj}\right)\frac{\partial}{\partial A^0_3} . \qquad (12)$$

In (11), (12) A^0_i (i=1,2,3) –the algebraic invariants of Green deformation tensor in elementary state; ε^0_{ij} - containing the Green deformation tensor that are defined by various ways within the small and large deformation theory. While researching the natural distribution of elastic waves in the states of elementary deformation, two cases of plane harmonic waves are distinguished. In the first case - the distance changes between the material particles because of elementary deformation aren't taken into account, and the wave velocity distribution is called the "natural" velocity (Trurston and Brugger, 1964). In the second – the distance changes between the material particles because of elementary deformation are taken into account, the wave speed/velocity distribution is called the "real" velocity. In connection with the above said, comparing the theoretical results based on (7), on the results of the experimental (lab) and field seismic researches, it's necessary to distinguish all these nuances. For further researches it's necessary to concretize the structure of the elastic potentiality. The experiments carried out previously in compressed mediums (Trurston and Brugger, 1964) and analyses of the results (Guz, 1986) showed that for the explanation of the observed acoustoelastic effect onto the wave theory, the elastic potentialities containing the three algebraic invariants of Green deformation tensor must be involved in it, which predetermine the calculation of the nonlinearity process of deformation. The acoustoelastic effect describes the variety of the character and the velocity reaction degrees distribution of various polarization of the shear elastic wave on preliminary medium intensity. Due to it for getting quantity estimation, later the case on compressed medium submitted to Murnagan's type of elastic potential is considered. In this case (7) acquired the form

$$\Delta\rho = \frac{\rho^2 g\Delta l}{K_0 + PN} \approx \frac{\rho^2 g\Delta l}{K_0}\left(1 - \frac{NP}{K_0}\right), \qquad (13)$$

here the designations are accepted: 1. "Natural" speeds a) the theory of large (final) and the first variant of small elementary deformation theory and II. "Real" speeds: b) the second variant of small elementary deformation theory.

$$N = -\frac{1}{3} - N_1 ; \\ N_1 = \frac{2n}{3K_0} ; \; n = \frac{1}{3}c + 3a + 3b , \qquad (14)$$

In the case: II "Real" speeds: a) theory of large (final) and the final variant of small elementary deformation theory

$$N = -1 - N_1 \qquad (15)$$

And in the case: I. "Natural" speeds b) The second variant of small elementary deformation theory

$$N = \frac{1}{3} - N_1. \qquad (16)$$

Here – the constant a,b,c – the third order elasticity modules introduced to the theory through the Murnagan's type of elastic potential.

So, not breaking down the generality of all theories and variants mentioned above, moveout density by increasing the depth in Earth interior can be defined by the help of the following equation:

$$\Delta\rho \approx \frac{\rho^2 g\Delta l}{K_0}\left[1+\frac{P}{K_0}\left(\frac{m}{3}+\frac{2n}{3K_0}\right)\right], \qquad (17)$$

here m= 1 at (9); m=3 at (10); m= - 1 at (11).

From these results proceeds that in the case of physical non-linearity absence $(N_1 = 0)$ the change character of the parameter $\frac{K_0\Delta\rho}{\rho^2 g\Delta l} - 1$ is proportional to the change $\frac{P}{K_0}$, and the proportionality coefficient for various deformation theory variants is different. From the (13), (16) and (17) proceeds that in the case of б) in I, if the influence of physical non-linearity ($a = b = c = 0$) isn't taken into account, so the pressure size growth leads to moveout density reduction. Apparently, the given result is connected with inaccuracy of deformation process approximation in small elastic deformation only by involving in the geometrical non-linearity (at the same time the usage of Hook Law is demanded). In the case of three-dimensional tasks this is the rough approach. In mechanics, thin-walled bodies' research processes (plates and crust) in many applications such approaches are sufficiently used, where the occurrence of geometrical non-linearity is connected with large flexibility of thin-walled constructions.

From the (17) is followed that depending on size of numerical importance and the parameter mark n and m, with the growth $\frac{P}{K_0}$, joint impact/influence of physical and geometrical non-linearity on moveout density can be various.

Numerical results and discussion

By the external form (17) for "natural" and "real" velocity/speed and for various variants of the deformation theory doesn't differ. However, the elastic modules have significantly various qualitative meanings for these velocities/speeds and for the variants of the deformation theory as well. That's why according to the calculation due to the (17) all the same various results are got for these theories and variants. For example, proceed from the data (Guz, 1986)) that for organic glass with the n size in the case of "real" velocity/speed within the frame of large deformation and the first variant of small elementary deformation theory is equal to $38{,}21\cdot10^3$ МПа, but within the frame of the second variant of small elementary deformation theory is equal to $10{,}78\cdot10^3$ МПа. Hence, they differ from each other 3,54 times. The pressure size module for this material is $K_0 = 5{,}31\cdot10^3$ МПа. Some qualitative results about the influence of pressure changes on moveout density are reflected in the fig. 1. From the given results is seen that by the growth of pressure the size of moveout density is reduced within the frame of all analyzed deformation theory variants and within the notion of harmonic waves. Hence, the speed of compression process is reduced. In the case with "real" velocity/speed (fig. 1 line 1) this reduction, in other words, the compression process, by achieving certain size $\frac{P}{K_0}$, stops. The future pressure growth brings to uncompression process. The difference in quantitative results for various variants of deformation theory is considerably sufficient. In the case with "natural" velocity/speed (fig. 1 line 2) this phenomenon isn't observed. The dotted line corresponds to Adams-Williamson's equation. Here given results are applied within the limit of $\frac{P}{K_0} \le 0{,}36$ as by violating this setting with organic glass then "inner" instability process takes place (Biot, 1965; Guz, 1986) and dependences of non-classical linearization approach in the elastic deformation level are not applied.

While evaluating the quantitative numbers got in the frame of non-classical linearization approach, the most reliable one can be considered the results that correspond to the case $m = 3$, as in this case the shapes of the waves are modeled more grounded and the deformations in theoretical aspect are approximated more systematically and strictly. Accordingly the second and third ones out of this case can be considered $m = 1$ and $m = -1$. According to this note is achieved that in the case $m = 1$, the results for the organic glass are underestimated for 14, 8%, and in the case $m = -1$ - 33,4% with the comparison of results of the case $m = 3$. If we suppose that according to the case $m = 3$, transition from the compression zone on to the uncompression zone happens in the depth 1000km, then according to the cases $m = 1$ и $m = -1$ is got that this transition is realized in the depth 852 km and 666 km, in other words, the accepted simplification is considerably rough/rude. So, in the frame of non-classical linearization approach more adequate modeled shapes of seismic waves and more exact approximation of deformation (that is, accounting of physical, geometrical non-linearization and the deformation size) are of great importance in qualitative and quantitative respects.

In literature information for rock on non-linear elastic properties got in the frame of dynamic approach (that is by the usage of velocity/speed of elastic waves) isn't so wide (or much) (Aleksandrov etc., 1993; Bakulin and Protoseniya, 1982; Yin and Rasolofosaon, 1994). And what is more here isn't mentioned at measurement of which velocities – "natural" or "real"- they were determined. When it concerns the research of velocity/speed of elastic waves at changeable pressure, naturally to assume that the "real" velocities/speeds are measured. That's why while using these main data it's expedient to accept them as "real" velocities/speeds. In (Yin and Rasolofosaon, 1994) were sited quantitative meanings of linear and nonlinear elastic modules for some rocks of Mexican bay. According to these explanations the following is available for white granite Sierra

$$\lambda = 13{,}31 \cdot 10^3\, МПа,$$
$$\mu = 21{,}23 \cdot 10^3\, МПа;$$
$$a = -8{,}64 \cdot 10^3\, МПа,$$
$$b = 19{,}75 \cdot 10^3\, МПа,\ c = -77{,}49 \cdot 10^3\, МПа.$$

The analogical data are given in (26) for quartz within the Foicht approach.

$$\mu = 44{,}6 \cdot 10^3\, МПа;\ K_0 = 38{,}3 \cdot 10^3\, МПа;$$
$$a = -80{,}88 \cdot 10^3\, МПа;$$
$$b = 10{,}95 \cdot 10^3\, МПа;$$
$$c = -64{,}48 \cdot 10^3\, МПа$$
.

Using these data, results (Guz, 1986) and the given article, (14) was carried out calculation to define the moveout density with increasing/growing pressure. The results of calculations are given in the fig. 2. Dotted line is turned out by the classical formula Adams-Williamson's; line 1 belongs to quartz, and line 2 to white granite Sierra. Evidently, the density moveout character and velocity with the growth pressure sufficiently different for various earth materials and changes made in classical meaning (dotted line) of density moveout for various earth materials can be considerable. For quartz skip from density area on to indensity one was found. The given results here, analogical with the case on organic glass, can be applied accordingly while implementing the terms of $\frac{P}{K_0} \le 1{,}5$ and $\frac{P}{K_0} \le 1{,}16$ for granite and quartz.

Conclusion

According to the results the deformation nonlinearity and the differentiation of medium intensity make great impact on moveout density at the Earth's depth. The character of this impact for various mediums can essentially differ, that is, in one case the skip from compression area on to uncompression one can be realized, but in other cases only the process of compression can occur. For defining structure without taking into account such mechanisms of development and changes in the size density characteristics, can lead to doubtful results and ideas.

Influence of seismic parameter F in the case of the Earth's non-homogeneous models (Properties of geomaterials and physics of the Earth, 2000) is the same with the homogeneous models, that's non-homogeneity is related with the temperature field.

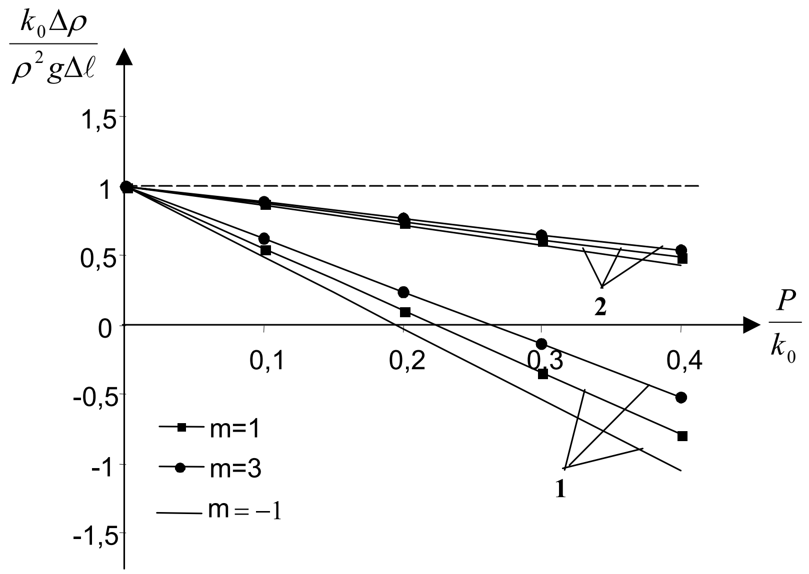

Fig. 1. Qualitative results about the pressure change impact on moveout density of organic glass.

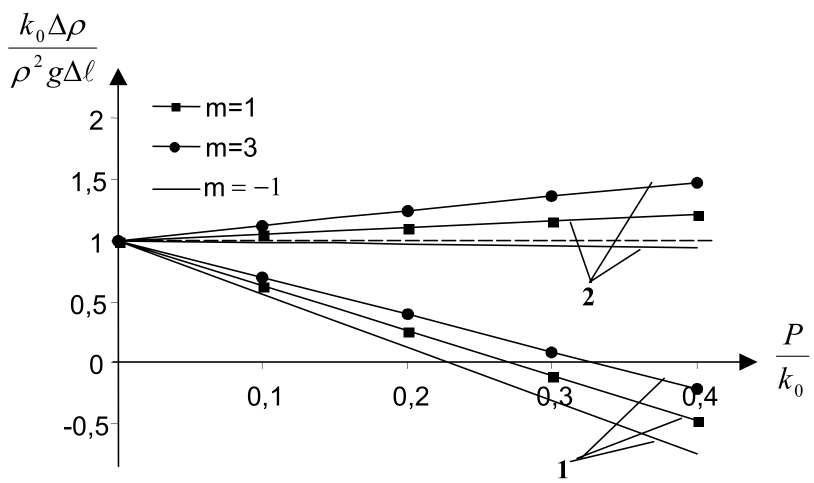

Fig. 2. Density changes of granite and quartz at increasing pressure according to non-classical linearization theory

Thus, enjoying the non-classical approach allows accurately define the character of material density distribution at depth, found out the mechanism of its formation and shed additional light on Earth depth structure. At suitable modeling the shapes of harmonic waves, that's in the case of applying the "real" velocity/speed within the limit of all variants of elementary deformation theory, a new phenomenon was predicted: with pressure growth at the Earth depth for separate types of geological subsurface the skip of compression process on to uncompression one can be realized

LITERATURE

ABASOV, M.T. et.al. 1992. *Geotectonics*, 26, 3, 90-101.

ABASOV, M.T., KULIEV, G.G., DJEVANSHIR, R.D. 2000. *Vestnik Ross. Acad. Nauk,* 70, 2, 129-135.

ALEKSANDROV, G.T., PRODAYVODA, G.T., MASLOV, B.P. 2001. *Dokl. Ross. Akad. Nauk,* 380, 1, 109-112.

ARTYUSHKOV, E.V. 1993. Physical Tectonics (in Russian). Nauka, Moscow, 457.

BAKULIN, V.N., PROTOSENIYA, A.G. 1982. *Dokl. Akad. Nauk SSSR*, 263, 2, 314-316.

BAYUK, E.I., VOLAROVICH, M.P., LEVITOVA, F.M. 1982. The rock elastic anisotropy under high pressures (in Russian). Nauka, Moscow, 170

BIOT, M.A. 1965. Mechanics of incremental deformations. New-York: Willey, 504.

GUZ, A.N. 1986. Elastic waves in bodies with elementary pressures (in Russian). Naukova Dumka, Kiev, 536.
JARKOV, V.N. 1983. The Earth Inner structure (in Russian). Nauka, Moscow, 416.
KLARCA YOUNGER S. 1969. Reference book on physical constants of rock. Mir, Moscow, 543.
KULIEV, G.G et al. 1998a. *Proceedings of Azerbaijan academy of sciences, sciences of Earth.* 4, 97-102.
KULIEV, G.G. 1998b. Extended volume 1 abstracts, 60th EAGE Conference and Technical Exhibition, 8-12 June, Leipzig, Germany, 081.
KULIEV, G.G. 1998c. *Geophysics news in Azerbaijan*, Bulletin, 1, 5-6.
KULIEV, G.G. 1998d. *Proceedings of Azerbaijan academy of sciences, the sciences of Earth,* 4, 134-140.
KULIEV, G.G. 2000. *Dokl. Ross. Akad. Nauk*, 370, 4, 534-537.
KULIEV, G.G. 2005. *Proceedings of Azerbaijan National Academy of Sciences the Sciences of Earth,* 1, 21-34.
KULIEV, G.G. et al. 1989. *Dokl. Akad. Nauk SSSR*, 305, 4, 926-929.
KULIEV, G.G. et.al. 1991. *Transaction (doclady) of the USSR Academy of Sciences. Earth science section*, 320, 7, 106-109.
KULIEV, G.G., DJEVANSHIR R.D. 2000. Abstracts 31st Intern.Geological Congress, Rio-de Janeiro, Brazil.
KULIEV, G.G., DJEVANSHIR, R.D., ABASOV, M.T. 1995. *Dokl. Ross. Akad. Nauk*, 340, 2, 222-224.
KULIEV, G.G., DJEVANSHIR, R.D., ABASOV, M.T. 1996a. Abstract, 30th Intern. Geolog. Congress, Beijing, China, 2, 257.
KULIEV, G.G., DJEVANSHIR, R.D., ABASOV, M.T. 1996b. *Transaction (report of the USSR Academy of Sciences. Earth science section,* 343, 5, 71-75.
KULIEV, G.G., JABBAROV, M.D. 1998. *Proceedings of Azerbaijan Academy of Sciences. The Sciences of Earth,* 2, 103-112.
KULIEV, G.G., JABBAROV, M.D. 2000. *Dokl. Ross. Akad. Nauk*, 370, 5, 672-674.
MAGNITSKIY, V.A. 1965. The Earth inner structure and physics (in Russian). Nedra, Moscow.
Properties of geomaterials and physics of the Earth / Kalinin V.A. 2000. Selected works. M.:RAS UIEP, 334.
RINGVUD, A.E 1982. The origin of the Earth and the Moon (in Russian). Nedra, Moscow.
TRURSTON, R., BRUGGER, K. 1964. *Phys. Rev. A*., 133, 6, 1604-1610.
YIN, H., RASOLOFOSAON, P.N.J. 1994. 64 SEG meeting Los Angeles, Expanded Abstracts, 3, 4, 1129-1132