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Fundamentals of the Non-Equilibrium Statistical Thermohydrodynamic Theory of the Small-Scale Dissipative Turbulence And The Deterministic Thermohydrogravidynamic Theory of the Glogal Seismotectonic, Volcanic and Climatic Activity of the Earth

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ABSTRACT: *The article presents the fundamentals of the Non-equilibrium Statistical Thermohydrodynamic Theory of the small-scale dissipative turbulence and the Deterministic Thermohydrogravidynamic Theory of the global seismotectonic, volcanic and climatic activity of the Earth based on the author's generalized differential formulations of the first law of thermodynamics (for the small and finite continuum regions* τ*, respectively) extending the classical Gibbs' formulation by taking into account the infinitesimal increment* dK_{τ} *of the macroscopic kinetic energy* K_{τ}*, the infinitesimal increment* $d\pi_{\tau}$ *of the gravitational potential energy* π_{τ}*, the generalized expression for the infinitesimal work* $\delta A_{np,\partial\tau}$ *done by the non-potential terrestrial stress forces acting on the boundary* $\partial\tau$ *of the continuum region* τ*, the infinitesimal increment* dG *of energy due to the combined cosmic and terrestrial non-stationary energy gravitational influence* dG *on the continuum region* τ*. Taking into account the previously established dates (6372±28) BC of the possible catastrophic seismotectonic event near Lake Agassiz, the established dates (1450±14) BC of the possible last major eruption of Thera (Santorini), the date 63 BC of the greatest earthquakes in the ancient Pontus, the established range (50±30) BC of the strong global volcanic activity of the Earth, the date 1928 AD of the previous eruption of Santorini, and the dates 818 AD, 1605 AD, 1703 AD, 1855 AD and 2011 of the previous strong earthquakes near Tokyo region, the Deterministic Thermohydrogravidynamic Theory presents the additional arguments concerning the previously (2013 AD and 2014 AD) established date 2016 AD of the forthcoming intensifications of the global seismotectonic, volcanic and climatic activity of the Earth (in the 21*st *century) determined by the combined predominant non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Mars, the Jupiter and the Sun owing to the gravitational interactions of the Sun with the Jupiter and the Saturn.*

KEYWORDS: *Small-scale dissipative turbulence, non-equilibrium statistical thermohydrodynamic theory, cosmic geophysics, deterministic thermohydrogravidynamic theory, generalized differential formulations of the first law of thermodynamics, non-stationary cosmic gravitation, global seismotectonic, volcanic and climatic activity of the Earth, natural disasters.*

I. INTRODUCTION

It is well known that the problem of turbulence "commonly regarded as the last unsolved problem of classical physics" [1]. It is clear that the solution of the turbulence problem [1] has the theoretical and practical significance for the humankind. There are different approaches to the turbulence problem [1]. The significant contributions to the turbulence problem are the Taylor's [2] and the Kolmogorov's [3] statistical theories of turbulence, the Townsend's [4] and Batchelor's [5] idea that the small-scale dissipative structures of turbulence may be well represented by random distributions of vortex sheets and vortex tubes and the hydrodynamic approaches [6, 7, 8] using the Navier-Stokes equation for averaging on the statistical ensemble of different turbulent flows and for the numerical modelling [9] of the turbulence. The problems of the long-term predictions of the strong earthquakes [10-13], the volcanic eruptions [13, 14] and the global climatic processes of the Earth [13, 15, 16] are also the significant problems of the modern geophysics. We present in this article the developed synthetic non-equilibrium statistical thermohydrodynamic theory of the small-scale dissipative turbulence [17, 18] and the developed synthetic deterministic thermohydrogravidynamic theory of the global seismotectonic, volcanic and climatic activity of the Earth intended for prediction [11-13, 16, 19-21] of the global seismotetonic, volcanic and climatic processes of the Earth. The non-equilibrium statistical thermohydrodynamic theory of the small-scale dissipative turbulence [17, 18, 22] and the thermohydrogravidynamic theory [11-13, 16, 18, 19-21, 23] of the global seismotectonic, volcanic and climatic processes are based on the author's generalized differential formulations (formulated previously in the works [18, 19, 24]) of the first law of thermodynamics. This article presents the evidence that the generalized differential formulations [18, 19, 24] of the first law of thermodynamics can be considered as the fundamental mathematical basis in the developed non-equilibrium statistical thermohydrodynamic theory of the small-scale dissipative turbulence [17, 18, 22] and for prediction [11-13, 16, 19-21, 23] of the global seismotetonic, volcanic and climatic processes of the Earth.

In Section 2.1 we present the classical differential formulation (3) of the first law of thermodynamics in non-equilibrium thermodynamics [25] for the one-component deformed macrodifferential continuum element with no chemical reactions, and also the Gibbs' [26] classical formulation (9) of the first law of thermodynamics for the fluid body. In Section 2.2 we present the generalized differential formulation (12) of the first law of thermodynamics [19, 24] for the individual finite continuum region τ (considered in the Galilean frame of reference) subjected to the combined (cosmic and terrestrial) non-stationary Newtonian gravitational field and non-potential terrestrial stress forces (characterized by the symmetric stress tensor $\mathbf{T}$ [27]) acting on the boundary surface $\partial\tau$ of the individual finite continuum region τ.

In Section 2.3 we present the generalized differential formulation (20) of the first law of thermodynamics for the deformed one-component individual finite continuum region τ (considered in the rotational coordinate system $K'(\mathrm{C}_3,\mathbf{\Omega})$ related with the mass center C_3 of the rotating Earth characterized by the constant angular velocity $\mathbf{\Omega}$ of the Earth's rotation) subjected to the non-stationary Newtonian terrestrial gravitational field, the tidal (of cosmic gravitational genesis), Coriolis and centrifugal forces, and non-potential terrestrial stress forces acting on the boundary surface $\partial\tau$ of the individual finite continuum region τ.

In Section 2.4 we present the generalized differential formulation (28) of the first law of thermodynamics [18] for the small individual macroscopic continuum region τ (considered in the Galilean frame of reference) subjected to the non-stationary Newtonian gravitational field and non-potential terrestrial stress forces (characterized by the symmetric stress tensor $\mathbf{T}$ [27]) acting on the boundary surface $\partial\tau$ of the small individual continuum region τ. Based on the generalized [17, 18] relation (34) for the macroscopic kinetic energy K_τ of the small macroscopic fluid particle τ, the classical [28] and generalized [18, 29] formulation (50) of the weak law of large numbers and the generalized differential formulation (28) of the first law of thermodynamics [18] for the small individual macroscopic continuum region τ, we present in Section 2.4 the summary of the non-equilibrium statistical thermohydrodynamic theory of the small-scale dissipative turbulence confirmed [17, 18, 22, 30-33] for laboratory and oceanic stratified turbulence in the wide range of the energy-containing length scales from the inner Kolmogorov length scale [3] to the length scales proportional to the Ozmidov length scale [17, 18].

In Section 3 we present the evidence of the cosmic and terrestrial energy gravitational genesis of the global seismotectonic, volcanic and climatic activity of the Earth. Based on the generalized differential formulation (12) of the first law of thermodynamics [19, 24] used for Earth (considered in the Galilean frame of reference) as a whole, in Section 3.1 we present the evidence of the cosmic and terrestrial energy gravitational genesis of the seismotectonic, volcanic and climatic activity of the Earth induced by the combined (cosmic and terrestrial) non-stationary energy gravitational influences on an arbitrary individual continuum region τ (of the Earth) and by the non-potential terrestrial stress forces acting on the boundary surface $\partial\tau$ of the continuum region τ. Based on the generalized differential formulation (12) of the first law of thermodynamics used for the Earth as a whole, in Section 3.2 we present the established [12, 13, 20, 21] fundamental global time periodicities (79) and (80) of the periodic global seismotectonic, volcanic and climatic activity of the Earth determined by the combined cosmic non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Mars, the Jupiter and the Sun owing to the gravitational interaction of the Sun with the Jupiter, the Saturn, the Uranus and the Neptune. Based on the formula (79), in Section 3.3 we present the established [12, 13, 20, 21] fundamental global seismotectonic, volcanic and climatic time periodicity 88 years (determined by the combined non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Jupiter and the Mars) confirmed by the reasonable prediction of "the time range $2010 \div 2011$ AD of the next sufficiently strong Japanese earthquake near the Tokyo region" [16].

Based on the formula (79), in Section 3.4 we present the established [12, 13, 20, 21] range of the fundamental seismotectonic, volcanic and climatic time reriodicities $T_{tec,f} = T_{clim1,f} = T_{energyf} = (702 \pm 6)$ years (determined by the combined predominant non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Jupiter and the Sun owing to the gravitational interactions of the Sun with the Jupiter and the Saturn) confirmed by the previous strong earthquakes, volcanic eruptions and climatic anomalies in the history of humankind [11-13, 20, 21].

In Section 3.5. we present the evidence of the synchronic fundamental seismotectonic, volcanic and climatic time periodicities $T_{tec,vol,clim,sf} = (6321 \pm 3)$ years [21] and $T_{tec,vol,clim,sf}/2 = 3160.5 \pm 1.5$ years determined by the combined predominant non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Mars, the Jupiter and the Sun owing to the gravitational interactions of the Sun with the Jupiter and the Saturn. In Section 3.5.1 we present the synchronic fundamental seismotectonic, volcanic and climatic time periodicities $T_{tec,vol,clim,sf} = (6321 \pm 3)$ years [21] and $T_{tec,vol,clim,sf}/2 = 3160.5 \pm 1.5$ years characterizing the time synchronization of the mean periodicities 702 years and 1581 years of the fundamental global seismotectonic, volcanic and climatic time periodicities $T_{tec,vol,clim,f} = (702 \pm 6)$ years [20, 21] and $T_{tec,vol,clim,cf} = (1581 \pm 189)$ years [21]. In Section 3.5.2 we present the evidence of the founded synchronic fundamental seismotectonic, volcanic and climatic time periodicity $T_{tec,vol,clim,sf} = (6321 \pm 3)$ years based on the established [21] causal link between the beginning (6372 BC) of the outstanding climate anomaly during (6372÷6192) BC in the North Atlantic [34] (owing to the very probable catastrophic seismotectonic event near 6372 BC [21] close to Lake Agassiz [34]) and the established range (50±30) BC [35] of the strong global volcanic activity of the Earth. In Section 3.5.3 we present the evidence of the founded synchronic fundamental seismotectonic, volcanic and climatic time periodicities $T_{tec,vol,clim,sf} = (6321 \pm 3)$ years [21] and $T_{tec,vol,clim,sf}/2 = 3160.5 \pm 1.5$ years based on the analysis of the greatest world volcanic eruptions BC [35]. In Section 3.6 we present the combined arguments concerning the possible forthcoming intensifications of the global seismotectonic, volcanic and climatic activity of the Earth in the 21st century since 2016 AD.

In Section 4 we present the summary and conclusion.

II. THE GENERALIZED DIFFERENTIAL FORMULATIONS OF THE FIRST LAW OF THERMODYNAMICS FOR THE NON-STATIONARY NEWTONIAN GRAVITATIONAL FIELD

2.1. The Classical Differential Formulations of the First Law of Thermodynamics : We shall consider the fluid moving in the three-dimensional Euclidean space with respect to a Cartesian coordinate system K centred at the origin O and determined by the axes X_1, X_2, X_3 (see Fig. 1). The unit normal K-basis coordinate vectors triad $\boldsymbol{\mu}_1, \boldsymbol{\mu}_2, \boldsymbol{\mu}_3$ is taken in the directions of the axes X_1, X_2, X_3, respectively. The local hydrodynamic velocity vector $\mathbf{v}$ is determined by the general equation of continuum movement [27]:

$$\frac{d\mathbf{v}}{dt} = \frac{1}{\rho} \operatorname{div} \mathbf{T} + \mathbf{g}, \tag{1}$$

where $\mathbf{T}$ is the general symmetric stress tensor [27] of the deformed continuum, $\mathbf{g}$ is the local gravity acceleration due to the combined (cosmic and terrestrial) non-stationary gravitational field. The operator

$d/dt = \partial/\partial t + \mathbf{v} \cdot \nabla$ denotes [6, 7, 27] the total derivative following the continuum substance. The relevant three-dimensional fields such as the velocity and the local mass density (and also the first and the second derivatives of the relevant fields) are assumed to vary continuously throughout the entire continuum bulk of the continuum region τ.

The macroscopic local mass density ρ of mass distribution and the local hydrodynamic velocity $\mathbf{v}$ of the macroscopic velocity field are determined by the hydrodynamic continuity equation [7, 27]:

$$\frac{\partial \rho}{\partial t} + \operatorname{div}(\rho \mathbf{v}) = 0 \tag{2}$$

under the absence of distributed space-time sources of mass output.

The differential formulation of the first law of thermodynamics [25] for the one-component deformed macrodifferential continuum element with no chemical reactions is given by:

$$\frac{du}{dt} = \frac{dq}{dt} - p\frac{d\vartheta}{dt} - \vartheta\ \mathbf{\Pi} : \operatorname{Grad} \mathbf{v}, \tag{3}$$

u is the specific (per unit mass) internal thermal energy, dq is the differential change of heat across the boundary of the macrodifferential continuum region (of unit mass) related with the thermal molecular conductivity, p is the thermodynamic pressure, $\vartheta = 1/\rho$ is the specific volume, $\mathbf{\Pi}$ is the viscous-stress tensor [25].

The differential change of heat dq across the boundary of the macrodifferential continuum region (of unit mass) is described by the heat equation [25]:

$$\rho \frac{dq}{dt} = -\operatorname{div} \mathbf{J}_q, \tag{4}$$

where $\mathbf{J}_q$ is the heat flux [25].

The viscous-stress tensor $\mathbf{\Pi}$ [25] is determined from the decomposition for the pressure tensor $\mathbf{P} = -\mathbf{T}$ [27]:

$$\mathbf{P} = p\boldsymbol{\delta} + \mathbf{\Pi}, \tag{5}$$

where $\boldsymbol{\delta}$ is the Kronecker delta-tensor.

Consider the Newtonian viscous-stress tensor $\mathbf{P}^v \equiv \mathbf{\Pi}$ of the compressible viscous Newtonian continuum with the components [27]:

$$\Pi_{ij} = \left\{\left(\frac{2}{3}\nu\rho - \eta_v\right)\operatorname{div} \mathbf{v}\right\}\delta_{ij} - 2\nu\rho\, e_{ij}, \tag{6}$$

where $\nu = \eta/\rho$ is the coefficient of the molecular kinematic (first) viscosity, $\nu_2 = \eta_v/\rho$ is the coefficient of the molecular volume (second) viscosity [36], $e_{ij}(\mathbf{r}, t)$ is the rate of strain tensor defined [17, 18] as follows:

$$e_{ij}(\mathbf{r}, t) = \frac{1}{2}\left(\frac{\partial v_i(\mathbf{r}, t)}{\partial X_j} + \frac{\partial v_j(\mathbf{r}, t)}{\partial X_i}\right). \tag{7}$$

Using the Newtonian viscous-stress tensor (6), we obtained that the differential formulation (3) of the first law of thermodynamics (for the continuum region (of unit mass) of the compressible viscous Newtonian one-component deformed continuum with no chemical reactions) can be presented as follows [11, 19]

$$\frac{du}{dt} = \frac{dq}{dt} - p\frac{d\vartheta}{dt} + \left(\nu_2 - \frac{2}{3}\nu\right)(\operatorname{div} \mathbf{v})^2 + 2\nu(e_{ij})^2. \tag{8}$$

The obtained differential formulation (8) of the first law of thermodynamics is the generalization of the Gibbs' [26] classical formulation of the first law of thermodynamics for the fluid body (fluid region of an arbitrary mass) given in Gibbs' designations:

$$d\varepsilon = dH - dW, \tag{9}$$

where $d\varepsilon$ is the differential of the internal thermal energy of the fluid body, dH is the differential change of heat across the boundary of the fluid body related with the thermal molecular conductivity (associated with the corresponding external or internal heat fluxes), $dW = pdV_\tau$ is the differential work produced by the considered fluid body on its surroundings (surrounding fluid) under the differential change dV_τ of the fluid region (of volume V_τ) characterized by the thermodynamic pressure p.

The first and the second terms in the right-hand side of relation (8) are analogous to the corresponding (respective) first and the second terms in the right-hand side of the classical formulation (9). The third term in the right-hand side of relation (8):

$$dq_{i,c} = \left(\frac{\eta_v}{\rho} - \frac{2}{3}\nu \right) (\mathrm{div}\ \mathbf{v})^2 dt \tag{10}$$

is related with the 'internal' heat induced during the time interval dt by viscous-compressible irreversibility [18]. The fourth term in the right-hand side of relation (8):

$$dq_{i,s} = 2\nu\,(e_{ij})^2\,dt \tag{11}$$

is related with the 'internal' heat induced during the time interval dt by viscous-shear irreversibility [18]. The differential formulation (8) of the first law of thermodynamics (for the continuum element of the compressible viscous Newtonian one-component deformed continuum with no chemical reactions) takes into account (in addition to the classical terms [26]) the viscous-compressible irreversibility and viscous-shear irreversibility inside the continuum element of the compressible viscous Newtonian one-component deformed continuum with no chemical reactions.

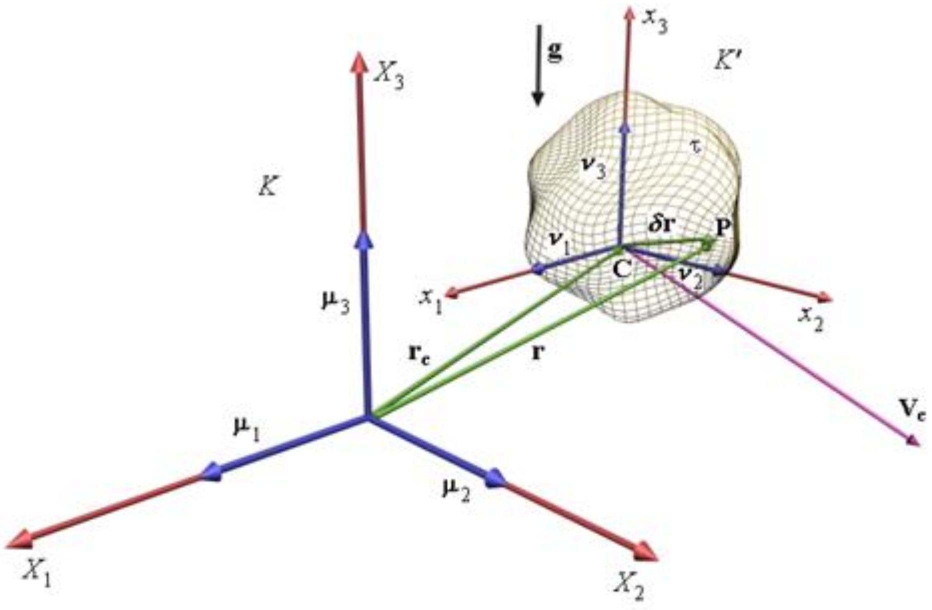

Fig. 1. Cartesian coordinate system K of a Galilean frame of reference and the Lagrangian coordinate system K' related with the mass center C of an individual finite continuum region τ (of a wide variety of sizes): the geo-block of the lithosphere, or the magma chamber, or the oceanic / atmosperic continuum region of the Earth, or the whole Earth, or the planet of the Solar System subjected to the non-stationary Newtonian gravitation

2.2.The Generalized Differential Formulation of the First Law of Thermodynamics for the Individual Finite Continuum Region τ (Considered in the Galilean Frame of Reference) Subjected to the Combined Non-stationary Cosmic and Terrestrial Newtonian Gravitational Field and Non-potential Terrestrial Stress Forces Acting on the Boundary Surface $\partial\tau$ of the Individual Finite Continuum Region τ

We shall assume that τ is an individual deformed finite one-component continuum region (bounded by the closed continual boundary surface $\partial\tau$) moving in the three-dimensional Euclidean space relative to a

Cartesian coordinate system K. Following the works [19, 24], we shall consider the individual deformed finite one-component continuum region τ characterized by the non-equilibrium shear-rotational states [17-19, 24] related with the continuum deformation. We shall consider the continuum region τ in a Galilean frame of reference with respect to a Cartesian coordinate system K centred at the origin O and determined by the axes X_1, X_2, X_3 (see Fig. 1). We take into account the time variations of the potential ψ of the combined (cosmic and terrestrial) non-stationary gravitational field (characterized by the local gravity acceleration $\mathbf{g} = -\nabla\psi$) inside of an arbitrary finite macroscopic individual continuum region τ subjected to the combined non-stationary cosmic and terrestrial Newtonian gravitational field.

Using the general equation (1) of continuum movement [27], the hydrodynamic continuity equation (2), the differential formulation (3) of the first law of thermodynamics [25] for the one-component deformed macrodifferential continuum element with no chemical reactions, the classical [25] heat equation (4), the classical [25] decomposition (5) for the pressure tensor $\mathbf{P} = -\mathbf{T}$ [27] related with the viscous-stress tensor $\mathbf{\Pi}$ [25], we derived [19, 24] the generalized differential formulation (for the Galilean frame of reference) of the first law of thermodynamics (for moving rotating deforming compressible heat-conducting stratified finite macroscopic individual continuum region τ presented on Fig. 1):

$$dU_\tau + dK_\tau + d\pi_\tau = \delta Q + \delta A_{np,\partial\tau} + dG, \tag{12}$$

where

$$U_\tau = \iiint_\tau u\rho dV \tag{13}$$

is the classical microscopic internal thermal energy of the finite macroscopic individual continuum region τ, dV is the mathematical differential of physical volume of the continuum region τ;

$$K_\tau = \iiint_\tau \frac{\rho\mathbf{v}^2}{2} dV \tag{14}$$

is the instantaneous macroscopic kinetic energy of the finite macroscopic individual continuum region τ;

$$\pi_\tau = \iiint_\tau \psi\rho dV \tag{15}$$

is the macroscopic potential energy (of the finite macroscopic individual continuum region τ) related with the non-stationary potential ψ of the combined (cosmic and terrestrial) gravitational field;

$$\delta Q = -dt\iint_{\partial\tau} (\mathbf{J}_q \cdot \mathbf{n})\, d\Omega_{\mathbf{n}} \tag{16}$$

is the classical [26] differential change of heat related with the thermal molecular conductivity of heat across the boundary $\partial\tau$ of the continuum region τ, $\mathbf{J}_q$ is the heat flux [25] across the surface element $d\Omega_{\mathbf{n}}$ of the continuum boundary surface $\partial\tau$, the differential surface element $d\Omega_{\mathbf{n}}$ (of the boundary surface $\partial\tau$ of the continuum region τ) is characterized by the external normal unit vector $\mathbf{n}$;

$$\delta A_{np,\partial\tau} = dt\iint_{\partial\tau} (\mathbf{v} \cdot (\mathbf{n} \cdot \mathbf{T}))\, d\Omega_{\mathbf{n}} \tag{17}$$

is the generalized infinitesimal work [18, 19, 24] done during the infinitesimal time interval dt by non-potential stress forces acting on the boundary surface $\partial\tau$ of the continuum region τ, $\mathbf{t} = \mathbf{n} \cdot \mathbf{T}$ is the stress vector [27];

$$dG = dt\iiint_\tau \frac{\partial\psi}{\partial t} \rho dV \tag{18}$$

is the infinitesimal amount dG of energy [19, 24] added or lost as the result of the Newtonian non-stationary gravitational energy influence [11-13, 16, 19, 20, 21, 24] on the finite macroscopic individual continuum region τ during the infinitesimal time interval dt. We use the common Riemann's integral here and everywhere.

The generalized differential formulation (12) of the first law of thermodynamics extends the classical [26] formulation by taking into account (along with the classical infinitesimal change of heat δQ and the classical infinitesimal change $dU_\tau \equiv dU$ of the internal thermal energy U_τ) the infinitesimal increment dK_τ of the macroscopic kinetic energy K_τ, the infinitesimal increment $d\pi_\tau$ of the gravitational potential energy π_τ, the generalized infinitesimal work $\delta A_{np,\partial\tau}$ done during the infinitesimal time interval dt by non-potential stress forces (pressure, compressible and viscous forces for Newtonian continuum) acting on the boundary surface $\partial\tau$ of the continuum region τ, the infinitesimal amount dG [19, 24] of energy added or lost as the result of the Newtonian non-stationary gravitational energy influence on the continuum region τ during the infinitesimal time interval dt. The infinitesimal amount dG [19, 24] of energy (added or lost as the result of the Newtonian non-stationary gravitational energy influence on the continuum region τ) may be interpreted [11-13, 19, 20, 24] as the differential energy gravitational influence dG on the continuum region τ during the infinitesimal time interval dt owing to time variations of the of the potential ψ of the combined non-stationary cosmic and terrestrial gravitational field (characterized by the local gravity acceleration $\mathbf{g} = -\nabla\psi$) inside of an arbitrary finite macroscopic individual continuum region τ subjected to the combined non-stationary cosmic and terrestrial Newtonian gravitational field.

2.3.The Generalized Differential Formulation of the First Law of Thermodynamics for the Deformed One-component Individual Finite Continuum Region τ (Considered in the Rotational Coordinate System) Subjected to the Non-stationary Newtonian Terrestrial Gravitational Field, the Tidal, Coriolis and Centrifugal Forces, and Non-potential Terrestrial Stress Forces Acting on the Boundary Surface $\partial\tau$ of the Individual Finite Continuum Region τ

The local hydrodynamic velocity vector $\mathbf{v}$ (of continuum movement relative to the rotational coordinate system $K'(C_3, \boldsymbol{\Omega})$ related with the mass center C_3 of the rotating Earth characterized by the angular velocity $\boldsymbol{\Omega}$ of the Earth's rotation) is determined (for rotational coordinate system related with the rotating Earth) by the general equation of continuum movement:

$$\frac{d\mathbf{v}}{dt} = \frac{1}{\rho}\operatorname{div}\mathbf{T} + \mathbf{g}_{ter} - 2[\boldsymbol{\Omega}\times\mathbf{v}] - [\boldsymbol{\Omega}\times[\boldsymbol{\Omega}\times\mathbf{r}]] + \mathbf{F}_{tidal}, \qquad (19)$$

where $\mathbf{T}$ is the symmetric stress tensor [27], $\mathbf{g}_{ter} = -\nabla\psi_{ter}$ is the local gravity acceleration determined by the terrestrial non-stationary Newtonian gravitational field, ψ_{ter} is the potential of the terrestrial non-stationary Newtonian gravitational field, $\boldsymbol{\Omega}$ is the angular velocity characterizing the rotation of the rotational coordinate system $K'(C_3, \boldsymbol{\Omega})$ related with the mass center C_3 of the rotating Earth, $-2[\boldsymbol{\Omega}\times\mathbf{v}]$ is the Coriolis force [37], $-[\boldsymbol{\Omega}\times[\boldsymbol{\Omega}\times\mathbf{r}]]$ is the centrifugal force [37], $\mathbf{r}$ is the position vector of the one-component deformed macrodifferential continuum element (inside the individual continuum region τ) having the acceleration $d\mathbf{v}/dt$, $\mathbf{F}_{tidal}$ is the classical tidal force [38] related with the cosmic non-stationary Newtonian gravitational field of the Moon, the Sun and the planets of the Solar System. Using the general equation (19) of continuum movement (considered in the rotational coordinate system $K'(C_3, \boldsymbol{\Omega})$ related with the mass center C_3 of the rotating Earth characterized by the angular velocity $\boldsymbol{\Omega}$), the hydrodynamic continuity equation (2), the differential formulation (3) of the first law of thermodynamics [25] for the one-component deformed macrodifferential continuum element with no chemical reactions, the heat equation (4) [25] and the decomposition (5), we derive the generalized differential formulation of the first law of thermodynamics (applicable for the rotational coordinate system $K'(\mathrm{C}_3, \mathbf{\Omega})$):

$$\mathrm{dU}_\tau + \mathrm{dK}_\tau + \mathrm{d}\pi_{\tau,\mathrm{ter}} = \delta\mathrm{Q} + \delta\mathrm{A}_{\mathrm{np},\partial\tau} + \mathrm{dG}_{\mathrm{ter}} + \delta\mathrm{A}_{\mathrm{tidal,c},\tau} \qquad (20)$$

for non-equilibrium shear-rotational states of the deformed finite one-component individual continuum region τ (characterized by the symmetric stress tensor $\mathbf{T}$) subjected to the non-stationary Newtonian terrestrial gravitational field, the tidal (of cosmic genesis) forces, Coriolis and centrifugal forces, and the non-potential terrestrial stress forces acting on the boundary surface $\partial\tau$ of the continuum region τ. The generalized differential formulation (20) takes into account (along with the classical infinitesimal change of heat $\delta\mathrm{Q}$ [26, 39] and the classical infinitesimal change of the internal thermal energy dU_τ [26, 39]) the established [19, 24] infinitesimal increment dK_τ of the macroscopic kinetic energy K_τ:

$$\mathrm{K}_\tau = \iiint\limits_\tau \frac{\rho\mathbf{v}^2}{2} \mathrm{d}\,\mathrm{V}, \qquad (21)$$

the infinitesimal increment $\mathrm{d}\pi_{\tau,\mathrm{ter}}$ of the gravitational terrestrial potential energy $\pi_{\tau,\mathrm{ter}}$:

$$\pi_{\tau,\mathrm{ter}} = \iiint\limits_\tau \psi_{\mathrm{ter}}\rho\mathrm{dV}, \qquad (22)$$

the established [11-13, 18, 19, 20, 24] generalized infinitesimal work $\delta\mathrm{A}_{\mathrm{np},\partial\tau}$:

$$\delta\mathrm{A}_{\mathrm{np},\partial\tau} = \mathrm{dt}\iint\limits_{\partial\tau} (\mathbf{v}\cdot(\mathbf{n}\cdot\mathbf{T}))\, \mathrm{d}\Omega_{\mathbf{n}} \qquad (23)$$

done during the infinitesimal time interval dt by non-potential stress forces (pressure, compressible and viscous forces for Newtonian continuum) acting on the boundary surface $\partial\tau$ of the continuum region τ, the infinitesimal energy gravitational terrestrial influence $\mathrm{dG}_{\mathrm{ter}}$ on the continuum region τ:

$$\mathrm{dG}_{\mathrm{ter}} = \mathrm{dt}\iiint\limits_\tau \frac{\partial\psi_{\mathrm{ter}}}{\partial\mathrm{t}}\rho\mathrm{dV} \qquad (24)$$

as the result of the non-stationary Newtonian terrestrial gravitational field acting on the continuum region τ during the infinitesimal time interval dt, and the additional (especially for rotational coordinate system related with the rotating Earth) infinitesimal work $\delta\mathrm{A}_{\mathrm{t,c},\tau}$:

$$\delta\mathrm{A}_{\mathrm{tidal,c},\tau} = \mathrm{dt}\iiint\limits_\tau (\mathbf{v}\cdot(\mathbf{F}_{\mathrm{tidal}} - [\mathbf{\Omega}\times[\mathbf{\Omega}\times\mathbf{r}]]))\,\rho\,\mathrm{dV} \qquad (25)$$

done during the infinitesimal time interval dt by the tidal and centrifugal forces acting on the continuum region τ.

The generalized differential formulation (20) of the first law of thermodynamics (for rotational coordinate system related with the rotating Earth) can be rewritten as follows:

$$= \frac{\mathrm{dE}_\tau}{\mathrm{dt}} = \frac{\mathrm{d}}{\mathrm{dt}}(\mathrm{K}_\tau + \mathrm{U}_\tau + \pi_{\tau,\mathrm{ter}}) = \iiint\limits_\tau \left(\frac{1}{2}\mathbf{v}^2 + \mathrm{u} + \psi\right)\rho\mathrm{dV} =$$

$$= \iint\limits_{\partial\tau} (\mathbf{v}\cdot(\mathbf{n}\cdot\mathbf{T}))\, \mathrm{d}\Omega_{\mathbf{n}} - \iint\limits_{\partial\tau} (\mathbf{J}_{\mathrm{q}}\cdot\mathbf{n})\, \mathrm{d}\Omega_{\mathbf{n}} +$$

$$+ \iiint\limits_\tau \frac{\partial\psi_{\mathrm{ter}}}{\partial\mathrm{t}}\rho\mathrm{dV} + \iiint\limits_\tau (\mathbf{v}\cdot(\mathbf{F}_{\mathrm{tidal}} - [\mathbf{\Omega}\times[\mathbf{\Omega}\times\mathbf{r}]]))\,\rho\,\mathrm{dV}, \qquad (26)$$

which gives the evolution equation for the total mechanical energy $\left(K_\tau + \pi_{\tau,ter}\right)$ of the deformed finite individual macroscopic continuum region τ (considered in the rotating coordinate system) of the Newtonian continuum:

$$\frac{d}{dt}\left(K_\tau + \pi_{\tau,ter}\right) = \frac{d}{dt}\iiint_\tau \left(\frac{1}{2}\mathbf{v}^2 + \psi\right)\rho dV = -\iiint_\tau 2\nu\left(e_{ij}\right)^2 \rho dV - \iiint_\tau \left(\frac{\eta_v}{\rho} - \frac{2}{3}\nu\right)\left(\operatorname{div}\mathbf{v}\right)^2 \rho dV +$$
$$+ \iiint_\tau p \operatorname{div}\mathbf{v} dV - \iiint_{\partial\tau} p(\mathbf{v}\cdot\mathbf{n})d\Omega_{\mathbf{n}} - \iint_{\partial\tau}\left(\frac{2}{3}\eta - \eta_v\right)\left(\operatorname{div}\mathbf{v}\right)(\mathbf{v}\cdot\mathbf{n})d\Omega_{\mathbf{n}} + \iint_{\partial\tau} 2\eta v_\beta n_\alpha e_{\alpha\beta} d\Omega_{\mathbf{n}} +$$
$$+ \iiint_\tau \frac{\partial\psi_{ter}}{\partial t}\rho\, dV - \iiint_\tau \left(\mathbf{v}\cdot[\mathbf{\Omega}\times[\mathbf{\Omega}\times\mathbf{r}]]\right)\rho\, dV + \iiint_\tau \left(\mathbf{v}\cdot\mathbf{F}_{tidal}\right)\rho\, dV \tag{27}$$

The first term on the right hand side of the evolution equation (27) represents the total rate of the viscous dissipation (related with the viscous dissipation rate per unit mass $\varepsilon_{dis,v} = dq_{i,s}/dt = 2\nu\,(e_{ij})^2$ determined by the relation (11)) of the macroscopic kinetic energy inside of the individual continuum region τ of the Newtonian continuum. The second term on the right hand side of the evolution equation (27) represents the total rate of the viscous-compressible dissipation (related with the viscous-compressible dissipation rate per unit mass $\varepsilon_{dis,c} = dq_{i,c}/dt$ determined by the relation (10)) of the macroscopic kinetic energy inside of the individual region τ of the Newtonian continuum. The third term on the right hand side of the evolution equation (27) describes the compressibility effects (related with the divergence $\operatorname{div}\mathbf{v} \neq 0$ of the local hydrodynamic velocity $\mathbf{v}$) on the total mechanical energy $\left(K_\tau + \pi_{\tau,ter}\right)$ of the deformed compressible finite individual macroscopic continuum region τ. The fourth, fifth and sixth terms on the right hand side of the evolution equation (27) describe the total mechanical energy exchange per unit time across the boundary surface $\partial\tau$ between the individual macroscopic continuum region τ and its surrounding environment. The seventh term describes the power of the energy gravitational influence of the terrestrial non-stationary gravitational field on the individual macroscopic continuum region τ. The eighth term describes the power of the energy gravitational influence of the centrifugal force on the individual macroscopic continuum region τ. The ninth term describes the power of the energy gravitational influence of the tidal force $\mathbf{F}_{tidal}$ [38] (related with cosmic non-stationary gravitational field) on the individual macroscopic continuum region τ. The energy gravitational influence of the Coriolis force is not presented in the evolution equation (27) since the Coriolis force $-2[\mathbf{\Omega}\times\mathbf{v}]$ is perpendicular to the hydrodynamic velocity vector $\mathbf{v}$ of continuum movement.

2.4.The Generalized Differential Formulation of the First Law of Thermodynamics for the Small Individual Macroscopic Continuum Region τ (considered in the Galilean Frame of Reference) Subjected to the Stationary Newtonian Gravitational Field and Non-potential Terrestrial Stress Forces Acting on the Boundary Surface $\partial\tau$ of the Small Individual Continuum Region τ

The first fundamental foundation of the non-equilibrium statistical thermohydrodynamic theory of the three-dimensional small-scale dissipative turbulence is the generalized differential formulation [18, 30] of the first law (in a Galilean frame of reference) of thermodynamics (for the small individual macroscopic fluid particle τ (continuum region) characterized by the symmetric stress tensor $\mathbf{T}$):

$$d(U_\tau + K_\tau + \pi_\tau) = d(U_\tau + K_t + K_r + K_s + K_{s,r}^{coup} + K_{res} + \pi_\tau) =$$
$$= \delta Q + \delta A_{np,\partial\tau} + dG\,, \tag{28}$$

where $dG = 0$ for the stationary Newtonian gravitational field characterized by the condition $\frac{\partial\psi}{\partial t}=0$. The generalized differential formulation (28) (considered in this Section 2.4 and in the non-equilibrium statistical thermohydrodynamic theory of the small-scale dissipative turbulence [17, 18, 22] under condition $dG=0$

corresponding to the stationary Newtonian gravitational field) extends the classical [26] formulation (9) (given in Landau's and Lifshitz's designations [39])

$$dU_\tau = \delta Q - pdV, \; (dU_\tau \equiv d\varepsilon, -dW \equiv -pdV) \tag{29}$$

by taking into account (along with the classical infinitesimal change of heat

$$\delta Q = -dt \iint_{\partial\tau} (\mathbf{J}_q \cdot \mathbf{n}) d\Omega_{\mathbf{n}} \tag{30}$$

across the boundary $\partial\tau$ of the small fluid particle τ and the classical infinitesimal change dU_τ of the internal thermal energy (of the small fluid particle τ)

$$U_\tau = \iiint_\tau u\rho dV) \tag{31}$$

the infinitesimal increment dK_τ of the macroscopic kinetic energy K_τ [17, 18], the infinitesimal increment $d\pi_\tau$ of the gravitational potential energy π_τ (determined by the potential ψ of the gravity field related with the local gravity acceleration $\mathbf{g} = -\nabla\psi$)

$$\pi_\tau \equiv \iiint_\tau \psi\rho dV \tag{32}$$

and the generalized [18] infinitesimal work (determined by the stress vector $\mathbf{t} = \mathbf{n} \cdot \mathbf{T}$ [27])

$$\delta A_{np,\partial\tau} = dt \iint_{\partial\tau} (\mathbf{v} \cdot (\mathbf{n} \cdot \mathbf{T}))\, d\Omega_{\mathbf{n}} \tag{33}$$

done during the infinitesimal time interval dt by non-potential surrounding stress forces acting on the boundary fluid surface $\partial\tau$ of the small fluid particle τ. $\mathbf{J}_q$ is the heat flux, u is the specific internal thermal energy, ρ is the local mass density, $d\Omega_{\mathbf{n}}$ is the differential surface element (of the boundary fluid surface $\partial\tau$ of the small fluid particle τ) characterized by the external normal unit vector $\mathbf{n}$.

The macroscopic kinetic energy K_τ of the small macroscopic fluid particle τ is given by the following relation [17, 18]

$$K_\tau = \varepsilon_k\, m_\tau = K_t + K_r + K_s + K_{s,r}^{coup} + K_{res} = \frac{1}{2} m_\tau \mathbf{V}_c^2 + \frac{1}{2}\sum_{i,k=1}^{3} I_{ik}\omega_i(\mathbf{r_c})\omega_k(\mathbf{r_c}) +$$

$$+ \frac{1}{2}\sum_{i,j,k=1}^{3} J_{jk} e_{ij}(\mathbf{r}_c) e_{ik}(\mathbf{r}_c) + \sum_{i,j,k,m=1}^{3} \varepsilon_{ijk} J_{jm} \omega_i(\mathbf{r_c})\, e_{km}(\mathbf{r_c}) + K_{res}, \tag{34}$$

where m_τ is the mass of the small continuum region τ, $\mathbf{V}_c$ is the speed of the mass center C of the small continuum region τ (defined by the following expression)

$$\mathbf{V}_c = \frac{\iiint_\tau \mathbf{v}\rho dV}{m_\tau}, \tag{35}$$

$$\boldsymbol{\omega}(\mathbf{r}_c) \equiv \frac{1}{2}(\nabla \times \mathbf{v}(\mathbf{r}_c)) = (\omega_1(\mathbf{r}_c), \omega_2(\mathbf{r}_c), \omega_3(\mathbf{r}_c)) \tag{36}$$

is the angular velocity of internal rotation (a half of the vorticity vector [7, 17, 18, 27]) in the K- coordinate system at the position-vector $\mathbf{r_c}$ (of the mass center C of the continuum region τ in the K- coordinate system) given by the following expression

$$\mathbf{r_c} = \frac{1}{m_\tau}\iiint_\tau \mathbf{r}\rho dV, \tag{37}$$

$$e_{ij}(\mathbf{r}_c) = \frac{1}{2}\left(\frac{\partial v_i(\mathbf{r}_c)}{\partial X_j} + \frac{\partial v_j(\mathbf{r}_c)}{\partial X_i}\right) \tag{38}$$

is the rate of strain tensor in the K- coordinate system at the position-vector $\mathbf{r_c}$ (i, j=1, 2, 3), I_{ik} is the ik- component of the classical inertia tensor depending on the mass distribution in the small continuum region τ under consideration:

$$I_{ik} = \iiint\limits_{\tau,K'}\left(\delta_{ik}\left(\sum_{j=1}^{3} x_j^2\right) - x_i\ x_k\right)\rho dV, \tag{39}$$

where x_i, x_k are the i, k- components of the vector $\delta\mathbf{r}$, respectively, in the $K' -$ coordinate system; δ_{ik} is the Kronecker delta-tensor; ε_{ijk} is the third-order permutation symbol; J_{jk} is the j,k- component classical centrifugal tensor depending on the mass distribution in the small continuum region τ under consideration:

$$J_{jk} = \iiint\limits_{\tau,K'} x_j\ x_k\ \rho dV, \tag{40}$$

$K_{res} = O\,(d_\tau^7)$ is a small residual part [17, 18] of the macroscopic kinetic energy (34).

Formula (34) states that the macroscopic kinetic energy K_τ of the small continuum region τ is the sum of the macroscopic translational kinetic energy K_t of the continuum region τ:

$$K_t = \frac{1}{2} m_\tau \mathbf{V}_\mathbf{c}^2; \tag{41}$$

the macroscopic internal rotational kinetic energy K_r of the continuum region τ:

$$K_r = \frac{1}{2}\sum_{i,k=1}^{3} I_{ik}\omega_i(\mathbf{r_c})\omega_k(\mathbf{r_c}) \equiv \frac{1}{2} I_{ik}\,\omega_i(\mathbf{r_c})\omega_k(\mathbf{r_c}); \tag{42}$$

the macroscopic internal shear kinetic energy K_s of the continuum region τ:

$$K_s = \frac{1}{2}\sum_{i,j,k=1}^{3} J_{jk} e_{ij}(\mathbf{r_c}) e_{ik}(\mathbf{r_c}) \equiv \frac{1}{2} J_{jk} e_{ij}(\mathbf{r_c}) e_{ik}(\mathbf{r_c}); \tag{43}$$

the macroscopic kinetic energy of shear-rotational coupling $K_{s,r}^{coup}$ of the continuum region τ:

$$K_{s,r}^{coup} = \sum_{i,j,k,m=1}^{3} \varepsilon_{ijk} J_{jm}\omega_i(\mathbf{r_c})\ e_{km}(\mathbf{r_c}) \equiv \varepsilon_{ijk} J_{jm}\omega_i(\mathbf{r_c}) e_{km}(\mathbf{r_c}), \tag{44}$$

where ε_{ijk} is the third-order permutation symbol [17, 18].

The generalization (34) is based on the Taylor series expansion [17, 18] of the hydrodynamic velocity vector $\mathbf{v}\,(\mathbf{r})$ (for each time moment t) in the vicinity of the position-vector $\mathbf{r_c}$ of the mass center $\mathbf{C}$ of a small macroscopic fluid particle τ:

$$\mathbf{v}\,(\mathbf{r_c} + \delta\mathbf{r}) = \mathbf{v}\,(\mathbf{r_c}) + \boldsymbol{\omega}\,(\mathbf{r_c}) \times \delta\mathbf{r} + \sum_{i,j=1}^{3} e_{ij}(\mathbf{r_c})\delta r_j\ \boldsymbol{\mu}_i + \frac{1}{2}\sum_{i,j,k=1}^{3}\frac{\partial^2 v_i}{\partial X_j \partial X_k}\delta r_j \delta r_k\ \boldsymbol{\mu}_i + \mathbf{v}_{res}, \tag{45}$$

where $\mathbf{v}\,(\mathbf{r}) \equiv (v_1(\mathbf{r}),\ v_2(\mathbf{r}),\ v_3(\mathbf{r}))$; $\delta\,\mathbf{r} \equiv \mathbf{r} - \mathbf{r_c} \equiv (\delta r_1, \delta r_2, \delta r_3)$; $\boldsymbol{\omega}\,(\mathbf{r}) \equiv \frac{1}{2}(\nabla \times \mathbf{v}\,(\mathbf{r}))$ = $(\omega_1, \omega_2, \omega_3)$ is the angular velocity of internal rotation; $\boldsymbol{\omega}_v\,(\mathbf{r}) \equiv$

$(\nabla \times \mathbf{v}(\mathbf{r}))$ is the local vorticity [1, 7, 36]; $e_{ij}(\mathbf{r})$ is the rate of strain tensor (i, j=1, 2, 3); ∇ is the gradient operator, $\mathbf{v}_{res}$ is the residual part of the Taylor series expansion (45).

The classical expression [25, 27]

$$\varepsilon_k = \varepsilon_t + \varepsilon_r \tag{46}$$

for the macroscopic kinetic energy per unit mass ε_k was generalized [17, 18] by founding the expression

$$\varepsilon_k = K_\tau / m_\tau = \varepsilon_t + \varepsilon_r + \varepsilon_s + \varepsilon_{s,r}^{coup} + \varepsilon_{res} \tag{47}$$

taking into account (along with the classical macroscopic translational kinetic energy per unit mass ε_t [25, 27], the classical macroscopic internal rotational kinetic energy per unit mass ε_r [25, 27] and a small correction ε_{res}) a new macroscopic internal shear kinetic energy per unit mass [17, 18]

$$\varepsilon_s = \frac{1}{2} \sum_{i,j,k=1}^{3} \beta_{jk} e_{ij} e_{ik} , \tag{48}$$

which expresses the kinetic energy of macroscopic shear (deformed) motion (characterized by the rate of strain tensor e_{ij} and the centrifugal tensor per unit mass β_{jk}), and a new macroscopic internal kinetic energy of a shear-rotational coupling per unit mass [17, 18]

$$\varepsilon_{s,r}^{coup} = \sum_{i,j,k,m=1}^{3} \varepsilon_{ijk} \beta_{jm} \omega_i e_{km} , \tag{49}$$

which expresses the kinetic energy of local coupling between the shear and rotational (characterized by the angular velocity vector ω_i of internal rotation) continuum motions.

The second fundamental foundation of the non-equilibrium statistical thermohydrodynamic theory of the three-dimensional small-scale dissipative turbulence is the generalization [18, 29] of the classical special formulation [28] of the weak law of large numbers by taking into account the coefficients of correlations $\rho(x_i, x_k) \neq 0$ between the random variables x_i and x_k of the infinite set of random variables $x_1, x_2, \ldots, x_n$ …. characterized by the same variance $\sigma^2 = \overline{(x_i - a)^2}$ and the same mathematical mean $a = \overline{x_i}$ of the random variables $x_1, x_2, \ldots, x_n$ …. . It was proved [29] mathematically that the limit of probability

$$\lim_{n\to\infty} \Pr\left\{ \left| \frac{(x_1 + x_2 + \ldots + x_n)}{n} - a \right| < \varepsilon \right\} = 1 \tag{50}$$

is satisfied (for any $\varepsilon > 0$) if the following condition [18, 29]:

$$\lim_{n\to\infty} \frac{\sigma^2}{n^2} \sum_{i,k=1;i\neq k}^{n} \rho(x_i, x_k) = 0 \tag{51}$$

is satisfied for the coefficients of correlations $\rho(x_i, x_k)$.

The non-equilibrium statistical thermohydrodynamic theory of the three-dimensional small-scale dissipative turbulence was synthesized [17, 18, 22] based on the generalized [17, 18] expressions (34) and (47) for ε_k and K_τ, the classical hydrodynamic statistical approaches [2-3, 8], the classical [28] and generalized [29] formulation (50) of the weak law of large numbers, the generalized [18] differential formulation (28) of the first law of thermodynamics and the conception of the statistical ensemble [40] of different thermohydrodynamic unclosed dissipative [28] non-equilibrium subsystems of randomly and isotropically rotating and randomly and isotropically sheared small-scale turbulent eddies.

By averaging the macroscopic internal kinetic energy $K_{int}(\tau_i)$ of each homogeneous fluid cube τ_i [17, 18]

$$K_{int}(\tau_i) = K_r^{tur}(\tau_i) + K_s^{tur}(\tau_i) = \frac{1}{2} I \, (\boldsymbol{\omega})^2 + \frac{1}{2} J e_{jk} e_{jk} \tag{52}$$

on the statistical ensemble of fluid eddies (characterized by the speeds of the mass centers $\mathbf{v}_{\mathbf{c}}^{\tau_i} \equiv 0$ for each fluid cube τ_i) with randomly and isotropically oriented vorticity vectors $\boldsymbol{\omega}_v$ and randomly and isotropically distributed rates of strain tensors e_{jk}, we obtained [17, 18] the closure relation (based on classical formulation [28] of the weak law of large numbers):

$$b_{tur} = \langle \varepsilon_s \rangle + \langle \varepsilon_r \rangle = \frac{1}{24 n_e \nu} l^2 \overline{\varepsilon_{dis,v}} \,, \ (n_e = 1) \qquad (53)$$

for the three-dimensional isotropic homogeneous small-scale dissipative turbulence.

We obtained [18, 22] the closure relation (based on the generalized formulation [29] of the weak law of large numbers) :

$$b_{tur} = \langle \varepsilon_s \rangle + \langle \varepsilon_r \rangle = \frac{(1+n_e)}{48 n_e \nu} l^2 \overline{\varepsilon_{dis,v}} \,, \ (n_e \neq 1) \qquad (54)$$

for the three-dimensional anisotropic small-scale dissipative turbulence characterized by the coefficient $n_e = \langle \varepsilon_s \rangle / \langle \varepsilon_r \rangle$ of local thermodynamic non-equilibrium.

The turbulent kinetic energy per unit mass $b_{tur} = \langle \varepsilon_s \rangle + \langle \varepsilon_r \rangle$ is determined by the following variables: the mean kinetic energy viscous dissipation rate per unit mass $\overline{\varepsilon_{dis,v}} = 2\nu \overline{(e_{ij})^2}$, the energy-containing length scale l of the three-dimensional small-scale dissipative turbulence and the coefficient $n_e = \langle \varepsilon_s \rangle / \langle \varepsilon_r \rangle$ of local thermodynamic non-equilibrium. The three-dimensional small-scale dissipative turbulence was modeled by the statistical ensemble [40] of the "large-grained" [9] dissipative velocity structures [28] (of the energy-containing length scale l) determined (in accordance with the Kolmogorov's theory [3]) by the stochastic Taylor series expansions (45) with deterministic space ($\delta \mathbf{r}$) and random tensorial [2, 7] variables (e_{ij} and $\boldsymbol{\omega} = \boldsymbol{\omega}_v / 2$) and also under deterministic conditions $\mathbf{v}_{res}$ =0.

The physical correctness and practical significance of the established closure relations (53) and (54) was demonstrated [17, 18, 22, 30-33] for laboratory and oceanic stratified turbulence in the wide range of the energy-containing length scales from the inner Kolmogorov length scale [3] to the length scales proportional to the Ozmidov length scale [17]. The obtained analytical dependences for $\overline{\varepsilon_{dis,v}}$ and b_{tur} explained the initial [18], intermediate [22] and final (viscous) [22] hydrodynamic regimes of turbulence decay in homogeneous Newtonian fluids. It was shown [22] that the established [18] Batchelor-Townsend length scale (determined by $\overline{\varepsilon_{dis,v}}$, ν and by the dimensional parameter l_o characterized by the dimension of length)

$$L_{BT} = (\overline{\varepsilon_{dis,v}})^{-1/7} (\nu l_o)^{3/7} \qquad (55)$$

can explain the viscous dissipation at the final hydrodynamic stage of turbulence decay. The founded critical kinetic energy viscous dissipation rates per unit mass $\varepsilon_{dis,cr}(\langle l_{cr} \rangle, R(a), n_e)$ explained [17, 18] the transition of turbulent regimes to wave regimes (in Newtonian viscous stratified fluid) for the average critical size $\langle l_{cr} \rangle$ of the energy-containing overturning turbulent eddies, the coefficient of "rigidity" $R(a)$ [18] of the local fluid motion, the coefficient of local anisotropy a [18] of the turbulent velocity pulsations and the coefficient n_e [18] of local thermodynamic non-equilibrium.

It was demonstrated [17, 18, 22, 30] that the classical [25, 27] macroscopic internal rotational (ε_r) and the established [17] macroscopic non-equilibrium kinetic energies (ε_s and $\varepsilon_{s,r}^{coup}$) represent the thermohydrodynamic basis of the non-equilibrium statistical thermohydrodynamics of turbulence [18]. It was shown [17, 18, 22] that the established [17] proportionality (of the macroscopic internal shear kinetic energy per unit mass ε_s and the kinetic energy viscous dissipation rate per unit mass $\varepsilon_{dis,v}$ for the cubical particles in Newtonian continuum)

$$\varepsilon_s = \beta(e_{ij})^2/2 \Leftrightarrow \varepsilon_{dis,v} = 2\nu\,(e_{ij})^2 \quad (56)$$

gives the physical foundation of the remarkable association [28] between a structure and the irreversible dissipation for the dissipative structures in Newtonian fluids.

Taking into account the fundamental physical difference [41] between the classical "reversible" macroscopic rotational ε_r [25, 27] and "irreversible" macroscopic non-equilibrium kinetic energies ε_s and $\varepsilon_{s,r}^{coup}$ [17, 18], the classical Gibbs relation [40]:

$$du = Tds - pd\vartheta \quad (57)$$

for the differential ds of entropy per unit mass s (of a fluid element characterized by the specific volume $\vartheta = 1/\rho$ and the absolute temperature T) and the classical de Groot and Mazur [25] expression for the entropy production ds/dt (in a one-component Newtonian fluid):

$$\frac{ds}{dt} = \frac{1}{T}\frac{dq}{dt} + \frac{1}{T}2\nu\,(e_{ij})^2 + \frac{1}{T\rho}\left(\eta_v - \frac{2}{3}\eta\right)(\text{div}\,\mathbf{v})^2 \quad (58)$$

were generalized [18, 22], respectively, as follows:

$$du + d\varepsilon_r - d\varepsilon_s - d\varepsilon_{s,r}^{coup} = Tds - pd\vartheta, \quad (59)$$

$$\frac{ds}{dt} = \frac{1}{T}\frac{dq}{dt} + \frac{1}{T}2\nu\,(e_{ij})^2 + \frac{1}{T\rho}\left(\eta_v - \frac{2}{3}\eta\right)(\text{div}\,\mathbf{v})^2 + \frac{1}{T}\frac{d\varepsilon_r}{dt} - \frac{1}{T}\frac{d\varepsilon_s}{dt} - \frac{1}{T}\frac{d\varepsilon_{s,r}^{coup}}{dt} \quad (60)$$

extending the Boltzmann's classical statistical approach (identifying the entropy with the molecular chaos) by taking into account (along with the classical macroscopic internal rotational kinetic energy per unit mass ε_r [25, 27]) the established macroscopic non-equilibrium kinetic energies ε_s and $\varepsilon_{s,r}^{coup}$ [17, 18]. Based on the generalized formulation (50) of the weak law of large numbers [29], we obtained [22] from equation (60) the following evolution equation (for an incompressible viscous Newtonian fluid) for the average entropy per unit mass $\bar{s}$:

$$\frac{\partial \bar{s}}{\partial t} = \frac{\overline{\varepsilon_{dis,v}}}{T} + \frac{1}{T}\frac{\partial}{\partial t}\left(b_{tur}\frac{(1-n_e)}{(1+n_e)}\right) \quad (61)$$

determined by the turbulent kinetic energy per unit mass b_{pul} of the anisotropic wave-turbulent velocity pulsations, the coefficient $n_e = \langle\varepsilon_s\rangle/\langle\varepsilon_r\rangle$ of local thermodynamic non-equilibrium, the mean kinetic energy viscous dissipation rate per unit mass $\overline{\varepsilon_{dis,v}} = 2\nu\overline{(e_{ij})^2}$ and the absolute temperature T. The validity of the Prigogine's foresight that the Boltzmann's "identification of entropy with molecular disorder could contain only one part of the truth" (Ilya Prigogine – Autobiography, 1977) was confirmed [22] by revealing the creative role of the macroscopic non-equilibrium kinetic energies ε_s and $\varepsilon_{s,r}^{coup}$ [17, 18] determining the time reduction of entropy at the initial stage of stratified turbulence collapse and irreversible transition [42] to internal gravity waves.

The general equation (1) of continuum movement gives the Navier-Stokes equations for the compressible viscous Newtonian one-component continuum characterized by the stress tensor [27]

$$T_{ij} = -\left\{p + \left(\frac{2}{3}\nu\rho - \eta_v\right)\text{div}\,\mathbf{v}\right\}\delta_{ij} + 2\nu\,\rho\,e_{ij} \quad (62)$$

assuming the constant kinematic viscosity ν, the constant volume viscosity η_v and the variable (in time and space) equilibrium thermodynamic pressure p. However, the generalized differential formulations (12), (20) and (28) of the first law of thermodynamics are valid for general symmetric stress tensor $\mathbf{T}$ (including the compressible viscous Newtonian one-component continuum characterized by the variable kinematic viscosity ν and variable volume viscosity η_v). It gives the possibility to use the generalized differential formulations (12) and (20) for foundation of the cosmic and terrestrial energy gravitational genesis of the seismotectonic, volcanic and climatic activity of the Earth induced by the combined (cosmic and terrestrial) non-stationary energy gravitational influences on an arbitrary individual continuum region τ (of the Earth) and by the non-potential terrestrial stress forces (characterized by general symmetric stress tensor $\mathbf{T}$) acting on the boundary surface $\partial\tau$ of the continuum region τ. The generalized differential formulation (12) (given for the Galilean frame of reference) is preferable for this foundation since it gives the possibility to not consider the variable (in time and space) tidal, Coriolis and centrifugal forces acting on the individual finite continuum region τ of the Earth.

III. COSMIC AND TERRESTRIAL ENERGY GRAVITATIONAL GENESIS OF THE GLOBAL SEISMOTECTONIC, VOLCANIC AND CLIMATIC ACTIVITY OF THE EARTH

3.1.Cosmic and Terrestrial Energy Gravitational Genesis of the Seismotectonic, Volcanic and Climatic Activity of the Earth Induced by the Combined (Cosmic and Terrestrial) Non-stationary Energy Gravitational Influences on an Arbitrary Individual Continuum Region τ (of the Earth) and by the Non-potential Terrestrial Stress Forces Acting on the Boundary Surface $\partial\tau$ of the Continuum Region τ

We have shown [11-13, 19-21] that the global seismotectonic, volcanic and climatic activity of the Earth is determined by the combined (cosmic and terrestrial) non-stationary energy gravitational influences on the individual continuum region τ and by the non-potential terrestrial stress forces acting on the boundary surface $\partial\tau$ of the arbitrary continuum region τ of the Earth. To demonstrate this statement, we consider the evolution equation for the total mechanical energy $(K_\tau + \pi_\tau)$ of the deformed finite individual macroscopic continuum region τ [11-13, 19-21, 24]:

$$\frac{d}{dt}(K_\tau + \pi_\tau) = \frac{d}{dt}\iiint_\tau \left(\frac{1}{2}\mathbf{v}^2 + \psi\right)\rho dV =$$

$$= \iiint_\tau p\,\mathrm{div}\mathbf{v}\,dV + \iiint_\tau \left(\frac{2}{3}\eta - \eta_v\right)(\mathrm{div}\mathbf{v})^2 dV - \iiint_\tau 2\nu(e_{ij})^2 \rho dV +$$

$$+ \iint_{\partial\tau} (\mathbf{v}\cdot(\mathbf{n}\cdot\mathbf{T}))\, d\Omega_{\mathbf{n}} + \iiint_\tau \frac{\partial\psi}{\partial t}\rho dV \qquad (63)$$

obtained from the generalized differential formulation (12) of the first law of thermodynamics for the compressible viscous Newtonian one-component continuum subjected to the non-stationary gravity field. The evolution equation (63) takes into account the dependences of the coefficient of molecular kinematic viscosity $\nu = \eta/\rho$ and the coefficient of molecular volume viscosity $\nu_2 = \eta_v/\rho$ on the space (three-dimensional) Cartesian coordinates.

To understand the theoretical genesis of the global seismotectonic and volcanic time periodicities, we consider the generalized termohydrogravidynamic shear-rotational model of the earthquake focal region [11, 20] based on the generalized differential formulation (12) of the first law of thermodynamics. Using the evolution equitation (63) of the total mechanical energy $(K_\tau + \pi_\tau)$ of the macroscopic continuum region τ of the Earth, we showed [11, 16, 19, 20] that the formation of fractures (modeling by the jumps of the continuum velocity on some surfaces) are related with irreversible dissipation of the macroscopic kinetic energy. We considered the formation of the main line flat fracture (associated with the surface $F_1(\tau)$ of the continuum velocity jump) inside of the macroscopic continuum region τ (bounded by the closed surface $\partial\tau$). The macroscopic continuum region τ may be divided into two subsystem τ_1 and τ_2 by continuing mentally the surface $F_1(\tau)$ by means of surface $R_1(\tau)$ crossing the surface $\partial\tau$ of the macroscopic region τ. The surface of the subsystem τ_1 consists of the surface $(\partial\tau)_1$ (which is the part of the surface $\partial\tau$) and the surfaces $F_1(\tau)$ and $R_1(\tau)$. The surface of the subsystem τ_2 consists of the surface $(\partial\tau)_2$ (which is the part of the surface $\partial\tau$) and the surfaces $F_1(\tau)$ and $R_1(\tau)$.

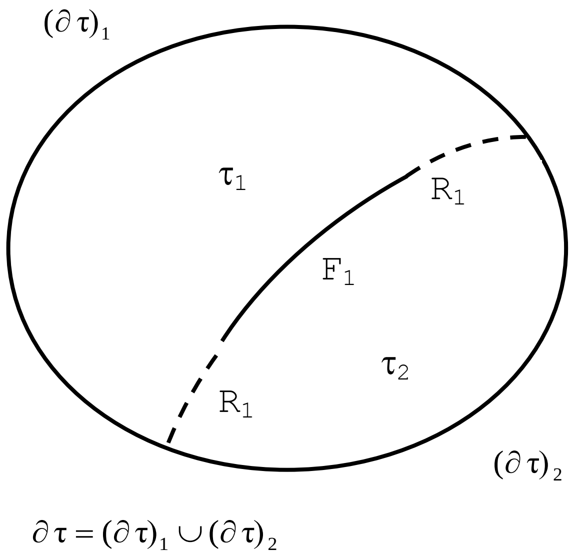

Fig. 2. The macroscopic continuum region τ containing two subsystem τ_1 and τ_2 interacting on the surface $F_1(\tau)$ of the tangential jump of the continuum velocity

Using the evolution equitation (63) of the total mechanical energy $(K_\tau + \pi_\tau)$ of an arbitrary macroscopic continuum region τ of the Earth, we obtained [11, 16] the evolution equations for the total mechanical energy of the macroscopic subsystems τ_1 and τ_2:

$$\frac{d}{dt}(K_{\tau_1} + \pi_{\tau_1}) = \frac{d}{dt}\iiint\limits_{\tau_1}\left(\frac{1}{2}\mathbf{v}^2 + \psi\right)\rho dV =$$

$$= \iiint\limits_{\tau_1} p\,\mathrm{div}\mathbf{v}dV + \iiint\limits_{\tau_1}\left(\frac{2}{3}\eta - \eta_v\right)(\mathrm{div}\mathbf{v})^2 dV - \iiint\limits_{\tau_1} 2\nu(e_{ij})^2\rho dV + \iint\limits_{(\partial\tau)_1}(\mathbf{v}\cdot(\mathbf{n}\cdot\mathbf{T}))\,d\Omega_{\mathbf{n}} +$$

$$+ \iint\limits_{F_1(\tau)}(\mathbf{v}_1(\tau_1)\cdot(\zeta_1\cdot\mathbf{T}))\,d\Sigma_{\zeta_1} + \iint\limits_{R_1(\tau)}(\mathbf{v}_1(\tau_1)\cdot(\zeta_1\cdot\mathbf{T}))\,d\Sigma_{\zeta_1} + \iiint\limits_{\tau_1}\frac{\partial\psi}{\partial t}\rho dV, \qquad (64)$$

$$\frac{d}{dt}(K_{\tau_2} + \pi_{\tau_2}) = \frac{d}{dt}\iiint\limits_{\tau_2}\left(\frac{1}{2}\mathbf{v}^2 + \psi\right)\rho dV =$$

$$= \iiint\limits_{\tau_2} p\,\mathrm{div}\mathbf{v}dV + \iiint\limits_{\tau_2}\left(\frac{2}{3}\eta - \eta_v\right)(\mathrm{div}\mathbf{v})^2 dV - \iiint\limits_{\tau_2} 2\nu(e_{ij})^2\rho dV + \iint\limits_{(\partial\tau)_2}(\mathbf{v}\cdot(\mathbf{n}\cdot\mathbf{T}))\,d\Omega_{\mathbf{n}} -$$

$$- \iint\limits_{F_1(\tau)}(\mathbf{v}_1(\tau_2)\cdot(\zeta_1\cdot\mathbf{T}))\,d\Sigma_{-\zeta_1} - \iint\limits_{R_1(\tau)}(\mathbf{v}_1(\tau_2)\cdot(\zeta_1\cdot\mathbf{T}))\,d\Sigma_{-\zeta_1} + \iiint\limits_{\tau_2}\frac{\partial\psi}{\partial t}\rho dV, \qquad (65)$$

where ζ_1 is the external unit normal vector of the surface (of the subsystem τ_1) presented by surfaces $F_1(\tau)$ and $R_1(\tau)$, $-\zeta_1$ is the external unit normal vector of the surface (of the subsystem τ_2) presented also by surfaces $F_1(\tau)$ and $R_1(\tau)$. Adding the equations (64) and (65) (by using the equality $d\Sigma_{\zeta_1} = d\Sigma_{-\zeta_1}$ of the elements of area of surfaces $F_1(\tau)$ and $R_1(\tau)$), we get the evolution equation for the total mechanical energy $(\mathrm{K}_\tau + \pi_\tau) = (\mathrm{K}_{\tau_1} + \mathrm{K}_{\tau_2} + \pi_{\tau_1} + \pi_{\tau_2})$ of the macroscopic region τ consisting from subsystems τ_1 and τ_2 interacting on the surface $\mathrm{F}_1(\tau)$ of the tangential jump of the continuum velocity:

$$\frac{d}{dt}(\mathrm{K}_\tau + \pi_\tau) = \frac{d}{dt}\iiint_\tau \left(\frac{1}{2}\mathbf{v}^2 + \psi\right)\rho dV =$$

$$= \iiint_\tau p\,\mathrm{div}\mathbf{v} dV + \iiint_\tau \left(\frac{2}{3}\eta - \eta_v\right)(\mathrm{div}\mathbf{v})^2 dV - \iiint_\tau 2\nu (e_{ij})^2 \rho dV +$$

$$+ \iint_{\partial\tau} (\mathbf{v}\cdot(\mathbf{n}\cdot\mathbf{T}))\, d\Omega_{\mathbf{n}} + \iiint_\tau \frac{\partial\psi}{\partial t}\rho dV + \iint_{\mathrm{F}_1(\tau)} ((\mathbf{v}_1(\tau_1) - \mathbf{v}_1(\tau_2))\cdot(\zeta_1\cdot\mathbf{T}))\, d\Sigma_{\zeta_1}, \qquad (66)$$

where $\mathbf{v}_1(\tau_1)$ is the vector of the continuum velocity on the surface $\mathrm{F}_1(\tau)$ in the subsystem τ_1, $\mathbf{v}_1(\tau_2)$ is the vector of the continuum velocity on the surface $\mathrm{F}_1(\tau)$ in the subsystem τ_2. The evolution equation (66) represents the generalized thermohydrogravidynamic shear-rotational model **[**11, 16, 19**]** of the earthquake focal region τ.

The evolution equation (66) takes into account the total mechanical energy $(\mathrm{K}_\tau + \pi_\tau)$ of the macroscopic region τ consisting from subsystems τ_1 and τ_2 interacting on the surface $\mathrm{F}_1(\tau)$ of the tangential jump of the continuum velocity. The first term in the right-hand side (of the evolution equation (66)) describes the evolution of the total mechanical energy of the macroscopic continuum region τ due to the continuum reversible compressibility. Taking into account the relations (10) and (11), we see that the second and the third terms in the right-hand side (of the evolution equation (66)) expresses the dissipation of the total mechanical energy $(\mathrm{K}_\tau + \pi_\tau)$ owing to production of the 'internal' heat by viscous-compressible irreversibility [18] and by viscous-shear irreversibility [18], respectively. The forms of three mentioned above terms in the right-hand side (of the evolution equation (66)) are related with the considered model of the compressible viscous Newtonian continuum [27]. The fourth, fifth and the sixth terms in the in the right-hand side (of the evolution equation (66)) are the universal terms for arbitrary model of continuum characterized by symmetrical stress tensor $\mathbf{T}$. The fourth term in the right-hand side (of the evolution equation (66)) express the power $W_{np,\partial\tau} = \delta A_{np,\partial\tau}/dt$ [11, 19] of external (for the continuum region τ) non-potential stress forces acting on the boundary surfaces $\partial\tau$ of the macroscopic continuum region τ. Based on the expression for the generalized infinitesimal work $\delta A_{np,\partial\tau}$ (given by the relation (17)), the power $W_{np,\partial\tau} = \delta A_{np,\partial\tau}/dt$ (during the infinitesimal time interval $(t, t+dt)$) of the non-potential stress forces can be presented for Newtonian continuum as follows

$$W_{np,\partial\tau} = \delta A_{np,\partial\tau}/dt = W_{p,\partial\tau} + W_{c,\partial\tau} + W_{s,\partial\tau} =$$

$$= -\iint_{\partial\tau} p(\mathbf{v}\cdot\mathbf{n})\, d\Omega_{\mathbf{n}} - \iint_{\partial\tau}\left(\frac{2}{3}\eta - \eta_v\right)\mathrm{div}\,\mathbf{v}(\mathbf{v}\cdot\mathbf{n})\, d\Omega_{\mathbf{n}} + \iint_{\partial\tau} 2\eta\, v_\beta n_\alpha e_{\alpha\beta} d\Omega_n, \qquad (67)$$

where

$$W_{p,\partial\tau} = \delta A_p/dt = -\iint_{\partial\tau} p(\mathbf{v}\cdot\mathbf{n})\, d\Omega_{\mathbf{n}} \qquad (68)$$

is the power of the hydrodynamic pressure forces acting on the boundary surface $\partial\tau$ of the individual continuum region τ;

$$W_{c,\partial\tau} = \delta A_c/dt = -\iint_{\partial\tau}\left(\frac{2}{3}\eta - \eta_v\right)\mathrm{div}\,\mathbf{v}(\mathbf{v}\cdot\mathbf{n})\, d\Omega_{\mathbf{n}} \qquad (69)$$

is the power (related with the combined effects of the acoustic compressibility ($\mathrm{div}\,\mathbf{v} \neq 0$), the coefficient of molecular dynamic shear viscosity η and the coefficient of molecular volume (second) viscosity η_v) of the acoustic (compressible) pressure forces acting on the boundary surface $\partial\tau$ of the individual continuum region τ;

$$W_{s,\partial\tau} = \delta A_s / dt = \iint_{\partial\tau} 2\eta\, v_\beta n_\alpha e_{\alpha\beta} d\Omega_n \tag{70}$$

is the power of the viscous Newtonian forces (related with the combined effect of the molecular shear viscosity and the velocity shear, i.e. the deformation of the continuum region characterized by the rate of strain tensor $e_{\alpha\beta}$ [17, 18]) acting on the boundary surface $\partial\tau$ of the continuum region τ.

The fifth term in the in the right-hand side (of the evolution equation (66)) express the power of the combined (cosmic and terrestrial) non-stationary energy gravitational influences on the individual continuum region τ related with time variations of the potential ψ of the combined (cosmic and terrestrial) non-stationary gravitational field (characterized by the local gravity acceleration $\mathbf{g} = -\nabla\psi$) inside of an arbitrary finite macroscopic individual continuum region τ subjected to the combined (cosmic and terrestrial) non-stationary Newtonian gravitational field.

It was pointed out [39] the significance of the non-stationary gravitational field for the creative thermodynamic evolution of the large thermodynamic subsystems (of the universe), which are far from the state of the thermodynamic equilibrium due to the velocity shear related with the rate of strain tensor $e_{\alpha\beta} \neq 0$ [17, 18]. It was concluded [39] that the total energy of the open thermodynamic system (subjected to the non-stationary gravitational field) is the function of time, i.e. not a constant value. In accordance with this conclusion [39], we see that the generalized differential formulation (12) of the first law of thermodynamics [19, 24] states that the total differential change $dU_\tau + dK_\tau + d\pi_\tau$ of the total energy $U_\tau + K_\tau + \pi_\tau$ of the continuum region τ is determined by the differential energy gravitational influence dG on the continuum region τ during the infinitesimal time interval dt due to the non-stationary gravitational field.

The necessity to consider the combined (cosmic and terrestrial) non-stationary gravitational field (during the strong earthquakes) is related with the observations of the slow gravitational [43, 44] ground waves resulting from strong earthquakes and spreading out from the focal regions [45, 46] of earthquakes. Lomnitz pointed out [45] that the gravitational ground waves (related with great earthquakes) "have been regularly reported for many years and remain a controversial subject in earthquake seismology". Richter presented [10] the detailed analysis of these observations and made the conclusion that "there is almost certainly a real phenomenon of progressing or standing waves seen on soft ground in the meizoseismal areas of great earthquakes". Lomnitz presented [46] the real evidence of the existence of the slow gravitational waves in sedimentary layers during strong earthquakes.

The generalized differential formulation (12) of the first law of thermodynamics shows that the combined (cosmic and terrestrial) non-stationary gravitational field (related with the non-stationary gravitational potential ψ) gives the following gravitational energy power

$$W_{gr}(\tau) = \frac{dG}{dt} = \iiint_\tau \frac{\partial\psi}{\partial t}\rho dV \tag{71}$$

associated with the gravitational energy power of the total combined (cosmic and terrestrial of the Earth's genesis including the component related with the macroscopic continuum region τ) gravitational field. The generalized differential formulation (12) of the first law of thermodynamics and the expression (71) for the gravitational energy power $W_{gr}(\tau)$ demonstrate that the local time increase of the potential ψ of the gravitational field inside the continuum region τ ($\partial\psi/\partial t > 0$) is related [11, 16, 19, 24] with the gravitational energy flux into the continuum region τ. According to the generalized differential formulation (12) of the first law of thermodynamics, the total energy $(K_\tau + U_\tau + \pi_\tau)$ of the continuum region τ is increased if $\partial\psi/\partial t > 0$. According to the evolution equation (66) for the total mechanical energy $(K_\tau + \pi_\tau)$ of the terrestrial continuum region τ of the lithosphere of the Earth, the gravitational energy flux into the continuum region τ may induce the formation of fractures [11, 16, 19, 24] related with production of earthquake. This conclusion is confirmed by different observations [47-51] of the identified anomalous variations of the gravitational field before strong earthquakes.

The generalized differential formulation (12) of the first law of thermodynamics gives also the theoretical foundation of the detected non-relativistic classical "gravitational" waves [12, 13, 20, 21, 52] (the propagating disturbances of the gravitational field of the Earth) from the moving material bodies (continuum regions) such as the focal regions of earthquakes. The theoretical foundation of the non-relativistic classical "gravitational" waves was made [12, 13, 20, 21, 52] based on the following rewritten relation (71) for the gravitational energy power $W_{gr}(\tau)$ (related with the last differential term dG of the generalized differential formulation (12) of the first law of thermodynamics):

$$W_{gr}(\tau) = \frac{dG}{dt} = \iiint_\tau \frac{\partial\psi}{\partial t}\rho dV = -\iint_{\partial\tau} (\mathbf{J_g} \cdot \mathbf{n}) d\Omega_\mathbf{n}, \tag{72}$$

where $\mathbf{J_g}$ is the gravitational energy flux determined by the divergence [12, 13, 20, 21, 52]

$$\operatorname{div} \mathbf{J_g} = -\rho \frac{\partial\psi}{\partial t} \tag{73}$$

of the gravitational energy across the boundary $\partial\tau$ of the continuum region τ due to the time change of the potential ψ of the combined (cosmic and terrestrial) gravitational field inside the continuum region τ. It was pointed out [50] that "earthquakes typically occur within one to two years after a period of significant gravity changes in the region in question". It was pointed out [12, 13, 21] that the gravitational energy power $W_{gr}(\tau)$ (related with the last differential term dG of the generalized differential formulation (12) of the first law of thermodynamics) represents the useful thermodynamic variable, which can be used "to remove the subjective nature in the determination of the timeframe of a forecasted earthquake" [50]. The sixth term in the right-hand side (of the evolution equation (66)) express the power of external (for the continuum region τ) forces on different sides the surfaces $F_i(\tau)$ characterized by the velocity jump during the fracture formation.

According to the evolution equation (66), the energy power of the combined (cosmic and terrestrial) non-stationary energy gravitational influences may produce the fractures [12, 13, 20, 21, 52] in the terrestrial continuum region τ of the lithosphere of the Earth. According to the generalized differential formulation (12) of the first law of thermodynamics, the supply of energy (related with the energy flux) into the continuum region τ is related also with the differential work [12, 13, 20, 21, 52] (founded previously in monograph [18]):

$$\delta A_{np,\partial\tau} = dt \iint_{\partial\tau} \left(\mathbf{v} \cdot (\mathbf{n} \cdot \mathbf{T})\right) d\Omega_\mathbf{n} \tag{74}$$

done by non-potential stress forces (pressure, compressible and viscous forces for Newtonian continuum) acting on the boundary surface $\partial\tau$ of the continuum region τ during the differential time interval dt. The founded [12, 13, 20, 21, 52] physical mechanisms of the energy fluxes into the continuum region τ are related with preparation of earthquakes and volcanic eruptions. The considered mechanisms of the energy flux into the Earth's macroscopic continuum region τ should result to the irreversible process of the splits formation in the rocks related with the generation of the high-frequency acoustic waves from the focal continuum region τ before the earthquakes and volcanic eruptions. Taking this into account, the sum $\delta A_c + \delta A_s$ in the expression (74) for $A_{np,\partial\tau}$ may be interpreted (according to the classical hydrodynamic approach [36]) [11, 16, 19] as the following energy flux (for Newtonian continuum)

$$\delta F_{vis,c} = \delta A_c + \delta A_s \tag{75}$$

directed across the boundary $\partial\tau$ of the continuum region τ due to the compressible and viscous forces acting on the boundary surface $\partial\tau$ of the continuum region τ. The considered two mechanisms of the energy flux into the Earth's macroscopic continuum region τ should result to the significant increase of the energy flux of the geo-acoustic energy from the focal region τ before the earthquakes and volcanic eruptions.

The results of the detailed experimental studies [53] are in a good agreement with the deduced conclusion. Using the generalized differential formulation (12) of the first law of thermodynamics for the Earth, we established [11-13, 20, 21] the successive approximations (in the frame of the real elliptical orbits of the Moon, the Earth and the planets of the Solar System) for the time periodicities T_{energy} of the maximal (instantaneous and integral) energy gravitational influences on the Earth of the Sun (owing to the gravitational interactions of the Sun with the Jupiter, the Sun with the Saturn, the Sun with the Uranus and the Sun with the Neptune), or the Moon, or an arbitrary planet of the Solar System.

The evolution equation (66) for the total mechanical energy $(K_\tau + \pi_\tau)$ of the macroscopic continuum region τ (consisting from subsystems τ_1 and τ_2 interacting on the surface $F_1(\tau)$ of the tangential jump of the continuum velocity) gives the opportunity to explain the validity of the foundation of the time periodicities [11-13, 16, 19, 20, 21] of the global seismotectonic, volcanic and climatic activity of the Earth. The periodic recurrence (characterized by the time periodicity T_{energy}) of the separate maximal (integral and instantaneous) energy gravitational influences on the Earth (determined by the Sun owing to the gravitational interaction of the Sun with an arbitrary outer large planet: the Jupiter, or the Saturn, or the Uranus, or the Neptune; or by the Moon; or by an arbitrary planet of the Solar System) must lead (according to the evolution equation (66)) to the periodic recurrence of the maximal tectonic activity (characterized by the same time periodicity $T_{tec} = T_{energy}$) of the macroscopic continuum region τ (geo-block τ) of the Earth's crust. The periodic recurrence of the maximal (integral and instantaneous) energy gravitational influences on the Earth's crust must lead (according to the evolution equation (66)) to the periodic recurrence of the maximal tectonic activity (characterized by the same time periodicity $T_{tec} = T_{energy}$) of each macroscopic continuum region τ (geo-block τ) of the Earth's crust. The periodic recurrence of the maximal tectonic activity of each geo-block of the Earth's crust (characterized by the time periodicity $T_{tec} = T_{energy}$) must lead to the periodic recurrence (characterized by the time periodicity $T_{tec} = T_{energy}$) of the maximal concentration of the atmospheric greenhouse gases (especially, the carbon dioxide CO_2) owing to the periodic increase (characterized by the time periodicity $T_{tec} = T_{energy}$) of the output of the greenhouse gases related with the periodic tectonic-volcanic activization of the Earth. The periodic increase (characterized by the time periodicity $T_{tec} = T_{energy}$) of the average planetary concentration of the atmospheric greenhouse gases (especially, the carbon dioxide CO_2) must lead (as a consequence of the increased greenhouse effect) to the periodic global planetary warming related with the increase (characterized by the time periodicity $T_{clim1} = T_{tec} = T_{energy}$) of temperature of the system atmosphere-oceans of the Earth. The periodic decrease (characterized by the time periodicity $T_{tec} = T_{energy}$) of the average planetary concentration of the atmospheric greenhouse gases (especially, the carbon dioxide CO_2) must lead (as a consequence of the decreased greenhouse effect) to the periodic global planetary cooling related with the fall of temperature of the Earth's system atmosphere-oceans characterized by the same time periodicity $T_{clim1} = T_{tec} = T_{energy}$.

Using the evolution equation (66) for the total mechanical energy $K_\tau + \pi_\tau$ (of the deformed finite individual macroscopic continuum region τ of the Earth's crust) and the generalized differential formulation (12) of the first law of thermodynamics, we derived [20, 21] the evolution equation for the internal thermal energy U_τ of the deformed finite individual macroscopic continuum region τ:

$$\frac{d}{dt}U_\tau = -\iint_{\partial\tau}\left(\mathbf{J}_q \cdot \mathbf{n}\right) d\Omega_{\mathbf{n}} + \iiint_\tau 2\nu\left(e_{ij}\right)^2 \rho dV - \iiint_\tau \left(\frac{2}{3}\eta - \eta_v\right)(\mathrm{div}\mathbf{v})^2 dV - \iiint_\tau p\,\mathrm{div}\mathbf{v} dV . \tag{76}$$

Taking into account the relations (10) and (11), we see that the second and third terms in the right-hand side of the evolution equation (76) for the internal thermal energy U_τ are related with the increase of the internal thermal energy U_τ owing to production of the 'internal' heat by viscous-compressible irreversibility [18] and by viscous-shear irreversibility [18], respectively. Considering the periodic recurrence (characterized by the time periodicity T_{energy}) of the separate maximal (integral and instantaneous) energy gravitational influences on the macroscopic continuum region τ (geo-block τ) of the Earth's crust, we have the same time periodicity T_{energy} characterizing the periodic variations of the rate of strain tensor e_{ij} [17, 18] (along with the divergence $\mathrm{div}\mathbf{v}$ of the velocity vector $\mathbf{v}$ of the continuum motion and the angular velocity of internal rotation $\boldsymbol{\omega} \equiv (\nabla \times \mathbf{v})/2$ [27]) inside of the subsystem τ of the Earth. Taking into account that the quadratic functions $(e_{ij})^2$ and $(\mathrm{div}\mathbf{v})^2$ have the time periodicity $T_{energy}/2$ of the temporal variations, we obtained [16, 19, 20], according to the evolution equation (76), the time periodicity $T_{endog} = T_{energy}/2$ of time variations of the internal thermal energy U_τ of the macroscopic continuum region τ as a result of the irreversible dissipation of the macroscopic kinetic energy determined by the second and the third terms in the right-hand side of the evolution equation (76). The periodic recurrence (characterized by the time periodicity $T_{endog} = T_{energy}/2$) of the maximal tectonic-endogenous heating (each geo-block of the Earth, the geo-spheres of the Earth including the atmosphere and the oceans) of the Earth must lead to (according to the evolution equation (76)) to the periodic temperature variations (characterized by the same time periodicity $T_{clim2} = T_{endog} = T_{energy}/2$) of the system atmosphere-oceans of the Earth. The periodic recurrence of the maximal tectonic-endogenous heating of the geo-spheres of the Earth (characterized by the time periodicity $T_{endog} = T_{energy}/2$) must lead (according to the evolution equation (66) for the total mechanical energy $(K_\tau + \pi_\tau)$) to the periodic recurrence of the maximal tectonic activity (characterized by the same time periodicity $T_{tec\text{-}endog} = T_{endog} = T_{energy}/2$) of each macroscopic continuum region τ (geo-block τ) of the Earth's crust.

Thus, based on the generalized differential formulation (12) of the first law of thermodynamics, the evolution equation (66) for the total mechanical energy $(K_\tau + \pi_\tau)$ and the evolution equation (76) for the internal thermal energy U_τ used for the Earth as a whole subjected to the periodic recurrences of the maximal (integral and instantaneous) energy gravitational influences of the Sun, the Moon and the planets of the Solar System, we present the foundation [16, 19, 20] of the global seismotectonic, volcanic and climatic time periodicities:

$$T_{tec} = T_{vol1} = T_{clim1} = T_{energy}, \tag{77}$$

$$T_{tec\text{-}endog} = T_{vol2} = T_{clim2} = T_{endog} = T_{energy}/2 \tag{78}$$

of the periodic global seismotectonic, volcanic and climatic activities of the Earth determined by the separate energy gravitational influences on the Earth of the Sun (owing to the gravitational interaction of the Sun with the Jupiter, or with the Saturn, or with the Uranus, or with the Neptune), or of the Moon, or of an arbitrary planet of the Solar System.

3.2. The Fundamental Global Time Periodicities of the Periodic Global Seismotectonic, Volcanic and Climatic Activity of the Earth

Based on the generalized differential formulation (12) of the first law of thermodynamics used for the Earth as a whole, we established successive approximations for the different time periodicities T_{energy} of recurrence of the maximal (instantaneous and integral) energy gravitational influences on the Earth: $\{(T_{S\text{-}MOON,3})_i\} = 3$ years $(i=1)$, 8 years $(i=2)$, 19 years $(i=3)$, 27 years $(i=4)$ for the system Sun-Moon

[19] including 11 years (i=2) [11, 20]; $\{(T_{V,3})_j\} = 3$ years $(j=1)$, 8 years $(j=2)$ for the Venus [19] including 11 years (j=3) [11, 20]; $\{(T_{MARS,3})_k\} = 15$ years $(k=1)$, 32 years $(k=2)$, 47 years $(k=3)$ for the Mars [19]; $\{(T_{J,3})_n\} = 11$ years $(n=1)$, 12 years $(n=2)$, 83 years $(n=3)$ for the Jupiter [19] and for the Sun owing to the gravitational interaction of the Sun with the Jupiter [20]; $\{(T_{SAT,3})_m\} = 29$ years $(m=1)$, 59 years $(m=2)$, 265 years $(m=3)$ for the Saturn [20] and for the Sun owing to the gravitational interaction of the Sun with the Saturn [20]; $\{(T_{U,3})_q\} = 84$ years $(q=1)$ for the Uranus [20] and for the Sun owing to the gravitational interaction of the Sun with the Uranus [20]; $\{(T_{N,3})_r\} = 165$ years $(r=1)$, 659 years $(r=2)$, 2142 years $(r=3)$ for the Neptune [20] and for the Sun owing to the gravitational interaction of the Sun with the Neptune [20]. We founded [11-13, 16, 19, 20] that the time periodicities of the global seismotectonic, volcanic and climatic activity of the Earth are determined by the combined cosmic factors: G-factor related with the combined cosmic non-stationary energy gravitational influences on the Earth, $G(a)$-factor related to the tectonic-endogenous heating of the Earth as a consequence of the periodic continuum deformation of the Earth due to the G-factor, $G(b)$-factor related to the periodic atmospheric-oceanic warming or cooling as a consequence of the periodic variable (increasing or decreasing) output of the greenhouse volcanic gases and the related variable greenhouse effect induced by the periodic variable tectonic-volcanic activity (intensification or weakening) due to the G-factor, and $G(c)$-factor [16, 20] related to the periodic variations of the solar activity owing to the periodic variations of the combined planetary non-stationary energy gravitational influence on the Sun. In this article, we take into account the combined cosmic G, $G(a)$ and $G(b)$-factors related with the cosmic non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Mars, the Jupiter and the Sun owing to the gravitational interaction of the Sun with the Jupiter, the Saturn, the Uranus and the Neptune.

Based on the generalized differential formulation (12) of the first law of thermodynamics used for the Earth as a whole, we founded [12, 13, 20, 21] the fundamental sets of the fundamental global seismotectonic and volcanic time periodicities $T_{tec,f}$ (of the periodic global seismotectonic and volcanic activities owing to the G-factor) and the fundamental global climatic periodicities $T_{clim1,f}$ (of the periodic global climate variability and the global variability of the quantities of the fresh water and glacial ice resources owing to the $G(b)$-factor):

$$\begin{gathered} T_{tec,f} = T_{clim1,f} = T_{energy,f} = \\ L.C.M.\{(T_{S\text{-}MOON,3})_i^{l_o}, (T_{V,3})_j^{l_2}, (T_{MARS,3})_k^{l_4}, (T_{J,3})_n^{l_5}, (T_{SAT,3})_m^{l_6}, (T_{U,3})_q^{l_7}, (T_{N,3})_r^{l_8}\} \end{gathered} \quad (79)$$

determined by the successive global fundamental periodicities $T_{energy,f}$ (defined by the least common multiples $L.C.M.$ of various successive time periodicities related to the different combinations of the following integer numbers: $i=1,2,3,4$; $j=1,2$; $k=1,2,3$; $n=1,2,3$; $m=1,2,3$; $q=1$; $r=1,2,3$; $l_o=0,1$; $l_2=0,1$; $l_4=0,1$; $l_5=0,1$; $l_6=0,1$; $l_7=0,1$; $l_8=0,1$) of recurrence of the maximal combined energy gravitational influences on the Earth of the different combined combinations of the cosmic non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Mars, the Jupiter and the Sun owing to the gravitational interactions of the Sun with the Jupiter, the Saturn, the Uranus and the Neptune.

Based on the generalized differential formulation (12) of the first law of thermodynamics used for the Earth as a whole, we founded [12, 13, 20, 21] the fundamental set of the fundamental global seismotectonic and volcanic time periodicities $T_{tec\text{-}endog,f}$ (of the periodic global seismotectonic and volcanic activities determined by the $G(a)$-factor related with the tectonic-endogenous heating of the Earth as a consequence of the periodic continuum deformation of the Earth due to the G-factor) and the fundamental global climatic periodicities $T_{clim2,f}$ (of the periodic global climate variability and the global variability of the quantities of the fresh water and glacial ice resources owing to the $G(a)$ and $G(b)$-factors):

$$\mathrm{T_{tec\text{-}endog,f}} = \mathrm{T_{clim\,2,f}} = \mathrm{T_{endog,f}} = \mathrm{T_{energy\,f}}/2 =$$
$$\frac{1}{2} L.C.M.\{(\mathrm{T_{S\text{-}MOON,3}})_{\mathrm{i}}^{l_o}, (\mathrm{T_{V,3}})_{\mathrm{j}}^{l_2}, (\mathrm{T_{MARS,3}})_{\mathrm{k}}^{l_4}, (\mathrm{T_{J,3}})_{\mathrm{n}}^{l_5}, (\mathrm{T_{SAT,3}})_{\mathrm{m}}^{l_6}, (\mathrm{T_{U,3}})_{\mathrm{q}}^{l_7}, (\mathrm{T_{N,3}})_{\mathrm{r}}^{l_8}\} \quad (80)$$

determined by the successive global fundamental periodicities $\mathrm{T_{energy\,f}}$ (defined by the least common multiples $L.C.M.$ of various successive time periodicities related to the different combinations of the following integer numbers: $\mathrm{i}=1,2,3,4;$ $\mathrm{j}=1,2;$ $\mathrm{k}=1,2,3;$ $\mathrm{n}=1,2,3;$ $\mathrm{m}=1,2,3;$ $\mathrm{q}=1;$ $\mathrm{r}=1,2,3;$ $l_o=0,1;$ $l_2=0,1;$ $l_4=0,1;$ $l_5=0,1;$ $l_6=0,1;$ $l_7=0,1;$ $l_8=0,1$) of recurrence of the maximal combined energy gravitational influences on the Earth of the different combined combinations of the cosmic non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Mars, the Jupiter and the Sun owing to the gravitational interactions of the Sun with the Jupiter, the Saturn, the Uranus and the Neptune.

3.3. The Fundamental Global Seismotectonic, Volcanic and Climatic Time Periodicity 88 Years

We have (for $l_o=1,$ $l_2=1,$ $l_4=0,$ $l_5=1,$ $l_6=0,$ $l_7=0,$ $l_8=0$) from the formula (79) the following fundamental global seismotectonic, volcanic and climatic periodicity $\mathrm{T_{tec,f}} = \mathrm{T_{clim\,1f}}$ (determined by the G-factor related with the combined predominant non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Jupiter and the Sun owing to the gravitational interactions of the Sun with the Jupiter) [12, 13, 20, 21]:

$$\mathrm{T_{tec,f}} = \mathrm{T_{clim\,1,f}} = L.C.M.\{8,8,11\} = L.C.M.\{8,11,11\} = L.C.M.\{11,8,11\} = 88 \text{ years}, \quad (81)$$

which is in agreement with the empirical time periodicity 88 years [54] of the seismotectonic activity of the Earth (in the considered seismically active region) and with the empirical climatic periodicity 88 years [55]. Since the ratio 88 years/ $\mathrm{T_{MARS}}$=46.786 in near the integer number 47, we concluded [11, 16] that the time periodicity 88 years is determined also by the non-stationary energy gravitational influence of the Mars on the Earth. The good agreement (of the independent experimental seismotectonic [54] and the climatic [55] periodicity 88 years with the fundamental global seismotectonic, volcanic and climatic periodicity (81)) is the additional confirmation of the validity of the thermohydrogravidynamic theory of the global seismotectonic, volcanic and climatic activity of the Earth [11-13, 20, 21].

Taking into account the year 1923 AD of the strongest Japanese earthquake near the Tokyo region, we predicted in advance [16] "the time range $2010 \div 2011$ AD of the next sufficiently strong Japanese earthquake near the Tokyo region" based on the established time periodicities $(\mathrm{T_{J,3}})_3 = 83$ years (determined [16, 19] by the non-stationary energy gravitational influences on the Earth of the Jupiter) and 88 years $= 8 \times 11$ years (determined [16] by the combined non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Jupiter and the Mars). The founded [16, 19] cosmic energy gravitational genesis of the strongest Japanese earthquakes (near the Tokyo region) was confirmed by occurrence of the strong Japanese earthquakes on 14 March, 2010 and on 11 March, 2011 near the Tokyo region. The obtained (in 2009 AD) decomposition [16]

$$2011 = 1923 + 88 \quad (82)$$

indicated the definable date 2011 AD of the possible strong earthquakes near the Tokyo region. The occurrence (on 11 March, 2011) of the strong 2011 earthquake near the Tokyo region confirmed the validity of the established fundamental global seismotectonic, volcanic and climatic periodicity (81). In the special issue on "Geophysical Methods for Environmental Studies" of the International Journal of Geophysics, Tinivella et al. [56] confirmed that the article [11] (based on the previous studies [16, 19]) "proposes a possible cosmic energy gravitational genesis of the strong Chinese 2008 and the strong Japanese 2011 earthquakes, based on the established generalized differential formulation of the first law of thermodynamics".

Taking into account the date 1925 AD of the previous eruption of Santorini [60], we see that the sum (of the date 1925 AD and the fundamental global seismotectonic, volcanic and climatic periodicity (81)) gives the date of the possible intensification of Santorini volcano:

$$1925 + 88 = 2013 \text{ AD}, \quad (83)$$

which is in agreement with the date 2013 AD of the modern intensification [57] of microseismic activity near Santorini volcano and significant ground uplift.

3.4. The Range of the Fundamental Seismotectonic, Volcanic and Climatic Time Periodicities $T_{tec,f} = T_{clim1,f} = T_{energyf} = (702 \pm 6)$ Years Determined by the Combined Predominant Non-stationary Energy Gravitational Influences on the Earth of the System Sun-Moon, the Venus, the Jupiter and the Sun owing to the Gravitational Interactions of the Sun with the Jupiter and the Saturn

We deduced [20, 21, 23, 52] from the formula (79) (for $l_o = 1,\ l_2 = 1,\ l_4 = 0,\ l_5 = 1,\ l_6 = 1,\ l_7 = 0,\ l_8 = 0$) the range of the following fundamental global seismotectonic, volcanic and climatic periodicities $T_{tec,vol,clim,f}$ (determined by the G-factor related with the combined predominant non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Jupiter and the Sun owing to the gravitational interactions of the Sun with the Jupiter and the Saturn):

$$T_{tec,vol,clim,f} = T_{tec,f} = T_{clim1,f} = 696 \div 708 \text{ years} = (702 \pm 6) \text{ years}, \tag{84}$$

which contains the empirical time periodicity 704 years [54] of the seismotectonic activity of the Earth (in the considered seismically active region). The range of the fundamental global seismotectonic, volcanic and climatic periodicities (84) contains approximately 8 cycles of the fundamental global seismotectonic, volcanic and climatic periodicity (81). The founded [20, 21, 23, 52] range of the fundamental global seismotectonic, volcanic and climatic periodicities $T_{tec,vol,clim,f} = 696 \div 708$ years contains the evaluated (based on the wavelet analysis) time periodicity of approximately 700 years [58] characterizing the regional climate variability of the Japan Sea.

The above agreements (of the founded [20, 21, 23, 52] range of the fundamental global seismotectonic, volcanic and climatic periodicities $T_{tec,vol,clim,f} = 696 \div 708$ years with the empirical seismotectonic [54] and climatic [58] periodicities) confirm the established cosmic energy gravitational genesis of the founded range (84) of the fundamental global seismotectonic, volcanic and climatic periodicities (of the global seismotectonic, volcanic and climatic activity of the Earth). The range (84) of the fundamental global seismotectonic, volcanic and climatic periodicities gives the mean fundamental global seismotectonic, volcanic and climatic periodicity (which is near the empirical seismotectonic time periodicity 704 years [54])

$$\langle T_{tec,f} \rangle = \langle T_{clim1,f} \rangle = 702 \text{ years} \tag{85}$$

determined by the G-factor related with the combined predominant non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Jupiter and the Sun owing to the gravitational interactions of the Sun with the Jupiter and the Saturn. Since the ratio $\langle T_{tec,f} \rangle / (T_{MARS,3})_1 = 46.8$ is near the integer number 47 and the ratio $\langle T_{tec,f} \rangle / (T_{MARS,3})_2 = 21.937$ is near the integer number 22, we concluded [20, 21] that the time periodicities (84) are determined also by the non-stationary energy gravitational influence of the Mars on the Earth.

The validity of the established [20, 21, 23, 52] range of the fundamental seismotectonic, volcanic and climatic time reriodicities (84) is confirmed [13, 21] by the analysis of the different realized strong earthquakes, volcanic eruptions and climatic anomalies in the history of humankind.

3.5. The Evidence of the Synchronic Fundamental Seismotectonic, Volcanic and Climatic Time Periodicities $T_{tec,vol,clim,sf} =$ (6321±3) Years and $T_{tec,vol,clim,sf}/2$ = 3160.5±1.5 Years Determined by the Combined Predominant Non-stationary Energy Gravitational Influences on the Earth of the System Sun-Moon, the Venus, the Mars, the Jupiter and the Sun owing to the Gravitational Interactions of the Sun with the Jupiter and the Saturn

3.5.1. The Synchronic Fundamental Seismotectonic, Volcanic and Climatic Time Periodicities $T_{tec,vol,clim,sf}$ =(6321±3) Years and $T_{tec,vol,clim,sf}/2$ = 3160.5±1.5 Years Characterizing the Time Synchronization of the Mean Periodicities 702 Years and 1581 Years of the Fundamental Global

Seismotectonic, Volcanic and Climatic Time Periodicities $T_{tec,vol,clim,f}$ = (702 ±6) Years and $T_{tec,vol,clim,cf}$ = (1581±189) Years

Based on the formulas (79) and (80), we founded [21] the following range of the fundamental global seismotectonic, volcanic and climatic periodicities (determined by the combined predominant non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Mars, the Jupiter and the Sun owing to the gravitational interactions of the Sun with the Jupiter and the Saturn):

$$T_{tec,vol,clim,cf} = T_{tec,tec\text{-}endog,f} = T_{clim1,clim2,f} = (1581 \pm 189) \text{ years}. \qquad (86)$$

Based on the ranges (84) and (86), we founded [21] synchronic fundamental seismotectonic, volcanic and climatic time periodicity

$$T_{tec,vol,clim,sf} = (6321 \pm 3) \text{ years} \qquad (87)$$

characterizing the time synchronization of the mean periodicities $702\,\text{years}$ and $1581\,\text{years}$ of the fundamental global seismotectonic, volcanic and climatic time periodicities (84) and (86). Using the arguments presented in Subsection 3.1 and 3.2, we deduce that the synchronic fundamental seismotectonic, volcanic and climatic time periodicity (87) gives the following time periodicity

$$T_{tec,vol,clim,sf}/2 = (3160.5 \pm 1.5) \text{ years} \qquad (88)$$

of the periodic variations of the global seismotectonic, volcanic and climatic activity of the Earth related with the periodic intensifications of the endogenous heating of the Earth.

3.5.2. The Evidence of the Founded Synchronic Fundamental Seismotectonic, Volcanic and Climatic Time Periodicity $T_{tec,vol,clim,sf}$ =(6321±3) Years Based on the Causal Link Between the Beginning (6372 BC) of the Outstanding Climate Anomaly During (6372÷6192) BC in the North Atlantic and the Established Range (50±30) BC of the Strong Global Volcanic Activity of the Earth

The outstanding climate anomaly (8380÷8200) years before the present (B.P.) in the North Atlantic was revealed [34]. The genesis of this outstanding climate anomaly (8380÷8200) years before the present (B.P.) in the North Atlantic is associated [34] with the weakened overturning circulation (which "begins at ~ 8.38 thousand years B.P." [34]) triggered by the freshwater outburst related with catastrophic drainage of Lake Agassiz. We established [21] that this outstanding climate anomaly in the North Atlantic is related with the possible catastrophic seismotectonic event (related with catastrophic drainage of Lake Agassiz) near Lake Agassiz during the range (8380÷8200) B.P. = (8290±90) BP [34]. Taking into account the date 2008 of the publication [34], the range (8290±90) BP [34] gives the corresponding range of the possible catastrophic seismotectonic event near Lake Agassiz [21]

$$(8290 \pm 90) - 2008 = (6282 \pm 90) \text{ BC} = (6372 \div 6192) \text{ BC}. \qquad (89)$$

We proved [21] that the catastrophic seismotectonic event near Lake Agassiz was realized more probably (to all appearances) near the lower date 6372 BC [34] of the range (89).

Using the lower date 6372 BC (of the range (89) [34]) as the possible date of the catastrophic seismotectonic event near Lake Agassiz and using the synchronic fundamental seismotectonic, volcanic, climatic and magnetic time periodicity (87), we have the time range of the possible strong seismotectonic, volcanic and climatic activity of the Earth (after 1 cycle of the time periodicity $T_{tec,vol,clim,m,sf} = (6321 \pm 3)$ years):

$$-6372 + 1 \times (6321 \pm 3) = -51 \pm 3 = (51 \pm 3) \text{ BC}, \qquad (90)$$

which represents very well the center of the established range [35]

$$(50 \pm 30) \text{ BC} = (80 \div 20) \text{ BC} \qquad (91)$$

of the strong global volcanic activity of the Earth. The mean date 51 BC of the range (90) is in very good agreement with the mean date 50 BC [35] of the established range (91). It gives the significant evidence of the validity of the mean period 6321 years of the founded [21] synchronic fundamental seismotectonic, volcanic and climatic time periodicity (87).

3.5.3. The Evidence of the Founded Synchronic Fundamental Seismotectonic, Volcanic and Climatic Time Periodicities $T_{tec,vol,clim,sf}$ =(6321±3) Years and $T_{tec,vol,clim,sf}/2$ = 3160.5±1.5 Years Based on the Analysis of the Greatest World Volcanic Eruptions BC

The real dates T_k of the greatest world volcanic eruptions BC (and the corresponding fallouts f_k in Greenland ice in $kg\,km^{-2}$) are given by the following empirical sequence [35]: $T_k(f_k) = T_1(f_1), T_2(f_2),.... , T_{18}(f_{18}) =$ **50±30** BC (192), 210±30 BC (72), 260±30 BC (54), 1120±50 BC (99), 1390±50 BC (98), 2690±80 BC (96), **3150±90** BC (255), 4400±110 BC (156), 5470±130 BC (90), 6060±140 BC (119), 6230±140 BC (102), 7090±160 BC (79), 7240±160 BC (124), 7500±160 BC (51), **7640±170** BC (412), 7710±170 BC (69), 7810±170 BC (73), 7910±170 BC (95). The time ranges characterized by the largest three fallouts are presented in this sequence (and in Tables 1 and 2) by bold. Taking into account this sequence, we obtain from this sequence [35] the different binary combinations $((t_2)_i, (t_1)_i)$ of two dates $(t_1)_i$ and $(t_2)_i$ (characterized by the differences $(\Delta t)_i = (t_2)_i - (t_1)_i = (\Delta t)_{i,lower} \div (\Delta t)_{i,upper}$ between the dates of different greatest world volcanic eruptions) presented in Table 1 for i = 1, 2, 3, 4, 5, 6, 7. Taking into account the above empirical sequence [35] $T_k(f_k) = T_1(f_1), T_2(f_2),.... , T_{18}(f_{18})$, we take into account all possible binary combinations $((t_2)_i, (t_1)_i)$ (considered as the binary combinations of the random variables $(t_1)_i$ and $(t_2)_i$), which give the differences $(\Delta t)_i = (t_2)_i - (t_1)_i = (\Delta t)_{i,lower} \div (\Delta t)_{i,upper}$ (considered also as the binary combinations of the random variables $(\Delta t)_{i,lower}$ and $(\Delta t)_{i,upper}$) containing the range (87) of the synchronic fundamental seismotectonic, volcanic and climatic time periodicities $T_{tec,vol,clim,sf}$ =(6321±3) years. Considering all possible binary combinations $((t_2)_i, (t_1)_i)$, we obtain the mean values (considered also as the random variables)

$$(\Delta t)_{i,\,mean} = \frac{((\Delta t)_{i,lower} + (\Delta t)_{i,upper})}{2}. \qquad (92)$$

The numerical values $(\Delta t)_{i,\,mean}$ are presented in Table 1 for i = 1, 2, 3, 4, 5, 6, 7.

We shall use the generalization [29] (previously used [13, 20] for the statistical analysis of volcanic eruptions of Katla and Hekla volcanic systems in Iceland) of the classical special formulation [28] of the weak law of large numbers for the analysis of the numerical values $(\Delta t)_{i,\,mean}$ presented in Table 1 for i = 1, 2, 3, 4, 5, 6, 7. The generalization [29] of the classical special formulation [28] of the weak law of large numbers takes into account the coefficients of correlations $\rho(x_i, x_k) \neq 0$ between the random variables x_i and x_k of the infinite set of random variables $x_1, x_2,...., x_n$ …. characterized by the same variance $\sigma^2 = \overline{(x_i - a)^2}$ and the same statistical mean $a = \overline{x_i}$ of the random variables $x_1, x_2,...., x_n$ …. . According to the generalized formulation [29] of the weak law of large numbers, we have that the limit (50) of probability is satisfied (for any $\varepsilon > 0$) if the condition (51) is satisfied for the coefficients of correlations $\rho(x_i, x_k)$.

Identifying the random variable x_i with the random variable (defined by (92)) $(\Delta t)_{i,\,mean}$, i.e. assuming that $x_i \equiv (\Delta t)_{i,\,mean}$, we can obtain the mean random variable

$$\langle \Delta t \rangle_{mean,n} = \frac{1}{n}\sum_{i=1}^{n} (\Delta t)_{i,\,mean} \qquad (93)$$

which must be very close to the statistical mean $a = \overline{x_i} \equiv \overline{(\Delta t)_{i,\,mean}}$ for sufficiently large number n according to the generalized [29] formulation (50) if the condition (51) is satisfied for the coefficients of correlations $\rho(x_i, x_k)$. We assume that the condition (51) is satisfied, that means the small correlations between the different world greatest eruptions characterized by the founded synchronic fundamental seismotectonic, volcanic and climatic time periodicity $T_{tec,vol,clim,sf}$ = (6321±3) years. Based on the numerical values $(\Delta t)_{i,mean}$ presented in Table 1 for i = 1, 2, 3, 4, 5, 6, 7, we obtain the corresponding mean value

$$\langle \Delta t \rangle_{mean,7} = \frac{1}{7}\sum_{i=1}^{7}(\Delta t)_{i,mean} = 6274.28 \text{ years,} \tag{94}$$

which is in a fairly good agreement (taking into account only 7 considered combinations in Table 1) with the founded synchronic fundamental seismotectonic, volcanic and climatic time periodicity $T_{tec,vol,clim,sf}$ =(6321±3) years.

Table 1. Dates $(t_1)_i$, $(t_2)_i$ of different greatest world volcanic eruptions [35] and differences $(\Delta t)_i = (t_2)_i - (t_1)_i = (\Delta t)_{i,lower} \div (\Delta t)_{i,upper}$ for i =1, 2, 3, 4, 5, 6, 7

$(t_2)_i$	6230± 140	7240± 160	7500± 160	7640± 170	7710± 170	7810± 170	7910± 170
$(t_1)_i$	**50± 30**	1120± 50	1390± 50	1390± 50	1390± 50	1390± 50	1390± 50
$(\Delta t)_i =$ $(\Delta t)_{i,lower} \div$ $(\Delta t)_{i,upper}$	6180± 170= 6010÷ 6350	6120± 210= 5910÷ 6330	6110± 210= 5900÷ 6320	6250± 220= 6030÷ 6470	6320± 220= 6100÷ 6540	6420± 220= 6200÷ 6640	6520± 220= 6300÷ 6740
$(\Delta t)_{i,mean}$	6180	6120	6110	6250	6320	6420	6520

Taking into account the above empirical sequence [35] $T_k(f_k) = T_1(f_1), T_2(f_2),...., T_{18}(f_{18})$, we take into account all possible binary combinations $((t_2)_i, (t_1)_i)$ (considered as the binary combinations of the random variables $(t_1)_i$ and $(t_2)_i$), which give the differences $(\Delta t)_i = (t_2)_i - (t_1)_i$ $= (\Delta t)_{i,lower} \div (\Delta t)_{i,upper}$ (considered also as the binary combinations of the random variables $(\Delta t)_{i,lower}$ and $(\Delta t)_{i,upper}$) containing the range (88) of the synchronic fundamental seismotectonic, volcanic and climatic time periodicities $T_{tec,vol,clim,sf}/2 = (3160.5 \pm 1.5)$ years. Considering all possible binary combinations $((t_2)_i, (t_1)_i)$, we obtain the mean values $(\Delta t)_{i,mean}$ (given by (92)) considered also as the random variables. The numerical values $(\Delta t)_{i,mean}$ are presented in Table 2 for i = 1, 2, 3, 4, 5, 6, 7, 8.

Identifying the random variable x_i with the random variable (defined by (92)) $(\Delta t)_{i,mean}$, i.e. assuming that $x_i \equiv (\Delta t)_{i,mean}$, we can obtain the mean random variable (given by (93)) $\langle \Delta t \rangle_{mean,n}$, which must be very close to the statistical mean $a = \overline{x_i} \equiv \overline{(\Delta t)_{i,mean}}$ for sufficiently large number n according to the generalized [29] formulation (50) if the condition (51) is satisfied for the coefficients of correlations $\rho(x_i, x_k)$. We assume also that the condition (51) is satisfied, that means the small correlations between the different world greatest eruptions characterized by the founded range of the synchronic fundamental seismotectonic, volcanic and climatic time periodicities $T_{tec,vol,clim,sf}/2 = (3160.5 \pm 1.5)$ years. Based on the numerical values $(\Delta t)_{i,mean}$ presented in Table 2 for i = 1, 2, 3, 4, 5, we obtain the corresponding mean value

$$\langle \Delta t \rangle_{mean,5} = \frac{1}{5}\sum_{i=1}^{5}(\Delta t)_{i,\,mean} = 3160 \text{ years}, \tag{95}$$

which is in a very good (despite of only 5 considered combinations in Table 2) agreement with the founded range of the synchronic fundamental seismotectonic, volcanic and climatic time periodicities $T_{tec,vol,\ clim,sf}/2 = (3160.5\ \pm 1.5)$ years. We have not used the last three columns (corresponding to i = 6, 7, 8) in Table 2 since the corresponding ranges $(\Delta t)_{i,lower} \div (\Delta t)_{i,upper}$ (for i = 6, 7, 8) contain completely the established [20, 21, 52] range of the fundamental global seismotectonic, volcanic and climatic periodicities $T_{tec,f} = T_{clim\,1,f} = T_{energy f} = (3510 \pm 30)$ years. We take into account (for the estimation (95)) the fifth column (corresponding to i = 5) in Table 2 since the corresponding range $(\Delta t)_{5,lower} \div (\Delta t)_{5,upper}$ = 2960÷3520 (for i = 5) contains only partially the range $T_{tec,f} = T_{clim\,1,f} = T_{energy f} = (3510 \pm 30)$ years [20, 21, 52]. Based on Table 2, we obtain the estimation for n = 4:

$$\langle \Delta t \rangle_{mean,4} = \frac{1}{4}\sum_{i=1}^{4}(\Delta t)_{i,\,mean} = 3140 \text{ years}, \tag{96}$$

which is in a fairly good agreement with the founded range of the synchronic fundamental seismotectonic, volcanic and climatic time periodicities $T_{tec,vol,\ clim,sf}/2 = (3160.5\ \pm 1.5)$ years. Using all columns in Table 2, we obtain the estimation for n = 8:

$$\langle \Delta t \rangle_{mean,8} = \frac{1}{8}\sum_{i=1}^{8}(\Delta t)_{i,\,mean} = 3236.25 \text{ years}, \tag{97}$$

which is only in a satisfactory agreement with the founded range of the synchronic fundamental seismotectonic, volcanic and climatic time periodicities $T_{tec,vol,\ clim,sf}/2 = (3160.5\ \pm 1.5)$ years.

Table 2. Dates $(t_1)_i$, $(t_2)_i$ of different greatest world volcanic eruptions and differences $(\Delta t)_i = (t_2)_i - (t_1)_i = (\Delta t)_{i,lower} \div (\Delta t)_{i,upper}$ for i =1, 2, 3, 4, 5, 6, 7, 8

$(t_2)_i$	**3150± 90**	4400± 110	6230± 140	7500± 160	**7640± 170**	*6060± 140*	*7710± 170*	*7810± 170*
$(t_1)_i$	**50± 30**	1120± 50	**3150± 90**	4400± 110	4400± 110	*2690± 80*	*4400± 110*	*4400± 110*
$(\Delta t)_i =$ $(\Delta t)_{i,lower} \div$ $(\Delta t)_{i,upper}$	3100± 120= 2980÷ 3220	3280± 160= 3120÷ 3440	3080± 230= 2850÷ 3310	3100± 270= 2830÷ 3370	3240± 280= 2960÷ 3520	*3370± 220= 3150÷ 3590*	*3310± 280= 3030÷ 3590*	*3410± 280= 3130÷ 3690*
$(\Delta t)_{i,\,mean}$	3100	3280	3080	3100	3240	*3370*	*3310*	*3410*

Thus, the founded ranges of the synchronic fundamental seismotectonic, volcanic and climatic time periodicities $T_{tec,vol,clim,sf}$ =(6321±3) years and $T_{tec,vol,\ clim,sf}/2 = (3160.5\ \pm 1.5)$ years (determined by the combined predominant non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Mars, the Jupiter and the Sun owing to the gravitational interactions of the Sun with the Jupiter and the Saturn) are confirmed statistically based on the empirical dates of different greatest world volcanic eruptions

[35]. The very good agreement (of the mean value (95) with the founded range of the synchronic fundamental seismotectonic, volcanic and climatic time periodicities $T_{tec,vol,\ clim,sf}/2 = (3160.5\ \pm 1.5)$ years despite of only correctly 5 considered combinations in Table 2) confirm the established conception [12, 13, 20, 21, 52, 59] that the periodic intensifications of the endogenous heating of the Earth (related with the periodic Earth's continuum deformation induced by the periodic cosmic energy gravitational influences on the Earth) result to the periodic variations of the global seismotectonic, volcanic and climatic activity of the Earth. It gives the additional argument of the validity of the obtained previously results [12, 13, 20, 21, 52, 59] summarized more definitely in the following Section 3.6 concerning the forthcoming intensifications of the global seismotectonic, volcanic and climatic activity of the Earth in the 21st century since 2016 AD.

3.6. The Combined Arguments Concerning the Forthcoming Intensifications of the Global Seismotectonic, Volcanic and Climatic Activity of the Earth in the 21st Century Since 2016 AD

By assuming that the intensification of the seismotectonic, volcanic and climatic activity worldwide (including near Lake Agassiz [34]) occurred during the established possible range [21]

$$(6372\pm28)\ \text{BC}, \tag{98}$$

we evaluated [59] the time range of the possible strong seismotectonic, volcanic and climatic activity worldwide (after 1 cycle of the synchronic fundamental seismotectonic, volcanic and climatic time periodicity (87)):

$$-6372 \pm28 +1\times(6321\pm3) = -51\pm31 = (51\pm31)\ \text{BC} =(82\div20)\ \text{BC}, \tag{99}$$

which is slightly more wider than the range (91). Consequently, the range (98) can be considered as the range representing the real intensification of the seismotectonic, volcanic and climatic activity worldwide including the Lake Agassiz [34]. We obtained [59] the additional explanation of the intensification of the global seismotectonic, volcanic and climatic activity (in the beginning of the 21st century AD) based on the founded range (6372±28) BC (given by (98)) of the strong intensification of the seismotectonic, volcanic and climatic activity worldwide (including near Lake Agassiz [34]) and using the founded synchronic fundamental seismotectonic, volcanic and climatic time periodicity (87) together with the range of the fundamental global seismotectonic, volcanic and climatic periodicities periodicities (84). Considering the founded [59] range (98) of the intensification of the seismotectonic, volcanic, climatic and magnetic activity worldwide (including near Lake Agassiz [34]), we evaluated [59] the range of the dates of the next possible intensification of the global seismotectonic, volcanic and climatic activity (after 1 cycle of the fundamental global periodicity (87) and 3 cycles of the fundamental global periodicities (84))

$$-6372\pm28 +1\times(6321\pm3) +3\times(702\pm6)=(2055\pm49)\ \text{AD} =(2006 \div 2104)\ \text{AD}. \tag{100}$$

Considering the established range (50±30) BC of the strong global seismotectonic [21] and volcanic [35] activity of the Earth, we evaluated [59] the range of the dates of the next possible intensification of seismotectonic, volcanic and climatic activity (after 3 cycles of the fundamental global periodicities (84)):

$$-50\pm30+3\times(702\pm6)=(2056\pm48)\text{AD} = (2008\div2104)\ \text{AD}. \tag{101}$$

The nearly consistent ranges (100) and (101) include the dates 2008 AD and 2011 AD of the realized strong Chinese 2008 (predicted in advance [19], see page 155) earthquakes and the realized strong 2011 Japanese earthquakes (predicted in advance [16], see page 167). We have shown [21] that the intensification of the global seismotectonic, volcanic and climatic activity of the Earth in the beginning of the 21st century AD is closely related with the intensification of the amplitude of oscillation of the inner rigid core of the Earth (relative to the fluid core of the Earth) and related intensification of the amplitude of the gravitational disturbances radiating from the heterogeneous regions (especially, between the rigid core of the Earth and the fluid core of the Earth). Consequently, we can conclude that the the realized strong Chinese 2008 earthquakes and the realized strong 2011 Japanese earthquakes are related casually with the intensification of the oscillation of the inner rigid core of the Earth relative to fluid core of the Earth. The mean date 2056 AD (of the obtained range (101)) is in perfect agreement with the obtained date 2056 AD [21] corresponding to the maximal combined synchronization of the mean periodicities 702 years and 1581 years in the ranges (84) and (86). Considering the range of the established dates (1450±14) BC [13, 21] of the possible last major eruption of Thera, we evaluated [13, 21, 59] the range of the dates of the possible intensification of the global seismotectonic, volcanic and climatic activity (after 5 cycles of the fundamental global periodicities (84)):

$$-(1450\pm14)+5\times(702\pm6)=(2060\pm44)\text{AD} = (2016\div2104)\ \text{AD}. \tag{102}$$

Taking into account that the possible catastrophic seismotectonic event near Lake Agassiz was realized more probably (to all appearances, as it was shown [21]) near the lower date 6372 BC [34] of the range (57), we evaluated [21] the range of the dates of the previous possible intensification of volcanic, seismic and climatic activity (before 6 cycles of the fundamental global periodicities $T_{tec,f} = T_{clim\,1,f} = T_{energy\,f} = (702 \pm 6)$ years):

-6372-6×(702±6)= (-10584±36) =(10584±36) BC =(10620 ÷ 10548) BC. (103)

Considering the range (103) of the previous possible intensification of seismotectonic, volcanic, and climatic activity of the Earth, we evaluated [21] the range of the dates of the forthcoming intensification of seismotectonic, volcanic and climatic activity (after 2 cycles of the synchronic fundamental seismotectonic, volcanic and climatic time periodicity (87))

-10584±36 +2×(6321±3)= (2058±42) AD =(2016 ÷ 2100) AD (104)

which is in good agreement with the obtained range (102). The ranges (102) and (104) contain the evaluated subsequent three subranges (2023 ± 3) AD [20, 21], (2040.38 ± 3) AD [20, 21] and (2059.5 ± 4.5) AD [21] of the increased intensification of the global seismotectonic, volcanic and climatic activity of the Earth in the 21st century AD. Taking into account the date 1928 AD of the previous eruption of Santorini [60], we obtained [21] that the date of the next possible intensification of Santorini volcano:

1928 +88 = 2016 AD, (105)

which cannot be considered (as it was pointed out [21]) as rigorous prediction of the next eruption of Santorini volcano without the detailed combined experimental studies of the increased microseismic activity [57] and the gravitational field near Santorini volcano (in the near future) based on the generalized differential formulations (12) and (20) of the of the first law of thermodynamics. The perfect equality of the established lower boundaries 2016 AD (of the obtained ranges (102) and (104)) and the evaluation (105) (of the date of the next possible intensification of Santorini volcano) leads us to the additional analysis of the date 2016 AD as the possible beginning of the forthcoming intensifications of the global seismotectonic, volcanic and climatic activity of the Earth in the 21st century.

Considering the date 1318 AD of the strong earthquake in England [61] and using the range of the fundamental global periodicities $T_{tec,f} = T_{clim\,1,f} = T_{energy\,f} = (702 \pm 6)$ years, we evaluated [20, 21, 59, 62] the following range of the forthcoming intensification of the global seismotectonic, volcanic and climatic activity worldwide (and especially the "next possible strong earthquake in England" [20])

(1318+696÷1318+708) = (2014÷2026) AD, (106)

which contains the established subrange (2023 ± 3) AD [20, 21] of the increased intensification of the global seismotectonic, volcanic and climatic activity of the Earth in the 21st century AD. Based on the analyzed ranges (102) and (106), we established in 2013 AD "the linkage of the last major volcanic eruption of Thera (1450±14 BC) with possible forthcoming intensification (from 2014÷2016 AD) of the seismic and volcanic activity of the Earth determined by the non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Mars, the Jupiter and the Sun owing to the gravitational interactions of the Sun with the Jupiter and the Saturn" [62]. The occurred outstanding global climate anomaly worldwide (especially in the USA) in winter of 2014 AD belongs to the established range (2014÷2016) AD [62]. Based on occurrence of this outstanding global climate anomaly worldwide in winter of 2014 AD, we stated "the possible moderate intensification of the global seismic, volcanic and climatic activity of the Earth during 2014÷2016 AD related with the last major eruption of Thera (1450 ±14 BC)" [21]. That is why, the detailed combined experimental studies (based on the generalized differential formulations (12) and (20) of the of the first law of thermodynamics) of the increased microseismic activity [57] and the gravitational field near Santorini volcano (in the near future) are very important for the verification of the date 2016 AD (given by the relation (105)) as the next possible eruption of Santorini volcano. There are the additional following important arguments to assume the forthcoming intensifications of the global seismotectonic, volcanic and climatic activity of the Earth in the 21st century near 2016 AD, which enhance the significance of the detailed combined experimental studies (based on the generalized differential formulations (12) and (20) of the of the first law of thermodynamics) of the increased microseismic activity [57] and the gravitational field near Santorini volcano in the near future.

Considering the founded decompositions [12, 21] for the initial date 63 BC of the greatest earthquakes in the ancient Pontus [63], we estimated [59] the date of the next increased intensification of the global seismotectonic, volcanic and climatic activity of the Earth (including the seismotectonic intensification near the region of the ancient Pontus) based on the following decomposition (using the established mean fundamental global seismotectonic and volcanic periodicities $T_f(1) = 702$ years [12] and $T_f(8) = 16.5$ years [12]) relative to the initial date t_0 = 63 BC:

$$-63 + 3\times(702) + 16.5 = 2059.5 = 2059.5 \text{ AD}, \qquad (107)$$

which is perfectly consistent with the mean date 2059.5 AD of the established subrange (2059.5 ± 4.5) AD [21] of the increased intensification of the global seismotectonic, volcanic and climatic activity of the Earth in the 21st century AD. Considering the founded decompositions [12, 21] for the initial date 63 BC of the greatest earthquakes in the ancient Pontus [63], we can estimate the date of the previous nearest increased intensification of the global seismotectonic, volcanic and climatic activity of the Earth (including the seismotectonic intensification near the region of the ancient Pontus) based on the following decomposition (using the established mean fundamental global seismotectonic and volcanic periodicities $T_f(1) = 702$ years [12] and $T_f(9) = 12$ years [12]) relative to the initial date t_0 = 63 BC:

$$-63 + 3\times(702) + 12 = 2055.5 = 2055.5 \text{ AD}, \qquad (108)$$

which is located perfectly between the mean dates 2055 AD and 2056 AD of the ranges (100) and (101), respectively. The obtained date 2055.5 AD (given by the decomposition (108)) is very close to the established date 2056 AD [21] corresponding to the maximal combined synchronization of the mean periodicities 702 years and 1581 years of the fundamental global seismotectonic, volcanic and climatic time periodicities (84) and (86). The above two agreements of the previously obtained dates (the mean value 2059.5 AD [21] of the established subrange (2059.5 ± 4.5) AD [21], and the date 2056 AD [21] corresponding to the maximal combined synchronization of the mean periodicities 702 years [21] and 1581 years [21]) with the obtained (independently based on the founded decompositions [12, 21]) dates 2059.5 AD (given by (107) [59]) and 2055.5 AD (given by (108)) give the evidence to take into account the next relevant decompositions concerning the possible forthcoming intensifications of the global seismotectonic, volcanic and climatic activity of the Earth in the 21st century since 2016 AD.

Considering the founded decompositions [12, 21] for the initial date 63 BC of the greatest earthquakes in the ancient Pontus [63], we can obtain the following decomposition of the date 2016 AD (represented by (105) and by the lower boundaries 2016 AD of the obtained ranges (102) and (104)) relative to the initial date t_0 = 63 BC (using the established mean fundamental global seismotectonic and volcanic periodicities $T_f(1) = 702$ years [12], $T_f(2) = 351$ years [12], $T_f(3) = 176$ years [12], $T_f(4) = 88$ years [12], $T_f(5) = 44$ years [12], $T_f(8) = 16.5$ years [12]):

$$2016 = -63 + 2\times(702) + 351 + 176 + 88 + 44 + 16.5 - 0.5 = 2016.5 - 0.5 \qquad (108)$$

characterized by the small residual term t_{res} =-0.5 years, which means that the date 2016.5 AD is represented by the perfect decomposition

$$2016.5 = -63 + 2\times(702) + 351 + 176 + 88 + 44 + 16.5. \qquad (109)$$

Remember that we consider the date 2016 AD (represented by (105) and by the lower boundaries 2016 AD of the obtained ranges (102) and (104)) as the possible beginning of the forthcoming intensifications of the global seismotectonic, volcanic and climatic activity of the Earth in the 21st century based on the following combined independent experimental information: the date 1928 AD of the previous eruption of Santorini [60], the established dates (1450±14) BC [13, 21, 62] of the possible last major eruption of Thera (Santorini) [64], the possible date 6372 BC (which is the lower date 6372 BC [34] of the range (89)) of the possible catastrophic seismotectonic event (to all appearances, as it was shown [21]) near Lake Agassiz [34]. Let us take into account also the independently considered dates (818 AD, 1605 AD, 1703 AD, 1855 AD and 2011) of the previous strong earthquakes near the Tokyo region [12].

Using the established [12] fundamental global seismotectonic and volcanic periodicity $T_f(10) = 6$ years and the date 2011 AD of the strong Japanese 2011 earthquakes, we evaluated [12] the following date of the possible intensification of the Japanese seismic activity (including the Tokyo region)

$$2011 + 6 = 2017 = 2017 \text{ AD}, \qquad (110)$$

which gets into of the obtained ranges (102) and (104). Taking into account the established [12, 21] decompositions and using the previous dates (818 AD, 1605 AD, 1703 AD, 1855 AD and 2011 AD [12]) of the strong earthquakes near the Tokyo region, we obtained [12] the decompositions of the obtained date 2017 AD (given by (110)) relative to the dates (818 AD, 1605 AD, 1703 AD, 1855 AD and 2011) of the previous strong earthquakes near the Tokyo region as follows [12]

$$2017 = 2011 + 6, \qquad (111)$$

$$2017 = 1855 + 88 + 44 + 24 + 6, \qquad (112)$$

2017= 1703+176+88+44+6, (113)
2017= 1605+351+44+16.5+0.5, (114)
2017= 818+702+351+88+44+12+2 (115)

characterized by the narrow range $0 \le t_{res} \le 2$ of the residual parts. Taking into account these decompositions (111)-(115), we obtained [12] the refined range (including the possible preventive foreshocks)

$$(2015 \div 2017) \text{ AD} \qquad (116)$$

of the possible intensification of the Japanese seismic activity (including the Tokyo region). We see that the considered date 2016 AD (as the possible beginning of the forthcoming intensifications of the global seismotectonic, volcanic and climatic activity of the Earth in the 21[st] century) represents the center of the obtained independently [12] refined range (116).

IV. SUMMARY AND CONCLUSION

We have presented in this article the fundamentals of the non-equilibrium statistical thermohydrodynamic theory of the small-scale dissipative turbulence [17, 18, 22, 30-33] and the deterministic thermohydrogravidynamic theory [11-13, 16, 19-21] of the global seismotectonic, volcanic and climatic activity of the Earth intended for the predictions of the global seismotetonic, volcanic and climatic processes of the Earth. The non-equilibrium statistical thermohydrodynamic theory of the small-scale dissipative turbulence [17, 18, 22, 30-33] and the thermohydrogravidynamic theory [11-13, 16, 18, 19-21, 23, 52, 59, 62] of the global seismotectonic, volcanic and climatic processes are based on the author's generalized differential formulations (28) and (12) of the first law of thermodynamics, respectively, (for the Galilean frame of reference) for the small individual continuum region τ (subjected to the stationary Newtonian gravitational field) [18] and for the individual finite continuum region τ (subjected to the combined non-stationary cosmic and terrestrial Newtonian gravitational field) [11, 19, 24]. We have presented the evidence that the generalized differential formulations (28) and (12) of the first law of thermodynamics, respectively, can be considered as the fundamental mathematical basis for the subsequent development of the non-equilibrium statistical thermohydrodynamic theory of the small-scale dissipative turbulence [17, 18, 22, 30-33] and for deterministic predictions [11-13, 16, 18, 19-21, 23, 52, 59, 62] of the global seismotetonic, volcanic and climatic processes of the Earth.

In Section 2.1 we have presented the classical differential formulation (3) of the first law of thermodynamics in non-equilibrium thermodynamics [25] for the one-component deformed macrodifferential continuum element with no chemical reactions, and also the Gibbs' [26] classical formulation (9) of the first law of thermodynamics for the fluid body. In Section 2.2 we have presented the generalized differential formulation (12) of the first law of thermodynamics [19, 24] for the individual finite continuum region τ (considered in the Galilean frame of reference) subjected to the combined (cosmic and terrestrial) non-stationary Newtonian gravitational field and non-potential terrestrial stress forces (characterized by the symmetric stress tensor $\mathbf{T}$ [27]) acting on the boundary surface $\partial\tau$ of the individual finite continuum region τ.

In Section 2.3 we have derived the generalized differential formulation (20) of the first law of thermodynamics for the deformed one-component individual finite continuum region τ (considered in the rotational coordinate system $K'(C_3, \mathbf{\Omega})$ related with the mass center C_3 of the rotating Earth characterized by the constant angular velocity $\mathbf{\Omega}$ of the Earth's rotation) subjected to the non-stationary Newtonian terrestrial gravitational field, the tidal (of cosmic gravitational genesis), Coriolis and centrifugal forces, and non-potential terrestrial stress forces acting on the boundary surface $\partial\tau$ of the individual finite continuum region τ. Since the generalized differential formulation (12) (given for the Galilean frame of reference in Section 2.2) gives the possibility to not consider the variable (in time and space) tidal, Coriolis and centrifugal forces acting on the individual finite continuum region τ of the Earth, we have used in Section 3 the preferable (with respect to the derived generalized differential formulation (20) of the first law of thermodynamics formulated for the rotational coordinate system) generalized differential formulation (12) for the foundation of the cosmic and terrestrial energy gravitational genesis of the global seismotectonic, volcanic and climatic activity of the Earth.

In Section 2.4 we have used (for the non-equilibrium statistical thermohydrodynamic theory of the small-scale dissipative turbulence [17, 18, 22, 30-33]) the generalized differential formulation (28) of the first law of thermodynamics for the small individual macroscopic continuum region τ (considered in the Galilean frame of reference) subjected to the stationary Newtonian gravitational field (determined by the partial condition $dG = 0$ owing to the stationary Newtonian gravitational field characterized by the condition $\frac{\partial \psi}{\partial t} = 0$ for the gravitational potential ψ) and non-potential terrestrial stress forces (characterized by the symmetric stress tensor $\mathbf{T}$ [27]) acting on the boundary surface $\partial\tau$ of the small individual continuum region (fluid particle) τ. Based on the generalized [17, 18] relation (34) for the macroscopic kinetic energy K_τ of the small macroscopic fluid particle τ, the classical [28] and generalized [18, 29] formulation (50) of the weak law of large numbers (taking into account the coefficients of correlations $\rho(x_i, x_k) \neq 0$ between the random variables x_i and x_k of the infinite set of random variables $x_1, x_2, \ldots, x_n$ …. characterized by the same variance $\sigma^2 = \overline{(x_i - a)^2}$ and the same mathematical mean $a = \overline{x_i}$) and the generalized differential formulation (28) of the first law of thermodynamics [18] for the small individual macroscopic continuum region τ, we have presented in Section 2.4 the summary of the non-equilibrium statistical thermohydrodynamic theory of the small-scale dissipative turbulence confirmed for laboratory and oceanic stratified turbulence in the wide range of the energy-containing length scales [17, 18, 22, 30-33] from the inner Kolmogorov length scale to the length scales proportional to the Ozmidov length scale.

We have modeled the three-dimensional small-scale dissipative turbulence by the statistical ensemble [40] of the "large-grained" [9] dissipative velocity structures [28] (of the energy-containing length scale l) determined (in accordance with the Kolmogorov's theory [3]) by the stochastic Taylor series expansions (45) with deterministic space ($\delta\,\mathbf{r}$) and random tensorial [2, 7] variables (e_{ij} and $\boldsymbol{\omega} = \boldsymbol{\omega}_v / 2$) and also under deterministic conditions $\mathbf{v}_{res} = 0$. We have demonstrated that the classical [25, 27] macroscopic internal rotational (ε_r) and the established [17] macroscopic non-equilibrium kinetic energies (ε_s and $\varepsilon_{s,r}^{coup}$) represent the thermohydrodynamic basis of the non-equilibrium statistical thermohydrodynamics of the three-dimensional small-scale dissipative turbulence [17, 18, 22, 30]. We have shown [18, 22] that the established [17] proportionality (56) (of the macroscopic internal shear kinetic energy per unit mass ε_s and the kinetic energy viscous dissipation rate per unit mass $\varepsilon_{dis,v}$ for Newtonian continuum) is the physical foundation of the remarkable association [28] between a structure and the irreversible dissipation for the dissipative structures in Newtonian fluids. The founded non-equilibrium statistical thermohydrodynamic theory of the small-scale dissipative turbulence [17, 18, 22, 30-33] confirmed the validity of the Prigogine's foresight (that the Boltzmann's "identification of entropy with molecular disorder could contain only one part of the truth" (Ilya Prigogine – Autobiography, 1977)) by revealing [22] the creative role of the macroscopic non-equilibrium kinetic energies ε_s and $\varepsilon_{s,r}^{coup}$ [17, 18] determining the time reduction of entropy at the initial stage of stratified turbulence collapse and irreversible transition [42] to internal gravity waves. The subsequent discovery [19, 24] of the creative role of the macroscopic non-equilibrium kinetic energies ε_s and $\varepsilon_{s,r}^{coup}$ [17, 18] reducing the entropy of the thermohydrogravidynamic system $(\tau + \bar{\tau})$ (consisting on large subsystem $\bar{\tau}$ and small subsystem τ) under the external momentary deformational influence (especially, by the non-stationary cosmic gravitation) on the small subsystem τ (which can be the focal region of earthquakes) resulted to the "generalization of the Le Chatelier – Braun's principle on the rotational thermodynamic systems by taking into account the shear-rotational states of the considered subsystem τ" [19].

Taking into account the established fundamental cosmic energy gravitational influences on the Earth [11-13, 16, 19-21, 23, 24, 52, 59, 62] of the Moon, the Sun and the planets of the Solar System (related with the cosmic non-stationary Newtonian gravitational fields of the Moon, the Sun and the planets of the Solar System), in Section 3 we have presented the evidence (based on the generalized differential formulation (12) of the first law of thermodynamics [19, 24] given for the Galilean frame of reference) of the cosmic and terrestrial energy gravitational genesis of the global seismotectonic, volcanic and climatic activity of the Earth. Based on the generalized differential formulation (12) of the first law of thermodynamics [19, 24] used for Earth (considered in the Galilean frame of reference as a whole) subjected to the cosmic non-stationary Newtonian gravitational fields of the Moon, the Sun and the planets of the Solar System, in Section 3.1 we have presented the evidence of the cosmic and terrestrial energy gravitational genesis of the seismotectonic, volcanic and climatic activity of the Earth induced by the combined (cosmic and terrestrial) non-stationary energy gravitational influences on an arbitrary individual continuum region τ (of the Earth) and by the non-potential terrestrial stress forces acting on the boundary surface $\partial\tau$ of the continuum region τ. Based on the generalized differential formulation (12) of the first law of thermodynamics, the evolution equation (66) for the total mechanical energy $(K_\tau + \pi_\tau)$ and the evolution equation (76) for the internal thermal energy U_τ used for the Earth as a whole (subjected to the periodic recurrences of the maximal integral and instantaneous energy gravitational influences of the Sun, the Moon and the planets of the Solar System), we have presented the established [12, 13, 20, 21] global seismotectonic, volcanic and climatic time periodicities (77) and (78) of the periodic global seismotectonic, volcanic and climatic activities of the Earth determined by the separate energy gravitational influences on the Earth of the Sun (owing to the gravitational interaction of the Sun with the Jupiter, or with the Saturn, or with the Uranus, or with the Neptune), or of the Moon, or of an arbitrary planet of the Solar System.

Based on the generalized differential formulation (12) of the first law of thermodynamics used for the Earth as a whole, in Section 3.2 we have presented the established [12, 13, 20, 21] fundamental global time periodicities (79) and (80) of the periodic global seismotectonic, volcanic and climatic activity of the Earth determined by the combined cosmic non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Mars, the Jupiter and the Sun owing to the gravitational interaction of the Sun with the Jupiter, the Saturn, the Uranus and the Neptune. Based on the formula (79), in Section 3.3 we have presented the established [12, 13, 20, 21] fundamental global seismotectonic, volcanic and climatic time periodicity 88 years (determined by the combined non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Jupiter and the Mars [12, 13, 20, 21]) used for prediction of "the time range $2010 \div 2011$ AD of the next sufficiently strong Japanese earthquake near the Tokyo region" [16]. This prediction was confirmed by the realized (in 2010 and 2011) strong Japanese earthquake near the Tokyo region.

Based on the formula (79), in Section 3.4 we have presented the established [12, 13, 20, 21] range of the fundamental seismotectonic, volcanic and climatic time periodicities $T_{tec,f} = T_{clim1,f} = T_{energyf} = (702 \pm 6)$ years (determined by the combined predominant non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Jupiter and the Sun owing to the gravitational interactions of the Sun with the Jupiter and the Saturn) confirmed by the realized strong earthquakes, volcanic eruptions and climatic anomalies in the history of humankind [12, 20, 21], including "the linkage of the different distinct great volcanic eruptions of the Thera (Santorini) in the range (1700÷1450±14) BC and the related subsequent intensifications of the global seismicity and volcanic activity in the end of the 19th century and in the beginning of the 20th century, in the end of the 20th century, and in the beginning of the 21st century AD" [13]. In Section 3.5 we have presented the evidence of the synchronic fundamental seismotectonic, volcanic and climatic time periodicities $T_{tec,vol,clim,sf} = (6321 \pm 3)$ years [21] and $T_{tec,vol,\ clim,sf}/2$ = 3160.5±1.5 years determined by the combined predominant non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Mars, the Jupiter and the Sun owing to the gravitational interactions of the Sun with the Jupiter and the Saturn. In Section 3.5.1 we have presented the synchronic fundamental seismotectonic, volcanic and climatic time periodicities $T_{tec,vol,clim,sf} = (6321 \pm 3)$ years [21] and $T_{tec,vol,\ clim,sf}/2$ = 3160.5±1.5 years characterizing the time synchronization of the mean periodicities 702 years and 1581 years of the fundamental global seismotectonic, volcanic and climatic time periodicities $T_{tec,vol,clim,f}$ = (702 ±6) years [12, 13, 20, 21] and $T_{tec,vol,clim,cf}$ = (1581±189) years [21]. We have shown that the synchronic fundamental seismotectonic, volcanic and climatic time periodicity $T_{tec,vol,\ clim,sf}/2$ = 3160.5±1.5 years is related with the periodic intensification of the endogenous heating of the Earth owing to the periodic deformation of the Earth's continuum determined by the combined predominant non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Mars, the Jupiter and the Sun owing to the gravitational interactions of the Sun with the Jupiter and the Saturn.

In Section 3.5.2 we have presented the evidence of the founded synchronic fundamental seismotectonic, volcanic and climatic time periodicity $T_{tec,vol,clim,sf}$ =(6321±3) years based on the established [21] causal link between the beginning (6372 BC) of the outstanding climate anomaly during (6372÷6192) BC in the North Atlantic [34] (owing to the very probable catastrophic seismotectonic event near 6372 BC [21] close to Lake Agassiz) and the established range (50±30) BC [35] of the strong global volcanic activity of the Earth. In Section 3.5.3 we have presented the evidence of the founded synchronic fundamental seismotectonic, volcanic and climatic time periodicities $T_{tec,vol,clim,sf}$ =(6321±3) years [21] and $T_{tec,vol,\ clim,sf}/2$ = 3160.5±1.5 years based on the analysis of the greatest world volcanic eruptions BC [35].

In Section 3.6 we have presented the combined arguments concerning the possible forthcoming intensifications of the global seismotectonic, volcanic and climatic activity of the Earth in the 21st century since the date 2016 AD, which was founded previously [21] based on the following combined independent information: the date 1928 AD of the previous eruption of Santorini [60], the established dates (1450±14) BC [13, 21, 62] of the possible last major eruption of Thera (Santorini) [64], and the date 6372 BC (which is the lower date 6372 BC [34] of the range (89)) of the possible catastrophic seismotectonic event (to all appearances, as it was shown [21]) near Lake Agassiz [34]. We have presented the additional arguments that the perfect equality of the established lower boundaries 2016 AD (of the previously obtained [13, 21] ranges (102) and (104)) and the evaluation (105) (of the date 2016 AD of the next possible intensification of Santorini volcano [13, 21]) give the evidence to consider the date 2016 AD as the possible beginning of the forthcoming intensifications of the global seismotectonic, volcanic and climatic activity of the Earth in the 21st century. The first argument is related with the fact that the date 2016 AD can be satisfactory presented (with the small residual term t_{res} =-0.5) by the established [12, 21] decomposition (108) relative to the initial date t_0 = 63 BC (of the greatest earthquakes in the ancient Pontus [63]) using the established mean fundamental global seismotectonic and volcanic periodicities $T_f(1) = 702$ years [12], $T_f(2) = 351$ years [12], $T_f(3) = 176$ years [12], $T_f(4) = 88$ years [12], $T_f(5) = 44$ years [12], $T_f(8) = 16.5$ years [12], which was used for the explanation [12] of the dates (818 AD, 1605 AD, 1703 AD, 1855 AD and 2011 AD) of the previous strong earthquakes near the Tokyo region, including the date 2011 AD predicted in advance [16]. The first argument is enhanced by the first strong result that the date 2059.5 AD of the previously established [59] decomposition (107) (based on the established mean fundamental global seismotectonic and volcanic periodicities $T_f(1) = 702$ years [12] and $T_f(8) = 16.5$ years [12]) is perfectly consistent with the mean date 2059.5 AD of the established subrange (2059.5 ± 4.5) AD [21] of the increased intensification of the global seismotectonic, volcanic and climatic activity of the Earth in the 21st century AD. The first argument is enhanced by the second strong result that the obtained date 2055.5 AD of the obtained decomposition (108) is located perfectly between the mean dates 2055 AD and 2056 AD of the ranges (100) and (101), and the obtained date 2055.5 AD (given by the decomposition (108)) is very close to the established date 2056 AD [21] corresponding to the maximal combined synchronization of the mean periodicities 702 years and 1581 years of the fundamental global seismotectonic, volcanic and climatic time periodicities (84) and (86).

We have shown that the second argument (to consider the date 2016 AD as the possible beginning of the forthcoming intensifications of the global seismotectonic, volcanic and climatic activity of the Earth in the 21st century) is related with the third strong result that the date 2016 AD represents the center of the obtained independently [59] refined range ($2015 \div 2017$) AD (given by (116)) of the possible intensification of the Japanese seismic activity (including the Tokyo region) based on the independently analyzed dates (818 AD, 1605 AD, 1703 AD, 1855 AD and 2011 AD) of the previous strong earthquakes near the Tokyo region [12].Thus, the additional analysis (based on the date 63 BC of the greatest earthquakes in the ancient Pontus [63] and the dates 818 AD, 1605 AD, 1703 AD, 1855 AD and 2011 AD of the previous strong earthquakes near the Tokyo region [12]) of the obtained date 2016 AD [21] (as the possible beginning of the forthcoming intensifications of the global seismotectonic, volcanic and climatic activity of the Earth in the 21st century) gives the additional evidence concerning the forthcoming intensifications of the global seismotectonic, volcanic and climatic activity of the Earth (in the 21st century since 2016 AD) determined by the combined predominant non-stationary energy gravitational influences on the Earth of the system Sun-Moon, the Venus, the Mars, the Jupiter and the Sun owing to the gravitational interactions of the Sun with the Jupiter and the Saturn.

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