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HIERARCHICAL CLUSTERING OF SEISMIC ACTIVITY LOCAL TERRITORIES GLOBE

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Abstract

In article, the interrelation between energy parameters of Globe moving in a system Sun-Earth-Moon has been established. It includes features of a seasonal energy condition of an internal core of Earth and the key energy parameters of tectonic activity of seismically dangerous local territories of the planet. These parameters have been systematized by means of a clustering method hierarchical. The mechanism of energy influence of core Earth fluctuations on variations of axial rotation speed of the Globe and level of seismic activity has been grounded. The phenomenon of a periodic oscillation of planet condition seismic and effect of asymmetric distribution of the emergency situations (ES) of tectonic origin on the Earth's surface has been established. For the first time, ranging of the seismically fissile local territories of the Globe in the parameters determining the level of seismic activity and ranges of magnitudes was carried out. Based on these results the effect of division of the seismically fissile local territories into three main clusters that characterized by rather high, average and low degrees of seismic activity was established. Join of the ranged seismically fissile local territories of the Globe permit to establish zones with various degree of seismic activity along the section of various geophysical plates.

The results received in article are a basis for further carrying out complex assessment of interrelations between key parameters of moving Globe in a system Sun-Earth-Moon and key parameters of tectonic danger of the seismically fissile local territories of Earth. It is base for further increase in effectiveness of monitoring of origin tectonic emergency by development of neural network prognostic models.

Keywords: emergency situation, seismic activity, seismic danger, monitoring of emergency situations, cluster analysis.

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1. Introduction

Many processes occurring during the operation of the natural-artificial-social system of the Earth and their mutual transformation gives rise to many natural phenomena dangerous to the Earth's biosphere, such as earthquakes, tsunamis, volcanic eruptions, floods, hurricanes and others [1, 2].

The tendency to an abrupt increase in the number and destructive power of natural disasters over the past few decades of the life of society leads to a deterioration of socio-economic and environmental consequences. It indicates the need to develop effective measures to prevent and eliminate emergencies of various nature on the globe [3–5].

A promising direction for solving this problem is the development of an effective hazard detection system at the stage of their inception. Also, the causes will be establishing of the occurrence these factors manifestations and effects on them in order to prevent the occurrence of emergencies. This has been implemented on the basis of the classical control loop presented in **Fig. 1** [6–9].

This article is part of a planned set of scientific studies aimed at developing a safety system. This eliminates or minimizes losses as much as possible under conditions of manifestation of an emergency. The work is focused on studying the processes of emergence and spreading of emergencies of lithospheric origin, which represent or may pose a serious danger to the life of society [10, 11]. A general assessment of the degree of negative impact of emergency situations of lithospheric origin on the conditions for the normal functioning of the natural-technogenic-social system is carried out using tectonic parameters characterizing the level of seismic danger of local Earth territories. A comprehensive assessment of the unsTable seismically the parameters area was carried out using a set of basic multidimensional statistical methods. In this paper the solution of the problem was implemented using cluster analysis.

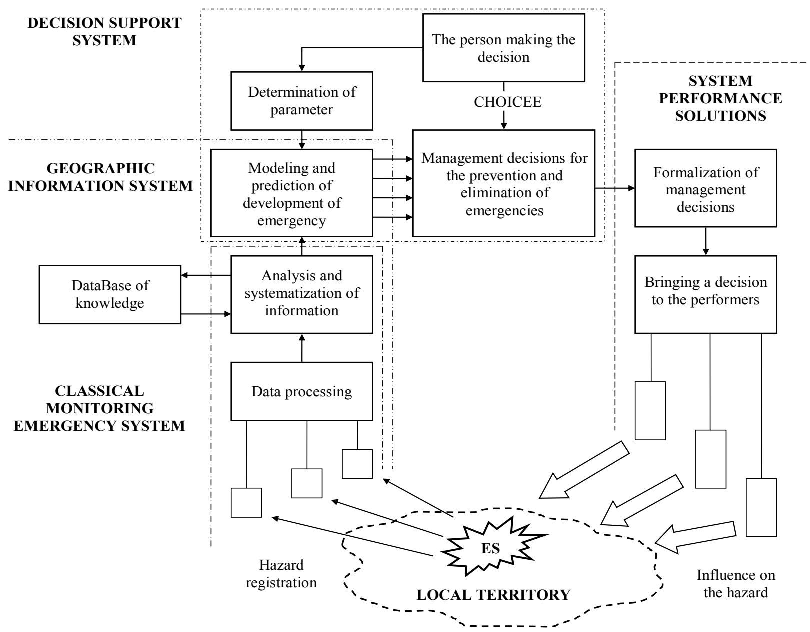

Fig. 1. Diagram of the emergencies monitoring structure as a means of control [15]

2. Methods of research the clustering of seismic activity local territories globe

2. 1. Analysis of recent achievements and publications

The dynamics of the physical processes of the Sun-Earth-Moon system affecting the seismic hazard level of the local territory functioning can be schematically represented according to **Fig. 2–4**. This can be characterized by the following spatial constructions within the solar galaxy.

1. The axis of rotation of the Earth in the celestial sphere describes a complex wave-like trajectory. The points of the axis of rotation are at an angular distance of about from the pole ecliptic (**Fig. 2**). The vertex of the cone coincides with the Earth center. The points of equinoxes and solstices move along the ecliptic towards the sun. Moments of gravitational forces influence on

the equatorial bulges and vary depending on the positions of the Moon and the Sun relative to the Earth. When the Moon and the Sun are in the plane of the Earth's equator the moments of forces disappear. If tilts of Moon and Sun are the maximum, then the magnitude of the torque will be greatest. The nutations, owing to fluctuations in the moments of the forces of the axis of rotation of the Earth have been observed by consist of a series of small periodic oscillations. The main nutations have a period of 18.6 years – the time of the orbital nodes of the Moon. Movement with this period occurs on an ellipse. The major axis of the ellipse is perpendicular to the direction of the precessional motion and is equal to; small – parallel to it and equal. Next in magnitude of the amplitude are the components with a period of 0.5 year, 13.7 days, 9.3 years, 1 year, 27.6 days etc., therefore the trajectory has the form of "thin laces" (shown on the enlarged fragment in the left part of **Fig. 2**) [12–19].

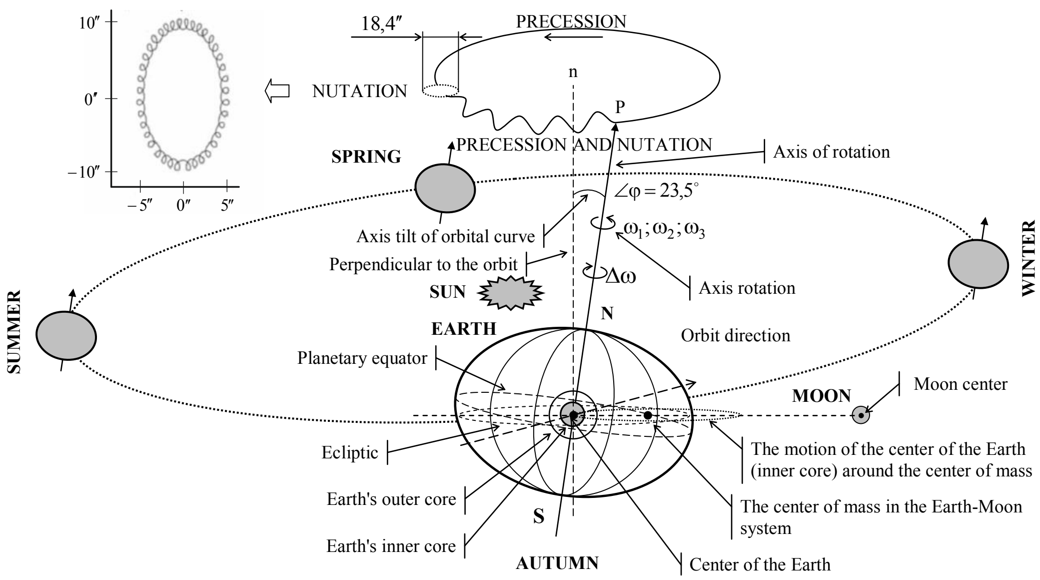

Fig. 2 Motion diagram of the inner core of the Earth in the Sun-Earth-Moon system

2. The pressure from the solid inner core and the surrounding melt (outer core) onto the mantle arises as a result of the eccentric revolution of the Earth's shell around the displaced inner core, which squeezes the shell from the inside. The forces compressing the shell of the sphere (planet) and drawing it inward to the core arise in other parts of the planet. This process has two components: impact at the expense of the annual displacement of the center nucleus relative to the center of the globe (**Fig. 2–4**); impact at the expense of eccentric circulation of the core relative to the lower mantle, when due to the difference in angular rotation velocity of the core and lower mantle (ω_1 – angular velocity of rotation of the mantle; ω_2 – angular velocity of rotation of the outer core; ω_3 – angular velocity of rotation of the inner core; $\Delta\omega = \omega_2 - \omega_1$ – angular velocity of rotation of the outer core relative to mantle ("western drift")), therefore, there are zones of high pressure and vacuum ($P_1 \neq P_2$, where P_1 and P_2 are indicators of pressure of the inner core of the globe on its surface), affecting the level of seismic activity of the surface of the Earth (**Fig. 3**). As long as there is a difference in the angular velocity of rotation and displacement of the nucleus, the appearance of such zones will be maintained [20–25].

3. Internal elastic stresses arise in the process of moving lithospheric plates (**Fig. 4**), which are energy sources of earthquakes [26–30]. The occurrence depth of elastic stresses depends on the nature of a movement plates. The relative motion of lithospheric plates leads to the emergence of shallow (not deeper than 20–25 km) earthquake sources and dipping of lithospheric plates into the mantle initiates the appearance of sources of deep (exceeding 70 km) earthquakes. The probability of elastic stresses – sources of earthquakes decreases with increasing distance from the interface of the lithospheric separation plates.

4. Surface and bulk seismic waves are the propagation factors of earthquake hazards Z_0, that can cause secondary earthquakes [30, 31].

5. The probability of mutual amplification or weakening of bulk seismic waves increases in the process of spatial-vibrational movement of the Earth's internal core and its effect on the external core. Consequently, the possibility of secondary earthquakes Z' increases also [32].

6. The possibility of the impact of surface and bulk seismic waves on stresses in the lithosphere is not excluded. It occurs near earthquakes and initiates the occurrence of a seismic hazard Z'' propagation chain reaction [33–35].

7. The territorial-temporal changes in the intensity of the natural electromagnetic field pulses of the Earth initiating anomalous processes in the atmosphere occur due to the movement of the Earth's inner core has been established [36–42].

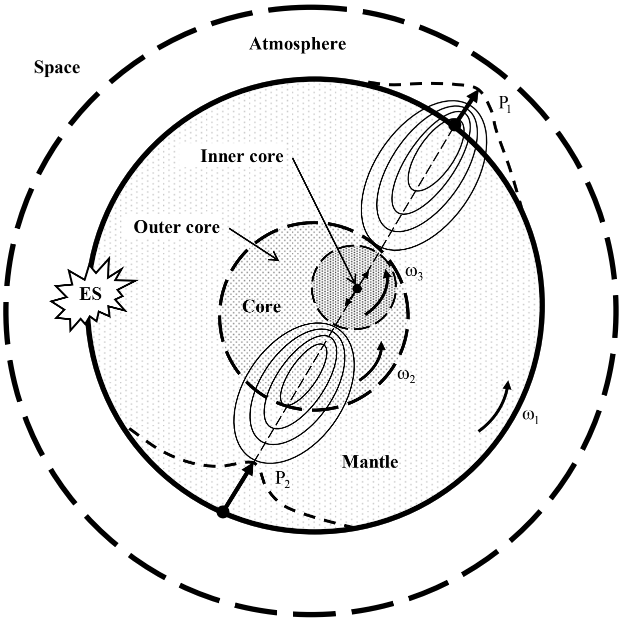

Fig. 3. Influence diagram of internal core oscillations on seismic activity

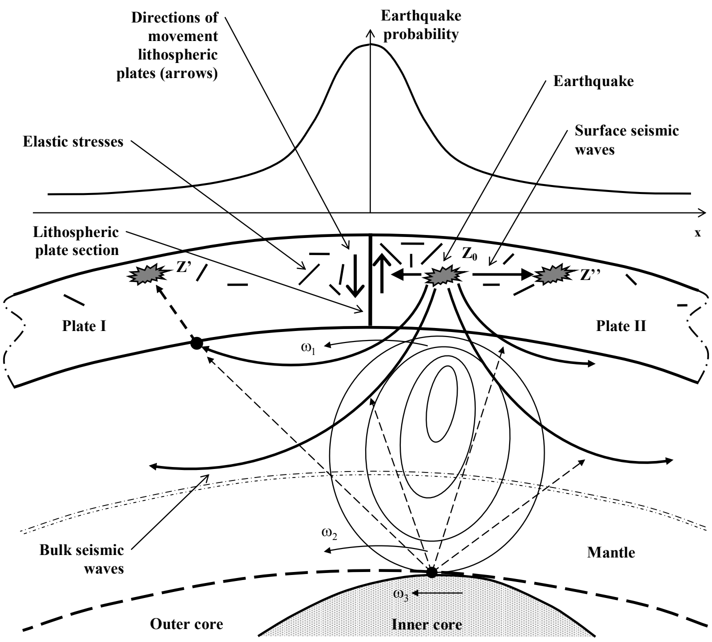

Fig. 4. Process diagram of earthquake and the spread of seismic activity

Thus, combining the analysis results of the impact dynamics and energy of the internal physicochemical processes of the Earth on the origin generating tectonic processes allowed to formulate an approach to studying the nature of seismic phenomena. It is an important tool for analyzing the results of civil defense research on the development of models for the development of ES tectonic nature.

2. 2. Problem statement and solution

The development of scientific and technical foundations creating an artificial intelligence system for monitoring emergencies of tectonic origin was the article purpose. The development of the scientific and technical foundations of system ascertains two necessary requirements:

1) increasing the efficiency of processing information about the processes occurring in the Sun-Earth-Moon system (the processes are schematically presented in **Fig. 2–4**);

2) conducting scientific research is aiming at the classification and ranking of multidimensional statistical methods of local areas of the globe in seismic activity terms. Cluster analysis of data using statistical packages STATISTICA 6.1 and SPSS 20 has been performed in this article.

The purpose of cluster analysis is to find groups of similar objects in the data sample, the so-called clusters characterized by the following main properties: density, dispersion, size, shape and separability, according to [43, 44]. By density is meant a property that defines a cluster as an accumulation of points in data area. It is relatively dense compared to other regions of area that contain either a small number of points or do not contain them at all. Dispersion characterizes the degree of dispersion points in area relative to the cluster center. Cluster size is closely related to variance. The shape of the cluster is determined by the position of the points in area. The definition of "connectedness" of points in a cluster as a relative measure of the distance between them is required when depicting clusters of various shapes. Distance measures are usually not limited from above and depend on the choice of index (scale) measurements. Separability characterizes the degree of cluster overlap and how far apart these located in area.

The Euclidean distance when determining a measure of distance is one of the most known

$$d_{ij} = \sqrt{\sum_{z=1}^{p} \left(X_{iz} - X_{jz} \right)^2}, \tag{1}$$

where d_{ij} – distance between objects *i* and *j*; X_{iz} – absolute a values *z*-th variable for *i*-th objects; X_{jz} – absolute a value *z*-th variable for *j*-th objects.

However, the similarity score strongly depends on differences in data shifts when analyzing the distance measure. Thus, variables characterized by large absolute values and standard deviations can suppress the influence of variables, which is characterized by small absolute values and standard deviations. To reduce this effect, the process of data standardization in the article has been carried out before determining the distance measure. It is based on the normalization of variables to unit variance and zero mean:

$$X_{iz}^{*} = \frac{X_{iz} - M\left[X_i\right]}{\sigma_{X_i}}; \ X_{jz}^{*} = \frac{X_{iz} - M\left[X_j\right]}{\sigma_{X_j}}, \tag{2}$$

where X_{iz}^{*}, X_{jz}^{*} – standardized values *z*-s variables for *i*-th and *j*-th objects; $M\left[X_i\right]$, $M\left[X_j\right]$ – mathematical expectations for variables *i*-th and *j*-th objects; σ_{X_i}, σ_{X_j} – standard deviations, characteristic of variables *i*-th and *j*-th objects.

Known cluster analysis methods can be divided into two groups-hierarchical and non-hierarchical methods.

The essence of hierarchical clustering is to successively merge smaller clusters into larger, so-called agglomerative methods, or to divide large clusters into smaller, so-called divisional methods.

In this article, the Ward method has been used to carry out hierarchical clustering of the Earth's territory in terms of seismic activity. This method is one of the widely used agglomerative methods. The advantage of the Ward method is the use of analysis of variance to estimate the distance between the clusters. This is different from all other agglomerative methods. The method minimizes the sum of dispersion squares for clusters that can be formed at each step. New results have been obtained using the Ward method.

In this paper, the system of dividing maps into detached sheets for cluster analysis of the territory of the globe on the level of seismic activity has been used. It is based on the international plots of 1:1,000,000 scale maps in accordance with **Fig. 5**. At the same time, the division into rows by parallels is made from the equator at every 4^{o} latitude. Rows represent letters of the Latin alphabet: A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, V, W. The columns in their borders coincide with 6^{o} the Gauss-Kruger projection zones. The columns are numbered from the meridian $\pm 180^{o}$ to the east and denoted (by number) by Arabic numerals [45].

The article measures the Euclidean distances between the standardized values of the variables that determine the degree of seismic activity of seismically active local territories of the Earth (obtained by dividing the maps into separate sheets of 1:1,000,000 scale) over the period 2009–2018 have been determined. The initial sample included 4580 observations of the occurrence of earthquakes with a magnitude $M \geq 4$ on the Richter scale over 2640 local territories of the globe. The following indicators have been used for cluster analysis of local Earth territories by seismic activity: K – the number of earthquakes; M_{max} – the maximum magnitude of earthquakes arising; M_{min} – the minimum magnitude of earthquakes. A fragment of the calculations results have been presented in **Table 1**.

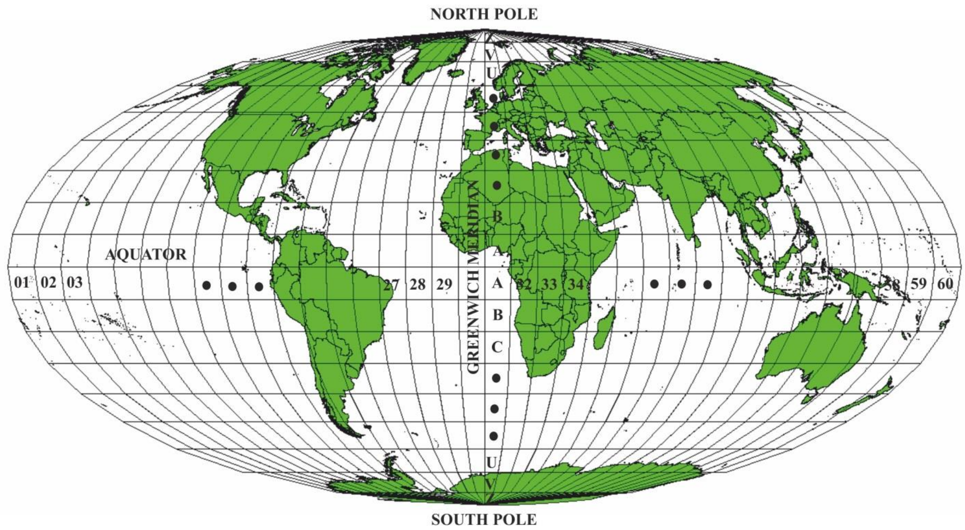

Fig. 5. Scheme of the division cards into detached sheets

The process of using the step-by-step agglomerative method for combining seismically active (in terms of indicators K, M_{max} and M_{min}) local territories of the Earth as a result of dividing maps into detached sheets of a 1:1,000,000 scale into clusters according to the degree of seismic activity has been presented in **Fig. 6**.

The result of hierarchical clustering by the Ward method according to the degree of seismic activity (earthquakes with magnitude $M \geq 4$ on the Richter scale have been taken into account) for the period 2009–2018 local territories of the Earth obtained as a result of dividing maps into detached sheets of a scale 1:1,000,000 have been presented in **Fig. 7**. It can be noted that a comprehensive analysis of the local territories of the globe according to the degree of seismic activity allowed to rank the seismically active territory of the planet into three main clusters at a distance of 100 Euclidean distances.

Table 1

A fragment of the calculations results of the Euclidean distances between the standardized values of the variables determining the degree of seismic activity of seismically active local territories of the Earth

	N-A-15	N-A-16	N-A-17	N-A-18	×	S-Q-1	S-Q-55	S-Q-56	S-T-6
N-A-15	0,0	0,4	2,3	1,7	×	0,3	1,2	1,7	0,6
N-A-16	0,4	0,0	2,7	2,1	×	0,2	1,2	1,8	0,5
N-A-17	2,3	2,7	0,0	0,6	×	2,6	2,4	2,5	2,5
N-A-18	1,7	2,1	0,6	0,0	×	2,0	1,9	2,0	1,9
×	×	×	×	×	×	×	×	×	×
S-Q-1	0,3	0,2	2,6	2,0	×	0,0	1,3	1,8	0,6
S-Q-55	1,2	1,2	2,4	1,9	×	1,3	0,0	0,5	0,7
S-Q-56	1,7	1,8	2,5	2,0	×	1,8	0,5	0,0	1,2
S-T-6	0,6	0,5	2,5	1,9	×	0,6	0,7	1,2	0,0

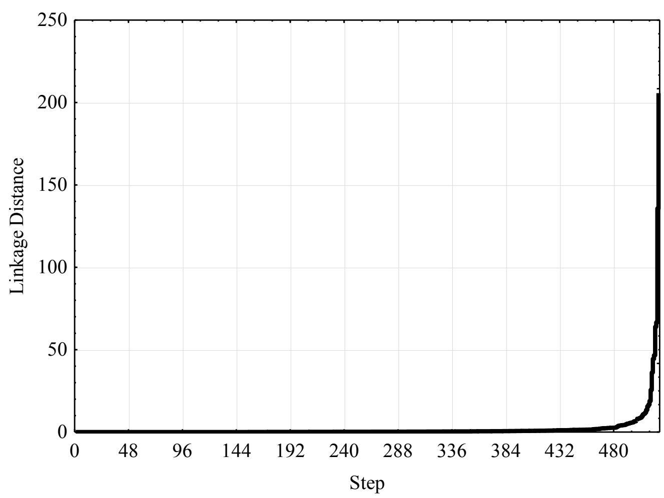

Fig. 6. Schedule of step-by-step merging of seismically active local territories of the Earth obtained as a result of dividing maps into separate sheets of 1:1,000,000 scale into clusters according to the degree of seismic activity for the period 2009–2018

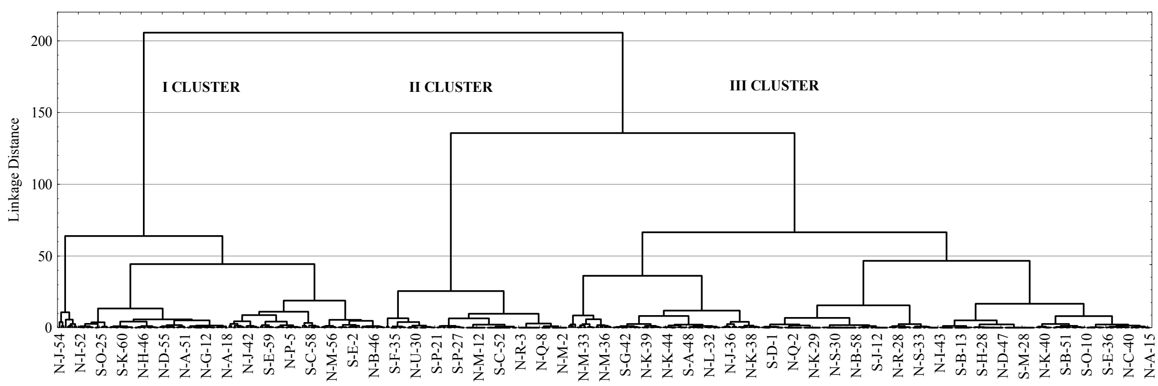

Fig. 7. Dendrogram of clustering of seismically active local Earth territories obtained as a result of dividing maps into detached sheets of 1:1,000,000 scale according to the degree of seismic activity over the period 2009–2018 (on the dendrogram there are numbers of cards in 10 units increments)

The first cluster, with a high degree of seismic activity over the period 2009–2018 includes the following seismically active local territories of the Earth. It has been obtained as a result of dividing the maps into detached sheets of 1:1,000,000 scale, namely: N-A-17; S-L-18; N-D-46; N-J-55; S-E-18; N-B-46; S-E-60; N-E-55; N-N-59; N-N-9; N-C-52; N-N-60; N-A-46; N-A-47; S-F-19; S-E-2; N-D-15; S-I-19; N-E-14; S-E-58; N-H-45; S-A-53; S-A-50; N-D-16; N-L-56; N-M-56; S-K-59; N-G-41; N-G-54; N-N-2; N-J-43; N-A-52; S-C-57; S-A-47; S-D-58; S-C-58; S-J-18; N-G-51; S-B-54; S-H-1; N-B-17; N-H-54; N-N-3; N-R-6; N-F-51; N-P-5; N-K-33; N-K-43; N-B-51; N-I-53; N-N-57; S-H-19; S-I-1; N-C-51; S-B-52; S-E-59; S-C-50; S-O-26; N-L-55; S-B-48; N-G-52; N-J-38; N-O-58; S-B-55; S-G-1; N-J-42; N-O-6; N-H-40; N-I-54; N-I-35; N-J-35; N-H-52; N-N-1; N-K-34; N-K-35; N-A-18; N-D-54; N-C-20; S-B-18; N-O-57; S-M-58; N-C-17; S-P-26; S-A-55; N-E-13; N-G-12; S-D-18; N-F-47; N-J-44; S-N-32; N-H-12; S-H-18; N-N-46; S-F-20; S-O-35; N-A-51; S-B-53; N-G-46; N-M-57; S-C-51; N-B-52; S-A-54; S-A-51; S-A-52; S-D-2; N-D-55; S-J-60; S-I-18; N-B-47; N-C-54; N-I-11; N-C-19; S-E-19; S-A-56; N-E-19; N-H-46; N-L-45; S-B-50; S-A-27; S-O-55; N-H-48; N-K-10; N-K-55; N-M-9; S-A-28; S-K-60; N-O-4; N-N-25; S-I-12; N-N-58; N-N-56; S-I-60; N-C-45; S-L-58; S-F-58; S-O-25; N-C-46; N-H-41; S-P-23; N-E-16; N-E-18; N-R-54; S-A-18; N-F-46; N-I-46; N-I-52; S-C-48; N-I-38; S-E-1; N-K-54; S-B-56; S-F-59; N-L-35; N-J-34; S-F-1; N-J-54.

The second cluster, with a middle degree of seismic activity over the period 2009–2018, includes the following seismically active local territories of the Earth obtained by dividing maps into detached sheets of 1:1,000,000 scale, namely: N-A-36; N-F-24; N-M-2; N-Q-55; S-C-55; S-F-55; S-G-43; S-G-56; N-G-37; N-J-29; N-L-10; N-N-48; N-Q-8; N-B-10; N-D-19; N-G-19; N-G-49; S-A-29; S-O-29; S-T-6; N-H-32; N-M-45; N-R-3; N-U-31; N-B-56; N-P-7; S-P-20; N-J-47; N-N-51; N-N-54; N-T-18; S-C-47; S-C-52; S-G-11; S-H-11; S-I-14; S-J-14; S-J-54; S-Q-55; N-H-35; N-J-17; N-J-26; N-M-12; S-M-52; S-O-57; N-M-54; N-S-15; S-F-49; S-J-19; N-C-55; N-P-8; S-C-36; S-P-27; N-H-11; N-K-42; S-G-44; S-G-52; S-L-36; N-D-21; N-O-8; S-G-20; S-H-20; S-P-21; N-A-50; N-N-8; S-N-57; N-B-55; N-O-7; S-O-27; S-P-28; S-Q-56; N-C-23; N-U-30; S-C-46; S-L-46; S-M-54; S-P-35; N-C-13; S-C-19; N-N-47; S-N-21; N-F-12; S-F-35; S-N-31; S-O-28; N-E-17; S-B-46.

The third cluster, with a low degree of seismic activity over the period 2009–2018, includes the following seismically active local territories of the Earth obtained as a result of dividing the maps into detached sheets of 1: 1,000,000 scale, namely: N-A-15; S-J-39; S-M-51; N-J-45; S-H-41; S-C-56; S-N-8; S-O-9; S-K-28; S-Q-1; N-C-40; N-J-52; S-L-47; N-E-15; S-K-45; N-Q-5; S-H-43; N-J-31; N-L-18; S-C-37; S-E-36; S-H-12; N-B-18; N-H-47; S-K-38; S-P-24; N-C-18; S-B-28; N-J-14; N-D-37; S-O-10; N-B-50; S-I-28; S-J-28; N-P-1; N-J-46; S-O-19; S-D-19; N-D-50; N-I-48; S-B-51; N-J-30; S-A-17; S-B-17; N-E-20; N-L-9; S-P-56; N-D-22; N-F-18; S-N-6; N-K-40; S-L-59; N-F-50; S-F-36; S-A-35; N-A-16; N-C-21; N-H-24; N-H-36; S-J-55; S-M-28; S-P-58; N-O-53; N-R-4; S-A-15; S-E-56; S-F-26; S-G-35; S-G-59; S-I-11; N-D-47; N-F-17; N-I-12; N-K-28; S-K-18; S-N-30; S-O-34; N-L-25; N-P-57; N-T-30; S-H-28; S-C-17; S-L-17; S-J-13; S-O-20; N-B-24; N-K-48; N-N-45; S-A-13; S-B-13; S-B-29; S-I-51; S-M-47; N-D-20; N-L-43; N-L-48; N-Q-1; S-I-31; S-N-35; N-I-43; N-A-25; N-H-22; N-N-30; N-O-54; N-O-55; S-D-42; N-O-3; N-Q-31; N-S-33; N-V-30; N-V-36; S-B-36; N-D-40; N-M-26; N-E-4; N-L-53; N-O-40; N-Q-22; N-R-28; N-F-5; N-L-46; N-M-44; S-F-33; N-B-25; N-F-19; N-M-37; S-C-42; S-D-37; S-J-12; S-J-44; N-E-23; S-E-20; N-I-32; S-C-18; S-J-38; S-P-57; S-F-42; S-K-44; N-B-58; N-E-12; N-F-55; N-O-56; S-K-1; S-L-37; S-P-55; N-P-10; N-P-6; N-Q-3; N-S-30; S-B-5; S-C-12; S-F-9; S-I-50; S-G-28; N-B-40; N-G-45; N-J-32; N-K-29; S-L-13; N-P-60; N-Q-6; N-U-51; S-A-26; N-C-24; N-L-26; N-O-36; N-O-51; N-Q-2; N-V-45; S-B-42; S-C-28; S-A-42; N-D-23; S-D-59; S-G-12; S-D-28; N-E-47; S-D-1; N-G-23; N-K-26; N-P-25; N-J-25; N-G-42; N-A-26; N-J-37; N-G-40; N-L-44; N-K-38; N-S-29; N-C-16; N-J-53; N-K-9; S-B-47; S-F-2; N-H-39; S-G-60; S-D-38; N-J-36; N-M-32; N-J-40; N-K-37; N-O-5; N-D-17; N-J-41; N-Z-40; S-C-35; N-G-48; N-L-32; S-C-49; S-G-19; N-G-39; S-N-34; N-G-47; N-P-58; N-K-45; S-A-36; N-H-53; S-A-48; N-D-51; N-E-51; N-E-46; S-I-40; N-F-54; N-E-5; N-J-10; S-E-42; N-F-23; N-K-44; N-M-55; N-S-31; N-D-39; N-I-40; N-Q-28; N-K-53; N-N-4; N-O-25; N-H-42; N-K-39; N-I-36; N-N-40; N-E-37; S-H-60; N-V-29; S-B-49; N-I-44; N-I-45; N-H-44; S-G-42; N-I-47; N-T-32; N-I-42; N-L-51; N-L-54; N-O-49; N-I-34; N-L-37; N-L-33; N-M-36; N-I-39; N-N-33; N-K-36; N-L-34; N-J-33; S-F-60; N-M-1; N-J-39; N-L-36; N-M-33; N-L-38; N-O-33; N-U-11; N-M-34; N-M-35; N-N-35; N-N-34.

3. Discussion of the research results to the clustering of seismic activity local territories globe

The remainders of the local Earth territories obtained as a result of dividing maps into detached sheets of a scale of 1:1,000,000 were not seismically active for the period 2009–2018. The results of the clustering of the local territories of the Earth obtained as a result of dividing the maps into detached sheets of a scale of 1:1,000,000 according to the degree of seismic activity for the period 2009–2018 graphically for the northern hemisphere have been presented in **Fig. 8** (for the southern hemisphere in **Fig. 9**). The summarized results have been presented in **Fig. 10**.

Areas of research were for time period specified:

1) the arisen earthquakes magnitude on the Richter scale;

2) 2640 local territories of the Globe received as result of division cards into single sheets of scale 1:1000000.

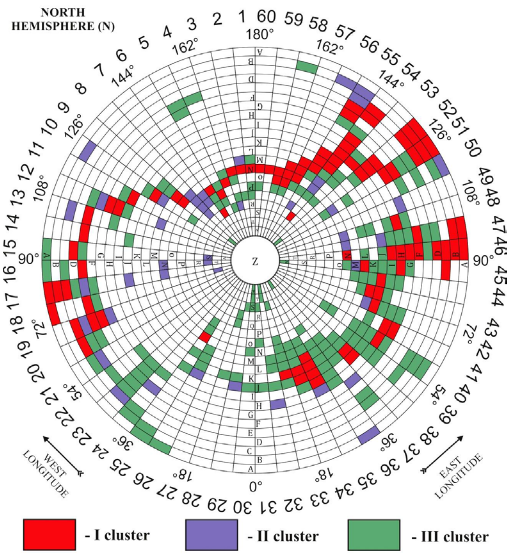

Fig. 8. Cartographic presentation of clustering results seismically active local territories of the northern hemisphere of the Earth obtained as a result of dividing maps into separate sheets of 1:1,000,000 scale according to the degree of seismic activity for the period 2009–2018

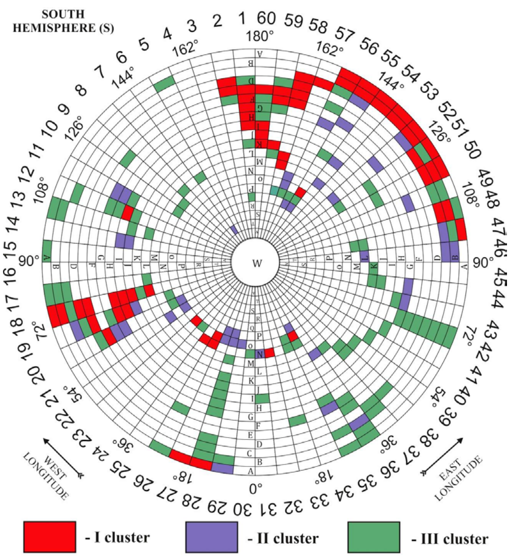

Fig. 9. Cartographic presentation of clustering results seismically active local territories of the southern hemisphere of the Earth obtained as a result of dividing maps into detached sheets of 1:1,000,000 scale according to the degree of seismic activity for the period 2009–2018

From the data analysis **Fig. 8–10** that:

1) territory of the Earth is divided into areas with different levels of seismic activity, which corresponds to different degrees of risk emergency situations of tectonic origin;

2) seismically active local areas have been concentrated along the section of lithospheric plates;

3) occurrence of earthquakes in seismically active local territories has been synchronized with the kinetics and energetics of the motion of the Earth in the Sun–Earth–Moon system.

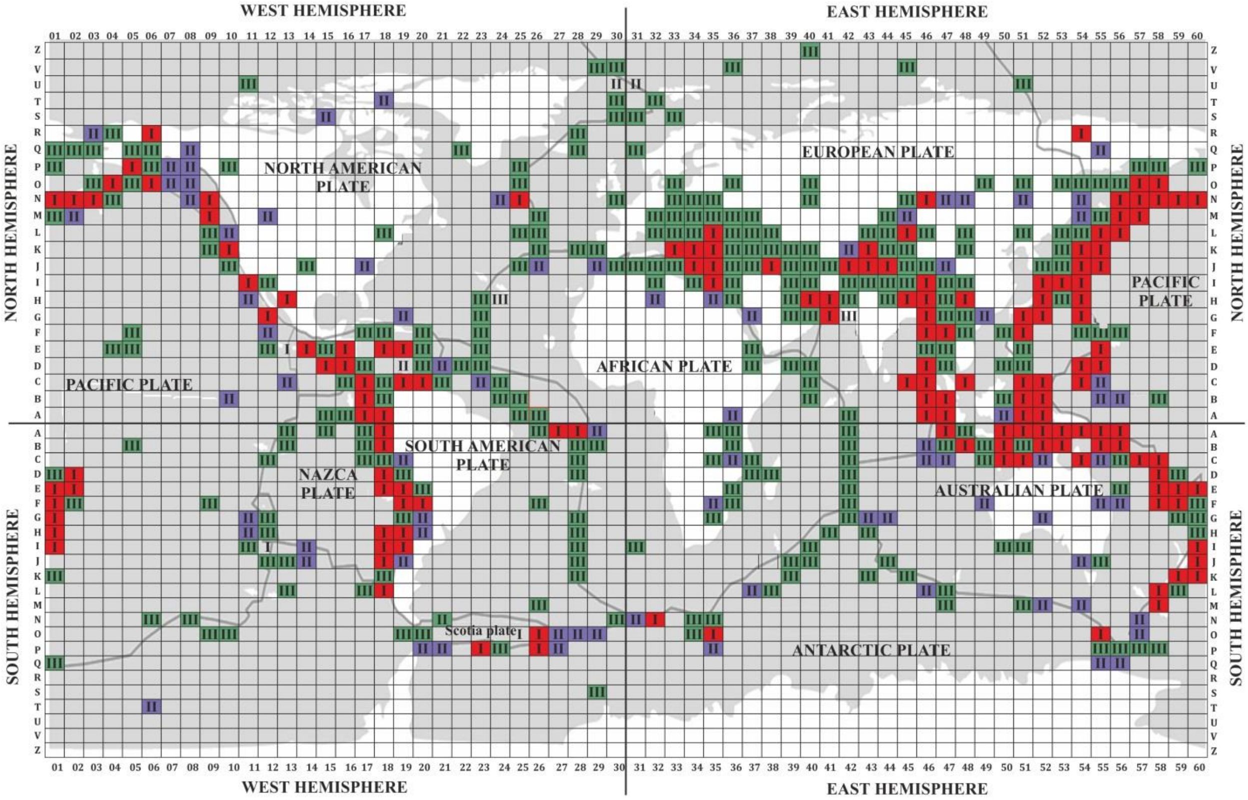

Fig. 10. A cartographic representation of the results clustering seismically active local areas of the globe obtained as a result of dividing maps into detached sheets of a scale of 1:1,000,000, according to the degree of seismic activity over the period 2009–2018

The results of the clustering of the planet's territory in terms of seismic activity over the period 2009–2018 allowed to single out the following zones with a relatively high degree of seismic activity. These zones unite local territories of the Earth obtained as a result of dividing maps into detached sheets of 1:1,000,000 scale constitute the first cluster.

Zones with a relatively high degree of seismic activity are:

– in the northern hemisphere:
  – along the section of the European and Pacific plates;
  – around the Philippine Plate;
  – along the section of the North American and Pacific plates;
  – around the Caribbean plate;

– in the southern hemisphere:
  – along the section of the Australian and Pacific plates;
  – along the section of the South American plate and the Nazca plate.

Zones with a relatively low seismic activity obtained in this way are:

– in the northern hemisphere:
  – mainly along the southern part of the European plate on its section with African, Arab and Indian plates;

– along the section of the European and North American plates;

– in the southern hemisphere:

– mainly along the western and eastern part of the African Plate on its section with South American and Australian plates;

– along the section of the Antarctic Plate with the Pacific, South American, African and Australian plates.

The basis for further scientific research aimed at a comprehensive assessment of the level of seismic hazard of the Earth's territory is the results obtained in this article. Thus, it is planned to assess the degree of interrelation between the main parameters of the Earth's motion in the Sun–Earth–Moon system and the main parameters of tectonic danger of seismically active local territories of the Earth, using the basic multidimensional statistical analysis methods: discriminant, canonical and classification trees.

The research results have practical significance in the field of civil protection of the population and the planet's territory. It is aimed at developing the scientific basis for creating an effective geo-information subsystem for monitoring emergencies of tectonic origin based on the development of neural network prediction models.

4. Conclusions

1. Creating a comprehensive four-level (taking into account the relationships between the facility, city, regional and state levels) automated emergency monitoring system is a prerequisite for establishing an appropriate level of seismic safety of the controlled local territory. This system should include a subsystem for early detection of seismic activity seat and prediction of seismic hazard across the globe. The basis of the subsystem for the early detection of seismic seat and prediction of seismic hazard in a controlled local area is the classic control loop. It provides for the collection, processing and analysis of information, as well as modeling the development of seismic hazard across the globe.

2. The mechanism of the energy influence seasonal fluctuations of the globe core: variations in the speed of the globe rotation axial; the level of seismic activity of the Earth was justified in the development of a systematic approach for predicting the occurrence of emergencies of tectonic origin. Based on the analysis of the variations in the speed of the globe rotation axial and the eccentric uniform translational-rotational dynamic motion of the inner core of the Earth, the possibility of establishing a periodic oscillation of the seismic state of the planet has been considered. Based on the results of monthly variations in the speed of the globe rotation axial and seismic activity on the surface of the Earth relative to the route of its internal core a seasonal redistribution of the energy influence of the internal core on the speed of the globe rotation axial and the level of seismic activity of the seismically unsTable territories of the Earth has been established. Based on the analysis of the processing results number of earthquakes over the surface of the globe an asymmetric distribution of ES of tectonic origin over the surface of the Earth has been established.

3. Using the method of hierarchical clustering of seismically active local territories of the Earth, obtained by dividing maps into detached sheets of 1:1,000,000 scales by the main parameters of seismic activity and by the number of earthquakes and magnitudes in a certain local area ranking has been applied.

As a result, the value of these variables for the period 2009–2018 has been combined in each cluster using the Ward method. The effect of seismically active local areas of the Earth into three main clusters characterizing seismic activity has been established.

4. The combination of the ranked seismically active local territories of the Earth in terms of the hazard level allowed to establish that the zones with a relatively high degree of seismic activity have been revealed: along the section of the European and Pacific plates; around the Philippine Plate; along the section of the North American and Pacific plates; around the Caribbean Plate; along the section of the Australian and Pacific plates; along the section of the South American plate and the Nazca plate. Obtained in this way, zones with a relatively low degree of seismic activity have been located: mainly along the southern part of the European Plate on its section with African, Arab and Indian plates; along the section of the European and North American plates; mainly

along the western and eastern parts of the African Plate on its section with the South American and Australian plates; along the section of the Antarctic Plate with the Pacific, South American, African and Australian plates.

5. The results obtained in this article are the basis for further carrying out a comprehensive assessment of the relationships between the main parameters of the Earth's movement in the Sun – Earth – Moon system and the main tectonic danger parameters of seismically active local territories of the Earth. The subsequent comprehensive assessment is formed using the basic multidimensional statistical analysis methods – discriminant, canonical and classification tree. The use of complex multidimensional statistical methods based on neural network predictive models is necessary for successfully solving the problem of improving the efficiency of monitoring emergencies of tectonic origin.

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