Bull. Nov. Comp. Center, Math. Model. in Geoph., 25 (2023), 35–47

The development dynamics of the “Afro-Baikal” and the expanded “Indonesian” transregional seismolineaments based on the creepex analysis*

A.V. Mikheeva

Abstract. A study to identify the spatio-temporal relationship between strong $M_S \geq 7$ seismic shocks and the preceding moderate mid-depth seismicity has led to the need to consider territories that go far beyond the area of preparation of its individual foci. First, there are the areas along the global seismolineaments to which the events in question belong. In the 10 % confidence band of these regional (and then the global) structures, a pattern of high correlation of magnitude $M_S(t)$ and creepex $\mathrm{Cr}(t)$ graphs on the eve of strong earthquakes has been revealed. It indicates the creation of a special organized state of the geophysical environment during their preparation, possibly associated with the environment consolidation along the global tectonic structures (in the case of an inverse correlation of $M_S(t)$ and $\mathrm{Cr}(t)$), or with increased environment heterogeneity in the linear region under consideration (in the case of direct correlation of these parameters).

Keywords: mid-depth seismicity, focus mechanism, creepex, correlation of seismicity parameters graphs, global tectonics

Introduction

The parameter of creepex (creep & explosion) determined by the difference between the surface M_S and volumetric m_b magnitudes [1] shows the relative contribution of “soft” (creep) and “hard” (explosion) movements to the overall process of focal radiation, allowing us to identify patterns of correlation dependence of the creepex on the magnitude of the events set and to interpret it from the view point of the environment stress-strain state dynamics from focus to focus [2].

Earlier, in the paper [3] it was noted that two recent, close-in-time strong earthquakes in Indonesia (January 8–9, 2023) were timed to the regional “Indonesian” seismolineament identified in the GIS-ENDDB geo-information system [4] by the method of the Great Circle of the Earth [5]. Then, along the “Indonesian” lineament, based on an assessment of the ratio of changes in the time of the creepex parameter [6] with a change in the magnitude of mid-depth ($50 \geq H \geq 300$ km) seismicity events, the presence of signs of the influence of this global geotectonic structure on the preparation of a series of the strongest Indonesian earthquakes with $M_S \geq 7$ in the first half

*Supported by Project 0251-2021-0004 of the ICM&MG SB RAS state assignment.

of 2023 was shown. This influence was confirmed by the fact that the whole world seismic activity for the largest events of this half-year (except for the multi-earthquake of Turkey) was concentrated along the "Indonesian" lineament [7].

There is also a longer version of the "Indonesian" seismolineament of the Great Circle, covering within its confidence band not only the Indonesian series of major events of the 1st half of 2023, but also the simultaneous Turkish multi-earthquake 06.02.2023 ($M_W = 7.8$ and 7.7) [7]. Let us note, that terms "double-earthquake" and "multi-earthquake" means two and more than two simultaneous shocks of close (with a difference of up to 0.1) magnitudes.

In Figure 1, the expanded "Indonesian" seismolineament mentioned above, as well as the previously identified "Afro-Baikal" seismolineament of diagonal orientation [5], are shown in white against the background of two "main Great circles" of the Earth (I and II), indicated in lilac. The term "main circles" is introduced here for two strictly orthogonal Great circles of the Earth detected by the GIS-ENDDB algorithm, whose 3000-kilometer confidence intervals cover 100 % of all earthquakes of the Globe with $M_S \geq 7.5$. It is possible that these "seismic belts" reflect modern manifestations of tectonic activity associated with the rotation of the Earth. For example, according to theoretical calculations (shown in [8]), the reduction

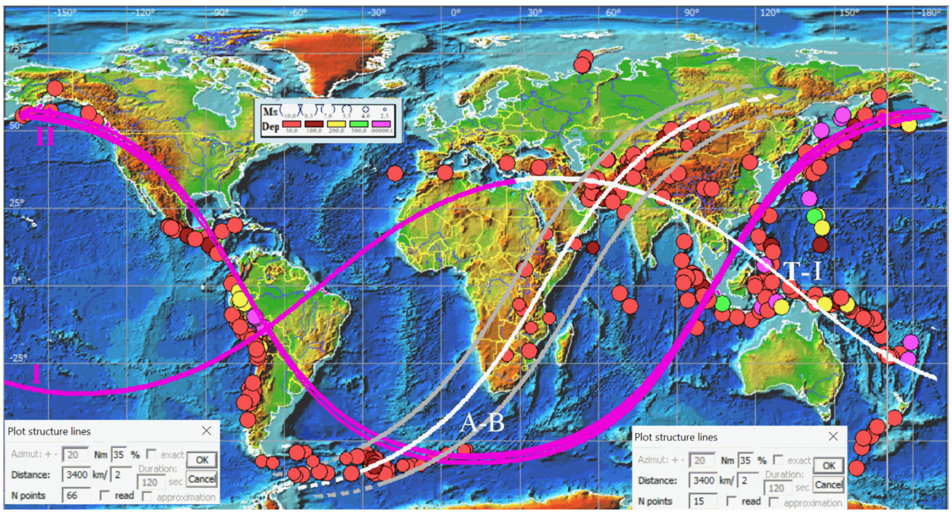

Figure 1. Afro-Baikal (A-B) and Turkish-Indonesian (T-I) seismolineaments constructed in the GIS-ENDDB software (white color) against the background of two "main Great Circles" of the Earth (lilac color) also identified by GIS-ENDDB. For A-B lineament, a confidence interval with a full width of ~ 2500 km is shown (gray). The earthquakes of the NEIC catalog with $M_S \geq 7.5$ for 1973–2023 (219 events) around the whole world and earthquakes with $M_S \geq 6.5$ in the confidence band of the A-B lineament are shown

in the Earth's rotation speed (due to tidal friction [9]), which began from the most intensity at the End of the Middle Eocene and is currently being recorded by astronomical observations, should lead to the occurrence of compression stresses parallel to the equator. Due to it there should be the widespread formation of upthrow dislocations of the submeridional strike (they may be the latest folding movements and subduction episodes in the Cordillera, Andaman Islands, Sumatra, Sulawesi, Solomon and New Hebrides Islands, Philippines and Mariana Islands, Taiwan, Ryukyu, Japan, the Kuril Islands and Kamchatka, covered by the "main circle" II), and closer to the equatorial zone — the formation of dislocations of the sublatitudinal strike (for example, in the young folded structures of southern Europe and North Africa, the Greater Caucasus Range, the Kopet Dagh, the Himalayas, as well as in the Zavaritsky-Beniof zones activations of the islands of Java, New Guinea and Samoa covered by the "main circle" I). Note that although the intersection points of the "main circles" are located $\sim$ 1600 km north of the modern equator in the eastern hemisphere and south — in the western hemisphere, however, it is known from paleomagnetic data that in the Oligocene (when the Alps, the Caucasus, the Atlas, etc. were formed) "the equator was located exactly where these mountain buildings currently rise" [8].

Let us note that the Afro-Baikal seismolineament located at an angle of $\sim 55°$ to the "main circle" I is detected by the algorithm of the Great Circle for significantly weaker events ($M_S \leq 6.5$) in comparison with the "main circles", i.e. it is a geotectonic structure of lower rank. However, it practically coincides with the "big diagonal" of L.M. Rastsvetaev [10] (rather, with his "Baluchistan-Siberian transcontinental shear zone"), as well as with the global "African-Chukchi" lineament of the diagonal strike of A.I. Poletaev [11]. Obviously, according to the world seismicity, other minor and less extended seismolineaments can be distinguished, for example, the seismolineament perpendicular to the "main circle" I with coverage of the seismicity of the islands of New Zealand, Tonga and Kermadec.

In this paper, we propose a study of the dynamics of mid-depth seismicity in the area of "Afro-Baikal" and extended "Indonesian" (or "Turkish-Indonesian") seismolineaments against the background of the dynamics of the development of the "main circles" global seismicity. The purpose of this study is to find out how typical and regular for global seismicity is the presence of correlation anomalies detected on a regional scale a few days before the January Indonesian events [7].

1. Factual material and research methods

The factual material of the work is the data from the NEIC global catalog [12] for 1973–2023 (when constructing seismolineaments by the Great

Circle method), as well as a selection of records from the global catalogs: CSN [13] and ISC [14] with reference to IDC (International Data Centre, Vienna, Austria), all containing definitions of two earthquake parameters: surface M_S and volumetric m_b magnitudes from the same agency (used for calculating the creepex and comparative correlation analysis).

At the time writing of this paper, the global sample from the CSN catalog amounted to 58931 records for 26.07.1999–31.08.2017 (of these, 8938 events with $H \geq 50$ km), and from the ISC — to 308879 records for 26.02.2000–07.11.2023 (of these, 51747 events with $H \geq 50$ km).

The study also uses the method described in [5] for identifying regional and global seismolineaments over the Great Circle of the Earth, and the approach described in [2] based on the pair correlation calculation of the creepex and magnitude time changes. To calculate the relative creepex $\mathrm{Cr}_0^{\mathrm{ISC}}$ a corresponding algorithm has been added to the GIS-ENDDB seismic data analysis software [6].

In this paper, the geodynamic properties of environment expressed in seismicity parameters are considered in the vicinity of the transregional and the global seismolineaments. To do this, first using the GIS-ENDDB algorithm, seismolineaments are constructed (according to the samples of the NEIC catalog: $4 \leq M_S \leq 6.5$, $5 \leq M_S \leq 7.5$ or $M_S \geq 7.5$, depending on the lineament scale) [5]. Then in its band neighborhood (the half-width of which is defined as 10 % of its length) a polygonal area (band) is plotted on the resulting map and the parameters ($H \geq 50$ km and $M_S \geq 2$) are set for automatic earthquakes selection from the ISC catalog sample described above.

To evaluate the synchronous behavior in time of the $\mathrm{Cr}_0^{\mathrm{ISC}}$ and M_S parameters of the resulting sample, two methods are used to calculate the pair correlation coefficient K_{COR}: 1) with a fixed size of the sliding time window, and 2) with one sliding edge of the window and the other edge fixed at zero time corresponding to the moment of the strongest event (for example, 09.01.2023).

The algorithm of the second method is described in detail in [2]. In it, the size of the calculation window $t(t_0)$ decreases as it approaches the moment of the main event t_0 [2, Figure 3]. In the first algorithm, the length of the considered sequence of events t is constant (it is an initially set parameter) and each chronological point of the series is assigned a value of the correlation coefficient calculated from the sum of preceding and subsequent relative to this central point the number of events t. The paper shows the results for the window size $t = 50$ and 20 points.

2. Distribution of the correlation parameter of mid-depth seismicity along the studied seismolineaments

Previously, the dynamics of the largest earthquakes preparation at depths of more than 50 km were considered by us in the 1000-kilometer neighborhood of the largest events with $M_S \geq 7$ of the South Asian region [2]. For example, in the vicinity of the last largest Indonesian event on 09.01.2023 ($M_S = 7.6$) a correlation (K_{COR}) anomaly was observed, indicating uniform environment consolidation throughout the all seismically active depth (including $H \geq 50$ km) ~ 80 days before the shock (i.e. during its preparation) [3]. Then, when expanding the earthquakes sample under consideration to the 950-kilometer neighborhood of the regional "Indonesian" seismolineament activated by the January events of 8–9.01.2023, a similar manifestation of the environment consolidation along its entire length was detected 33 days before this strongest shock [7]. Using the same approaches on a more global scale, we will consider the dynamics of the development of the Afro-Baikal and expanded Indonesian transregional seismolineaments for the entire registration period covered by the catalog (26.07.1999–11.09.2023) against the background of the dynamics of the K_{COR} parameter change around the whole world (Figure 2).

Graphs of changes in the creepex-magnitude correlation for mid-depth earthquakes (see Figure 2a, b) show slight differences in the curves plotted for earthquakes all over the world and for the Turkish-Indonesian seismolineament (covering ~ 2 times fewer events with $H \geq 50$, 84 % of which belong to "Indonesian" lineament [7]). This difference is expressed not in the frequency of the considered parameter change, but in the amplitudes of its spread. For better stress the differences between these curves, they are shown on the same graph (see Figure 2b, c). Vice versa, the graph of the Afro-Baikal seismolineament (1291 events with $H \geq 50$ differs significantly from them (see Figure 2a). For example, it clearly shows a sharp negative jump in the level of the curve (up to -0.45 values according to the schedule for $t = 20$ points) during the preparation period of the pair event (preceding the Tohoku earthquake) on 18.01.2011 ($M_S = 7.0, 7.0$) in Pakistan. The preparation period of this event is determined as 121 days before the shock (according to the schedule at $t = 20$ points — see Figure 2a). The event of 18.01.2011 is also marked on the chart of the whole world (see Figure 2b) in minimum, although more local, but pronounced in amplitude (one of the three minima exceeding the amplitude of the level $|K_{\mathrm{COR}}| = 0.6$, which are numbered in Figure 2b). Note that the comparison of the correlation curves of the Afro-Baikal seismolineament for $t = 20$ and $t = 50$ points (see Figure 2a) shows a typical picture when the preparation period marked by curves increases with an increase in the size of the sliding window of correlation calculation, but at the same time the anomalous correlation value

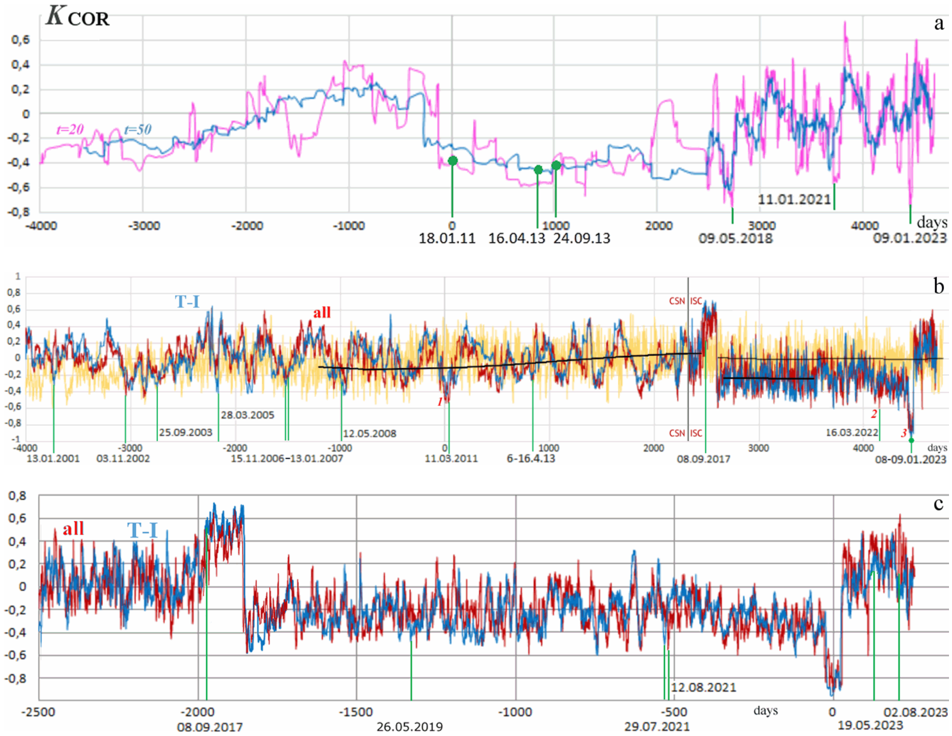

Figure 2. Graphs of changes in the creepex-magnitude correlation (calculation method with a fixed size of the sliding time window) for mid-depth earthquakes of 26.07.1999–07.11.2023 from the CSN and ISC catalogs: a) for the Afro-Baikal seismolineament (blue: $t = 50$, lilac: $t = 20$); b) for the Turkish-Indonesian lineament (blue) and for the whole world (red and yellow (by ISC data of the November 2023 edition) colors): $t = 50$, the change boundary for the red line from CSN to ISC data at the mark of 2214 days (or 1.1.2017) is shown by a gray vertical line, black lines show fragmentary polynomial trends of the 3rd order according to the ISC catalog of both editions; c) the same for 20.04.2016–07.11.2023 (alone ISC data). The Pakistani double earthquake of 18.01.2011 ($M_S = 7.0, 7.0$) are taken as the zero time stamp on graphs (a) and (b), and Indonesian 08–09.01.2023 ($M_S = 7.0, 7.6$) are on the graph (c). The green lines show the largest earthquakes both belonging to seismolineaments and remote from it, but manifested on their curve

of the preparation period decreases somewhat (at $t = 50$, this is 265.5 days before the push with a correlation value of -0.27 after a sharp jump from the positive values level — see Figure 2a). Subsequent strongest events of the Afro-Baikal seismolineament occurred south of the Pamir-Hindu Kush Seismofocal Zone (PHZ): 16.04.2013 ($M_S = 7.7$) and 24.09.2013 ($M_S = 7.7$) on the background already changed by the previous earthquakes, and the period of their preparation is expressed on a more detailed curve for $t = 20$ by a decrease in K_{COR} to values -0.59 starting 243 days before the event (see Figure 2a). Further, by more local minima are manifested the events: on 9.05.2018 in PHZ ($M_S = 7.0$, $K_{\mathrm{COR}} = -0.76$) and 11.01.2021 in Baikal zone ($M_S = 7.1$, $K_{\mathrm{COR}} = -0.57$). There is also a minimum corresponding to the Indonesian event on 9.01.2023 ($K_{\mathrm{COR}} = -0.76$), although it does not belong to this lineament.

Let us consider in chronological order the largest events in the whole world against the background of a correlation curve reflecting the dynamics of the environment state from the source to the source of mid-depth seismicity events (see Figure 2b). Recall that the reduced values correspond to a consolidated environment state or a high level of tectonic stresses in the sources. The first minimum of the world chart does not strictly (within the window of a correlation calculation) correspond to the earthquake of 13.1.2001 ($M_S = 8.4$, Central America), and the minimum of the Turkish-Indonesian lineament curve is more pronounced (K_{COR} up to -0.25 at 25 points before it, and in the case of $t = 20$ K_{COR} up to -0.5 at 2 points before it), the second minimum is the earthquake of 3.11.2002 ($M_S = 8.1$, Alaska, K_{COR} up to -0.44 at 6 points after it), then 25.09.2003 ($M_S = 8.2$, Hokkaido, K_{COR} up to -0.3 at 9 points after it). The Sumatran mega-earthquakes of 23-26.12.2004 ($M_S = 8.0$, 8.9) are not manifested by a minimum (K_{COR} up to 0.56), and the Sumatran earthquake of 28.03.2005 ($M_S = 8.6$) is weakly manifested, however, the its minimum amplitude reaching a value of K_{COR} up to -0.42 at 9 points before the event is well expressed on the curve of the Turkish-Indonesian lineament. This is followed by the minima of two Kuril earthquakes of 15.11.2006 ($M_S = 8.0$, K_{COR} up to -0.31 at 19 points after it on the curve of the Turkish-Indonesian lineament) and of 13.1.2007 ($M_S = 8.1$, also better expressed on the curve of the Turkish-Indonesian lineament: K_{COR} up to -0.33 at 8 points before it), Tibetan of 12.5.2008 ($M_S = 8.2$, better manifested on the curve of the Turkish-Indonesian lineament: K_{COR} up to -0.32 at 13 points after it on the curve of the Turkish-Indonesian lineament) and the Tohoku mega-earthquake of 11.3.2011 ($M_S = 8.7$, $K_{\mathrm{COR}} = -0.53$ at 27 points before the event). This is followed by a notable positive anomaly associated with the event of 8.9.2017 ($M_S = 8.3$, Central America), after which the world graph trend is significantly changed from a positive (0.1) to a negative (-0.2) level (see Figure 2b, c). In total, out of 30 earthquakes with $M_S \geq 8$ in the whole world (ISC catalog), 26 occurred before this event. Of these 26 ones, the minima of the graph are expressed only by the listed 8 events related to the "main circle“ *II*. The remaining 18 ones are not expressed on the chart by negative anomalies: these are the first two (1999 and 2000, for which there are no data), the Chilean ones (of 23.06.2001, 15.8.2007, 27.2.2010, 1.4.2014 and 16.9.2015), Sumatran (2004, double of 12.9.2007 and double 11.4.2012), Chukchi (20.04.2006), Antarctic (17.11.2013), Kashmir (25.4.2015), New Zealand (13.11.16) and Indonesian (8.12.2016). All of them (except Chukchi) belong to the "main circle" I. The remaining set of minima of the graph may correspond to major events with $7 \leq M_S < 8$, for example, the graph shows events close in time and corresponding to a defined minimum: of 6.04.2013 ($M_S = 7$, $K_{\mathrm{COR}} = -0.25$) in Indonesia, of 16.04.2013 ($M_S = 7.7$, $K_{\mathrm{COR}} = -0.25$) in Pakistan and of 16.03.2022 ($M_S = 7.3$, $K_{\mathrm{COR}} = -0.6$, marked by the number (2) in Figure 2b) off the Pacific coast of Japan. The latter is characterized by a particularly high correlation for $t = 10$ ($K_{\mathrm{COR}} = -0.96$).

Note that out of the marked in Figure 2b 11 anomalous minima exceeding in amplitude the level $|K_{\mathrm{COR}}| = 0.2$, five ones are expressed by the same minima on the graph for the initially identified by the Indonesian series of events of the regional "Indonesian" seismolineament, despite their distance from this lineament. These events are: 13.1.2001 (Central America), 25.09.2003 (Hokkaido), 12.5.2008 (Tibet), 11.3.2011 (Tohoku), and 16.03.2022 (Honshu).

So, one of the key events for the studied property of seismicity occurred on 8.9.2017 ($M_S = 8.3$) near the Pacific coast of Mexico (Central America). It is not only characterized by a transition to positive values of the creepex-magnitude correlation (with the value $K_{\mathrm{COR}} = 0.46$ 24 days before the event), but also by an influence on the change in the trend level of further behavior of correlation curves, which is especially noticeable from earlier operational ISC data. Let us us note that in November 2023, the compilers of the original IDC catalog recalculated all its magnitudes, therefore, Figure 2b also shows in yellow the data from a later edition of the ISC, according to which the trend level is also changing in this area, although not so pronounced. The growth of positive correlation values corresponds to a relatively high temperature in the sources and/or increased heterogeneity of its environment, for example, when the processes of brittle destruction of the blocks of the advancing crust are adjacent to the processes of receipt of deep mantle material. The subsequent change in the graph is manifested in an increase in the amplitudes of negative correlation (we see a large number of points with an amplitude near -0.5). At the same time, the frequency of the largest events with $M_S \geq 8$ decreases sharply, and until 2021, they completely disappear.

The behavior of the correlation properties of seismogenic foci following the event of 8.9.2017 is considered on a separate graph (see Figure 2b). Since, according to the ISC catalog, there are only 3 events with $M_S \geq 8$ (of 29.07.2021, $M_S = 8.3$; 19.05.2023, $M_S = 8.7$ and 02.08.2023, $M_S = 8.6$), we will also consider 2 events with $M_S \geq 8$ in the NEIC catalog (26.05.2019, $M_S = 8.0$ and 12.08.2021, $M_S = 8.1$). Among the five earthquakes considered, the following 3 were shown by the minima of the graph: the Peruvian one of 26.05.2019 ($M_S = 8.3$, $K_{\mathrm{COR}} = -0.37$ at 4 points after the event), the Aleutian of 29.07.2021 ($M_S = 8.3$, $K_{\mathrm{COR}} = -0.52$ at 24 points after the event on the curve of the Turkish-Indonesian Lineament) and the double Antarctic of 12.08.21 ($M_S = 8.1$, $K_{\text{COR}} = -0.54$ at 37 points after the event), all belonging to the "main circle" II from Figure 1. Earthquakes in Chile and Indonesia, timed to the "main circle" I, were not manifested.

Also, on the curves under consideration, attention is drawn to a sharp negative anomaly (from $K_{\text{COR}} = -0.71$, marked by number (3) in Figure 2b), marking a pair of Indonesian earthquakes of 8–9.01.2023 ($M_S = 7.0$–7.7, $K_{\text{COR}} = -0.95$ at the point of events), 21 days before the strongest shock on the seismicity of the "Turkish-Indonesian" seismolineament, and 27 days before it - according to the seismicity of the whole world. The devastating Turkish multi-earthquake of 06.02.2023 ($M_W = 7.8$ and 7.7) occurred at the tipping point of the chart trend transition from negative values (persisting within 26 days after the January events) to the level of anomalous positive values (apparently characterizing the altered environment state), which persists to this day. Thus, the earthquakes with $M_S \geq 8$ of the Indonesian series manifested by positive anomalies: 19.05.2023 ($M_S = 8.7$, $K_{\text{COR}} = 0.45$) and 02.08.2023 ($M_S = 8.6$, $K_{\text{COR}} = 0.62$).

Building a logical chain based on the results of previous and current studies of the Indonesian earthquake series that followed the January events (according to the correlation graph calculated by the second method, and taking into account anomalies exceeding the 0.7 mark in amplitude), the following conclusion can be drawn. The consolidation of global deep faults begins with local areas of the order of 2000 km, for example, for the 1000-kilometer neighborhood of the 9.01.2023 event, this happened in two jumps 80 and 60 days before the strongest shock (Figure 3), then extends to the regional segment of the global seismolineament (for the "Indonesian"—33 days before the shock), and then to the entire global system of "the main circles" (see Figure 1) 31 days before the shock (see Figure 3). This process is transmitted to the assumed tectonic structures of a regional scale with an even greater delay. For example, according to the seismicity of the "Afro-Baikal" seismolineament, the consolidation process is recorded 10 days before the January Indonesian shock.

Thus, having considered the picture of global changes in the correlation parameter, we can conclude that most of even the strongest earthquakes with $M_S \geq 8$ are not associated with the environment consolidation or the increase in stresses along the global seismicity structures, which must be expressed in an increase in the correlation of the creepex and the magnitude parameters of mid-depth events in these structures. However, this relationship is found to a greater or lesser extent for $\sim 30\,\%$ of seismic events with $M_S \geq 8$, as well as individual earthquakes with $7 \leq M_S < 8$. The most noteworthy among them are earthquakes not only marked by the anomalies of K_{COR} graph, but also affect the properties of the subsequent global seismogeodynamic process, expressed by the parameter under consideration.

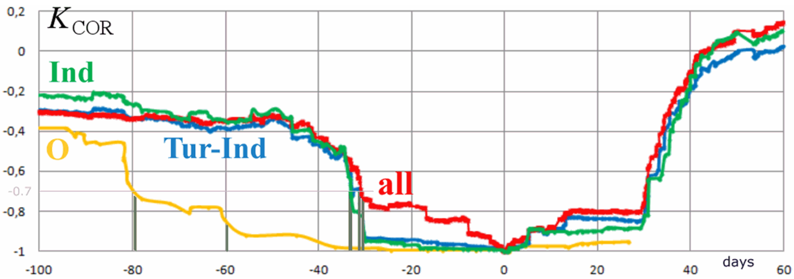

Figure 3. Graphs of changes in the creepex-magnitude correlation (calculation method with one fixed edge) for mid-depth earthquakes 100 days before the Indonesian earthquakes 8–9.01.2023: "O" (yellow) — in the vicinity of the earthquake 9.01.2023 ($M_S = 7.7$), "Ind" (green) — in the vicinity of the Indonesian regional seismolineament, "Tur-Ind" (blue) — in the vicinity of the Turkish-Indonesian transregional seismolineament and "all" (red) — throughout the global seismicity. Vertical lines show the moments of the beginning of anomalies with $|K_{COR}| \geq 0.7$

This obviously indicates some general planetary cause of such events (for example, associated with the most noticeable periodic fluctuations in the Earth's rotation speed, known by astronomical observations to occur "at intervals of 10 to 30 years or more" [8, 9]). These are, first of all, paired events: Pakistani 18.01.2011 and Indonesian 8–9.01.2023 (possibly related to geotectonic compression due to episodes of more intense deceleration of rotation), as well as a major Mexican earthquake of 8.9.2017 ($M_S = 8.3$) with opposite characteristics (i.e., presumably associated with an episode of relative acceleration of the Earth's rotation).

Conclusion

In this paper, we study the dynamics of the creepex-magnitude correlation (K_{COR} as correlation of the magnitude $M_S(t)$ and creepex $\mathrm{Cr}(t)$ parameters) by mid-depth seismicity along the Afro-Baikal and extended Indonesian seismolineaments, previously identified by the GIS-ENDDB algorithm. The changes in K_{COR} are analyzed against the background of the dynamics of the same parameter along two orthogonal to each other "main circles" of the Earth. By the term "main circles" there are called the Great Circles of the Earth, also detected by the GIS-ENDDB algorithm, the confidence intervals of which cover 100 % of all earthquakes of the Globe with $M_S \geq 7.5$.

The graphs show that earthquakes with $M_S \geq 8$ which belong to the "main circle" II (north of the areas of its intersections with the "main circle" I), are marked by negative anomalies of the K_{COR}. They account for ~ 30 % of the world seismic events of this rank and are obviously associated with the environment consolidation along the global seismicity belts, which is expressed in establishing the inverse synchronicity of the parameters of the creepex and the magnitude of the mid-depth events. The same relationship with global episodes of the environment consolidation of seismic belt is also found for some earthquakes with $7 \leq M_S < 8$. Let us clarify that this property applies to both "main circles" of the Earth, since these events are marked also by anomalies on the graph of the extended Indonesian seismolineament, which is part of the "main circle" I. The synchronous dynamics of the properties of mid-depth seismicity of various global seismolineaments of orthogonal strike during these earthquakes may be due to "the formation of deformation waves propagating in the process of the environment self-organization in the interblock seams of a fractally constructed lithosphere" [15].

In addition, among these events there are several, not only marked by notable anomalies of the K_{COR} graph, but also influencing the subsequent behavior of the parameter, apparently being the cause or the marker of changes in the environment state and a radical change in subsequent geodynamic processes detected by this parameter. These are: paired Pakistani of 18.01.2011 ($M_S = 7.0$ and 7.0) and Indonesian 8–9.01.2023 ($M_S = 7.0$ and 7.7) events marked by the largest in amplitude negative anomalies, starting 121 and 31 days before the shocks, respectively, as well as a major Mexican earthquake on 8.9.2017 ($M_S = 8.3$) corresponding to a positive anomaly and to the maximum of trend that has been growing for 6 years before the event. Since the negative anomaly corresponds to the cases of inverse correlation of $M_S(t)$ and $\mathrm{Cr}(t)$ (when stronger earthquakes have a smaller creepex, characterizing a greater contribution of brittle fractures), it is logical to associate the first two events with the environment consolidation along global seismolineaments (or the processes of stress growth in them) due to episodes of the most intense geotectonic compression of the latest time. The Mexican event can be associated with endogenous processes that can also affect global tectonics. The increased heterogeneity of the environment and/or the relative increase in its temperature as a result of such processes (for example, with the arrival of deep mantle material) is naturally manifested in the establishment of direct correlation the $M_S(t)$ and $\mathrm{Cr}(t)$ parameters.

References

[1] Prozorov A.G., Hudson D. Dependence between MLH and mPV on regional conditions and local interconnections // Magnitude and energy classification of earthquakes. Vol. 2.—Moscow: IFZ AN SSSR, 1974.—P. 208–216 (In Russian).

[2] Mikheeva A.V. Dynamics of parameters of intermediate-depth seismicity before large earthquakes of South Asian seismofocal zones // Russian Seismological J.—2023.—Vol. 5, No. 2.—P. 51–60 (In Russian).

[3] Mikheeva A.V., Kalinnikov I.I. Analysis of the dynamics of the faults and strong earthquakes development // InterExpo Geo-Siberia. — 2023. — Vol. 4, No. 1. — P. 120–128 (In Russian).

[4] Mikheeva A.V., Dyadkov P.G. Structural elements of seismicity detected using digital GIS ENDDB models // New technologies for processing and using Earth remote sensing data in geological exploration and monitoring of hazardous geological processes: Proc. of the Second International Conference, St. Petersburg, April 22–24, 2014. — P. 123–127 (In Russian).

[5] Kalinnikov I.I., Mikheeva A.V. The GIS-ENDDB algorithms and methods for geoinformation-expert data analysis // Machine Learning and Data Analysis. — 2017. — Vol. 3, Iss. 1. — P. 36–49.

[6] Mikheeva A.V., Kalinnikov I.I. Creepex as a Parameter of Seismo-Geodynamic Studies Based on Geo-Information Systems // CEUR Workshop Proceedings: All-Russian Conference "Spatial Data Processing for Monitoring of Natural and Anthropogenic Processes", Novosibirsk, Russia, August 24-27, 2021 / Edited by Y.I. Shokin, V.V. Alt, I.V. Bychkov, et all. — P. 194–202.

[7] Mikheeva A.V., Kalinnikov I.I. On the influence of a supposed deep fault on strong earthquakes in Indonesia // Russian Seismological J. — 2023. — Vol. 5, No. 4. — P. 51–60 (In Russian).

[8] Pukhlyakov L.A. Review of Geotectonic Hypotheses. — Tomsk: Tomsk Univ. Publishing House, 1970 (In Russian).

[9] Stephenson F.R., Morrison L.V., Hohenkerk C.Y. Measurement of the Earth's rotation: 720 BC to AD 2015 // Proc. of the Royal Society A. — 2016. — Vol. 472, Iss. 2196. — P. 1–26. doi: 10.1098/rspa.2016.0404.

[10] Rasvetaev L.M. Identification of paragenetic families of tectonic disjunctiva as a method of complete me-chanical analysis of stress and deformation fields of the Earth's crust // Stress and deformation fields in the Earth's crust. — Moscow: Nauka, 1987. — P. 171–181 (In Russian).

[11] Poletaev A.I. Scheme of modern rotational movements of the terrestrial crust blocks of the Earth's Eastern hemisphere // XV Gorshkov readings. Materials of the conference dedicated to the 104th anniversary of the birth of G.P. Gorshkov (1909–1984) / Edited by N.V. Koronovsky. — Moscow: MSU, 2013. — P. 24–25.

[12] National Earthquake Information Center: Earthquake Hazards // U.S. Geological Survey [Site]. — 2023. — URL: https://earthquake.usgs.gov/earthquakes/search/.

[13] CSN Catalog of the Earthquakes // China Seismological Network [Site]. — URL: https://data.earthquake.cn/gcywfl/index.html (date of application 09.11.2023). (In China).

[14] ISC Bulletin: event catalogue search // International Seismological Centre [Site].—United Kingdom, Thatcham: Internat. Seismol. Centre, 2023.—URL: www.isc.ac.uk/iscbulletin/search/catalogue/#iscbulletin/.

[15] Ulomov V.A. On the issue of planetary seismic activation // Georisk.—2010.—No. 3.—P. 4–8 (In Russian).