ON THE PRESENCE OF PULSATIONS OF THE EARTH TEMPORALLY ASSOCIATED WITH SOLAR ACTIVITY

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Abstract

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ON THE PRESENCE OF PULSATIONS OF THE EARTH TEMPORALLY ASSOCIATED WITH SOLAR ACTIVITY

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It has already been pointed out in the literature that the use of the method of repeated high-precision leveling in the study of contemporary tectonic movements is not fully substantiated. One of the more accurate methods for studying contemporary tectonic movements in coastal regions is to study them on the basis of tide-gauge observations.

We have processed the results of observations from more than 40 tide gauges of the Caspian Sea. Some results of these investigations are set forth in the present article, the principal subject of which is to clarify the question of the possible reflection of solar activity in pulsational vertical movements of the Earth' s crust.

As is evident from Fig. 1, the vertical movements of various tide gauges of the Caspian Sea relative to the Makhachkala tide gauge proceed differently, revealing their pulsational character. At the same time, both similarities and differences in the course of tectonic movements are revealed. Thus, some points, such as, for example, Baku, Sara Island, and Cheleken, are characterized by a general subsidence: the Baku tide gauge subsided by more than 35 cm during 1900–1960*, and the Sara Island tide gauge subsided by almost 15 cm during 1922–1954. At the same time, many other tide gauges did not reveal any predominant tendencies, and the curve of change in the course of tectonic movements for them reveals mainly a pulsational character.

Let us consider in more detail the changes of the Baku tide gauge, for which the longest series of observations is available (Fig. 1 B). The Baku tide gauge experienced pulsational changes in vertical movements, the rate of which reached 5-6 cm/year. However, these movements had an oscillatory character, alternately (often almost annually) changing sign and magnitude**. Smoothed by twice-sliding three-year intervals, the rates of vertical movements reveal 5-7-year and, in places, 10-12-year rhythms. Rhythms of various orders are clearly visible when the regional background of directed subsidence (at a rate of 5 mm/year) of the Baku tide gauge is removed. At the same time, contemporary pulsational movements are distinguished predominantly with periods of 3-4, 5-7, 10-11, and 20-25 years***.

Figure 1

Figure 1: Figure 1

A more sensitive quantity than velocity is the acceleration of tectonic movements (cm/year^2). Analysis of the absolute values of accelerations

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* If the rates of contemporary (in the 20th century) directed subsidence (with an average rate of about 5 mm/year) of the Baku tide gauge had persisted during Quaternary time, then over anthropogenic time the subsidence would have amounted to about 5 km. Such rates of subsidence could have led to rapid sinking of the bottom, for example, of a number of Far Eastern seas (the Sea of Japan, etc.); there, over only 0.5 million years, subsidence could have amounted to 2.5–3 km. And yet the rates at Baku are far from being the greatest rates of subsidence of the Earth' s crust.

** Tidal phenomena in the sea cannot exert any substantial influence on the observed pattern of changes in the rates of pulsational movements, since the hydrological method of investigation used in the article excludes them; this also applies, to a certain extent, to wind set-up and set-down phenomena and to seiches.

*** The presence of periods of lower order can create the impression of a cessation of directed subsidence (pulsational movements of higher orders), whereas in reality what occurs is the superposition upon it of these pulsations of lower categories. For example, in 1919–1941 there occurred not a cessation (or even an uplift) of the directed subsidence of Baku, but a superposition on this subsidence of a 22-year cycle, intensified by the presence (coincidence) within it of two distinct and independent 11-year cycles.

of present-day tectonic movements reveals a very interesting feature. In order to exclude the influence of random deviations, we use the method of moving averages over three-year intervals and, moreover, construct a curve based on twice-smoothed three-year intervals. As is evident from Fig. 1, the curve of change in the acceleration of vertical movements, based on twice-smoothed three-year intervals,

Fig. 1. Present-day vertical tectonic movements of the Caspian Sea tide gauges relative to the Makhachkala tide gauge. **A** –general resultant course of tectonic movements. 1 –Fort Shevchenko, 2 –Kuuly, 3 –Krasnovodsk, 4 –Cheleken, 5 –Zhiloi Island, 6 –Sara Island; **B** –present-day tectonic movements of the Baku tide gauge (Bailov Cape) relative to the Makhachkala tide gauge. 1 –velocity of present-day pulsational vertical movements of the Earth' s crust (cm/year), 2 –change in the mean velocity of present-day pulsational vertical movements of the Earth' s crust, calculated from twice-smoothed three-year intervals (cm/year) (moduli are given), 3 –change in the absolute values of the

velocities of present-day vertical movements of the Earth' s crust over twice-smoothed three-year intervals (cm/year); 4 –general resultant course of Baku tectonic movements (cm); 5 –the same after removal of the general directed course of tectonic movements (i.e., after removal of regional subsidence); 6 – curve of change in the resultant course of tectonic movements with allowance for regional subsidence over moving five-year intervals (cm); 7 –change in the absolute values of the accelerations of present-day pulsational vertical movements over twice-smoothed three-year intervals (cm/year^2), 8 –long-term fluctuations of solar activity (Wolf numbers W)

reveals a pattern of periodic increase and decrease in the absolute values of accelerations. The duration of the time between adjacent maxima of acceleration over the entire analyzed interval of observations (1900–1961) averages 8–12 years (Table 1). During the last 62 years, six maxima of pulsation acceleration are distinguished. The duration of these periodic (or cyclic) tectonic pulsations of the Earth (more precisely, their accelerations) is the same as the duration of the current cycles of solar activity, for which an eleven-year cycle is characteristic (Fig. 1B, 7, 8). The curves of solar activity and of the Earth' s pulsations in Baku relative to Makhachkala are in antiphase. A close relationship is obtained between the Earth' s pulsations and sol-

lunar activity, and moreover the phase of the oscillations of solar activity and of the Earth' s crust is anticipatory. High activity in the motion of the Earth' s crust often falls in epochs of current minima of solar activity and, conversely, a weakening of the accelerations of pulsational motions corresponds to epochs of current maxima of solar activity.

An approximately analogous picture of changes in the Earth' s pulsations is also often observed for other points on its surface, for which the available observational material, covering only a short period of time, makes it possible to identify only a few complete cycles of change in the acceleration in the pulsational motion of the Earth' s crust.

Thus, the question of whether traces of the manifestation of solar activity exist in the motions of the solid Earth receives a positive answer on the basis of analysis of concrete material. Modern pulsational vertical tectonic motions of the Earth are covertly connected with solar activity, and this connection becomes especially clear when a more sensitive criterion of motion—acceleration—is introduced into the analysis.*

Modern tectonic movements relative to tide gauges within the platform are revealed not only for regions of geosynclinal areas of the Caspian Sea (Makhachkala, Baku, Zhiloy Island, Cheleken, Sara Island, etc.), but also for regions of the platform areas of the eastern part of the Caspian Sea (Fort Shevchenko, Bektash, Kara-Bogaz-Gol, etc.).

Table 1

Acceleration of pulsational movements of the Earth' s crust in Baku

relative to Makhachkala (cm/year^2)

Years	Acceleration	Abs. magnitude of acceleration from wavelets with sliding thirds	Years	Acceleration	Abs. magnitude of acceleration from wavelets with sliding thirds
1901–1900	+7	4,5	1932–1931	−1	2,7
1902–1901	−6	4,9	1933–1932	+1	3,6
1903–1902	+3	4,2	1934–1933	+6	5,5
1904–1903	−4	3,2	1935–1934	−1	6,6
1905–1904	+2	2,2	1936–1935	+61	5,8
1906–1905	−1	1,4	1937–1936	+1	4,0
1907–1906	−1	1,0	1938–1937	−4	3,2
1908–1907	0	0,8	1939–1938	+2	2,8
1909–1908	+2	0,9	1940–1939	−5	3,4
1910–1909	0	1,0	1941–1940	0	3,5
1911–1910	+1	1,4	1942–1941	+8	4,3
1912–1911	−3	2,2	1943–1942	−4	4,0
1913–1912	−2	2,8	1944–1943	+2	3,7
1914–1913	+5	2,9	1945–1944	−4	3,2
1915–1914	−2	2,0	1946–1945	+3	2,9
1916–1915	0	1,0	1947–1946	−3	2,9
1917–1916	0	0,5	1948–1947	+1	3,0

Years	Acceleration	Abs. magnitude of acceleration from wavelets with sliding thirds	Years	Acceleration	Abs. magnitude of acceleration from wavelets with sliding thirds
1918–1917*	0	0,7	1949–1948	+5	3,5
1919–1918	+2	1,3	1950–1949	−5	3,6
1920–1919	−2	2,3	1951–1950	+1	3,9
1921–1920	−2	3,2	1952–1951	+4	4,9
1922–1921	+7	3,9	1953–1952	−9	6,0
1923–1922	−3	3,3	1954–1953	+7	5,9
1924–1923	−2	2,7	1955–1954	−4	4,6
1925–1924	−1	1,9	1956–1955	+2	3,2
1926–1925	+3	1,9	1957–1956	+2	2,5
1927–1926	−1	1,9	1958–1957	−4	2,6
1928–1927	−2	2,4	1959–1958	0	2,9
1929–1928	+3	3,1	1960–1959	+5	4,1
1930–1929	−5	3,5	1961–1960	−6	4,6
1931–1930	+4	3,1			

* Owing to the absence of a series of observations during 1917–1920, the data for these years are approximate.

Moreover, the velocities of pulsational vertical movements of tide gauges in platform regions are no less than the velocities of vertical movements of geosynclinal regions, and this is with respect to a tide gauge located in a platform region (Kuuli).**

* This correspondence is so distinct that the thought arises whether an intensification of solar activity, through a series of as yet unknown geophysical changes, causes activation of the processes of the internal development of our planet and of its tectonic rhythm, thereby determining, for modern pulsational vertical movements, to some extent both the rhythmicity itself and its duration.

** However, if the velocities of vertical movements in platform and geosynclinal regions are approximately the same, then the geosynclinal regions are often distinguished by a significant amplitude of the total resultant course of vertical movements (here a directed subsidence is often noted, as, for example, in Baku, Cheleken, on Sara Island, or uplift, for example, within the growing anticlinal fold of Zhiloy Island), whereas

Fig. 2. Contemporary pulsations of the Earth and fluctuations of solar activity. Change in the absolute values of the accelerations of contemporary pulsational vertical movements according to two-year moving intervals (cm/year^2): 1 —Sary relative to Baku, 2 —Sary relative to Makhachkala, 3 —Baku relative to Makhachkala, 4 —Baku relative to Kuli, 5 —multiyear fluctuations of solar activity (Wolf numbers W).

An interesting picture is revealed with respect to the acceleration of the vertical movements of Baku relative to Kuli (Fig. 2). It is approximately the same as for Baku—Makhachkala. However, the curve of the mean annual absolute values of the acceleration of the vertical movements of Baku relative to Kuli, in comparison with the curve of change in solar activity, is in the same phase (the increase in the accelerations of vertical movements occurs with intensification of solar activity). At the same time, the magnitude of the acceleration of the vertical movements of Makhachkala relative to that of Kuli, in comparison with the curve of change in solar activity, is, naturally, in antiphase.

Thus, the possibility arises of studying the influence of solar activity on pulsational oscillations of the Earth' s crust depending on the state of the latter in a given region (geosynclinal and platform areas, etc.).

Numerous works have proved the close connection of many geophysical processes with solar activity ((6) and others). This concerns the physics of the atmosphere and hydrosphere and the biosphere associated with them. In the present article it has been shown that such a connection also exists with respect to the solid Earth; thereby there arises the problem of geophysical changes in the structure and process of the internal development of the Earth in connection with cosmic influences.

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* Platform regions are usually marked by a smaller amplitude of the overall resultant course of these movements. Examples of the latter are Bektash, and also Krasnovodsk, where the resultant course of vertical movements for 1923–1960 amounted to only +5 cm. If, on the basis of this figure, the average velocity of vertical movements over 37 years is calculated, it amounts to about 0.14 cm/year. It is clear that this "average" value is of no significance for estimating the velocity of vertical movements for the same Krasnovodsk, which is measured by much larger values. The same is also true with respect to Fort Shevchenko, for which the resultant course of vertical movements over 34 years (1924–1957) led almost to the initial position (a lowering by 3 cm), whereas in fact Fort Shevchenko underwent a whole series of significant vertical displacements. Compared with Fort Shevchenko, even Makhachkala, situated near the trough, underwent somewhat smaller amplitudes in the course of vertical movements.

Note: Figure translations are in progress. See original paper for figures.