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Global factors in dynamics of petrophysical processes

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In the classical description of the structural-tectonic fragments of the earth crust the vast territories of ancient platforms are represented as geodynamically passive elements of the lithosphere. That is why the nature of various phenomena occurring on the platform (landslides and karst-suffosion processes, rock bursts and gas explosions in mines, pipeline breaks, etc.) is usually associated solely with the processes of exogenous changes in the geological environment, formed by rocks of sedimentary cover [*Natural Hazards in Russia*, 2002]. However, the results of many years investigations of the geodeformation regimes of the geodynamically (seismically) active and platform regions allowed experimentally establish [*Rudakov*, 2009] that in the preparation of catastrophic geodynamic phenomena (earthquakes and volcanic eruptions) prominent role played by the processes of global change of the stress-strain state of the lithosphere due to the processes of self-organization under the influence of the Earth velocity rotation variations. In particular, it was shown that these processes are reflected in the changes of fluid dynamic regimes of the fault structures of the East European Platform (EEP), influencing the processes of the exogenous geological environment transformation, and, appearing in the rocks of the sedimentary cover by the local geodynamic processes and phenomena. For example, it was found that the dynamics of accidents on the routes of gas pipeline networks of the EEP is connected with the wave motion of the platform, as well as with the processes of cyclic fluid transmission in the fault transcontinental and regional tectonic formations that form the dynamics of the karst-suffosion processes in the territories of the Moscow depression [*Rudakov*, 2008].

Continuing to investigate the links in the chain of cause-effect dependence of the local geodynamic phenomena and processes from the processes of global change in the stress-strain state of the earth's crust, we made spectral and correlation analysis of a half century (49 years) time series of mean annual cases of the karst gap formation in Dzerzhinsk, Nizhny Novgorod region in comparison with the variations of the water level in the Oka River, which flows in the area, variations in the Earth's rotation and the change in solar activity. It allowed to trace the development of karst-suffosion processes influenced by changes in fluid dynamic regimes in the region controlled by variations in the stress-strain state of the earth's crust in the region associated with variations in the Earth's rotation and changes in solar activity, controlling the climate changes on the Earth as a whole, and in each particular region of the planet.

Note that the problem of assessing the influence of solar-terrestrial relationships in the processes of the terrestrial atmosphere, hydrosphere, and even biosphere, after A.L. Chizhevsky concerned by many researchers [*Rivin*, 1989] but geological and geophysical aspects of this problem are practically not affected. Especially not enough investigated the processes that control in the platform conditions the development of the exogenous processes, such as the karst-suffosion. And in this respect the opportunity to examine long-term observations, of the" Dzerzhinsk karst observatory" of the Nizhny Novgorod region allowed, as it seems to us, to take another step toward assessing the extent of planetary processes influence on the dynamics of the geodynamic processes of the local scale.

Fig. 1 shows the original time series of mean annual variations of the Earth's rotation velocity (relative value), solar activity (Wolf numbers), cases of karst gaps in Dzerzhinsk and the water level in the Oka river, which were analyzed on the basis of calculation the spectral-temporal and correlation characteristics of these time series and their components identified by energy filtering.

Fig. 2 shows the calculated values of the cross-correlation function (CCF) between the analyzed time series.

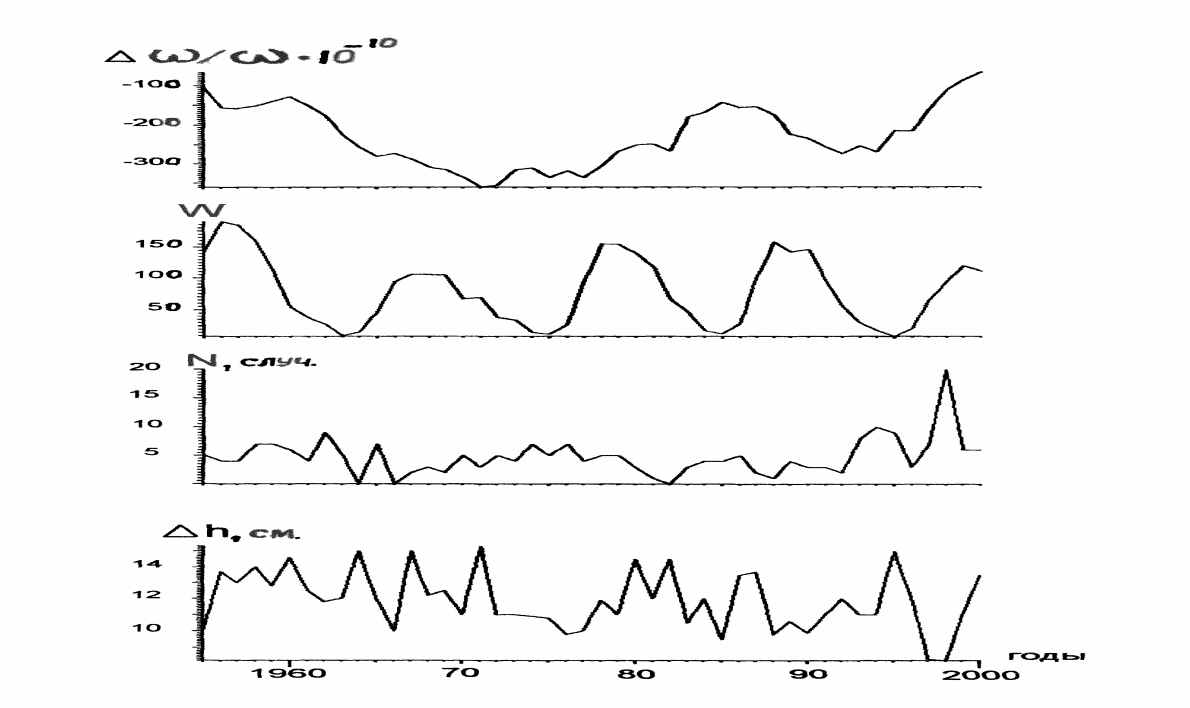

Fig. 1. Time series of variations of the average annual values (from top to bottom): the Earth's rotation velocity, solar activity index; karst gaps in Dzerzhinsk, water level variations in the river Oka

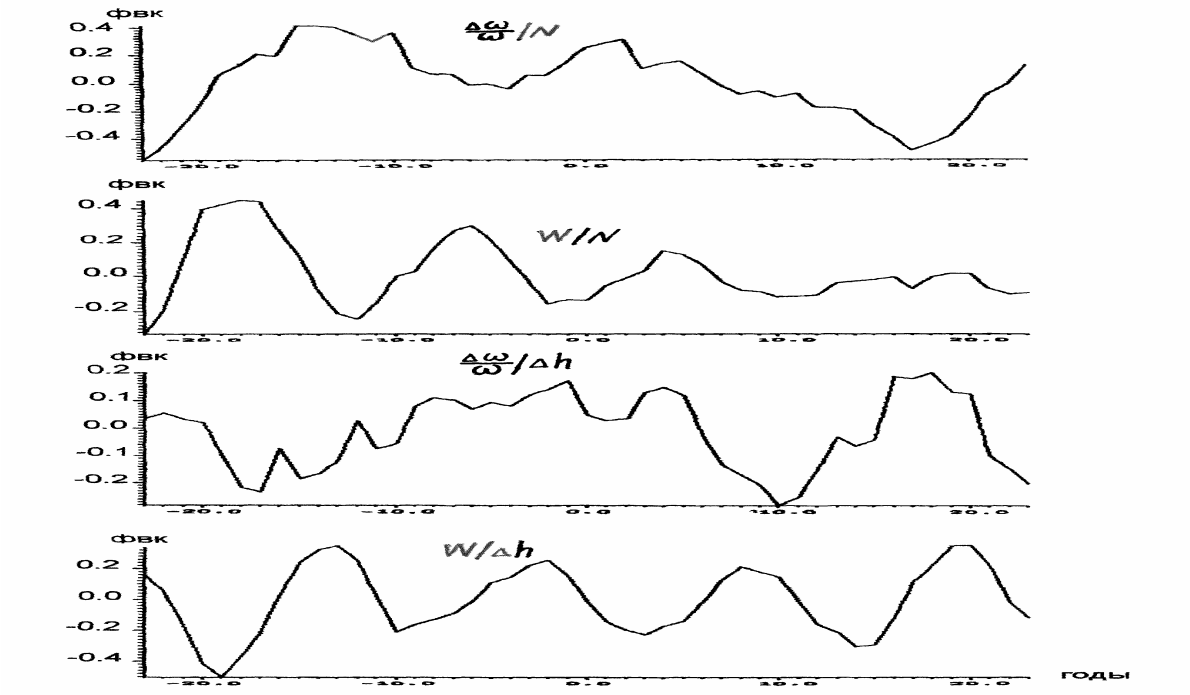

Fig. 2. Graphs of the cross-correlation between the time series (top to bottom): variations in the Earth's rotation and the number of karst gaps in Dzerzhinsk, variations in solar activity and the number of karst gaps in Dzerzhinsk, variations in Earth rotation velocity and variations of water level in the river Oka, variations in solar activity and water level variations in Oka river

As can be seen from fig. 2a, the characteristic of CCF between variations in the Earth's rotation and the number of karst gaps in Dzerzhinsk, indicate of a weak (K=0.25) but significant (P=0.9) direct correlation, as well as the correlation with a shift 2 years and 17 years. In this case, the spectrum allocated CCF peak with a period of 22 years, typical for a spectrum of variations in solar activity.

At the same time, from fig. 2b follows that, despite the absence between the time series of solar activity variations and the number of karst gaps in Dzerzhinsk (2b) direct significant correlation, the form, of resembling a damped sinusoid with a period of 11 years is testimony to the presence of a significant correlation in retrospect. In this case, the correlation coefficient with a shift in the past 17 years is significant K = 0.5 (P= 0.9). In the spectrum of the CCF of these parameters are distinguished peaks with a period of 11 and 5 years, which are also characteristic for the spectra of the time series of precipitation falling in the region.

The influence of global factors on the variation of water level in Oka, associated with the hydrodynamic regimen of the region, manifested as follows.

According to the cross-correlation function between the variations of Earth rotation and variations in water level in the Oka (fig. 2c) there is no direct significant correlation. However, with a lag of 10 years there has been significant (P = 0,9) negative correlation (R=-0.3) between these parameters and the spectrum of CCF stand out peaks with a period of 11 years and 22 years.

Between the time series of solar activity variations and water level variations in Oka (fig.2g) direct significant correlation is also absent, however, the function has the form of almost regular sinusoid with a period of 11 years, indicating the relationship of changes in water level in Oka with variations in solar activity. In the spectrum of CCF stands clear peak with a period of 11 years.

Proceeding from the results of mathematical analysis of time series of seemingly unrelated parameters, we attempt to assess the influence and role of global factors (variations in the Earth's rotation and changes in solar activity) in the chain of cause-effect relations of the formation and development of local geodynamic processes and phenomena to what are primarily karst-suffosion processes in the Russian platform.

Note that the conventional model of karst-suffosion processes and formation of karst gaps [*Lomtadze*, 1977] assume the aggressive participation in them of the upper aquifers of the underground hydrosphere. Nevertheless, this participation confined to the filtration properties of a specific rock complex, in which suffusion develops, and virtually ignored the space-time structure of the fluid dynamic regimes formation in the region under the influence of global geodeformation processes.

Influence of the fluid dynamic regime variations of the geostructural complex of Nizhniy Novgorod region on the dynamics of the karst gaps formation in Dzerzhinsk, as can be seen, have found an indirect reflection in the results of the interrelation and spectral analysis of the corresponding time series. The direct connection between dynamics of karst formation gaps and variations with variations of water level in the river Oka clear in the negative extremum in the curve of interrelation functions without any shift on the horizontal axis relative to the zero coordinates. Latter shows almost simultaneous increase in the number of failures in response to the lowering of water level in Oka. At the same time, the periodic components, released as a result of interrelation of time series analysis of water level variations in Oka, in comparison with the components of time series of solar activity variations and changes in the Earth's rotation for 11 years and 22 years, as well as the periodicity, standing out in the spectrum of time series of the karst gaps and water level in the Oka duration of about 2 and 4 years and 8, 11, and 22 years, directly indicate the relation with the processes of global scale [*Rivin*, 1989]. This is also confirmed by the results of spectral analysis of time series of monthly averages of solar activity variations and changes in the Earth's rotation, the frequency spectrum sliding correlation functions are fairly allocated the same frequency lasting 2 and 4 years, 8, 11 and 22 years, as well as components with a period of 1 year.

Nature of the trend (regional) component of the time series of karst failures, selected by the energy filter, similar to the nature of the trend component of the change in the Earth's velocity variations is an additional argument in favor of approval of the connection of local geodynamic phenomena, to what is the periodic activation of karst-suffusion processes in the Nizhny Novgorod region, with the processes of global scale.

Thus, according to the investigation results the dynamics of the karst-suffosion processes on the territory of the Nizhny Novgorod region (as, apparently, and the entire Russian platform) is due to changes in fluid dynamic regimes of underground hydrosphere. In turn, changes in fluid dynamic regimes of the geostructural elements of the Russian platform is controlled, on the one hand, by the variations of solar activity influencing change in the Earth rotation and the change of meteorological parameters and on the other hand, is determined by variations in the Earth's velocity rotation, controlling the nature of the stress-strain the Earth's crust as a whole and on a regional scale in particular.

Revealed regularity create the preconditions for creating an algorithm predicting the development of spatial-temporal structure formation and activation of a vertically upward flow of fluid in the structural-tectonic units of the earth crust, which accelerate the development of the karst-suffosion phenomena, representing one of the main geo-environmental problems in many regions of the Russian platform.

References

1. *Natural Hazards in Russia. Exogenous geological hazards* (2002), eds. V.I. Osipov, et al., Moscow: Kruk, 345.

2. Rudakov, V. P. (2009), *Emanation monitoring geo-environment and processes,* Moscow: Scientific World, 176 p.

3. Rudakov, V. P. (2008), *Manifestation of modern geodynamics of the Russian platform in the technological processes and emanation fields*, ANRI, № 2, pp. 64–71.

4. Rivin, Y. R. (1989), *Cycles of the Earth and Sun,* Moscow: Nauka, 165 p.

5. Lomtadze, V. D. (1977), *Engineering geology. Engineering Geodynamics*, L.: Nedra, 479 p.