Structure of East European plain as a geosystem forming factor

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Modern geodynamics is an active developing science which uses all achievements of dynamic systems theory and synergetics. It becomes clear nowadays that geodynamical processes include wide range of spatial-temporal frequencies commensurable with climatic and biophysical conditions. Latest researches of geodynamic processes in area of various scale faults demonstrate wide range of their biophysical and biochemical activity. Its research – is a task of near future. Modern data allow to believe that geodynamic state of specific territory is not a constant but an active factor of landscape dynamics and its components, connected with components by positive and negative feedback. The way to develop this research is through relief structure analysis. It reflects all spatial-temporal diversity of interactions between relief and other components. Relief is interpreted as reflection of dynamic processes for certain moment of time. This approach bases on classic Fourier analysis which connect the power of relief-generating process with spatial scale.

Analysis of Fourier spectrum enables to calculate fractal dimension of dynamic system attractor, to prove existence of quasiharmonic oscillations and to determine quantity of inducing factors (order parameters in terms of synergetic). Then we can explore spatial rules on level of each quasiharmonics. Every harmonic produces its own set of earth surface forms. Each harmonic has its own energy capacity. That is why we, staying within frames of classic landscape science, can assess the role of harmonics in spatial hierarchical organization of landscape. Thus, the proposed approach considers relief as the dynamic basis of landscape and explores its conditions not only as the function of denudation and accumulation but also as a function of geodynamic processes acting through geophysical and geochemical variables.

We considered territory of East European plain. Initial data is digital elevation model provided by US Geological Survey. Researched territory lays between 40º and 90º north and 20º and 60º east. Its initial projection – latitude/longitude, WGS-84 model. It was transformed to Albers equal area projection with reference longitude 40 degrees east and two transverse parallels – 45 and 65 degrees north. Spatial resolution – 1km^2.

Spectral analysis was realized for 2000 x 2000 km square in the center of image by standard forward Fourier transform. Two projections to X and Y axis were taken into analysis according to Turcotte method (1997). Spectrum power was used in logarithmic scale. Like all similar cases, spectrum power is function of frequency or wave number. The lower the frequency the higher power logarithm. Parameter of regression line allows to calculate fractal dimension – in our case it is 2.2 approx. This means that regression line has rather low slope degree and territory is characterized with rather low degree of disjunction, low diversity of relief forms. Regression residuals prove hypothesis of quasiharmonic existence. Their frequencies subordinate to the rule of non-linear oscillator ($f_i=nf_0$, where n is integer). Spectral analysis of residuals reveals that there are no more than three factors determining deviation from fractal process. Statistical reliability of quasiharmonisc allows to detach hierarchical levels of relief organization and most probably, the landscape.

Analysis of spatial structure of different hierarchical “waves” helps us to outspeak hypothesis of geodynamic forces direction. Each hierarchical level has been restored by inverse Fourier transform. First four of them can be seen on fig. 1. This hierarchy creates basis for researches of all components of landscape and their relations with relief on each hierarchy level. The highest level (820-1024 km) among all structures we can see the following ones with positive sign: 1. Kola peninsula, 2. Timan ridge, 3. Walday – Smolensk-Moscow – Minsk uplands, 4. Podolsk uplands, 5. Ergeny, 6. Bugulminsko-Belebeevskaya

upland. Negative structures on this level – 1. Onega-Baltika zone, 2. Watershed of Volga and Vyatka rivers, 3. Pridnieprovskaya lowland, 4. Pricaspiiskaya lowland.

By the same way we can describe hierarchical levels - 330 to 1024 km, 118 to 330 km, 52 to 118 km, 33 to 52 km and 16 to 33 km. Individual maps show that large-scale structures coincide with uplifting and sinking zones of East European platform. Middle-scale structures coincide with local zones of tectonic movements, low-scale structures reflect erosion network partially influenced with different glaciation zones (which are also seen on maps). The result of the work is detailed information about hierarchical structure of territory, morphological units on each hierarchical level, information about tectonic movements.

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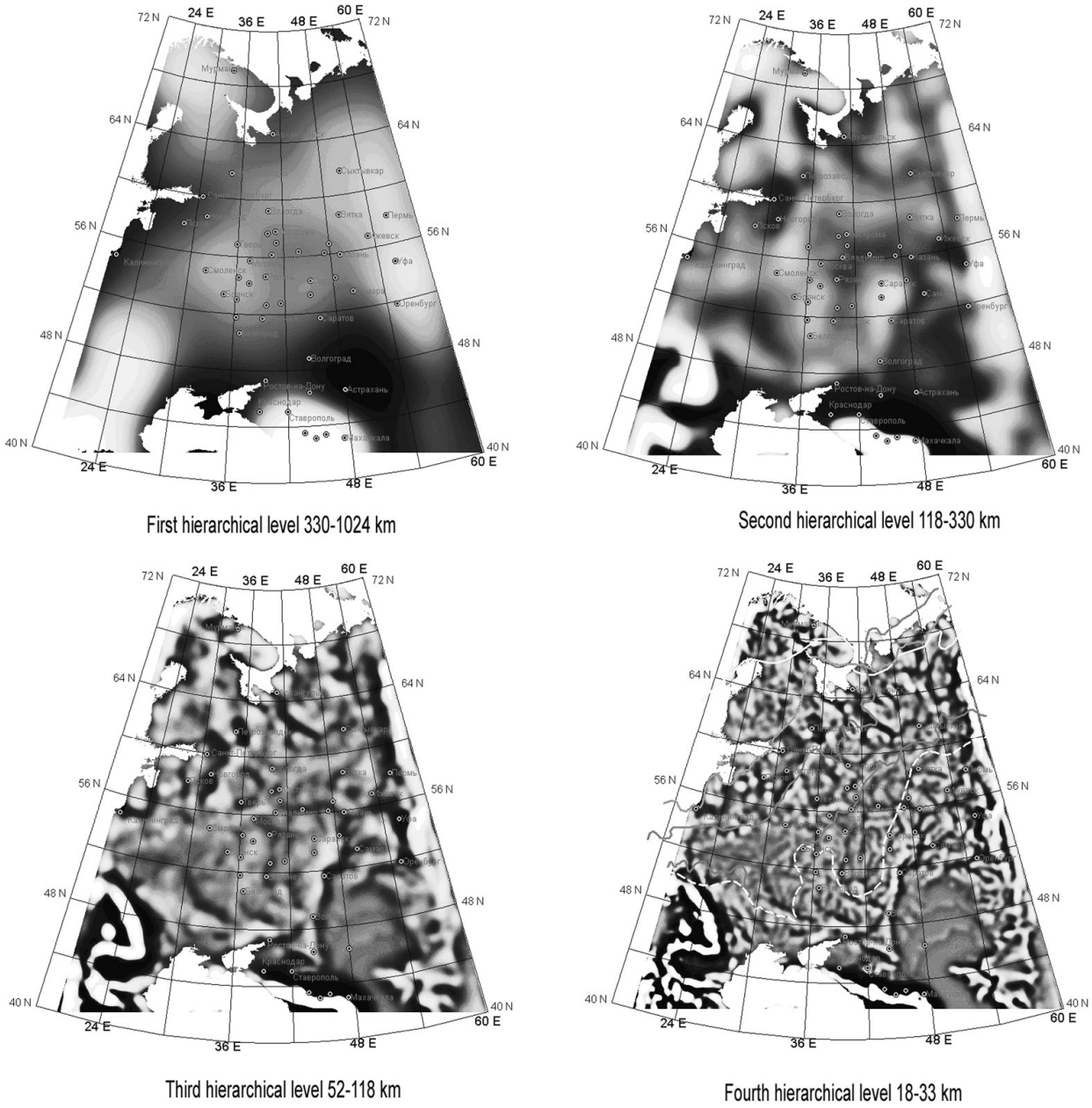

Figure 1. Four hierarchical levels of East European plain.

References

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