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Estimation of neotectogenesis factors of the Middle Dnieper region by structural-morphometric method

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SUMMARY

The research involved methods of remote sensing of the Earth, structural-morphometric analysis and geoinformation systems on the basis of which the connection and direct dependence of neotectonic movements, structural forms and modern relief were established. The main three morphostructural complexes (Kiev, Obukhiv, Kaniv-Trakhtemyriv blocks) were identified and analyzed, each with its own dominant factor. On the basis of the obtained indicators of the total amplitudes of the oscillations of the elevation of the relief, the features of the neotectonic evolution of different morphostructures, which are subject to individual rhythms, are revealed, and indicates the general complication of the morphostructural appearance of the region. It is confirmed that the northern regions of the region had an active upward movement dynamics in the Neogene epoch, and the southern ones in the Quaternary period. In general, the amplitude of fluctuations in the elevation of the right bank of the Middle Dnieper in the Neogene-Quaternary period in the northern part was 100 m, in the southern - 135 m. Obtained data on the dynamics of the region can serve as a basis for the estimation of erosion-denudation and landslide processes within the Middle Dnieper.

Introduction

The territory of the Middle Dnieper region is geostructurally related to the north-eastern slope of the Ukrainian Shield and the Dnieper-Donets Basin. Geomorphologically, the territory is located on the Kiev plateau within the Dnieper Upland, which is cut by ravines and beams from Kyiv to Kanev. Since modern relief is the result of the interaction of endogenous and exogenous processes, the study of relief forms with the determination of patterns of manifestation of structural and orographic forms is the main task in the analysis of the processes of influence of tectogenesis and morphogenesis, both on the morphostructural features of the territory and on the manifestation of modern. The applied structural-morphometric method makes it possible to determine the spatial-temporal patterns of the neotectonic activity zones, to identify areas with high gradients of the latest tectonic movements and their influence on the formation of modern relief. This method is a tool for detecting the genetic link between geomorphological and tectonic processes, between the forms of the earth's surface and the structures of the earth's crust. According to the results of structural and morphometric studies, the reconstruction of the tectonic development of the territory is carried out through the development of relief in modern times, the calculations of the amplitude of tectonic movements, the establishment of stages of tectonic activation and the analysis of the potential development of dangerous geological processes. (*Ivanik and Tustanovska, 2011*).

Method and/or Theory

One of the main methods that allows to determine the main stages of morphogenesis and tectogenesis of the territory is structural-morphometric, which in combination with methods of remote sensing of the Earth, GIS-analysis and statistical calculations provides an opportunity to reconstruct the latest geodynamics of the region. The method of structural morphometry is based on the graphical decomposition of the relief into basal, residual, top and erosion surfaces according to the order of valleys and watershed lines (*Philosofov, 1975*). It involves a series of mapping operations, making it difficult to use in regions with complex, sharply dismembered terrain.

Examples (Optional)

The dynamics of the structures formed in the recent period was evaluated by analyzing the constructed maps of valley order and base surface maps, taking into account the layered terrain and terraced levels (*Nasarenko, 1969*). To create a series of morphometric maps, we used Earth remote sensing data and geoinformation technologies, which are an effective tool in the comprehensive study of topography, first of all, quantitative and qualitative interpretation of morphometric data, as well as for the selection of diverse geo- and morphostructures by data set. Specialized GIS modules were used for satellite image processing (*Ivanik, et al, 2019*).

In the course of the research, a map of the valleys related to the geological age was constructed on the territory of the Middle Dnieper. The higher the order, the older the valleys, which are laid in tectonically weakened zones of the crust (faults, cracks). (*Mironenko, 2007*). The geological age of the valleys is determined by the age and number of terraces. On the territory of the studied region, the Dnieper River valleys (10th order) and Rosava (9th order) have the highest orders, which confirms their formation in the Quaternary time..

On the basis of the obtained map of the valley orders, 10 maps of baseline surfaces were constructed in the studied territory and further geological-geomorphological interpretation of the obtained data was performed.

The interpretation of the morphometric maps of the corresponding orders made it possible to trace the evolution of the relief of the morphostructures in the Quaternary period. In the Neogene, upward movements were prevalent in the study area, but with smaller rhythms and shorter periods and smaller amplitudes of tectonic movements (*Palienko, 1992*). Such changes took place all over the right bank, as evidenced by the construction of morphometric maps of the basic surfaces of the highest 10s, 9s and 8 orders, and the sequential block formation of morphostructures was recorded. Each of the maps

captures a separate stage of paleo-relief formation, which distinguishes the sequential formation of morphostructural complexes: the first of which is Obukhov block with maximum altitudes up to 140 m and minimum - 90 m; the second one is formed by the Kiev block, which has a slight relief in relief with maximum altitudes up to 120 m and minimum - up to 90 m; to the south of Rzhyshechiv the formation of the third lift, which in the future will form the Kaniv-Trakhtemyriv block, has been started, with a slight excess of relief up to 25 m (fig. 1).

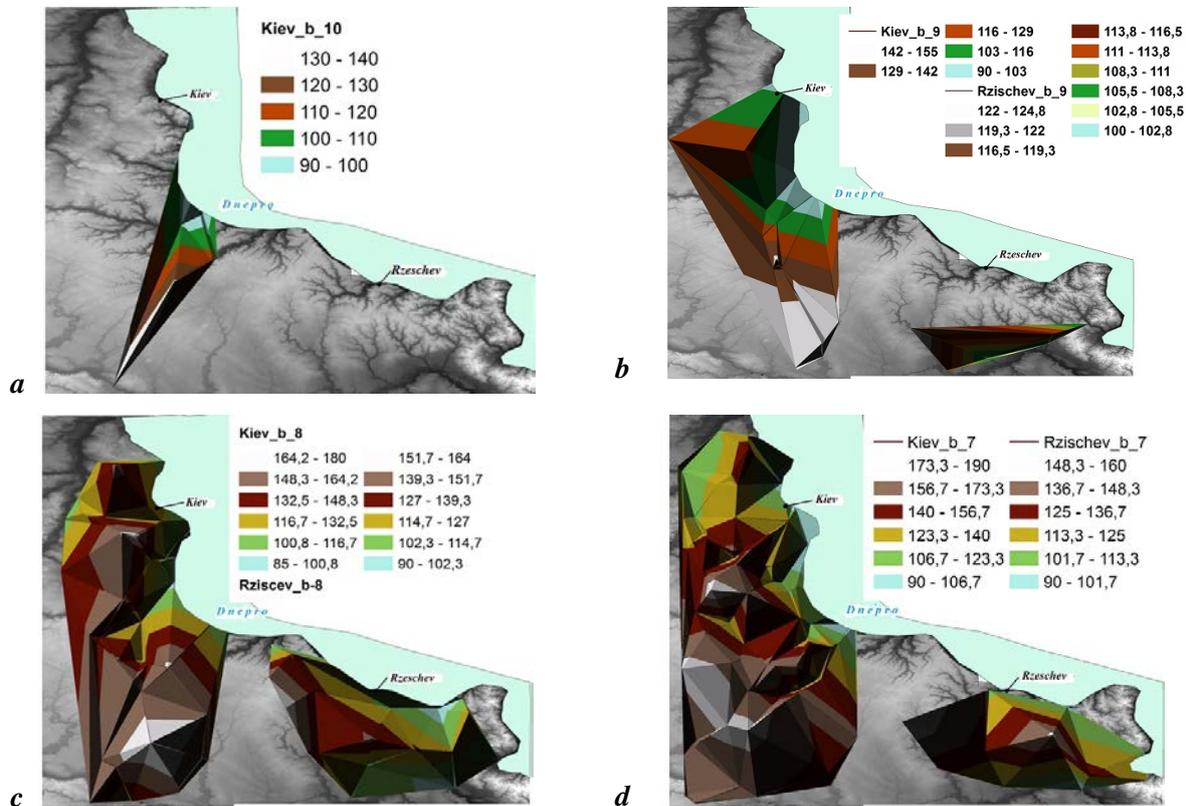


Figure 1. Formation of the Right Bank of the Middle Dnieper in the Quaternary (maps of the base surfaces of the 10th (a), 9th (b), 8th (c) and 7th (d) orders)

Further analysis of the morphometric data allows us to trace, during the Pliocene time, the differentiation of the activity of the earth's surface movements within the separate stages of paleorelief formation, which is fixed by a map of the basic surface of the 7th order. At this stage the weak tectonic activity of the Kiev and Obukhov blocks with elevations of up to 10 m is highlighted. The Dnieper valley at this time occupies the eastern position relative to the present. The end of the Neogene and the beginning of the Quaternary period is characterized by the restructuring of the structural plan of the Middle Dnieper and the activation of tectonic movements of the crust with dominant ascending movements, which outline the main heterogeneous regional morphostructures. At this time, almost completely formed dividing system of the right bank, which is confirmed by a map of the base surface of the 6th order. At this stage, the Kaniv-Trakhtemyrovsky block is clearly outlined, whose altitudes have increased by 25 m. At this time, the Dnieper Valley is being restructured, the erosion base is deepening by 5 m and is 85 m.

The next stage of the early Quaternary is recorded by a map of the basal surface of the 5th order, recording different dynamics in the northern and southern regions of the Middle Dnieper. The amplitude of the oscillations of the elevation of the relief of the Kiev block is insignificant and is 5 m, and the Kaniv-Trakhtemyrov block, on the contrary, with an intense tectonic activity of 25 m, is expressed in relief marks - 210 m.

The 4th order baseline map identifies the next stage of development of the Middle Dnieper, which probably corresponds to the formation of the Dnieper glacier and is characterized by uneven movement of the north and south regions of the Right Bank. The sections of the Kaniv-Trakhtemyrivsky block at this time rise to 250 m, which is 40 m higher than the previous stage of development. During this time, the Kiev block rises only by 10 m, and the base marks remain at the previous level. However, individual fragments of the Kyiv and Obukhov blocks are characterized by significant amplitudes of up to 100 m.

Interpretation of the data of the 3rd order basis surface map captures stable tectonic conditions in the northern parts of the region and slight activation of movements in the southern regions with maximum altitudes up to 255 m and minimum 80 m, erosion bases decreasing by 5 m. this time occupies the highest gypsum position in the relief. The northern slopes of the Right Bank are characterized by low activity of tectonic movements.

The penultimate stage of the formation of the Middle Dnieper is characterized by a map of the basal surface of the 2nd order. At this time, the Dnieper Valley is being restructured, the erosion base decreases by 5 m, the relief mark increases to 215 m, with corresponding oscillation amplitudes up to 5 m. At this stage, weak differentiated movements in the northern parts of the region (Kiev block) and stable in their altitudes are recorded. southern area caused by post-glacial processes (*Tustanovska, 2014*).

Modern relief develops against the background of prevailing upward movements along the Right Bank of the Dnieper. The interpretation of the data of the modern relief captures the dynamic activity of the northern part (Kyiv and Obukhov blocks) with the amplitudes of the elevation fluctuations up to 25 m, which results in the intensive cutting of the valleys into the intersectional spaces and the formation of positive structures. The southern area of this stage undergoes slight changes in the tectonic plan, the amplitude of the elevation oscillations increases only by 5 m, the highest altitudes recorded at Kaniv and Buchach-Trakhtemirev blocks are 260 m. m. According to MI Of Nikolaev, during the quarter period as a result of tectonic activity activation of fault zones which have inherited character occurs (*Nikolaev, 1962*).

Conclusions

On the basis of the complex application of structural-morphometric analysis, methods of remote sensing of the Earth and GIS-analysis, the evolution of the Middle Dnieper paleo-relief was reconstructed in the recent period, which was differentiated. Three large geostructures were identified and characterized (Kyiv, Obukhiv, and Kaniv-Trakhtemyriv blocks), quantitative terrain indices were determined during each stage, total amplitudes of terrain height fluctuations were analyzed both over short intervals of time and over the entire Neogene period. In general, the amplitude of fluctuations in the elevation of the Middle Dnieper terrain during the Neogene-Quaternary period in the northern regions was 100 m, in the southern 135 m. The differentiated nature of neotectonic movements and changes in their activity over time were reconstructed. It is confirmed that the northern regions of the region had an active upward movement dynamics in the Neogene era, and the southern ones in the Quaternary period. The data obtained can serve as a basis for analyzing the impact of tectonic processes on the activation of hazardous geological processes within the Kiev and Kaniv Dnieper and forecast their future development.

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