Geomorphosystemic prognostic model of technogenic pollutants migration in earth's crust

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SUMMARY

Direct man-made human activity in the lithosphere can now be traced to depths of more than 13 km. Solid and liquid wastes from various industries with groundwater can penetrate even deeper. Identification of migration routes and places of accumulation of man-made pollution in the earth's crust is an urgent task today. Their direct observation by technical means is limited by a grid and is possible only to certain depths. Therefore, it is necessary to create prognostic models of migration of man-made pollutants, using modern knowledge about the formation and spatio-temporal organization of the earth's crust. The geomorphosystem (the historical-dynamic morphosystem of the Earth) played an important role in this, creating its own "space-time" - the geomorpholithosphere. The geomorphosystem model of the geomorpholithosphere allows tracking the movement of man-made pollutants in the earth's crust. It uses the "natural" structural framework (buried valleys, etc.) of the geomorpholithosphere. In the geomorpholithosphere, in real time, the material reliefs of the previous cycles of development of the historical and dynamic morphosystem of the Earth are preserved. The Earth's gravitational field integrates geologically diverse elements, creates, forms systemic connections between them, determines their functions and trends of material displacements, energy transformations, information transfer, entropy exchanges in the geomorpholithosphere. The historical and dynamic morphosystem of the Earth and the geomorpholithosphere create a theoretical concept of a prognostic geomorphosystem model of migration of man-made pollutants in the Earth's crust. The prognostic geomorphosystem model of the geomorpholithosphere is created on the basis of the morphochronodynamic concept of geomorphology. In the geomorpholithosphere of the plain-platform territories, the structural elements of the historical-dynamic basin geomorphosystems are considered. They have been used in applied research (forecasting and exploration of various sedimentary minerals, forecasting the behavior of pollutants in the lithosphere).

Introduction

Man-made human activity can be traced in the earth's crust to a depth of more than 13 km, and waste from various industries can penetrate with groundwater even deeper. Identification of migration routes and places of accumulation of man-made pollution in the earth's crust is now an urgent task. Their direct monitoring by technical means is impossible from certain depths and is limited by a certain artificial grid. We need prognostic models of migration of man-made pollutants, which should be created on the basis of modern knowledge about the formation and spatio-temporal organization of the earth's crust. The geomorphosystem (*historical-dynamic morphosystem of the Earth*) played an important role in it, created its own space-time - *the geomorpholithosphere*. The geomorphosystem model of the earth's crust uses a *structural framework* created by its "natural" invariants, in particular, *buried valleys* and other conservative elements. Such a model logically and on the basis of actual data substantiates the migration of man-made pollutants in the earth's crust. Modern geomorphology is no longer a *"top"* science that studies only the ***exposed*** *earth's surface*. Its *common* object is the geomorpholithosphere, which is *five-dimensional* one, its real space-time is collected from the material ***reliefs*** of *previous* cycles of development of the historical-dynamic morphosystem of the Earth. The Earth's gravitational field integrates into the system various-cycle elements of the geomorpholithosphere, determines the functions of the latter (transit, accumulation), determines trends in matter movements, energy transformations, information transfer, entropy exchanges, and the *object-connection* (Platon) in it - *water*, with which moves man-made pollution. The historical-dynamic morphosystem of the Earth and its space-time - geomorpholithosphere create a theoretical, methodological, methodical basis for the *prognostic geomorphosystem model* of migration of man-made pollutants in the Earth's crust. The prognostic geomorphosystem model can be used in regional researches of territories and monitoring of ecological and nature protection orientation.

Method and theory

The prognostic geomorphosystem model is created on the basis of the following theories and methods:

- *The theory of nonequilibrium thermodynamics* theoretically substantiates the existence of the historical-dynamic morphosystem of the Earth and its geomorpholithosphere;
- *The general theory of systems* allows to allocate system elements of historical and dynamic morphosystem of the Earth;
- *Morphochronodynamic concept* substantiates at the level of theory, methodology, tasks, own method of studying the historical and dynamic morphosystem of the Earth;
- *Morphochronodynamic analysis* develops methodological algorithms for structuring the historical and dynamic morphosystem of the Earth at the regional level;
- *Paleogeomorphological analysis* performs historical (step-by-step) analysis of the historical-dynamic morphosystem of the Earth;
- *Socio-economic analysis* determines the sources, types and forms of man-made pollution of the studied areas;
- *Cartographic method* collects, summarizes, displays data on the historical and dynamic morphosystem of the Earth and man-made pollution of the geomorpholithosphere (*earth's crust).*

Examples

At the department of earthology and geomorphology of the faculty of geography of Taras Shevchenko National University of Kiyv, geomorphosystem modeling is used in various theoretical and applied directions of geomorphology: denudation chronology (I. Rosly); geomorphological mapping (Yu. Grubrin), paleogeomorphological analysis (Yu. Koshik, O. Komliev, S. Bortnik, N. Pohorilchuk, Yu. Filonenko), morphostructural analysis (S. Bortnik, V. Timofeev, O. Kovtoniuk , T. Lavruk), ecological geomorphology (V. Stetsiuk, O. Komliev), exploratory and engineering geomorphology (E. Palienko, V. Stetsiuk), beligerative geomorphology (O. Komliev, V. Stetsiuk, O. Kovtoniuk).

Results

The prognostic geomorphosystem model of the geomorpholithosphere (earth's crust) is created on the basis of the morphochronodynamic concept of geomorphology. Regional studies of the geomorpholithosphere on the example of plain-platform areas, allowed to establish the importance of historical and dynamic basin geomorphosystems as its structural elements. They are used in conducting forecasting and exploration work on various sedimentary minerals (Komliev, 2005; Pohorilchuk, 2002), predicting the behavior of pollutants in the lithosphere (Ivanik et al., 2009; Komliev, 2005; Komliev et al., 1997; Komliev and Filonenko, 2002). The methodical algorithm for the implementation of these tasks is the same and consists in creating *static* models of historical-dynamic basin geomorphosystems and their subsequent interpretations of the *dynamic* content. Some data from these maps are used on the final forecast map. The legends of maps created on a morphochronodynamic basis use their own terminology. Here are some of its concepts and terms used in this work: *morpholithohorizon* ("body" of the cyclic geomorphological formation, an element of the *vertical structure* of the geomorpholithosphere); *morpholithocomplex* ("body" composed of morpholithic horizons, an element of the *horizontal structure* of the geomorpholithosphere); *morpholytodynamic flow* (consists of horizons: *upper*, dynamically connected with modern bases of erosion; *the first buried*, dynamically connected with the exposed forms; *the second buried,* dynamically little connected with the exposed forms); *morpholithodynamic tunnels* (open morpholithocomplexes that are through for water flows); *morpholytodynamic barriers* (closed morpholytocomplexes that change the direction of groundwater flows); *morpholytodynamic traps* (areas of accumulation of substance and energy); landforms: *initial* (places of ascending chronicles), *transit* (places of transit of matter and energy), *therminal* (places of descending chronicles, accumulation of matter and energy).

There is the *basic*, integrating elements are *morpholithocomplexes* for the determine of migration of technogenic pollutants in the geomorpholithosphere, on the prognostic geomorphosystem model, which are divided according to different criteria. In this case, such important criteria as morphological inheritance (morpholytocomplexes are *inherited* or *not inherited*) (Fig. 1, 2) and their water permeability (morpholithocomplexes are *passable* or *transit*, *semiconductor* and *closed*) (Fig. 3-5).

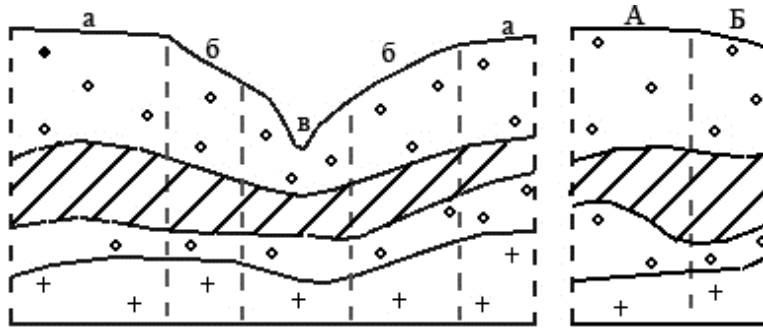


Figure 1

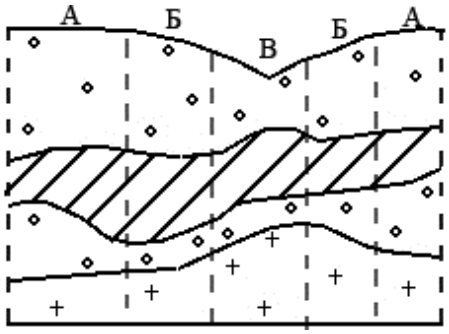


Figure 2

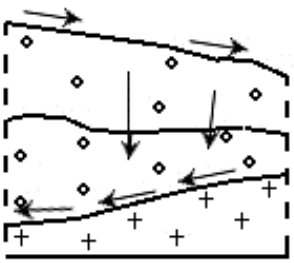


Figure 3

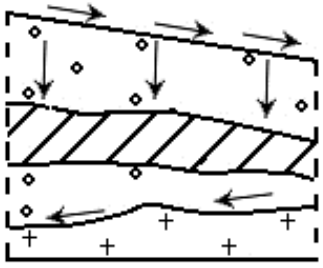


Figure 4

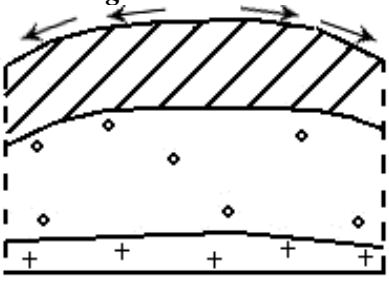
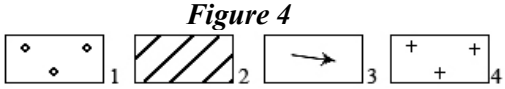


Figure 5



Symbols to figures: morpholithocomplexes: 1 – transit; 2 – closed; 3 - directions of movement, 4 - crystalline rocks

Chains of pass-through morpholithocomplexes integrate permeable horizons into one, create a *morpholitotunnel*, which there is a free movement of water and lithocurrents (Fig.6).

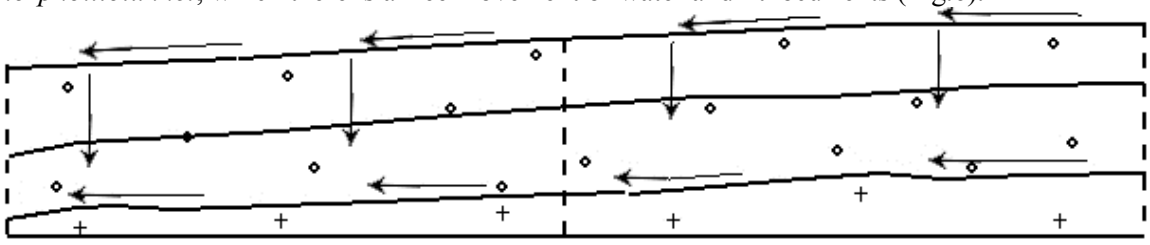


Figure 6

Morpholithbarriers are formed at the boundary of through and semi-through morpholytocomplexes. According to empirical data, the greater the thickness of the sedimentary cover (Fig.7-10).

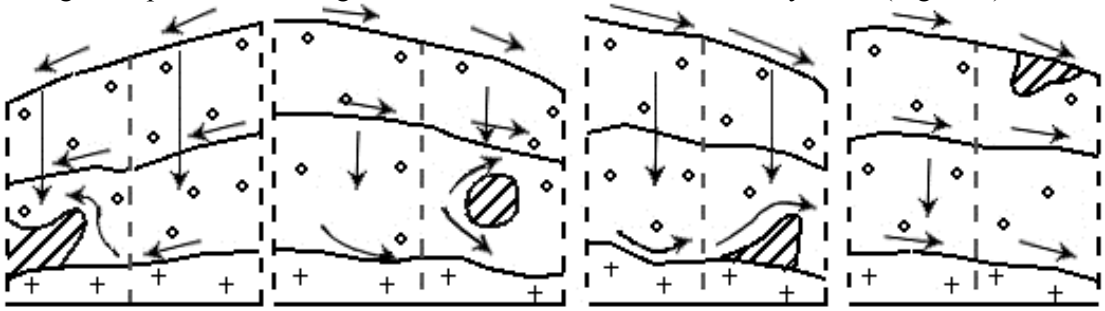


Figure 7 ***Figure 8*** ***Figure 9*** ***Figure 10***

In semi-through morpholithocomplexes, on the surface of rock layers that are impermeable or weakly permeable to water, there are closed depressions - *morpholithictraps* for contaminants (Fig.11, 12).

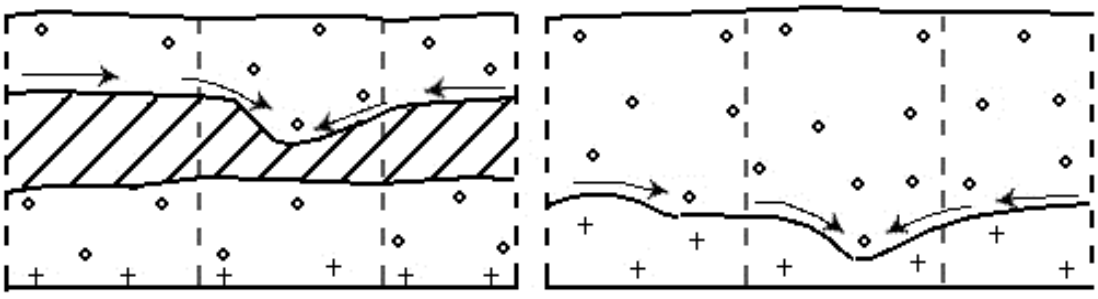


Figure 11 ***Figure 12***

If morpholithbarriers change the direction of lithodynamic flows and can be overcome, then morpholithic traps are long-term terminals for man-made pollution.

The prognostic geomorphosystem cartographic model *of migration of technogenic pollution in the earth's crust*, built for the part of plain-platform Ukraine, uses 3 additional data blocks - *geomorphosystem, socio-economic, prognostic*.The geomorphosystem block contains data on the nature of transit, the development of terminals, restructuring in the historical and dynamic basin geomorphosystems for the geomorphological stage of the Earth. The socio-economic block contains the following data: 1) settlements (cities); 2) natural and technical geosystems (transport, industrial, agricultural, water management, forestry, protected areas).

Conclusions

Direct man-made human activity in the lithosphere can now be traced to depths of more than 13 km. Solid and liquid wastes from various industries with groundwater can penetrate even deeper. Identification of migration routes and places of accumulation of man-made pollution in the earth's

crust is an urgent task today. Their direct observation by technical means is limited by a grid and is possible only to certain depths. Therefore, it is necessary to create prognostic models of migration of man-made pollutants, using modern knowledge about the formation and spatio-temporal organization of the earth's crust. The geomorphosystem (the historical-dynamic morphosystem of the Earth) played an important role in this, creating its own "space-time" - *the geomorpholithosphere*. The geomorphosystem model of the geomorpholithosphere allows tracking the movement of man-made pollutants in the earth's crust. It uses the "natural" structural framework (buried valleys, etc.) of the geomorpholithosphere. In the geomorpholithosphere, in real time, the material reliefs of the previous cycles of development of the historical and dynamic morphosystem of the Earth are preserved. The Earth's gravitational field integrates geologically diverse elements, creates, forms systemic connections between them, determines their functions and trends of material displacements, energy transformations, information transfer, entropy exchanges in the geomorpholithosphere. The historical and dynamic morphosystem of the Earth and the geomorpholithosphere create a theoretical concept of a prognostic geomorphosystem model of migration of man-made pollutants in the Earth's crust. The prognostic geomorphosystem model of the geomorpholithosphere is created on the basis of the morphochronodynamic concept of geomorphology. In the geomorpholithosphere of the plain-platform territories, the structural elements of the historical-dynamic basin geomorphosystems are considered. They have been used in applied research (forecasting and exploration of various sedimentary minerals, forecasting the behavior of pollutants in the lithosphere).

References

Ivanik, O., Lavrenyuk, M., & Shevchuk, V. (2009). Numerical modeling of geological environment impact on the pipelines. In *71st European Association of Geoscientists and Engineers Conference and Exhibition 2009: Balancing Global Resources. Incorporating SPE EUROPEC 2009*, 1, 146–150. Society of Petroleum Engineers.

Komliev, O.O. (2005). Historical and dynamic basin geomorphosystems of geomorphological formations of the Ukrainian shield. *Extended abstract ... dis. of Dr. geogr. sci.: 11.00.04*. Kiyv, 37 p. (in Ukranian)

Komliev, O.O., Pohorilchuk, N.M., Filonenko, Yu.M. (1997). On the problem of structuring and mapping of the geomorpholithosphere on a paleogeomorphological basis. *Coll. science of international conf. "Ukrainian geomorphology: state and prospects"*. Lviv: Mercator, 45-47. (in Ukranian)

Komliev, O.O., Filonenko, Yu.M. (2002). Socio-economic factors of technogenic pollution of the Mesozoic-Cenozoic sedimentary cover of the Right Bank of the Middle Dnieper. *Economic and social geography*, 52, 80-85. (in Ukranian)

Pohorilchuk N.M. (2002). Basin organization of Mesozoic-Cenozoic morpholitogenesis of northern and central Volyn-Podillya. *Extended abstract ... dis. of Cand. geogr. sci.: 11.00.04*. Kiyv, 19 p. (in Ukranian)