Basic Theoretical and Methodological Aspects of Geoecological Research of Cave Geosystems

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Abstract

Cave geosystems are appreciated as specific geoecological systems in the lithosphere. Their spatial differentiation is caused by properties of physical-geographical sphere components. A determination of partial quasi homogenous topic units (speleolithotopes, speleomorphotopes, speleohydrotopes, speleoclimatopes and speleobiotopes) and complex quasi homogenous units (speleotopes) respects the vertical structure of cave geosystems. Relatively homogenous choric units (speleochores, set of speleochores) correspond with the horizontal structure of cave geosystems. Time-spatial changes of cave geosystems are characterised by particular developmental states (regime, dynamics or evolution). A total carrying capacity of the cave, as a speleochore or set of speleochores, depends on the occurrence of particular speleotopes and their stability. Knowledge of the spatial structure and time-spatial changes of cave geosystems generates a precondition for the solution of various analytical and synthetical tasks including environmental problems of karst landscape.

Introduction

Applying the system approach in geoscientific disciplines is successively reflected also in the research of karst and caves. Existing published studies refer to the interaction among components of physical-geographical sphere and explain their very intense mutual relations (f. e. JAKAL, 1986). Likewise they emphasize a complex conception of specific karst and caves geosystems. However a spatial and chronological aspect of their research is not prevailingly presented in the context of theory and methodology of complex physical geography or geoecology.

Cave geosystems as specific geoecological systems are characterised by specific features of biocomponent, speleoclimate and water as a part of hydrosphere and lithosphere in the zone of hypergenesis, as well as by absence of pedogenetic processes and photosynthesis (GERGEDAVA, 1983; CIKISEV, 1987 and others).

The complex geoecological approach of cave geosystems interpretation is a necessary requirement for the recognition of their spatial differentation and behaviour in time, as well as changes of their spatial structure in certain chronological periods. The outstanding feature of cave geosystems is a spatial (vertical and horizontal) structure and their time-spatial changes, i. e. regime, dynamics or evolution (BELLA, 1998).

Spatial Structure of Cave Geosystems

The more extensive caves usually consist of various parts, which are different by the features of underground environment (morphology, segments of underground water flows, lakes, seepage of atmospheric water, occurrence of carbonate speleothems, etc.). It is desirable to determine the logical spatial units with a certain stability of natural structure on the basis of natural conditions analysis for the purpose of practical tasks. BELLA (1998) distinguishes cave geosystems of topic (from Greek, local) and choric dimension.

Vertical structure. The determination of partial quasi homogenous topic units (speleolithotopes, speleomorphotopes, speleohydrotopes, speleoclimatopes and speleobiotopes) respects the vertical intercomponent structure of cave geosystems. Speleotopes represent the complex quasi homogenous and threedimensional cartographic units of cave environment with nearly equal lithological, structural-tectonic, morphological, morphometric, speleoclimatic, hydrological and biospeleological conditions.

According to a dominant direction, activity and sequentiality of dynamic relations, speleotopes as complex topic cave geosystems are divided into intracommunicative primary and secondary speleotopes (vertical relations are predominant), postintracommunicative speleotopes (intracommunicative speleotopes in the inactive developmental stage), extracommunicative primary and secondary speleotopes (horizontal relations are predominant), and postextracommunicative speleotopes (extracommunicative speleotops in the inactive developmental stage).

Horizontal structure. Relatively homogenous choric units correspond with the horizontal structure of cave geosystems. A speleochore represents an ordered group of several speleotopes interconnected by one-direction flow of mass and energy, i. e. horizontal relations (paradynamic range, catena, cascade). Within the framework of morphochores J. Minar (2000) distinguishes a historical (genetic) or recent (morphodynamic) spatial interaction of georelief elements.

Primary active and inactive fluviokarst speleochores, secondary active and inactive fluviokarst speleochores, and combined fluviokarst speleochores are distinguished according to the originality or posteriority and activity of processes; one-phase and more-phase speleochores according to developmental stages.

The secondary acorrelative (reverse) type of speleochores relates to the original inactive fluviokarst phreatic cave passage in case of a backward direction flowing of vadose stream as compared to the previous phreatic water flow. The secondary correlative type of speleochores is equivalent to the identical direction of vadose and phreatic water flows. Combined speleochores are marked by the modification of their original character in certain sectors of cave passages.

The more extensive caves usually consist of several speleochores, i. e. a set of speleochores. We can distinguish synchronous and asynchronous sets of speleochores according to the developmental chronological period. According to the character of genesis they include harmonic (equal morphogenetic processes) and disharmonic sets of speleochores (different morphogenetic processes). Harmonic synchronous and asynchronous sets of speleochores include: conjunctive (connected fluviokarst speleochores in the direction of water flow), disjunctive (branched fluviokarst speleochores in the direction of water flow), conjunctive-disjunctive (fluviokarst speleochores with lateral conjunctive and disjunctive branch passages), collateral (branched and consecutively connected fluviokarst speleochores in the direction of water flow), parallel (main fluviokarst passages – speleochores are connected by a „pirate“ passage), non-branched, conjunctive and conjunctive-disjunctive single paragenetic sets of speleochores (genetic sequence – fluviokarst drawdown and invasion vadose caverns in the ponor part and caverns with mixture of phreatic and watertable-levelled segments in the middle and spring part of cave system, etc.).

Time-Spatial Changes of Cave Geosystems

The spatial structure of geosystems is not stable, it changes in time in dependence on input of mass and energy. Interpreting the time-spatial changes of cave geosystems particular developmental states refer to appropriate speleotopes and respondent speleochores or sets of speleochores. The several asynchronous features of time-spatial changes of surface and underground part of karst geosystem are in consequence of a „barrier“ position of cave geosystems against outside influences.

Regime (rhythm). The behaviour of geosystem is a continual sequence of processes delivering a mass and energy in the geosystem. This interaction keeps the state of geosystem peculiar to a certain chronological interval or stage. The rhythm is one of behaviour regimes of geosystem (NEEF et al., 1973; DEMEK, 1987). The annual course of underground water flows, the sequence and intensity of atmospheric water seepage, the seasonal change of current air direction in dynamic vertical dissected caves and the seasonal glaciation of some caves are examples of cave geosystems regime.

Within the framework of the seasonal rhythm of geosystems, BERUCASVILI (1986) interprets „steks“ (concrete states of geosystems as a consequence of spatial and chronological synthesis of geomasses and geohorizons) and „etocycles“ (trajectories of regular cyclical changes of „steks“ during year).

The self-regulation is a property of geosystem to keep typical states (regimes, state values of relations among components) during its functionality. Irreversible changes effect the transformation of geosystem to a different stability state (f. e. a disturbance of speleoclimatic conditions in ice hollows in consequence of opening new surface entrances or siphons leading to non-ice parts). The capacity of resistance is the ability of geosystem to withstand application of forces that have a trend to deflect the geosystem from its momentary typical state in a certain chronological interval (f. e. an equalization and compensation of speleoclimatic changes in consequence of visitors´ movement in show caves). The self-regulation of geosystem, as well as the capacity of resistance are connected with the behaviour of geosystem (DEMEK, 1987).

Dynamics. It represents changes of geosystems that include succession stages series connected with an effort to accomplish their stability, i. e. a climax in dependence to the geoecological invariant change

(SOCAVA, 1979; DEMEK, 1987). Some examples of cave geosystems dynamics are: the glaciation of drawdown inactive fluviokarst caverns beginning since the discontinuity of primary continued cave parts, the cave geosystem change of an inactive fluviokarst passage originated by the underground water flow in the phreatic zone since the time its successive transformation in the vadose zone without the fluvial effect and the hydrological active phase of cave genesis.

According to developmental chronological stages we can distinguish one-phase and more-phase speleomorphotopes. The development of one-phase speleomorphotopes relate to the dynamics of cave geosystems. More-phase speleomorphotopes are modelled by geomorphological processes in more developmental stages in dependence on the invariant changes, that exceed a framework of dynamics.

Evolution. It presents changes that include the alternation of geoecological invariants and the change of its spatial structure (SOCAVA, 1978; DEMEK, 1987). The evolution of cave geosystems is connected with the origin of cave passages in several chronological stages or periods (developmental process in the geological chronological scale, alternation of invariants). The more-phase speleomorphotopes include coincidence (consecutive morphogenetic process are identic or compatible with primary morphogenetic processes) and aincidence speleomorphotopes (modification of previous forms is in consequence of the effect of dissimilar non-compatible processes). The spatial structure of speleomorphotopes associated in choric units is changed during a successive development of caves (development of new branch passages in the horizontal dimension or multiple passages in the vertical dimension, in some cases invasion passages and wells interconnect developmental levels). The evolution of cave geosystems includes also other changes of invariants (fossil caves originated by morphogenetic process that correspond with natural conditions in past geological age, etc.).

Stability of Cave Geosystems

The utilisation of caves (show caves, speleotherapy, water source and other activities) increased with the development of human society. The deterioration of cave geosystems is caused both by accompanying negative anthropogenic phenomena „in situ“ and secondary negative phenomena with contamination sources outside the caves or karst areas (BELLA, 1992). The determination of geosystem stability is important for utilisation and protection of karst landscape and caves.

We can consider following fundamental stability categories of cave topic and choric geosystems: very instable geosystems with a slight carrying capacity value, instable geosystems with low carrying capacity value, medium-stable geosystems with normal carrying capacity value and comparatively stable geosystems with increased carrying capacity value in relation to anthropogenic activities (BELLA, 1997).

Conclusion

Knowledge about the spatial structure and time-spatial changes of cave geosystems not only contributes to the completion of existing karstological and speleological knowledge, but also generates a precondition for the solution of other analytic and synthetic tasks. Except for the tasks related to geomorphology, hydrology, climatology and other geoscientific disciplines, environmental problems of karst geosystems are topical. Presented theoretical and methodological approach of cave research demands a complex geographical mapping and visually suitable cartographic formulation of thematic content of maps.

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