TERRITORIAL STRUCTURE OF THE KARST GEOSYSTEMS AND THE INTERPRETATION OF NEGATIVE ANTHROPOGENIC INTERVENTIONS

TERITORIALNA STRUKTURA KRAŠKIH GEOSISTEMOV IN INTERPRETACIJA NEGATIVNIH ANTROPOGENIH VPLIVOV

PAVEL BELLA

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Pavel Bella: Teritorialna struktura kraških geosistemov in interpretacija negativnih antropogenih vplivov

V članku avtor predstavi značilnosti geosistemov in posebnosti kraških geosistemov, njihovo kompleksno strukturo ter strukturno stabilnost v okviru pokrajinskih sistemov. Neustrezna izraba kraške pokrajine povzroča primarne in sekundarne negativne pojave, ki se pojavljajo izven samega območja osnovnega onesnaževanja. Te sekundarne negativne pojave avtor razlaga na osnovi horizontalnih geosistemskih struktur. Tako nekraško ozemlje močno vpliva na alogeni kras s pomočjo vodnih tokov, kar je eden izmed najpomembnejših dejavnikov razširjanja onesnaževanja preko kraškega ozemlja.

Ključne besede: krasoslovje. človekov vpliv na kras, kraški geosistem, onesnaževanje krasa

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Pavel Bella: Territorial structure of the karst geosystems and the interpretation of negative anthropogenic interventions

Characteristic of geosystems, karst geosystems, their complex structure and structure stability in the landscape system are presented in the paper. Disproportional exploitation of the karst landscape produces primary and secondary negative phenomena which occur outside the source of contamination. The negative secondary phenomena are interpreted on the basis of horizontal geosystem structures. The allogeneous karst teritory is strongly influenced by the non karst territory through water streams which are one of the main factors of contamination spreading in the karst.

Key words: karstology, man's impact on karst, karst geosystem, karst pollution

Address - Naslov
Pavel Bella
Slovak Museum of Nature Protection
and Speleology
Liptovský Mikulaš
Slovakia

The karst landscape represents a specific geosystem. The karst process is the main factor at its forming. Besides the inevitable presence of karstic rocks this process is limited by the geographic position of geosystem. Morphogenesis is also influenced by tectonic movements.

Karst forming process is the complex of morphogenetic processes connected with corrosive and corrosive-erosive water activity and other morphogenetic processes, influenced by initial karstic form, that created a chronological system of individual generic states of georelief in the area built by karstic rocks.

Individuality of geomorphological forms of karst landscape is also pointed up by the presence of underground forms of georelief. Permeability and solubility of karstic rocks make rapid infiltration of atmospheric water. Surface water flows run into underground also by swallow holes. Karstic hydrogeological structures are marked by specific hydraulic conditions of water flow with the low filtering capability and specific regime of underground water stores draining. Calciferous soils have a shallow profile. Character of biotic components is determined by the abiotic components' properties. The main distinctive factor in the landscape is the georelief. Climatic and vegetation inversions occur in the depressed areas. Specific conditions of cave environment cause the presence of the relative independent underground geosystems but underground and surface parts of karst geosystem are strongly interdependent.

Landscape is the part of the geosphere consisting of its components - the upper part of lithosphere with georelief, lower part of atmosphere, hydrosphere, pedosphere, biosphere, and socioeconomic sphere. In the point of view of system interpretation the most important are the relations between individual geospheres. Geosystems are divided into geographic dimensions according to their size. Geosphere is not a static formation and it is exposed to evolution process. Within geosystems we can distinguish the space (vertical and horizontal) structure and chronological structure.

VERTICAL INTERCOMPONENT SYNERGETIC STRUCTURE

The structure is formed by the interrelations between the geographic sphere components or their parts. The interrelations are studied using monosysteme model. Geosystems of topic dimension are separated on the base of this model. Geotopes are the smallest elementary physical-geographic and cartographic units, quasi homogeneous concerning the individual components' properties. Abiogenetic and biogenetic parts of geotope form the physiotope that does not include the sociogenetic block. Partial quasi homogeneous physic-geographical units can be separated (lithotope, morphotope, hydrotope, climatotope, pedotope and biotope).

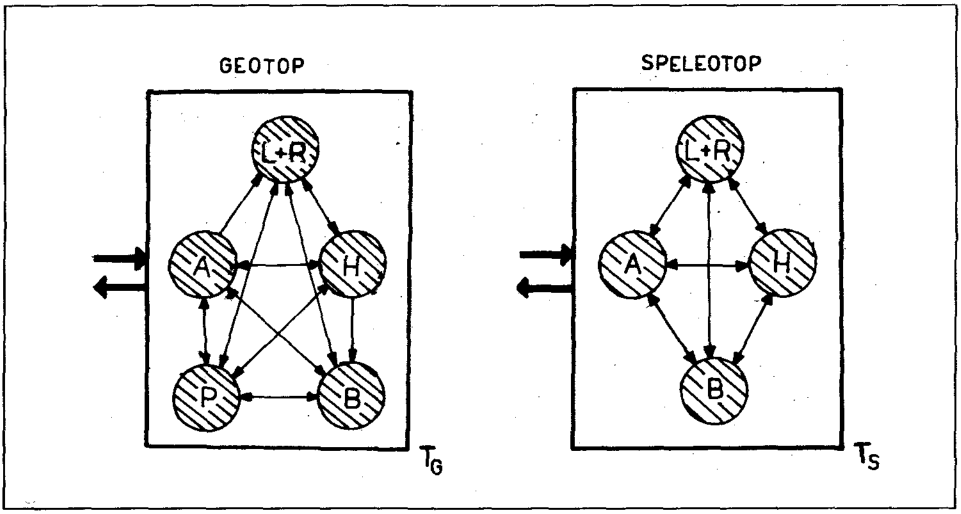

Fig. 1. Monosysteme model of geotope and speleotope (L + R - litosphere with georelief, A - atmosphere, H - hydrosphere, P - pedosphere, B - biosphere)

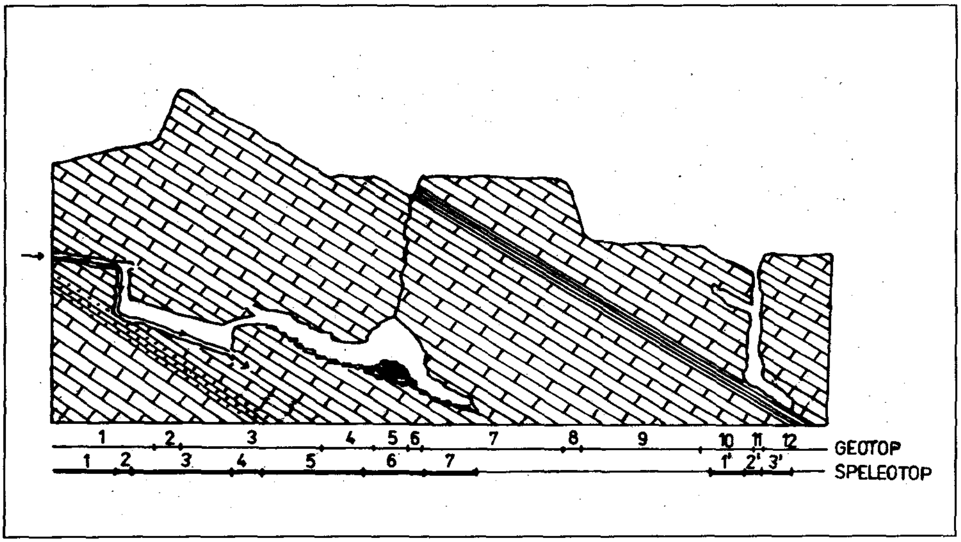

Fig. 2. Examples of geotopes and speleotopes selection

Speleotopes can be taken into account in the underground open space on the analogy of geotopes separation in the surface part of landscape. The speleotopes represent the complex quasi-homogeneous and cartographic units of cave environment with nearly equal lithological, texture-tectonic, morphological, morphometric, microclimatic, hydrological and biospeleological conditions (P. BELLA, 1991). Soil cover is not present in the underground space (B. A. GERGEDAVA, 1983). Overburden thickness and properties influence the grade of geotope and speleotope difference and interconnections of surface and underground. Overburden rocks suppressing karst forming process are significant by barrier effect. The surface boundaries of geotopes are often different from the boundaries of underground speleotopes. Speleotopes are often of the line character.

Ideas of component determination and separation are not uniform. V. N. SOLNCEV (1981) distinguishes massive and contact components. Ľ. MIČIAN (in Ľ. MIČIAN - F. ZATKALÍK, 1984) consider material and energetic components consisting of elements based on representative geographic publications of numerous German and Russian authors. N. L. VERUČAŠVILI (1986) uses the terms "geomass" and "geohorizons". Components do not enter the interaction "en bloc" but just by mediation of some their properties or parts (E. MAZÚR - J. DRDOŠ - J. URBÁNEK, 1983).

VERTICAL INTERCOMPLEX STRUCTURE

Underground forms of cave georelief determine specific physiognomic features, space organization and mass and energy flow in the underground space as an independent geosystem. This geosystem is characterized by specific features of biocomponent, microclimate and water as a part of hydrosphere and lithosphere in the zone of hypergenesis as well as by absence of pedogenetic processes and photosyntesis. The course of physical and chemical variable characteristics of components straightens with the closeness of georelief forms. Interaction increases in the underground space related to overburden part of lithosphere. Numerous authors deal with the reason of the idea of underground space as the individual geosystem (B. A. GERGEDAVA, 1983; A. G. ČIKIŠEV, 1987 and others).

Underground space is fully or prevailingly surrounded by underground form of georelief. The bearer of form is the rock environment. Boundary outside underground form is determinated on the base of geosphere discontinuity resulting from different surface and subsurface conditions (P. BELLA, 1989).

Presence of individual subsurface geosystems determines the existence of intercomplex vertical structure (besides intercomponent) that is of great importance considering dynamics, stability and other properties of karst geosystems. Strong vertical linkage between surface landscape and subsurface space creates the unique paradynamic systems (L. I. VOROPAJ - V. N. ANDREJČUK, 1985). Vertical structure of karst geosystems with caves is characterized by "mirror" structure and according to V. N. ANDREJČUK (1991a) consists of two subsystems of surface and subsurface part with their own component structure. As they together create greater geosystem, they represent two geosystems of lower hierarchic level.

Relation of intercommunicating geotope and speleotope is noted for vertical paradynamic relations from initial stage of underground geosystem evolution. In case of intercommunicating geotope and extracommunicating speleotope (flow of allochtonous submerged water, etc.) the vertical dynamic relations are topical just at more advanced stage of underground geosystem evolution. It causes certain autonomy of underground space evolution in initial stage.

Vertical intercomplex structure of karst geosystems as a component of geosphere refers to exokarst floor of karstosphere in sense of V. N. ANDREJČUK (1991b) formed in hypergenesis. This author also specified the endokarst floor of karstosphere that is however out of reach of exogene processes. Boundary of exogene energy influence forms the marked discontinuity. Therefore the endokarst floor of karstosphere surpasses the limit of geosphere.

The existence of subsurface caverns often occurring at several cave levels

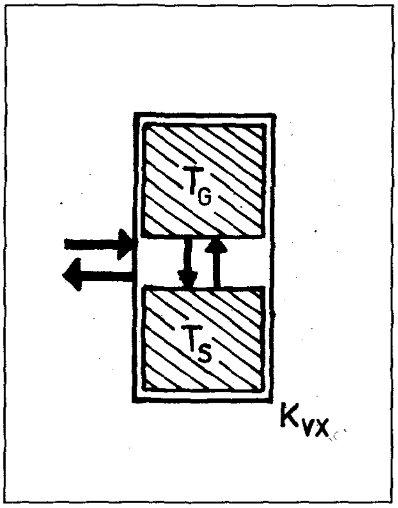

Fig. 3. Vertical intercomplex structure of karst geosystem

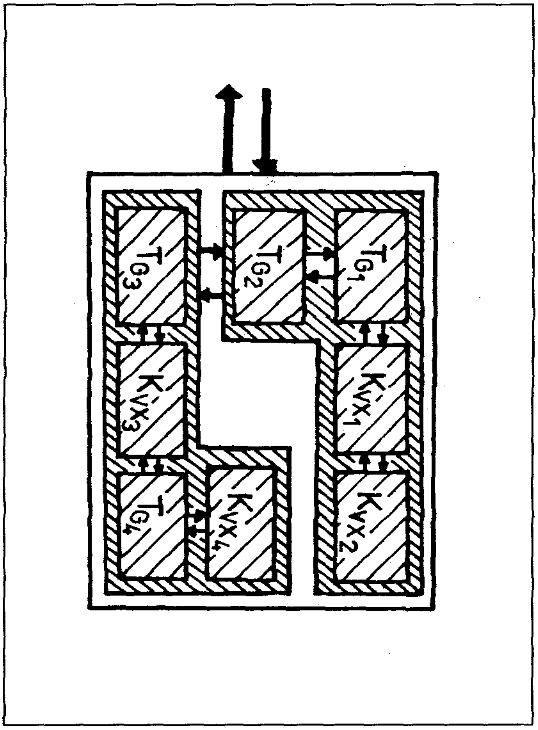

Fig. 4. Polysystem model of karst geosysteme

forces to think of vertical intercomplex structure with spatial relations and acquires character of chorologic system. This fact corresponds with including of vertical relations into the term "speleostructure" determined by V. N. ANDREJČUK (1987).

HORIZONTAL CHOROLOGIC STRUCTURE

Large territorial units consist of smaller territorial units of different vertical synergic structure. Their interrelations form the horizontal chorologic structure studied by polysystem model. Its hierarchic settlement results from various geographic dimensions influencing the degree of distinctive level, methods of study, ways of display, etc. Terminology of geographic dimensions is not uniform. In the German geographic literature the choric, regional and planetary dimensions are quoted besides topic dimension laying stress upon spatial aspect.

At the study of geosystem structures the attention is devoted to geosystems representing the base of larger landscape units. In frame of chorologic systems the units of choric dimension (nanochore, microchore, mezochore and macrochore) are the point in question. Nanochore has the simplest structure consisting of several physiotopes that are very similar or functionally complement. They are regularly settled into groups in space in consequence of the influence of landscape processes. The set of nanochores, created based on certain criteria (hillside, plane, etc.), represent the microchore. The remaining hierarchically

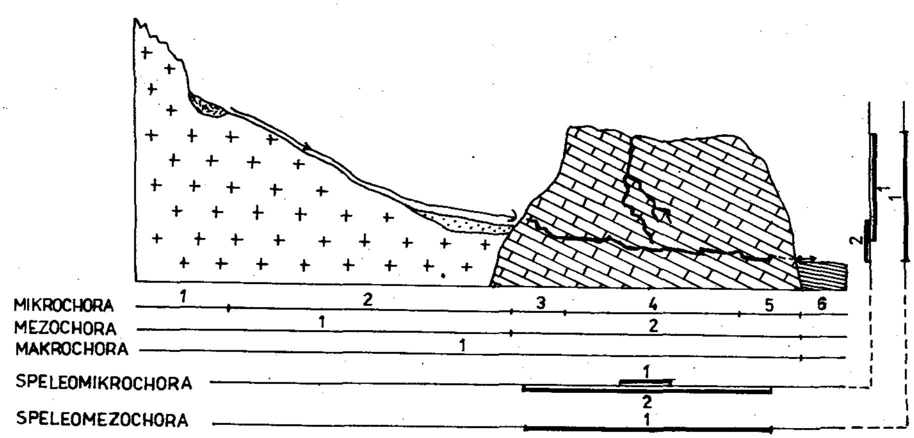

Fig. 5. Examples of larger choric units selection

higher choric units are determined based on certain logic context.

The georelief plays the important role at the determination of boundaries between individual geosystems as it directs the flow of matter and energy within the geosphere. The lithological and structure-tectonic predisposition are also important in case of underground karst geosystems. Morphologic contrast is typical to karst landscape georelief that reflects to its horizontal structure. Subsurface caverns are marked by considerable spatial differentiation too. Allogene karst is an example of outer chorologic relations of karst geosystem with hydrologicaly tending nonkarstic area.

Mediations of greater spatial units separation exist too. However it is necessary to comprehend the structure of karstosphere - karstic levels, karstogenetic environment and karstogenetic situations (V. N. ANDREJČUK, 1991b) in context with hierarchic geosystem levels of higher choric, regional and planetary dimension. The largest landscape geosystem is the whole geosphere. That is why the definition of terms "karstosphere" and "speleosphere" as specific parts of lithosphere must accept spatial integrity and hierarchy structure of geosphere in frame of exokarst stage.

Besides quasihomogeneous geocomplexes (units of topic dimension) and relative homogeneous geocomplexes (units of other dimensions) it is possible to distinguish paradynamic complexes as the systems of spatially neighboring contrast units interconnected by horizontal ties realized by the flow of matter and energy (F. N. MILĽKOV, 1981). Paragenetic complexes are the special case of paradynamic complexes. They also correspond with the terms "geochemical landscape" (A. I. PERELĽMAN, 1975) and "katena" (CH. OPP, 1983 in Ľ. MIČIAN - F. ZATKALÍK, 1984).

DYNAMICS AND STABILITY OF KARST GEOSYSTEM

System as the certain quantity of elements and their relations is determined mainly by processes, its conditions and behavior. Vertical synergic relations between components of karst geosystem are marked by higher dependence as in most non-karst areas. Considerable greater volume of mass flow between surface and underground arises. The energy of chemical reactions plays important role. Hydrologic activity determines markedly the course of karst morphogenetic processes. Zonal location of territory and tectonic movement need to be taken into account at the geosystem dynamic evaluation.

According to L. I. VOROPAJ and V. N. ANDREJČUK (1985) the importance of self-evaluation in karst geosystem increases. They lay stress upon less capability of its evolution control by outer mass and energy interferences. Asynchrone evolution of surface and underground parts of karst geosystem results from their different location related to outer creating and stabilizing factors of evolution of its balance.

The evolution of geosystems is interpreted by chronological structure including individual conditions and causal relations. Each evolution state is related to synergic or chorologic structure of geosystem. It is possible to distinguish cyclic, reverse and non-reverse sequences of states. V. B. SOČAVA (1978) determines the terms of "evolution" (evolution process in geologic time scale and invariants' alternation) and "dynamics" (alternation of variable states of geosystem subordinated to one invariant). E. NEEF, H. RICHTER, H. BARSCH and G. HAASE (1973) determine the term "regime, rhytmics" (seasonal changes dependent upon changes of seasons of the year). The behavior of geosystems with seasonal rhytmics analyzes N. L. VERUČAŠVILI (1986) in detail.

Stability of landscape structure indicates the stability of relations in the landscape system as a system of processes. Within the anthropocentric research it expresses the ability of landscape structure to resist to human activity (E. MAZÚR - J. DRDOŠ in E. MAZÚR et al., 1985). Karst landscape represents very unstable geosystem. It is disproportionately more complicated to maintain its balance than in most non-karst landscape systems. Unstability results from its well-organized character (J. JAKÁL, 1991). The fossil structure is marked by low stability. Inconvenient anthropogenic interferences into natural structure of karst geosystem result in its immediate affection. Regeneration ability of karst landscape is low and in some cases impossible.

SPATIAL RELATIONS AND INTERPRETATION OF NEGATIVE ANTHROPOGENIC INTERVENTIONS ON EXAMPLE OF KARST REGIONS OF WESTERN CARPATHIANS

Optimum and rational landuse require anthropogenic interventions respecting regularity of the landscape nature structure. Recently can be in many cases observed the disproportions between its exploitation and potential. E. MAZÚR and J. DRDOŠ (in E. MAZÚR et al., 1985) understand potential as the condition for performing the functions demanded by man without the affection of landscape structure stability.

Knowledge of recent reliefmorphic process, water movement and hydrological regime in the landscape can help to border the landscape units endangered by the negative anthropogenic activity. Flowing water with its erosive energy and material transport ability is the mediate of many kind of landscape devastation and contamination. It often leads to the depreciation of natural water sources - underground water resources, soil cover and biotic component. This fact shows up in the geosystems of choric dimension mainly. Research of these geosystems is of the extraordinary importance for social practice as many important kinds of human activity are realized within them (Ľ. MIČIAN in Ľ. MIČIAN - F. ZATKALÍK, 1984). The choric aspect shows up at harmful materials spreading not only by allochthonous position, mainly hydrological processes but also by air masses movement (contamination of precipitation with industrial exhalations, dust emission).

Improper location of farmyard manure near the swallow holes in Ponický kras in Zvolenská kotlina basin caused eutrophication of Oravecká vyvieračka karst spring. Inconvenient management of fields in the area of water dipping caused flooding of Domica cave in Slovenský kras including ablation of soil sediments with agrochemicals. Agricultural activity threatens the underground water quality in hydrological systems Suché doly - Teplica in Muránska planina plateau, Jašteričie jazero lake - Čierna a Biela vyvieračka karst springs in Silická planina plateau in Slovenský kras, Priepadlá - Teplica in Važecký karst and elsewhere. Water contamined by agriculture in Šumiacky karst in Horehronské podolie valley leaks into flood plane of the river. Contamination of karst hydrogeological structure threatens from the deposition of petrochemical industry wastes near Predajná in Lopejská kotlina in Horehronské podolie valley in Nízke Tatry mountains. The sewerage is constructed in alogene karst area that drains wastewater from higher situated recreation centre in non-karst area. This sewerage protects the water source of Demänovka submerged stream for Liptovský Mikuláš water conduit. Throwing down of perished animals and pouring waste into abysses and depressed areas of georelief in the karst hydrogeological structures have the negative influence of spatially wider signification. The changes of air mass movement in subsurface caverns influence the creation of sinter and ice filling.

Removing and damaging of vegetation cover, improper use of agrochemicals, ploughing in the slope course and other inconvenient anthropogene interferences markedly affects natural synergic relations between individual components in topic geosystems. Surface mining influences geotopes, nanochores and microchores.

From the point of view of intercomplex structure the affection of hydrologic regime of percolating atmospheric water into subsurface caverns arises that negative affects the sinter filling creation. Part of the plate above Važecká jaskyòa cave at the border of Kozie chrbty mountains was aforested for nature protection reasons. Seepage of agrochemicaly contamined atmospheric water causes the chemical decomposition of sinter filling. At the cave opening-up the affection of roof stone stability can arise.

Man with its activities enters natural processes, often speeds up their development (accelerated erosion and corrosion, acceleration of seepage and outflow, etc.). It affects the landscape structure stability. P. BELLA (1992) worked up the classification of negative anthropogene interferences into the karst landscape in Slovakia.

RESULTS

Landscape diagnosis consisting of gnozeologic part (knowledge of natural and anthropogene structure), evaluation part (knowledge of landscape potential and its limiting values) and comparative part (analysis of relations between landuse and landscape potential) forms the presumes of optimal anthropogene interventions into natural geosystems. As the knowledge of natural landscape structure is the primary condition of the diagnosis, we point at the need of geosystem interpretation that strongly influences the complexity of this recently actual problem solution. Disproportional exploitation of the landscape produces both accompanying negative phenomena "in situ" and secondary negative phenomena which occur outside the contamination source as a result of emissions and contamined materials transport by regions belong to the most valuable landscape units and that is why it is necessary to devote the adequate attention to their protection.

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TERITORIALNA STRUKTURA KRAŠKIH GEOSISTEMOV IN INTERPRETACIJA NEGATIVNIH ANTROPOGENIH VPLIVOV

Povzetek

Kraški svet je poseben geosistem. Prispevek podrobneje razlaga strukture geosistemov kot tudi njihovo strukturno stabilnost v okviru pokrajinskih sistemov. Posebej seznanja bralca z vertikalno interkomponentno sinergetsko strukturo (v podzemlju je to speleotop, ki odgovarja geotopu na površju), z vertikalno interkompleksno strukturo (taka struktura je značilna za speleotope) in s horizontalno horološko strukturo. Na koncu splošnega dela govori o dinamičnosti in stabilnosti kraških geosistemov. Praktični primer preučevanja kraškega ozemlja s pomočjo prej navedenih struktur je obdelan v poglavju o prostorskih odnosih in interpretaciji negativnih antropogenih vplivov, na primeru kraških regij v Zahodnih Karpatih.

Analiza pokrajine, ki sestoji iz gnozeološkega dela, iz ovrednotenja in iz primerjalnega dela, lahko predvidi optimalne antropogene vplive na naravni geosistem. Poznavanje naravnih pokrajinskih struktur je torej prvi pogoj za diagnozo in zato je potrebna interpretacija geosistemov, ki imajo močan vpliv na celotni kompleks. Neenakomerno izkoriščanje pokrajine povzroča tako negativne pojave "in situ" kot tudi sekundarne negativne pojave, ki nastopijo izven območja vira kontaminacije, s pomočjo prenosa kontaminiranega materiala.