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DETAILED GEOECOLOGICAL MAPPING - SOME ASPECTS

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Abstract: The identification and outline of solution of some problems of geoecological mapping that considerably influences the quality of detailed geoecological maps is the contents of the contribution. There is pointed out the importance of autonomic integral field geoecological research in model areas, the maximum quantification of geoecological data, the using of methods of multivariate statistics and the conception of geoecological gradient.

Key words: geoecological mapping, data quantification, multivariate statistics, geoecological gradient

1. INTRODUCTION

The ever-growing number of authors pays attention to the geoecological research and mapping (e.g. works of Mosiman 1984, Leser 1991, Richling And Solon 1996, Beručašvili and Žučkova 1997, Mičian 1999). They often describe particular aspects of this process in detail. The theoretic aspects, which are in generally rarely treated but have a significant importance for the quality and utilisation of geoecological maps, were pointed out in work Minár 1998. In the contribution, I intend to expand these considerations by some new aspects.

The term *geoecological mapping* expresses the process of creation of a map, which contains synthetic information about natural landscape complexes. The *geoecological map* mostly terms a map in which the complexes are described by a set of particular component characteristics of the natural landscape (lithosphere and landforms, pedosphere, hydrosphere, atmosphere and biosphere). However, it also is a map demonstrating the system attributes of the natural landscape (e.g. ecological stability, carrying capacity, potential, vulnerability or sensitivity). Maps of the first type, which may be called also *basic geoecological maps*, should be the informational basis (source) in creation of maps of the second type. The quality of basic geoecological maps limits the quality of derived application maps. Therefore, in further I will pay attention to some aspects of collection and elaboration of geoecological information that influence significantly the quality of basic geoecological maps.

In generally we can distinguish following basic attributes of the quality of a geoecological map:

1. **The quality of the used cartographic language** (it is defined by good arrangement, equipoise, cartographic entirety and the general readability of the map).
2. **The quality of the contents conception of the map** (its is given by the quality of the choice and the structure of information that contents the map).
3. **The accuracy of the map**, which has *the spatial aspect* (it expresses how exactly is the mapped reality limited in the space) and *the contents aspect* (how is the mapped category near or far from the reality in the core of the mapped area).

I will not deal with the problem of the cartographic language quality in geoecological maps in spite of its big importance. The map user can easy appreciate this quality. Its lowering makes the readability and using of the map difficult, but it is not the source of significant factual mistakes. The quality of the cartographic language can be estimated unambiguously by the direct analysis of the map.

The quality of the map contents conception can be estimated also by the analysis of the map (of its legend above all), but it demands a good theoretical knowledge of demonstrated problems. The lowering of the contents conception quality brings not only problems in communication but also it can be a source of factual mistakes in using of the map, mainly if the user does not realised the lowered quality (e.g. in the multiobjective decision, there are taken into account equivalently duplicate information and so the result will be negatively influenced by this duplicate information).

The spatial accuracy of the map reflects on the one side the spatial quality (the density and representability of the distribution) of input data and on the other hand the quality of extrapolation or interpolation method that was used for assignment of spatial validity of point geoecological data. Contents' accuracy depends on the quality of methods of the information collection and elaboration. We can not estimate the quality of its contents and spatial accuracy by the geoecological map studying. It can be estimated only by map confrontation with the mapped reality in the field. However, the confrontation is not only professionally but also time and financially demanding. The user obviously does not do it and so the contents and mainly spatial inaccuracy of the geoecological map may be a biggest source of weighty factual mistakes in its using.

2. SOME PROBLEMS OF GEOECOLOGICAL MAPPING

The creation of the geoecological map has several aspects. The solving of more problems has common features and conditions. The scheme on Fig. 1 demonstrates some of them. The way of these problems solving influences the quality of basic geoecological maps principally.

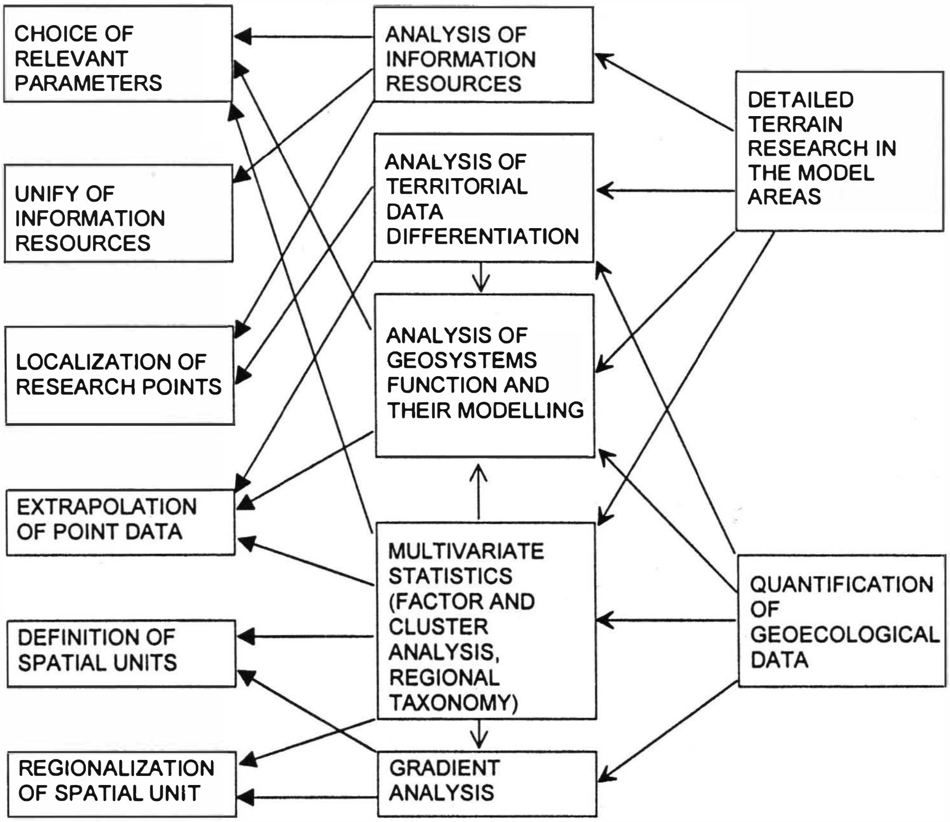

Fig. 1 Selected problems of geoecological mapping and their solution

The choice of relevant geoecological characteristics. The geoecological map should contain such characteristics of the elements of the natural landscape that determine the behaviour of geosystems. The analysis of the geosystem structure and function can provide us a set of such characteristics. A detailed integral field geoecological research in model areas, in which all partial geospheres are studied in mutual relations, is one of instruments of geosystem analysis. The effect of geosystem analysis distinctly raises with the quantification of observed data. The quantitative expressing of states and processes of the geosystem enables to compare better the importance of particular geoecological characteristics. The amount and quality of existing information (together with time and economic limits in creation of original complementary information) on the other side limit the choice of parameters, which the geoecological map will include. The detailed field research in small model areas provides the analysis of quality of information sources. One of basic condition of the geoecological parameters' choice shall be to eliminate its duplicity. The multivariate statistical analysis as a part of the geosystem analysis enables to identify the duplicity and to eliminate it.

The integration of information sources. The information sources used in the creation of basic geoecological map (first of all different analytic maps) contradict one another and they have very various contents and spatial accuracy. We often have several information sources about one landscape element (e.g. soil or geological maps). The analysis of the quality of these sources (based on their confrontation with detailed field research) enables their non-mechanical integration (the best source will be preferred).

The location of research points. The contents and spatial quality of existing analytic sources does not usually enable to create a good detailed geoecological map with using of only these sources. The complex geoecological research points (on which all relevant characteristics are in parallel observed) are an ideal source of geoecological information. The creation of a representative regular net of geoecological research points in the whole mapped area is usually unbearably expensive and time consuming. The creation of an irregular net of geoecological research points located mainly on places with a reduced amount and quality of existing sources is the way out. The knowledge about the regularities of the spatial differentiation of particular geoecological data is used as well. It has not been paid enough attention to detection of these regularities up till now. We do not know well the regularities of detailed spatial differentiation mainly of the data, which may be usually acquired only on points (state parameters of soil and lithosphere, but also most of dynamic characteristics). Detailed research in dense regular nets in small model areas may help to detect the regularities and determine the rules of location of research points in irregular nets. The quantification of observed geoecological data is again the condition of effectiveness.

The extrapolation of point data. The most positional mistakes in analytic and geoecological maps result in the extrapolation of geoecological data from non-representative (not sufficiently dense) point fields. The knowledge of regularities of spatial differentiation of extrapolated data on basis of the study of model areas is the basis for a correct extrapolation algorithm. Additionally, the using of existence of strong functional, genetic and therefore also spatial relations among various geoecological characteristics may be very perspective. The spatial differentiation of the characteristic that can be directly observed (landforms, land cover) may reflect also the spatial differentiation of the characteristics that can be only difficult observed. The character and power of such relation can not be good determined without quantitative expressing of observed characteristics. Even the quantification of characteristics enables to apply the methods of multivariate statistics on the data acquired in detailed field research and exactly define the closeness of spatial relations of observed characteristics. The data quantification is also a basic condition of mathematical modelling of geoecological processes, whose detailed spatial differentiation can be usually estimated only in this way.

The definition of spatial geoecological units. This problem is usually solved in geoecology only qualitatively and it is not solved sufficiently. Minár (1998a, 1998b, 1999) describes the exact definition of geoecological units through the *geoecological gradient* (the maximum summary change of all relevant geoecological characteristics). This definition is possible only on basis of a dense point field of input data with application of multivariate statistics and successive morphometric analysis of geoecological gradient. The quantification of primary geoecological data is an unambiguous condition of proposed process. The application of the regional taxonomy methods on a representative point field of quantitative geoecological data may be a contribution for the definition of spatial geoecological units, too.

The classification (regionalization) of geoecological units. The regional taxonomy is a progressive trend in geography that solves problems of the classification (typization) of spatial objects with using the multivariate statistics. The existence of quantitative regionalization criteria (geoecological data characterising the spatial geoecological units) is the basic condition for using of the regional taxonomy in geoecological regionalization. The geoecological gradient and from it derived parameters are synthetic quantitative characteristics which may serve for the classification of geoecological units.

In the scheme on Fig. 1 there are emphasised two basic conditions of solving selected problems of geoecological mapping. We may evaluate the contents and spatial quality of existing map sources, and formulate the regularities of detailed spatial differentiation of geoecological data only by *detailed field geoecological research in model areas*. Results of research like this are a needful input to the analysis of function of geosystems and their modelling. The multivariate statistical analysis and the conception of geoecological gradient are very hopeful tool of geoecological maps improvement. Nevertheless, their using is conditioned by perseverance in *quantification of geoecological data.*

3. THE QUANTIFICATION OF GEOECOLOGICAL DATA

The geological, soil or geomorphological maps are often used in creation of a basic geoecological map. These maps content mainly synthetic categories, whose the quantitative character is hidden (soil types, sorts of the rock, genetic landforms). Genetic categories are interesting and good for explanation, a lot of quantitative characteristics are used in their definition, but we can not usually express them simply quantitatively as a whole. Also, their conversion back to quantitative data, on whose basis they were defined (definitions often result from wide intervals of analysed quantitative characteristics), is not simply.

The detailed geoecological mapping demands the maximum measure of inner homogeneity of areas (geotops). The homogeneity can be from the point of view of soil cover, for example, characterised by one soil type (subtype). However, related soil types (subtypes) very often change continuously forming a gradient (e.g. in the slope direction) and they form a geoecological unit that is homogeneous just by this gradient (gradient unit). We can exactly define the measure of similarity or differentiation in such cases only if we quantify the characteristic that caused ordering into various soil taxons. For instance, the line Eutric Cambisol - Luvic Cambisol - Albic Luvisol - Albo-gleyic Luvisol - Plano-gleyic Luvisol can represent a soil succession on loamy to clayey-loamy substratum when rainfall predominate considerably over evaporation. Differentiation in soil can be in this case a consequence of their age, respectively rejuvenation by erosion and they may be quantitatively described e.g. by the thickness of illuvial horizon or by percentage wise share of oxide-reduction transformation in soil matrix. Strong gleyed albo-gleyic luvisol (with transformation of matrix 70 %) will be more similar to plano-gleyic luvisol than to weak gleyed albo-gleyic luvisol (with transformation of matrix 10 %) that is typologically in equal class (Hraško et al. 1991). It is necessary the quantitative expression of typological differences of soils like this for expressing the geoecological gradient. The expression like this is subsequently significant for definition of geoecologically maximum homogeneous areas as well as for their typization.

The way of the quantification of traditional soil, landforms and lithological categories, which are most often in soil, geological and geomorphological maps, is in Table 1 and Table 2.

Table 1 Scheme of quantification of traditional qualitative categories

Qualitative characteristic	Soil unit	Landform	Rock type
Quantitative parameters	Thickness of diagnostic horizons	Morphometric parameters	Content of main minerals
	Indications of pedogenetic processes	Spatial and positional relationship	Stability parameters
	Indications of subsoil influence	Soils and rock parameters	Granularity

The quantitative parameters, on whose basis the used qualitative categories are defined, are not usually in analytic databases (they are mostly in primary pedological database). Therefore, the more precise geoecological mapping requires creation of a geoecological database, which will systematically contain besides traditional qualitative characteristics also these primary quantitative data. The approach like this eliminates also the illogicalities of existing systematic, in which we apply classification criteria only on a selective basis. For example the sandy Eutric Fluvisol (fluvizem arenická) and Fluvi-eutric Gleysol (fluvizem glejová) are defined in the Slovak soil classification system on one level (Hraško et al. 1991), but the sandy Fluvi-eutric Gleysol (fluvizem arenická glejová) is not, in spite the fact that this combination usually occurs. The acquisition of quantitative values for all research points by laboratory analyses may be problematic in the practice. However, the estimate of parameters values (granularity, strength or content of chemicals) in certain interval values is allowed, too.

Table 2 Example of quantification of traditional qualitative categories

Qualitative characteristic	Stagno-gleyic (Vertic) Cambisol	Fault slope	Loess
Quantitative parameters	A_1 - 15cm (B) - 36 cm C - 55 cm	slope 33° curvature <0,000002 exposition 260°	SiO_2 75 % $CaCO_3$ 18 %
	A_1 humus 1,2 % (B) Feo : Fed 0,38 C Feo : Fed 0,86 gleyzation 20 %	r = 0,87 (space correlation with fault lines)	Compressive strength 0,02 MPa Angle of response 25°
	A_1 clay 69 % (B) clay 73 % C clay 72 %	jointing 25 % direction of joints 170° and 260°	sand 6 % loam 75 % clay 18 %

4. CONCLUSION

The contribution outlines a way of solving some significant problems that arise at creation of detailed basic geoecological map. Especially geoecological maps created for practice are usually based on available data sources of analytic geosciences. The sources were created on basis of knowledge and for needs of these sciences. But, the detailed geoecological mapping needs (of course besides the utilisation of existing sources) *an autonomous geoecological database,* which should be:

- result from an integral (in content and way of realising) detailed geoecological research in model areas,
- be quantified in maximum measure (i.e. content mainly primary quantitative characteristics and not only generalised classification categories, e.g. soil types, genetic rock types, or landforms).

The geoecological database like this enables to solve main problems of geoecological mapping by modern tools of statistical, gradient and functional analysis. Therefore, the detailed geoecological map will become really credible basis for applied landscape-ecological research.

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Resume

Podrobné geoekologické mapovanie - vybrané aspekty

Kvalita geoekologickej mapy závisí od kvality použitého kartografického jazyka (je definovaná prehľadnosťou, vyváženosťou, kartografickou úplnosťou a celkovou čitateľnosťou mapy), kvality obsahovej koncepcie mapy (je daná kvalitou výberu a štruktúry informácií obsiahnutých v mape) a presnosti mapy, ktorá má aspekt priestorový (vyjadruje nakoľko presne je mapovaná realita ohraničená v priestore) a aspekt obsahový (nakoľko je mapovaná kategória blízka alebo vzdialená realite v jadrovej oblasti mapovaného areálu). V obr. 1 sú uvedené niektoré kroky tvorby geoekologickej mapy (problémy), spôsob realizácie ktorých výrazne ovplyvňuje kvalitu tvorenej mapy:

- Výber relevantných geoekologických parametrov, ktoré sa stanú obsahom mapy
- Zjednotenie informačných zdrojov (najmä rôznych analytických máp),
- Lokalizácia výskumných geoekologických bodov, na ktorých sa zisťujú všetky relevantné informácie vo vzájomnom prepojení
- Extrapolácia bodových údajov (určenie ich priestorovej platnosti)

- Definícia priestorových geoekologických jednotiek (geoekologických indivíduí)
- Klasifikácia (regionálna typizácia) geoekologických jednotiek

Nástrojmi na riešenie uvedených predmetov sú rôzne typy analýzy, počnúc od analýzy informačných zdrojov, cez analýzu priestorovej diferenciácie v bode získavaných údajov (málo poznáme podrobnú diferenciáciu pôdnych a horninových vlastností ale i vlastností topoklímy, či hydrologických procesov), funkčnú analýzu geosystémov a ich modelovanie, využitie metód viacrozmernej štatistiky (faktorovej či zhlukovej analýzy) až po výpočet a analýzu priestorovej diferenciácie geoekologického gradientu (bližšie Minár 1998a,b). Podmienkou uplatnenia všetkých týchto nástrojov je na jednej strane tvorba autonómnej geoekologickej databázy (podrobný geoekologický výskum v modelových územiach) a na strane druhej maximálna možná kvantifikácia geoekologických údajov (spôsob takejto kvantifikácie naznačujú tabuľky 1 a 2).