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**GEOGRAPHICAL APPROACH TO INTERPRETATION OF DATA OBTAINED BY REMOTE SENSING OF EARTH ON THE EXAMPLE OF ANALYSIS OF LAND USE (LAND COVER)**

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The paper documents a geographic approach to interpretation of data obtained by remote sensing of Earth in theoretical plane. It indicates the priorities of use of interpretation of photographs which make exact the analysis of land use (land cover). On their basis the authors treat the present principles and the position of mapping in land use in a geographic analysis of landscape and present a diagram of logic processes of making map inventory of land use. They are indicating simultaneously the general application of a land use map, as a fundamental analytic document for further research purposes and operation processes.

## INTRODUCTION

The remote sensing supply to geography data whose properties: vertical, horizontal and dynamic connection [20] fulfil in a substantial measure the requirements and criteria of data used in landscape researches in analytic and synthetic position. As the photograph contains a great quantity of data that cannot be used directly, it is important to prepare for geography specific interpretation processes, enabling to obtain from aerial and space photographs and images the information of mentioned properties and to use them in landscape researches.

The way, how to obtain from photographs the information, is realized through the scientific method called interpretation [often used is also the expression of photointerpretation which indicates the acquisition of data from photographs]. Various definitions and theories of interpretation at a general level can be found in works [3, 6, 11, 16, 17] and in others. From the definition it results that interpretation of photographs represents a method by which it is possible to identify objects of earth's surface represented on various types of photographs and to characterize some of their properties.

The general theory of interpretation of photographs directed specifically to the use in geography is treated, e. g. in works [5, 10, 18] and others. The authors of these works indicate the given method as a geographical interpretation of photographs. This indication comprehends its substance. It starts

from the assumption that be it realized in any thematically oriented interpretation of earth's surface photographs, the studied objects and phenomena are in mutual link with that geographical environment in which they are found, or whose part they form. It is why, knowledge of objectively existing laws in the form of substance, spatial and time linkages, interaction and conditioning between objects and phenomena in the landscape, is very important in interpretation.

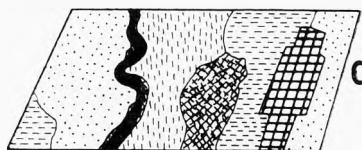
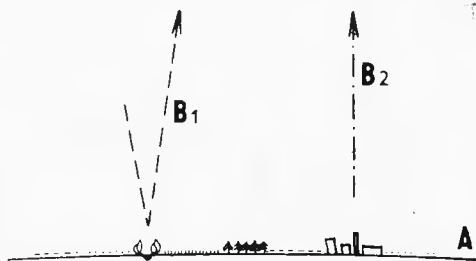


Fig. 1. Relationship between the representation of objects on the photograph and their real aspect and state in the landscape:

*A* — objects of the earth's surface,  
*B*<sub>1</sub> — electromagnetic radiation reflected,  
*B*<sub>2</sub> — electromagnetic radiation emitted,  
*C* — picture on which are represented the studied objects by interpretative symbols.



Consequently we directed the work purpose to the characterization of the interpretation method of photographs mainly from its concretization stand point for a general use in geography with the stress to solve some of the geographical tasks, as is the analysis of land use [land cover].

#### RELATION BETWEEN THE PHOTOGRAPH AND THE PHOTOGRAPHED PART OF THE EARTH'S SURFACE

From Fig. 1, which shows a generally drawn relation between the representation of objects on a photograph and their real aspect and state in the landscape, it results that studied objects are represented on photographs by interpretation symbols [form, shade, size, colour, structure, texture, etc.]. The medium of informations, between the earth's surface and the photograph, made by various photographic devices, is the electromagnetic radiation. This, in principle, represents the integrated reflected and emanated radiation by landscape elements. As under landscape is understood the spatial system composed of elements of physical, biotic and human nature, which interact between themselves, then, for ex., in vegetation research made by data acquired by interpretation of photographs, it is necessary to consider also some soil properties, groundwater, relief, etc., because they affect in a decisive measure its reflection and emission properties. The results is that in the

interpretation of photographs of the earth's surface, it is necessary to use also the existing relevant data on landscape elements, links between them, or to acquire new ones by field investigation.

The set of relative data, determined by land cover, qualitative state of landscape elements and their mutual links, position, properties of radiation flows and by climatic conditions which affect in a decisive measure the manifestation of studied objects (or their properties) on the photograph, are called geographic and physical-energetic characteristics.

The use of landscape data in the process of interpretation of photographs requires a specific methodic approach which should lead into the preparation of relative geographical and physical-energetic characteristics on the studied objects. Knowledge of these characteristics forms the fundamental basis of data, from which it is necessary to start in setting up the interpretation keys — fundamental means enabling the realization of interpretation of photographs. The example of the methodic process prepared by us, which starts also from the possibility of applying the map documents, is illustrated in Fig. 2.

#### CHARACTERISTIC OF THE METHODIC PROCESS

From Fig. 2 it results that part of data used in the preparation mainly of geographical characteristics (land cover, or qualitative state of objects, their position and mutual links in the landscape) can be acquired directly or indirectly by the analysis of existing thematic maps.

The map is considered as an important source of data. It is used almost in the entire process of analysis of photographs, beginning from the geographical orientation of the photograph and ending by the formulation of the results of interpretation. The fundamental aim of relationship photograph — map is to find out in the process of analysis of the photograph the possibilities of identification of represented object and phenomena on the photograph, to determine the possibilities of photograph use in the research of the problem in question and also to define preliminary the quantity of required data which the analyzed photograph contains. For the process of comparison „photograph — map“, the unification of scales is important.

The map is used in the conclusion of interpretation of photographs, in the extrapolation of interpreted data into corresponding spaces. From the thematic maps on individual natural landscape elements which it is necessary to analyze in relation to the interpretation of photographs in question, we give the following ones:

- geomorphological (maps of types and forms of relief),
- geological (maps of lithology, stratigraphy and tectonics),
- hydrologic (maps of river network, lakes and reservoirs, types of groundwaters),
- pedologic (maps of soil types and soil classes),
- vegetation (maps of real vegetation).

The geographical characteristics can be obtained also from field mapping works. Their purpose is to confront in the time of taking photographs the state of followed objects and phenomena represented in existing maps also to map some states and phenomena dynamically changing (for ex., recent geomorpho-

logic processes, anthropogeneous influences on the landscape elements, land use, etc.). They are usually synchronized with taking photographs on small representative-testing surfaces which are selected so as to cover the fundamental studied objects and phenomena. The obtained characteristics are used in identifying the objects not only on the testing surface, but also on lands genetically analogous.

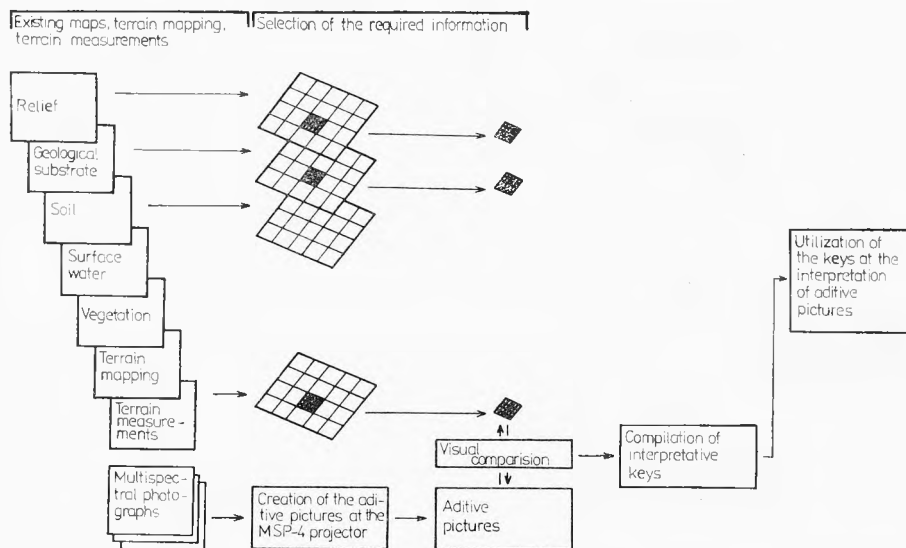


Fig. 2. Method of collection and processing of geographical and physical-energetic characteristics of photographed objects with relation to the creation of interpretative keys (for ex., multispectral photographs).

The fundamental aim of field measurements is to obtain in the time of taking photographs the spectral characteristics and also selected specific characteristics (for ex., on soil temperatures and humidity, biomass production, etc.). They form the basis of physical-energetic characteristics on studied objects. The extent of field measurements uses to be modified by the aim, for whose fulfilment data obtained by photographs are used. Field measurements are usually made on testing surfaces.

The relevant data on studied objects and phenomena, obtained by field measurements, field mapping and analysis of maps in question, can be added to their representation on the photograph by comparison process. Pairs of values are obtained by comparison: characteristic parameters of objects and phenomena obtained by field investigation and analysis of maps and manifestations — representation of respective objects and phenomena on the photograph (by interpretation symbols). They form the basis for the creation of interpretation keys.

The process characterized generally was modified in the theoretical level for the needs of land use (land covers) analysis.

# THEORETICAL ASSUMPTIONS OF APPLYING INTERPRETED DATA TO THE ANALYSIS OF LAND USE

Classical methods of field investigation and statistical data processing of land use permitted to analyze in detail the physiognomic character of objects (categories, types) of land use, equally their functional properties and other

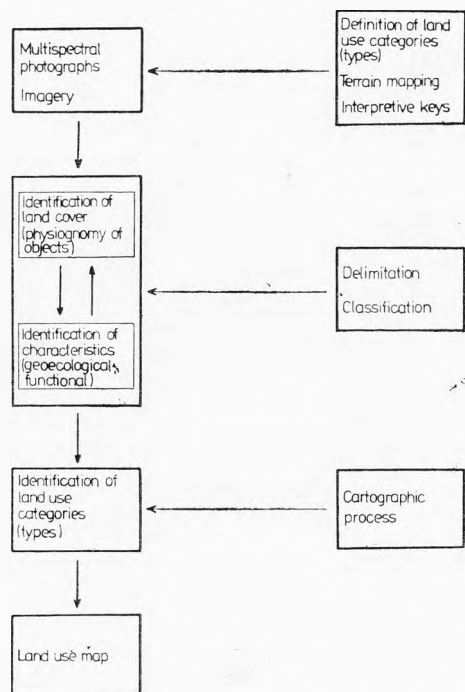


Fig. 3. Diagram of logic processes of land use inventory making.

specific symbols as the intensity and efficiency of use. The significance of classical approaches is even presently undeniable and in detailed investigations irreplaceable. The cultural-technical development of the society, growth of its needs and the process of their gratification lead to dynamic changes of landscape use. Their regular recording, necessary in consequent planning processes, requires to substitute laborious and time consuming classical field methods of investigation by data obtained from interpretation of photographs.

From the aspect of these data use we intend to point to some indications related to their priorities for the analysis of land use. They are the fundamental properties of photographs given already in the introduction, expressed by three kinds of linkages (continuities):

Vertical linkage — conditions a precise identification of physiognomic features of a concrete landscape object, mainly in the sense of spatial identification of differentiation in the vertical dimension, which from we can derive the method of its use or unuse. Particularly in relation to dynamic linkage, it

enables also the identification of the matter (material) substance of objects of land use. It concerns the knowledge of properties of the natural (geoeconomic) character, but also of properties of the socioeconomic state in the context of the landscape synergic system (see URBÁNEK, J., MAZÚR, E., DRDOŠ, J. [19]).

Horizontal linkage — enables, in spite of admissible mistakes, resulting from the used photographing techniques and interpretation method, to point to and to stress the significant priority of application of photographs in connection with the spatial precision, under which we understand the position of analyzed objects (categories) of land use and also their form and dimensional attributes. The spatial precision analyzed in this way is of prior significance for decision making processes in planning, particularly in conflicting types.

Dynamic linkage — by which is characterized the series of photographs obtained in regular time periods, compared with the classical collection of data, is more than evident for land use. The quantity of analyzed elements processed in a time unit speaks for the benefit of data obtained by the interpretation of photographs. The dynamic linkage is increased also by the advantage of using recording techniques, in multifold repetition for the followed period which enables a detailed investigation of time-spatial changes of analyzed object and phenomena, related to land use.

The functional classification of objects and the identification of their specific properties, related to the method of realizing functions, requires a more detailed changing over and confrontation of field mapping with the results of interpretation.

We indicated the priorities of data use obtained from the interpretation of photographs of the earth's surface. The vertical, horizontal and dynamic linkage can be considered also as the fundamental attributes of geographical approach to landscape investigation which by photographs enable to diagnose concretely the objects of land use in the sense of their material manifestation in space and time.

#### AIM OF ANALYSIS: LAND USE MAP

The research of land use led already traditionally to map presentation of results. The primary connection followed mainly the inventory of proprietary-legal facts. Only the next connections concerned the earth research as a natural resource and its use. They were raised mainly by questions of self-sufficiency and ensuring food resources and resulting from them the strenuous exertions for knowledge and making inventory of the soil fund and efficiency of its use. These researching-developing approaches formed, mainly due to the British geographer L. D. Stamp, an independent trend of the landscape scientific knowledge — land use just with the stress laid on its cartographic output. The works of british geographers became an incentive for the creation and activity of the Commission on World Land Use Survey, with the aim to know the methods of using the Earth's natural conditions and on their basis to prepare methods for bettering the development of world agriculture and ensuring sustenance for humanity. It is but understandable that these facts conditioned the orientation of the research trend to agriculture and preference of this specification within the frame of socioeconomic activities,

what was proved also by the analyzed categories (types) of land use and legends of cartographic outputs. Later on the dynamic process of urbanization, certainly also with regard to its spatial demands and conflicts with agricultural activity, forced its recording within the frame of research and mapping of land use and specification of its own methods. Similarly the development of recreation activities and problems connected with it required a survey of their manifestation in the landscape. The demands of social practice and the development proper in the context with geographical approaches drafted thus the object of research and inclusion of the research trend in the system of sciences. It is understandable that land use gained larger dimensions in the effort to comprise uniformly the manifestation of socioeconomic activities on the earth's surface and to transform it to the level of map expression.

The research trend, in the spirit of its initiators, developed mainly within the frame of the socioeconomic geography. In a narrower conceptual sense the land use is a social category [15], since its substance is to relate the concrete part of earth's surface to the sphere of human activity which is governed by social laws. Theoretically the conception is closely connected with that of the function of the place [14], where under place we understand part of the earth's surface and the function is near (even if not identical) to the conception of use. The function conception connects, on the one hand, with the social needs and, on the other hand, with the apparatus (usually a technical system), which activates and realizes these needs. These connections, however, relate to a concrete landscape space (earth), as it results also from the conceptual expression. In the sense of the above said we can characterize the land use as a material manifestation of socioeconomic activities in the landscape, which in the final consequence reflects the way of gratifying the social needs. T. M. BURLEY (2) expressed realistically the grasping of the land use category by the formula: land cover + land utilization = land use. Resulting from it is the fact that if to a certain material-physiognomic form (cover) of the earth's surface we can add the functional properties and the method of their realization, we are able to say that we know the category, or the type of land use.

The position of the object of the research trend in the level of socioeconomic geography led frequently the orientation of research only to the knowledge of functional properties and to processes and laws of their realization up to the detailed levels, which reflected also in the cartographic outputs. Physiognomic properties, mainly of areal categories, were not always valued on an adequate level, not speaking of geocologic properties.

The above mentioned indications, resulting from the interpretation of photographs, indicate simultaneously its transformation process to the level of a general use. This projection and purpose is the map of land use with the classification diagram of analyzed categories (types) of land use. The diagram of logic analysis operations of land use is illustrated in Fig. 3. From the diagram it results that the map of land use is the result of 3 fundamental operations:

- a) definition of land use categories,
- b) delineations and classifications of categories,
- c) localization of classified categories on the map.

The set of operations comprised in the diagram starts from the interpreta-

tion keys, which must be concretely thematically oriented well in the method of their setting up (in our case to the needs of identification of the land use categories). The determining criteria of setting up the interpretation key in question will be formed by the defined categories of land use. It is to be stressed that the definition of these categories is conditioned by the present state of facts in the given research direction, above all in connection with their application. The defined categories and the set up interpretation key need not be considered before starting the realization of logic processes (Fig. 3) as final ones, but in the consequent processing steps they may be mutually modified.

Starting from the interpretation key and from the results of field mapping, first of all we identify from the photographs the physiognomic form of land use objects, then we can eventually establish their geocologic and functional properties. With the identification closely connected is the delineation in precision of the land use categories and their classification, particularly in the sense of hierarchic organization. Classification is conditioned by the purpose and detail knowledge of analyzed categories and their properties. In the development stages in forming the research trend we indicated preference of various activities which stated the objective of land use research (for ex., agriculture), particularly for the applicable outputs in question. To these modified outputs corresponded also the classification system of map expression. Other modifications can be perceived in further scientific-research processes. In geographical works it is the typical synthetic stress, to relate fundamental categories of land use to the landscape context, in the sense of dynamic associations of its use (see A. COLEMAN [4] and E. MAZÚR, E. KRIPPEL [13]). These synthetic concepts are particularly important for a higher strategy of decision making processes in land use planning, meanwhile even the detailness of land use analysis contributed also in a significant measure to their quality.

## CONCLUSION

From the above said it is evident that map expression of categories of land use fulfilled in practical and scientific bearings the criteria of the input analytic document. It is confirmed and stressed also by the mentioned indications of interpretations of photographs, to comprise all the relevant categories of land use with equivalence in the analytic plane. Meanwhile the priorities of interpretation of photographs make exact not only the identification of land use categories, but also the complexity of their classification expression. A moment of importance is that the hierarchic organization of classification of land use categories corresponded to individual levels of synthetic processing and decision making processes (from comprehensive to detail ones). The projection of the classification to the level of general use is the map expression of land use categories, which is making inventory not only of functional surfaces, but it gives them also a physiognomic and geocologic content. It represents thus also the recording of the landscape visual analysis, primary from the stand point of consequent scientific evaluations (esthetic, etc.), as well as from the stand point of the planning practice decision making, which in its map expression is near the topographic projection. The land use map



represents thus the basic input document of specified research and operational processes, but at the same time reversely also their control apparatus in the sense of spatially correct and timely actual information on the key sphere of our existence.

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#### GEOGRAFICKÝ PRÍSTUP K INTERPRETÁCII ÚDAJOV ZÍSKANÝCH METÓDAMI DIALKOVÉHO PRIESKUMU ZEME NA PRÍKLADE ANALÝZY VYUŽITIA ZEME (FYZIOGNÓMIE KRAJINY)

Letecké aj kozmické snímky (urobené fotografickým aj nefotografickým spôsobom) obsahujú veľa údajov, ktoré nemožno vždy priamo využiť pri výskumoch krajiny. Preto, ak chceme tieto údaje využiť v geografických výskumoch, je dôležité

vypracovať špecifické interpretačné postupy, ktoré umožnia zo snímok získať požadované informácie. V tomto zmysle sa orientoval aj cieľ práce, a to konkretizovať metódy interpretácie snímok pre všeobecné využitie v geografii, s dôrazom na analýzu využitia zeme (fyziognómie krajiny).

Geografický prístup k interpretácii snímok vychádza z predpokladu, že nech sa tematicky orientovaná interpretácia snímok zemského povrchu realizuje akokoľvek, skúmané objekty a javy sú vo vzájomnej väzbe s tým geografickým prostredím, v ktorom sa nachádzajú, prípadne časť ktorého tvoria. Preto možno zdôrazniť, že pri geografickej interpretácii snímok je veľmi dôležité poznanie objektívne existujúcich zákonitostí vo forme látkových, priestorových i časových väzieb, vzájomného pôsobenia a podmieňovania medzi objektmi a javmi v krajine. Využitie údajov o krajine v procese interpretácie snímok si vyžaduje vypracovať špecifický metodický prístup, ktorý je dokumentovaný v teoretickej rovine ako Metodika zberu a spracovania geografických i fyzikálno-energetických charakteristík snímokovaných objektov vo vzťahu k tvorbe interpretačných kľúčov. Kľúče predstavujú základné prostriedky interpretačného procesu.

Všeobecne charakterizovaný interpretačný postup sme modifikovali pre potreby analýzy využitia zeme (fyziognómie krajiny). Vychádzajúc zo základných vlastností snímok, vertikálnej, horizontálnej a dynamickej spojitosti, ktorých vyzdvihnuté prednosti exaktizujú aj analýzu využitia zeme, uviedli sme schému logických postupov inventarizácie využitia zeme.

Cieľom je mapový výstup využitia zeme, ktorý chápeme ako materiálny prejav socioekonomických aktivít v krajine, v konečnom dôsledku odrážajúci spôsob uspokojovania spoločenských potrieb. V tomto zmysle v procese interpretácie snímok identifikujeme materiálno-fyziognomickú formu objektov využitia zeme a určujeme ich geoeologické a funkčné vlastnosti. Transformačný proces vyúsťuje do roviny všeobecného použitia. Táto koncepcia je zrejماً aj z doterajších výskumných a aplikačných tendencií a naznačujú ju aj základné indicie interpretácie snímok: zachytiť všetky relevantné kategórie využitia zeme v rovnocennej analytickej rovine.

Exaktnú identifikáciu kategórií využitia zeme dopĺňa komplexný klasifikačný systém. Treba zdôrazniť, že jeho hierarchická organizácia má korešpondovať s jednotlivými úrovňami syntetického spracovania i s rozhodovacími procesmi spoločenskej praxe. V zmysle uvedeného poznatku mapové vyjadrenie kategórií využitia zeme inventarizuje nielen funkčné plochy, ale dáva im aj fyziognomickú a geoeologickú náplň. Približuje sa zároveň záznamu vizuálnej analýzy krajiny, ktorý je blízky širšie chápanému topografickému priemetu. Mapa využitia zeme takto predstavuje základný vstupný podklad špecializovaných výskumných aj operatívnych postupov, ale zároveň spätne aj ich kontrolný aparát v zmysle priestorove korektnej a časove aktuálnej informácie o kľúčovej sfére našej existencie.

Obr. 1. Vzťah medzi zobrazením objektov na snímke a ich reálnym vzhľadom i stavom v krajine.

A — objekty zemského povrchu,  $B_1$  — elektromagnetická radiácia odrazená,  $B_2$  — elektromagnetická radiácia emitovaná, C — snímka, na ktorej sa zobrazujú skúmané objekty pomocou interpretačných znakov.

Obr. 2. Metodika zberu a spracovania geografických a fyzikálnoenergetických charakteristík snímokovaných objektov vo vzťahu k tvorbe interpretačných kľúčov [napr. multispektrálnych snímok].

Obr. 3. Schéma logických postupov inventarizácie využitia zeme.

## ГЕОГРАФИЧЕСКИЙ ПОДХОД К ИНТЕРПРЕТАЦИИ ДАННЫХ, ПОЛУЧЕННЫХ МЕТОДАМИ ДИСТАНЦИОННОГО ЗОНДИРОВАНИЯ ЗЕМЛИ НА ПРИМЕРЕ АНАЛИЗА ИСПОЛЬЗОВАНИЯ ЗЕМЕЛЬ (ФИЗИОНОМИИ ЛАНДШАФТА)

Аэроснимки, а также космические снимки (полученные фотографическим и нефотографическим путем), содержат множество информации, которые не всегда можно использовать прямо при исследованиях ландшафта. Поэтому, если мы хотим эти информации использовать в географических исследованиях, необходимо разработать специфические интерпретационные приемы, позволяющие из снимков получить требуемые данные. В этом смысле ориентировалась и наша работа, а именно на поиск конкретных методов интерпретации снимков в целях общего применения в географии, причем ударение нами положено на анализ использования земель (физиономии ландшафта).

Географический подход к интерпретации снимков основан на предположении, что пусть тематически ориентированная интерпретация снимков земной поверхности осуществляется любым путем, при этом изучаемые объекты и явления всегда находятся во взаимосвязи с той географической средой, в которой они находятся, или составную часть которой они образуют. Поэтому можно подчеркнуть, что при географической интерпретации снимков очень важным является познание объективно существующих закономерностей, имеющих форму вещественных, пространственных и повременных связей, взаимного воздействия и обусловленности объектов и явлений в ландшафте. Использование данных о ландшафте в процессе интерпретации снимков требует разработки специфического методического подхода, документированного в теоретическом плане как Методика сбора и обработки географических и физико-энергетических характеристик снимаемых объектов в отношении создания ключей интерпретации. Ключи представляют собой основные средства процесса интерпретации.

Характеризованный в общем процессе интерпретации нами видоизменен для нужд анализа использования земель (физиономии ландшафта). Исходя из основных свойств снимков, вертикальной, горизонтальной и динамической связи, достоинства которых уточняет также анализ использования земель, мы приводим схему логических приемов инвентаризации использования земель.

Целью являлась карта использования земель, понимаемая нами как материальное проявление социально-экономических воздействий в ландшафте, отражающая в конце-концов способ удовлетворения общественных потребностей. Исходя из этого в процессе интерпретации снимков нами идентифицированы материально-физиономические формы объектов использования земель и определены их геоэкологические и функциональные свойства. Процесс трансформирования завершается в плане общего использования. Такой подход очевиден также и из существующих к настоящему времени исследовательских и прикладных тенденций и предопределяют его также основные направления интерпретации снимков: зафиксировать все существенные категории использования земель в равнозначном, аналитическом плане.

Точная идентификация категорий использования земель дополняется комплексной дешифрировочно-классификационной системой. Необходимо подчеркнуть, что иерархическая организация этой системы должна согласовываться с отдельными уровнями синтетической обработки и с определяющими процессами общественной практики. В связи с этим картографическое отображение категорий использования земель дает не только инвентаризацию функциональных площадей, но придает им также физиономическое и геоэкологическое содержание. Оно приближается, одновременно, к записи визуального анализа ландшафта, близкого к более широко понимаемой топографической проекции. Карта использования земель, таким образом, представляет собой начальную основу специализированных исследовательских и оперативных процессов, а одновременно является также их контрольной системой в смысле передачи пространственно корректной и повременно актуальной информации о ключевой сфере нашего существования.

- Рис. 1. Отношение между изображением объектов на снимке и их реальным соотношением и состоянием в ландшафте.  
 $A$  — объекты земной поверхности,  $B_1$  — отраженная электромагнитная радиация,  $B_2$  — излучаемая электромагнитная радиация,  $C$  — снимок, на котором изучаемые объекты отображаются при помощи интерпретационных знаков.
- Рис. 2. Методика сбора и обработки географических и физико-энергетических характеристик снимаемых объектов в отношении к процессу создания интерпретационных ключей (напр. мультиспектральных снимков).
- Рис. 3. Схема логических приемов процесса инвентаризации использования земель.

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