PHOTOGRAMMETRIC PROBLEMS OF JOINT APPLICATION OF AERIAL-SPACE IMAGERY AND CARTOGRAPHY METHODS FOR THE STUDY OF THE NATURAL RESOURCES

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Abstract

The cartographic method of research is a part of cartography which studies the aspects of map application as a mean of reality cognition. The closely connected aerial-space imagery method is based upon of images obtained by photography and other techniques. The paper shows that photogrammetry (which in broad sense is understood as a mean of obtaining reliable information on environment and its components) may and must play an important role as a connecting link between the aerial-space and cartographic methods. The paper illustrates some practical possibilities of joint application of the two related methods based on photogrammetric approaches taking for examples the evaluation of cartometric qualities of scanned space images of the Earth, the compilation and use of orthophotomaps and in setting up environmental monitoring.

The modern understanding of photogrammetry defines it as a science and technique of obtaining reliable information about real world objects and their environment through registration, measurement and interpretation of photographs and electromagnetic impulses received from a system of sensing elements. Such an understanding enlarges to a great extent the circle of traditional tasks of photogrammetry assigning it a decisive role in aerial-spatial imagery method and presupposing its joint application with cartographic method. In this connection the main task in the application of aerial-space imagery method for the study of natural resources may be seen in obtaining and interpretation of qualitative deciphering and quantitative (i.e. photogrammetric) information contained in aerial and space images, considered as being one of the possible models of reality.

It is known that cartographic method of research is a part of cartography dealing with problems of utilization of maps as means of reality cognition. The kindred method of aerial-space imagery is based on the use of photographs and other images. Complex application of aerial-space imagery and cartographic methods in the study of natural resources must be based on the system of mutual penetration of the two kindred methods. That includes combined use of means of obtaining images, of various types of images and techniques of photogrammetric and cartographic processing of the data with the use of partly or fully automatic procedures.

From the multitude of cartographic methods of analysing and processing of maps may be isolated those, which are common to the aerial-space imagery method too on the condition of their being supplemented by photogrammetric approaches. For instance the graphic means of cartographic methods include the construc-

tion of map-based graphs, diagrams, profiles, cross-sections, block-diagrams. In many cases photogrammetric processing makes it possible to carry out similar procedures on aerial and space photographs. Furthermore, the possibility of analytical processing of information obtained and its simplicity (if computers are made use of) makes it possible to automatize the graphic oonstructions listed above relatively easily. That provides the possibility of higher general effectiveness of combined application of the two methods.

Still more expedient is making use of photogrammetry for cartometric measurements, that is for obtaining from serial and space photographs and images data like coordinates, distances, lengths, heights, areas, volumes, angles and other quantitative characteristics of depicted objects and phenomena, including the appraisal of realibility and accuracy of the results. It appears quite promising to apply photogrammetric methods for the purposes of direct reading of thematic cartometric information from aerial and space photographs, for example direct calculation of morphometric relief indices or else the determination of morphometric characteristics of river-bed forms of different order and their dynamics.

Notwithstanding considerable similarities in the application of above-mentioned ways of analysis and processing of maps and aerial-space photographs and images, certain restrictions must be mentioned. It is common knowledge that similarity of methods, ways and means of obtaining and processing information contained in maps aerophotographs and space images relies on a number of their common properties, such as scale and metricity, generality and generalization etc. At the same time photographs unlike maps are not able to reflect such scientific abstractions as, for instance, the mean annual temperatures field, density of population etc.

In aerial-space imagery method just as in cartographic one, of great importance is mathematical modelling of natural objects, processes and phenomena. It is appropriate here to emphasize that practically all ways and means of quantitative photogrammetrical interpretation of aerial-space information are in one way or another connected with mathematical modelling. Its relative importance is steadily growing particularly in quantitative processing of new types of images, such as scanned ones. With joint application of the two methods the mathematical-cartographic modelling performs a special function, that is it forms the main link between cartographic and aerial-space imagery models. Mathematical modelling in aerial-space imagery method and its photogrammetric aspects are closely linked with transformation of original images to obtain derivative images (in ciphered, analytical, orthophotographic, steroorthophographic or other forms) convenient for concrete study of natural objects and phenomena.

Undoubtedly, space photography influences further development of cartographic methods of research. This influence will grow in future as well. Joint application and combination of aerial-space imagery and cartographic methods of research resulting in mutual penetration of theoretic ideas and practical ways of application, must be aimed at greater reliability and effectiveness of the study of natural resources. Until recently

the interpretation of space information in the study of natural objects, processes or phenomena was mostly limited to qualitative analysis mainly through visual or semi-instrumental deciphering, but nowadays it becomes absolutely necessary to introduce photogrammetric approaches in order to obtain precise quantitative data.

So, considering the interaction of the two methods, photogrammetry as a means of information processing can and must play the role of important link between them. On the other hand the combination of the two kindred methods creates a basis for automatized obtaining of research results and their cartographic presentation.

To illustrate certain aspects of joint application of aerial-space imagery and cartographic methods let us consider cartometric characteristics of scanned space images of the Earth. From the viewpoint of cartometric analysis of scanned space images one may draw a difference between the possibility of obtaining various quantitative characteristics corrected by maps on the one hand, and direct application of scanned space information for morphometric and other mapping on the other. The latter is closely connected with the problem of geometrical correction of scanned space images, including the analytic transition to cartographic basis at given scales and projections.

It is evident that photogrammetric approaches to the analysis of cartometric characteristics of scanned space images of the Earth must be based both on taking into account the orbital movement of the carrier of scanning equipment and on separating various geometrical distortions resulting from the peculiarities of photography itself. They call for correction and cartographic coordination through simultaneous use of a map and scanned image. Mathematical interpretation of distortions and the causes of their appearance are known will enough from the photogrammetrical point of view, their analytical appraisal is of no problem neither. Still cartometric characteristics of scanned space images are subject to certain limitations. The most essential of them are as follows: 1) the difficulty of overall evaluation of all kinds of distortions, 2) lack of obviousness in their distribution. Besides the knowledge of average or maximum values of particular distortions for the scanned image as a whole is not enough to perform cartometric measurements on parts of it or to choose the least distorted areas. For that purpose it is necessary to know the exact value of overall distortions in any point of scanned image, moreover in practical purpose it is expedient to evaluate distortions of scanned image against the map of the same or close scale. In other words in order to solve cartometrical tasks it is desirable to know the pattern of spatial distribution of geometrical distortions on scanned images, to see their variations from place to place. This task can be solved by constructing the maps of overall geometrical distortions of scanned space images.

Such maps (scale approximately 1:1 200 000) for scanned space images of Saratov reservoir and Kalach Hills (Don r.) areas, taken in 1980 by multi-zonal "Fragment" system are presented accordingly on fig. 1a and 2a. Identification of a num-

ber of points on scanned images and maps of close scale with further graphic-optical transformations has made it possible to obtain the vectors of distortions of scanned images as compared to maps with the same points. Their proper interpolation allowed to draw the isograms of distortions, i.e. to obtain the spatial patern of their distribution. The geographic base of the maps is the result of deciphering of those same scanned images. Vectors have been drawn strictly to map scale. Maps with isograms of overall geometrical distortions are of considerable importance. They may be used to obtain general idea about the spatial distribution of distortions, to introduce corrections into linear, aerial and angular measurements, to correct deciphering procedures when transferring the deciphered contours to cartographic base of close scale. They also make easier the choice of optimal mathematical model for analytical "correction" of these images in the purposes of higher accuracy of cartometric measurement and, hence, for higher effectiveness of quantitative use of scanned space information in natural resources study.

In this connection of particular interest is the analytical "correction" of scanned images by means of mathematical modelling of coordinate measurements by scanned images and corresponding cartographic base employing various kinds of transformations such as transformations of similarity, affinity and projective, methods of approximation by interpolative polynomes, Gauss-Markov processes, spline-functions, Furie rows etc.

Research carried out on scanned space images "Fragment" of 1:500 000 scale has demonstrated that even application of interpolative polynomes has made it possible to analytically "correct" those images to a great extent. Thus for the Saratov reservoir area transformation using the 2-nd power polynomes which were modelled using the least squares method error of 200 m. This error value was received in cheking by three points which weren't used when defining the model parameters. For the Kalach Nills area (Don riv.) such modelling using 3-rd power polynome (20 points used) has resulted in the mean error of 300 m (4 points used in check). Such results are comparable with the accuracy of measurements on general-topographic maps of 1:500 000 scale. The same evidence is provided by maps of residual distortions (after analytical "correction") presented in figures 1-b and 2-b.

For many kinds of aerial-space photographs and other images demanding quantitative evaluation (either analogous or analytical) preparation for use in the optimal form is desirable, which is possible first of all through cartographic presentation of information they contain. Thus, the creation and application of orthophotomaps (aerial and space) is one more direction where photogrammetry plays an important role in the combination of aerial-space imagery and cartographic methods of research. Orthophotomap like photograph presents two-dimensional image of spatial object-Earth surface and carries a lot of information obtained during deciphering. This data are widely used in various branches of Earth sciences. It is expedient while constructing orthophotomaps to correct the original aerial and space images in such a way that after addition of appropri-

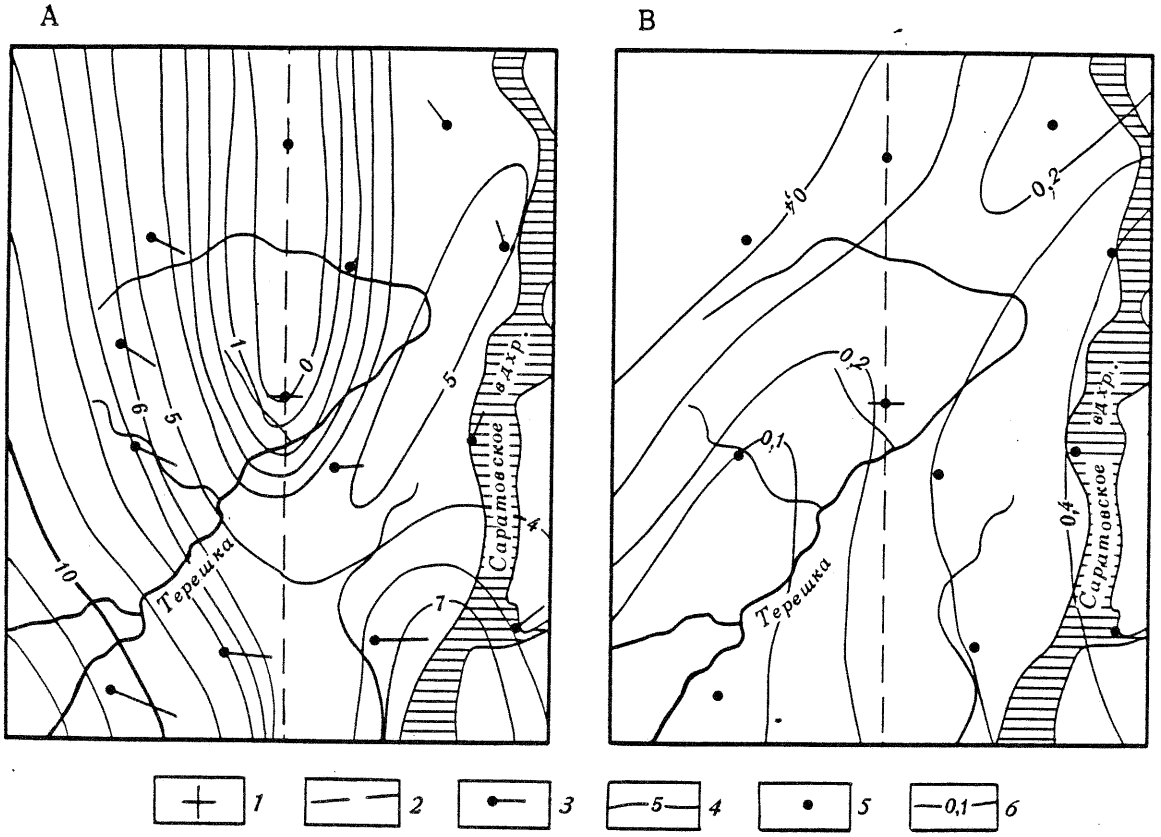

Fig.1. Maps of isograms of geometric distortions of "Fragment" scanned space images (Saratov reservoir area): 1-a map of overall geometrical distortions, 1-b map of residual geometrical distortions after analytical "correction": 1- conventional centre of scanning panorama, 2- axis line of scanning during photographing, 3- vectors of distortions, 4- isograms of distortions value before "correction", 5- location of points on scanned image, 6- isograms of residual distortions after "correction". Place names: Saratov reservoir, Tereshka riv.

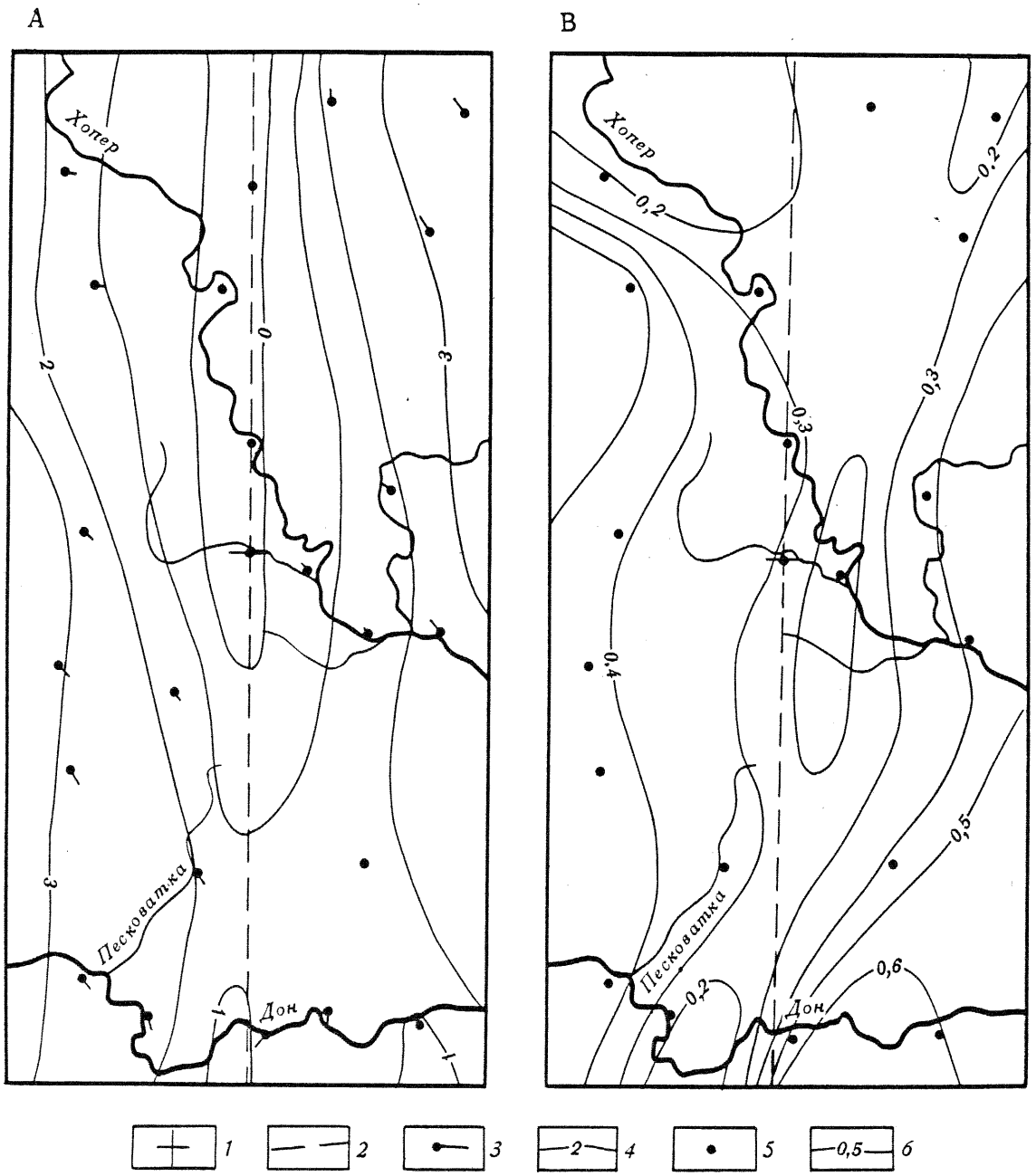

Fig.2. Maps of isograms of geometric distortions of "Fragment" scanned space image (Kalach Hills area, Don river). For references see Fig.1. Place names: Don riv., Khoper riv., Peskovatka riv.

ate thematic elements they might be used as a basis for compiling thematic photomaps.

The joint application of aerial-space imagery and cartographic methods is connected with one of the principal directions of improving the effectiveness of environmental protection and more rational use of natural resources. The two methods interact particularly closely in setting up of monitoring, i.e. multi-purpose information system, designed to monitor the condition of environment and the factors which influence it. Complex application of the two kindred methods in environmental monitoring must form a united system embracing methods and means of obtaining images, methods of their cartographic and photogrammetrical processing with the use of interactive automatized and automatic procedures. Immediate use of cartometric characteristics of two- and three-dimensional aerial-space models in the purposes of direct reading of quantitative information appears to be of importance. It is also necessary to develop photogrammetric principles of compiling ciphered information banks including substantiation of the choice of mathematical models of normalization of such information in the purpose of its automatic cartographic presentation and interpretation. Many information sub-systems of natural environment monitoring such as water, soil, vegetation, industrial activities monitoring, etc., should probably be built and expanded relying on precise quantitative photogrammetric data.

So, further development of aerial-space imagery and cartographic methods calls for their close interaction and combining. The role of connecting link in this process must be played by photogrammetry, broadly understood as a science about obtaining quantitative information from photographs and specifically, information about objects of natural world. Of great importance is the evaluation of cartometric characteristics of aerial-space photographs and images, particularly scanned ones, through compilation of maps of overall geometrical distortions which enable one to carry out direct quantitative measurements on them. Of interest is the use of orthophotomaps, especially space ones - a direction where the role of photogrammetry is important for many branches of the Earth sciences. The combination of aerial-space imagery and cartographic methods on the basis of precise photogrammetric processing opens up extra possibilities in environmental monitoring.

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