DOI: 10.2478/mgrsd-2002-0030

MISCELLANEA GEOGRAPHICA
WARSZAWA 2002 Vol. 10

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SEMIOTIC APPROACH TO CARTOGRAPHIC GENERALISATION

The development of theoretical studies assumes a particular significance in the contemporary cartography, owing, in particular, to the fact that it provides the basis, which is indispensable for the logical and substantially correct formalisation of the procedures used in the establishment of the spatial information systems and in the application of computer technologies in the elaboration of maps, including the issue of generalisation of the map contents. Among the various theoretical directions, which in the recent decades have developed in cartography, the semiotic direction offers the biggest possibilities of practical use. The semiotic approach may also constitute a good starting point for the elaboration of the theoretical foundations for the cartographic generalisation, and in particular — for the determination of its different types.

Generalisation is definitely an indispensable and essential process that makes a part of the procedure of elaboration of any map. The necessity of going through this process results from the need of adapting the scope and the manner of treating the contents of the map to the perception capacities of the map users. At the same time, the proper generalisation ought to ensure the reflection of the features of spatial differentiation of the Earth's surface that are essential for the map user, and of the most important characteristics of the objects presented.

Cartographic generalisation is a complex process. It is composed of various sub-processes of logical, graphical, and perception-related character. Despite the fact that this problem was taken up already almost a century and a half ago (Sydow, 1866), the ways of approaching generalisation are very differentiated. This is, in particular, apparent from the fact that the authors of the handbooks of cartography classify in a very different manner the types of generalisation. And so, for instance, A. Robinson, R. Sale and J. Morrison (1988) distinguish four types of generalisation: selection and simplification, classification, symbolisation and induction. According to L. Ratajski (1989) there are two essential kinds of generalisation: the quantitative generalisation (including the generalisation of form and contents) and the qualitative generalisation (including symbolisation, grouping, as well as a change in the perspective on the phenomenon). K.A. Salishchev (1998) distinguishes five

kinds of generalisation: selection of the phenomena mapped, simplification of the object outline, generalisation of the quantitative characteristic, generalisation of the qualitative characteristic, and replacement of the designation of the separate objects by the joint designation.

The generalisation process is considered from a broader perspective by A.M. Berlant (1996). The classical cartographic generalisation is treated by him as one of the four types of generalisation of the geo-presentations. Side by side with the cartographic generalisation he distinguishes the distance, dynamic, and logical-mathematical (computer) generalisations.

Distinction of the thus different types of generalisation results certainly from the variety of experiences of the authors of respective handbooks, and the associated variety of approaches to this process. Cartographic generalisation is one of the specific cases of the generalisation process, and that is why it should be seen in a broader perspective. This kind of perspective is provided by semiotics, as the general theory of sign, and by the cartographic semiotics, based upon it, which treats the map as a system of signs remaining in definite relations with the system represented by it, and with its users.

Semiotics was defined and systematised as a scientific discipline by the American philosopher Ch. Morris. Just before the World War II he distinguished three aspects of semiotics, which have become classical by now, namely:

— the semantic aspect (the relation of the sign to what it means),
— the syntactic aspect (the relations existing between the signs), and
— the pragmatic aspect (the relations between the sign and its user).

The three aspects of semiotics, mentioned above, will constitute the basis for distinguishing in the present paper the three fundamental stages of cartographic generalisation.

The beginnings of the semiotic direction in cartography are assigned to J. Bertin (1967), whose seminal book *Sémiologie graphique. Les diagrammes, les réseaux, les cartes* constitutes a classical reference in the field.

Two essential approaches are being distinguished in cartographic semiotics. The first consists in the treatment of the map as a specific language. This direction is represented in Poland by P. Neytchev (1999). We can also find it in the publications of L. Ratajski (1978). The second, much more popular approach, which can be referred to as the model-graphic direction, consists in treatment of the map as a logical-graphical model of a fragment of reality (Ostrowski, 1979; Czerny, 1994; Tikunov, 1997; Żyszkowska, 2000). It appears that the second approach reflects better the essence of the map, since it puts forward the basic relation of the map to the presented fragment of reality, given the limitations to perception.

The map constitutes both the thought (logical) model and the graphical one, with the two features of the model being closely associated with each other and mutually conditioned. The establishment of the cartographic model (the modelling process) aims first of all at the cognition of a fragment of geographical space. In view of the complexity of the space the necessary condition for the cognition is simplification and generalisation, as well as

demonstrative, holistic and ordered presentation. In this manner we adapt the model to the perception and intellectual capacities of the map user. Cartographic modelling consists therefore in presentation of the complex reality in the form of an image sufficiently simple to be understood and usable (Żyszkowska, 2000). The generalisation of the contents, side by side with the reduction of the space represented, is the most essential feature of the map as a specific model of the spatially, temporally and thematically limited fragment of reality.

Despite the generalisation and the significant reduction the map, as a model of geographical space remains in a definite relation of similarity to the presented fragment of reality, which corresponds to the **semantic aspect**. This aspect, in turn, refers to the conceptual stage of elaboration of the map, that is — to the establishment of the conceptual model of geographical space (Żyszkowska, 2000).

The **syntactic aspect** (the relations between the signs in the system) corresponds to the graphical design of the map (relations between the signs) and to what W. Żyszkowska calls the syntactic model of geographical space.

Finally, the **pragmatic aspect** (the relation between the sign and the user) refers to the broadly conceived perception of the map and the ways of using it.

Thus, on each of these stages and within each of the aspects mentioned we deal with the process of generalisation. It is possible, therefore, to speak of the semantic, syntactic and pragmatic aspects (dimensions) of generalisation.

The broadly conceived cartographic generalisation in the semantic aspect reduces to the selection of the region, the time, the classes of objects and their attributes, reference units, as well as magnitude or intensity classes of phenomena. The syntactic aspect of generalisation is equivalent to application of symbols, connection and simplification of contours, and simplification of lines. In the pragmatic aspect we deal with the visual generalisation (reading at a general level).

THE SEMANTIC ASPECT OF GENERALISATION

Semantics, having originated from linguistics, considers relations between signs and objects, to which these signs refer, that is — the designations of the signs. An intermediary in these relations is constituted by the notions, which define categories, classes or types of objects, and thereby also the properties of these objects. The categories and classes of objects, expressed through notions, emerge in the effect of the process of abstraction, that is — the thought distinction of certain essential features and omission of the inessential ones. A specific characteristic of the cartographic abstracting is that it refers not only to the objects and their attributes, presented on the map, but also to the space represented by the map (for instance, the shift from the contour presentation to the point symbols or linear one). In case of maps presenting the variability of phenomena in time we deal with abstraction of the

characteristics of their dynamics. It consists in presentation of changes considered to be important, and in neglecting the ones perceived as little significant.

The selection of classes and attributes of objects

The selection and classification of the contents to be presented on the map is being carried out at the conceptual stage of elaboration of the map. This is necessary in elaboration of all the cartographic representations, especially the more complex ones, and in the establishment of the databases. When the scale is being shrunk, the numbers of categories and classes of objects are as a rule decreased, so that the degree of abstraction of the map increases. The decrease of the number of classes takes place both through elimination of the categories of the less important objects, and through joining of several classes into one, broader category, which is usually associated with the decrease of the number of quantitative and qualitative characteristics (attributes), or with the reduction of precision of the quantitative ones.

It must be emphasised that in order to carry out a correct classification it is necessary to know or to identify the essence of the phenomena presented. In particular, in developing the comprehensive and synthetic representations it is necessary to analyse the relations between the objects or classes of objects (functional connections), to determine the similarities and dissimilarities between them, and to establish the hierarchy of importance of the individual classes of objects. This is decisive for the close association of cartography with other sciences or practical disciplines dealing with various aspects of geographical space. That is why it is not possible to agree with the view represented by some cartographers (Arnberger, 1970; Kretschmer, 1980), that the subject of cartography is constituted merely by the cartographic form of expression and its graphical elements, and that it should abstract from the essence of the phenomena presented. Cartography ought also consider the analysis of the substance matter presented, indispensable, in particular, for the correct generalisation, as indicated already by the present author (Ostrowski, 1979), and as emphasised also by the Russian cartographers (e.g. by Salishchev, 1970; Tikunov, 1997).

In the selection, classification and analysis of contents, already during the conceptual stage, it is also necessary to account for the purpose of the map (the knowledge and the needs of its users), as well as the way of using it (e.g. in the form of a wall map, a computerised map, a topographical map). The choice with this respect sets the conditions for the reading of the map (quantitative, selective, ordered perception) and determines the perception capacities of the users (resulting, in particular, from the maximum number of the diverse categories, which can be internalised by a reader when using the map).

The choice of the classes and attributes of the objects looks differently on the analytic, synthetic and comprehensive maps. On the analytic maps we choose a class of objects (say: forests) or a characteristic (attribute) of an object (like: air pressure), with the choice being determined by the theme of

the map. On the synthetic maps we choose the classes and attributes not presented directly in the map (e.g. the characteristics used for the definition of the types of farming or the types of climate). These characteristics serve as the basis for synthesising. On the comprehensive maps we select a set of object classes and their characteristics, which are presented on the map. They compose the contents defined by the subject matter of the map, which, in opposition to the analytic maps, has a broad semantic scope, like in the cases of topographical or economic maps.

Two basic types of attributes can be distinguished from the point of view of the generalisation process: the individual characteristics of objects and the characteristics in quantitative, ordered and qualitative classes.

In case of individual characteristics of particular objects, with which most often proper names and numbers are associated, we deal with the lowest degree of generalisation. These may be both the qualitative characteristics, in the form of, for instance labels of the tourist objects, proper names, or estate numberings, and the quantitative characteristics (like, e.g. the population number of a locality on the topographical map, the altitudes of peaks, or a graduated symbols map with the continuous scale of values).

A vast majority of the cartographic methods of presentation are used to show the characteristics expressed in terms of classes. These may again both be the quantitative characteristics (magnitude or intensity classes), ordered characteristics (like soil quality classes), or qualitative ones (such as, e.g., functional types of towns or kinds of structures). The degree of generalisation of the attributes expressed in terms of classes is always higher than in case of individual characterisation of objects, and it depends upon the magnitude or the semantic scope of the class.

Generalisation of the spatial characteristics

The degree of generalisation of the spatial characteristics depends upon the scale of the map and is first of all related to the number of spatial dimensions, whose reduction was performed in the development of presentation of individual objects and phenomena on the map. It is obvious that the more spatial dimensions are reduced, the higher the degree of generalisation. We can distinguish here four types of representation: without reduction of spatial dimensions, with reduction of the vertical dimension, with reduction of two dimensions, and with reduction of three dimensions.

Reduction of dimensions does not take place in case of three-dimensional representations (three-dimensional maps, block-diagrams), when the flat surfaces are represented (without consideration of the Earth's curvature), e.g. of the water surfaces, as well as in cartographic representation of lines and points in geometrical sense (e.g. of the watersheds, boundaries, altitude points).

We deal with the reduction of the vertical dimension most often in surface (contour) presentations, both qualitative (like in the area method) and

quantitative (reference units). Reduction of just one dimension (width) takes place also in presentation of rivers in the form of linear signatures.

Reduction of two spatial dimensions (height and width) takes place when we use linear symbols for presenting objects (like the signs of edges or roads).

Reduction of three dimensions (the highest degree of spatial generalisation) occurs most often in case of use of point signs, in case they represent the objects occupying a definite area (like the symbols of towns).

Generalisation of the spatial characteristics is also associated with the aggregation of the reference areas of the characteristics, both qualitative (e.g. the area method), and the qualitative (e.g. the methods of choropleth map, isoquants). In this case the generalisation of the spatial characteristics is frequently linked with the decrease of the number of categories or quantitative classes of the objects.

Generalisation of the characteristics of the dynamics of phenomena

We will give now a short survey of the methods of presentation of the dynamics of phenomena, starting, similarly as before, from the lowest degree of generalisation, and ending with the highest one. Thus, we can distinguish in this sense three essential types of representations:

— animated maps, where the degree of generalisation of the temporal characteristics depends upon the adopted scale of time;

— presentation of geographical space at a number of time points on one map or on a set of maps (the degree of generalisation depending upon the number of and the time intervals between these points and upon the speed of change of the phenomenon in question);

— maps presenting the average dynamics of the phenomenon in a definite time period (the longer the period and the more irregular the changes, the higher the degree of generalisation).

THE SYNTACTIC ASPECT OF GENERALISATION

The cartographic syntactics analyses mutual logical and spatial relations between signs and deals with the graphical form of signs representing particular categories of objects (or single objects) and their attributes.

Generalisation according to the syntactic aspect is taking place through the process of symbolisation, that is — graphical coding of the results of classification, and also coding of the fundamental characteristics of phenomena, the differences in their importance and the mutual positions of these elements, which we obtained from the process of selection and generalisation within the semantic aspect (Robinson et al., 1988). It is here that the visualisation of the conceptual model of geographical space takes place. The typical examples of generalisation according to the syntactic aspect are provided by simplification of lines and contours of objects.

A precondition for the correct generalisation according to the syntactic aspect is constituted by the possibly full representation of the characteristic features of the mapped objects and phenomena, in particular the similarities and the differences between them, finding a reflection in their classification, and in the hierarchy of their importance. On the other hand the graphical form ought to be adapted to the limitations and properties of the visual perception. This is first of all conditioned by the logically justified selection of symbols and methods of presentation, and, in particular, by:

— adaptation of the applied graphical (visual) variables to the characteristics presented by them,

— differentiation of the visual weight of the signs in accordance with the significance (importance) and the magnitude of objects, represented by the signs, or depending upon the intensity of the phenomena represented by them,

— adaptation of the graphical form of signs to the classification of objects through visual grouping of signs for purpose of enabling or facilitation of distinction of the particular categories of contents.

THE PRAGMATIC ASPECT OF GENERALISATION

Cartographic pragmatics deals with the relations between the presentation and the map users, and especially — with the perception of cartographic presentations. Perception consists in an active participation of the reader of a map. We find certain patterns in our memory and compare them with the map.

The process of generalisation at the stage of reading of the map, called by L. Ratajski (1989) "perceptional generalisation", is determined by the characteristic features of perception. These features include the holistic (*gestalt*) cognition of forms, and the organisation of the impression material through assignment of structure to what we see (Hilgard, 1968).

Three levels (degrees) of perception can be distinguished, namely the levels of visibility, understanding, and interpretation.

At the level of visibility a reader perceives the set of dots, points and lines. The generalisation in reading a map takes place uniquely in the syntactic dimension. We assess the setting and the density of points, dots, and lines.

At the level of understanding the result of perception is the establishment on the basis of the map where a given category of objects is located. We can speak here of the regionalisational generalisation, when the groups of objects form distinct regions of their appearance, and of the typological generalisation, when we distinguish a given category of the dispersed objects from among the objects belonging to other categories. Besides, when we read a map at the general level, we define also the characteristic spatial features of a given category of objects, like, for instance, the course of the climatic zones or of the mountain ridges, or the setting of the river network.

At the level of interpretation the generalisation takes place through the visual analysis of the map or through carrying out of appropriate measurements on it. It is possible to analyse the relations between the particular

categories of contents, to estimate or measure distances, average gradients or trends.

Generalisation according to the pragmatic aspect is closely related to the previously considered semantic and syntactic aspects of generalisation, and all the three aspects are mutually conditioned. A correct reading of the map on the general level is not possible or is made very difficult if the degree of generalisation of its contents and the graphical form are not adjusted to the perception and intellectual capacities of the reader of the map.

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