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## **The General Theory of Cartography Under the Aspect of Semiotics**

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Map language has been one of the most important means of social communication through the ages. It emerged at the dawn of human society as a means of communicating information about places to find food (hunting) [2], gradually grew in importance for transmitting other information about the surrounding area and finally evolved into a universal means of communication suitable practically for the transmission of any space-related information.

The semiotic approach to the general theory of cartography relates to the symbolic nature of maps, to the formulation of rules concerning the arrangement of signs and their combinations, to the study of the syntax of the symbolic system of maps (syntactics), to the determination of the semantic content of signs and their combinations (semantics), to the study of characteristic patterns of the signs used in the course of communication, and to the determination of the circumstances resulting in the emergence of certain symbolic features (pragmatics). Without a detailed consideration of all aspects of the semiotic approach in cartography, which have already been outlined [3], we would like to present the characteristics of map signs and the map as a sign from the point of view of semiotics.

According to the founder of modern semiotics, Charles Sanders Peirce, any sign has three main characteristics: 1) a material medium, 2) a designated object, and 3) the rules of interpretation determined by man [4]. All of these characteristics in their full scale are immanent to map signs as well as the map itself in general, because the map can also be considered as a sign.

When we speak about the map as a material medium, we cannot leave unconsidered its ontological status, i.e. the mode of being of a cartographic work as a material object, the degree of objectivity of its contents, the forms of its dependence (independence) from a perceiving subject as well as from its historical and cultural context.

The text is a material form of expression of the historical and cultural context. In a broad sense, any piece of culture or any object created in the course of material production can be called a text. Thus, any cartographical work can be regarded as an objectively existing text, characterized by relating material medium and structure. What are the peculiarities that allow this text with its constant connections and correlations to be opened for interpretations? Is there an unambiguous understanding of a map? The cartographic practice itself leads to the discussion of these problems. If, for example, we compare medieval world maps made by Europeans - the so called *mappaemundi* either from the treatise *Topographia Christiana* ("Christian topography") by Cosmas Indicopleustes, showing the orthogonal Earth surrounded by ocean on all sides or shaped as half of the ellipse or Macrobius' maps dividing the Earth into five zones (thermal belts), or numerous T-O-maps dividing the Earth into three parts of the world - Asia, Europe and Africa or modern maps of the hemispheres - in all cases they present different images of the Earth and even different initial semantic positions and aims of mapping. Tectonic maps are another example. They all have the same name but different basic conceptual views of the Earth tectonics (in terms of the folding age, the types of regional structures, and the time of the continental crust formation), resulting ultimately in absolutely different images of the tectonic structure of our planet. Thus, the *constant state of the mapping object* is not equivalent to the *constant state of its cartographical image* on different maps. This is one of the essentials of the general theory of cartography, which states the non-concurrence between the contents of a mapping object and the contents of its cartographic image, the dependence of a map theme upon conceptual views of the object of mapping.

Any text containing true statements (i.e. statements whose consistency can be proved by practice) relating the objects and phenomena of the surrounding world, reflects some aspects or other of the reality and is therefore its model [4]. The models represented by symbols are called symbolic or semiotic. Thus, *the map is a symbolic (semiotic) model of the real world*. The semiotic models are also called *information models* because such texts transmit information on some aspects of reality. Maps as symbolic models possess attributes of adequacy (similarity to the modeled reality), isomorphism, and homomorphism. The isomorphism of maps manifests itself in an unambiguous conformity of general geographical patterns shown on thematic maps of the same scale by using a unified base map for their compilation, for example, in geographical atlases or map series. The homomorphism of maps is expressed in the fact that the map of a larger scale is connected by the relation of unilateral similarity with the map of a smaller scale, meaning that for every object shown on the map of a smaller scale there can be found a related object on the map of a larger scale (not vice versa). The homomorphism of maps is vividly shown by an example of topographical maps of the whole succeeding scales. The adequacy of the map to the real world is achieved by keeping the spatial relations between real objects and the objects shown by signs on the map in the spatial structure of the map. That means that spatial (geographical) relations between map signs are identical to the spatial (geographical) relations between objects in the real world and are strictly determined by geographical coordinates. Some geometric proportions (of widths, angles, areas) will be distorted on the flat, according to the mathematic law employed (the chosen cartographic projection). The strict location of signs denoting geographical

objects on the map according to their geographical coordinates is the main condition of maintaining the adequacy of the map as the semiotic model of the real world.

Passing to the represented object as the next characteristic of the map as a symbol, we emphasize the epistemological functions of the map, regard the geographical map in terms of its cognitive possibilities as well as the relationship of the cartographic depiction and the real world. The problems of the relationship of the cartographic depiction and the reality are fundamental problems for comprehending the nature and peculiar features of the cartographic depiction, its expressiveness, because the surrounding world is the main object of mapping. At the same time, a cartographic image cannot always (or cannot at all) be presented as a replica or a copy of the reality: the process of mapping is often rather complicated from the semantic point of view. It is determined not only by the instructions on mapping (for example, topographic), but also depends on the initial scientific concepts concerning the object of mapping (for example, the concepts of the Earth tectonics, paleogeographical reconstructions, the elaboration degree of some scientific forecasts for the development of geographical objects and phenomena, etc.). Different initial hypotheses, concepts concerning the genesis and functioning of the real object of mapping within the cartographic image can change its symbols greatly. The use of different methods of cartographic depiction or graphic means of representation in order to show one and the same object or phenomena result ultimately in graphically absolutely dissimilar cartographic images. For example, cattle stock can be shown on agricultural maps by means of the dot, or collation, or diagram method, but every time in the end it will result in different images of the same object. Thus, the syntax of the reality does not coincide with the syntax of a map. The author of a map depicts the reality or its individual aspects in accordance with his scientific vision and understanding of the reality. Of course, a certain randomization in choosing the means of depiction cannot be eliminated. At the same time, from the point of view of its creator, the cognitive and transforming abilities of a geographical map (and, to a greater degree, of a thematic map) can be expressed by the following formula: "I depict in the way I imagine it and want others to imagine it as well". Thereby, an important part is assigned to the author of a map, his scientific outlook, and his mastery of map language.

While the objects and phenomena of the real world are thought to have such attributes as absoluteness and sensory reality, their cartographic image is perceived as something symbolic, created by human culture. The boundary between the symbolism of real phenomena and their cartographic depictions is always flexible - sometimes it is almost effaced (on photomaps), sometimes, to the contrary, it requires serious efforts to deduce the contents hidden in a cartographic image (for example, in 'navigation' charts of the inhabitants of the Marshall Islands).

The rules of interpretation of map symbols are determined by man to obtain information transmitted by them, and these rules are significantly influenced by the value and usefulness of this information for people; thus it is a matter of the axiological properties of the map as a source of information. The person interpreting a cartographic work should have the certain special knowledge needed for reading a cartographic text, especially in the case of thematic maps (geophysical, geological, hydrogeological, etc.).

Cartographic works utilize all three groups of signs specified by Ch. S. Pierce: *iconic signs* having similarity with a depicted object (for example, the so-called demonstrative signs), *index signs* connected with the depicting object due to spatial-temporal, causal, or contiguity relations (for example, a set of contours located close to each other denotes a steep slope, and, vice versa, sparsely located contours denote a slight slope), and *symbolic signs* apparently having nothing in common with the depicted object (the majority of conventional signs on geographical maps in the form of markers, other symbols, etc.) and connected with it only artificially. The two latter groups of signs are also called *designative* and *signal* signs.

The iconic signs denote the objects which have some limited set of features as the signs themselves [1]. U. E o specifies additionally that an iconic sign has common attributes not with the denoted object but with 'the structure of its perception' which is reconstituted by man using graphic means [5, p. 135]. Iconic signs are usually easy to identify and interrelate with definite groups of the objects they denote. In the era of the West European Middle Ages, iconic signs predominate on small-scale maps; these signs should not have been specially explained in the legend due to their outward resemblance to the objects they denote. The explanation of signs in the legend, as shown above [6], was introduced as early as the first half of the 16 th century, when the different functional peculiarities of the denoted objects were beginning to be mapped, for example, to show the main confession of the inhabitants in a community. An iconic sign more often denotes common rather than individual features. On medieval maps, communities were shown as a general schematic image of a castle, fortress, or church, i.e. as images of the buildings that are typical of all communities. But the meaning of an iconic sign is not always as distinct as it may seem at first sight. In most cases it is accompanied by an inscription, which allows the specification of general characteristics or provides an indication of the objects denoted by this sign as an individual feature denoting a concrete geographical object. The above-mentioned conventional signs of communities on the maps are necessarily accompanied by inscriptions - proper names of communities identifying a general sign with a concrete (individual) community.

According to Ch. S. Pierce, diagrams are also iconic signs because they render a kind of real relationships.

The index signs (indicator signs) include those signs, which allow one to identify them with spatial and/or temporal features of objects and phenomena as well as their contiguity. Such signs are used on maps to denote objects and phenomena (as well as their properties and characteristics), the area or width of which can be shown within the map scale. They are shown by means of the qualitative and quantitative background, areas, isolines, dots, collations, lineal signs, and movement signs. The index signs normally have an implicit (indirect, not-evident) character, i.e. they can be read only by means of special "deciphering" tables - map legends. For example, rocks, soil types on geological or soil maps are shown by areas of different colors (often combined with letter and figure indices) and are explained in rather long legends. In another case, index signs can be explicit, i.e. denote a concrete geographical object evidently by means of written signs (words of a natural language) and graphic techniques. For example, on general

geographical and hypsometric maps all large landforms are shown by means of contours, while inscriptions of their own names directly inform the reader about each such landform. An inscription within an area or without a border denotes the shown object distinctly, for example, on the maps showing distribution areas of animals or plants. Such index signs are informants about the depicted features.

Symbolic signs are widely used on maps, especially on topographic maps, to denote industrial, social, and cultural features, vegetation cover, boundaries, etc. Depending on the context of the usage, some signs (area, linear ones) can stand for symbolic signs; they may have certain colors traditionally associated with some characteristics of objects and phenomena, for example, the color red is associated with warmth as the color blue indicates cold. So, blue (cold) tones are used, for example, on air temperature maps to depict degrees below zero, while red and yellow tones are used to denote degrees above zero. Thus, a color - blue and red - on such maps acts as a symbol of warmth and cold, respectively.

The evolution of cartographic symbolism can be elucidated in terms of the theory of mimesis (imitation), which was actively developed as early as in antiquity. Imitation, in a broad sense, is an initial and very common fact in the life of any creature. The reconstitution of the surrounding world by means of map language is mainly based on the imitation of reality: some 'profile' demonstrative signs resemble the real objects outwardly (for example, a forest and its profile image are shown as separate signs (pictures) of trees on medieval maps), the color of the signs repeats or is close to the color of the real objects (the color green to show vegetation, blue to indicate water. The Red Sea was traditionally depicted by the color red on Portuguese portolan charts as an imitation of the reddish hue of its waters). Thus, there is an evident penetrability of borders between cartographic images and reality. The recognition of real features on the map is not a primitive process. It concerns the mechanisms of memory, association, comparison, assessment, etc. to the full extent. The notions of mimesis and recognition express a stable type of relationship between the cartographic depiction and reality.

The map signs can become *diagnostic signs*: for example, the fact that the map image of the individual parts of river systems resembles circles provides certain information about the tectonic structure of the region (circle structures). In such cases one and the same sign image can function as two signs - one interpreted by a hydrologist indicates its denotata (hydrography), and the other, interpreted by a geologist, indicates the peculiarities of the tectonic structure of the territory.

Overall, the map as a symbol is poly-functional: it is at the same time an iconic sign as well as an index and a symbol. Indicating some concrete reality, it is firstly and foremost an index sign having a clear representative function. While reading a map, a person can imagine the terrain shown on it or note the principles of the display of some phenomenon or other, i.e. a map itself acts as an iconic sign. As a language sign, the map is first of all a symbol, a symbol of the work of a cartographer and geographer, a symbol of geographic knowledge, a symbol of the era of geographic discoveries and so on and so forth.

One of the main principles, according to which any language, including map language, lives and develops, is its tendency to avoid 'excessiveness'. This principle manifests itself in the fact that only one graphic depictive means (one sign), not two at a time, should be used to show some object or its characteristic (attribute) on the map. For example, two graphic means were used at once to show woods on topographic maps in the 1920s - texture and color: circles were put within the areas of woods, and the areas themselves were colored green. One of these means was obviously excessive. This map language excessiveness was removed later, and woods were shown by using only one means - color. Another example of map language excessiveness could be seen in the inscriptions of river proper names. Each name was accompanied by an indication of the kind of object - "river", for example, "the Volga River". The indication of the object kind is also excessive in that case. The sign itself - a blue line denoting a river - indicates the object kind. Later this excessiveness was also removed, and now the additional indication "river" as the object kind is not used on maps together with the inscriptions of river proper names. One can still come across some elements of excessiveness on geographical maps. For example, near the proper names of islands the indication of the object kind is still given - 'island' or briefly 'I.'. Such an indication is obviously excessive, because the image of an island itself indicates the object kind, and additional explanations are not necessary. It is enough only to give the name of an island, and this is exactly how it is done on the maps of the well-known American cartographic company «Rand McNally». In fact, this company does not use indications of the object kind in proper name inscriptions of individual islands on its maps. The excessiveness of map language can also be seen in indications of the object kinds in inscriptions near lakes or wells on topographic maps (near a sign denoting a well they additionally put the letter "W" - abbreviation for 'well' - which doubles the indication of the object kind), and in some other cases. Such manifestations of the excessiveness of map language are connected either with a well-established tradition (in the case of depicting lakes) or with instructions (in the case of depicting wells). But in both cases these are evident indications of the excessiveness of map language, which can be easily removed.

Under the aspect of semiotics the properties of the map as a symbol reflect its cognitive possibilities. The first property is that the map as a sign appears (is created) and at first functions within a limited social and cultural group of cartographers, geographers, geologists, navigators, etc.

The second property of the map as a sign is its ability to be dated, to show a connection with certain historical ages, times, and to be read through the association with them. Maps of different historical ages (periods) have their distinct style of design and concrete contents determined by geographical knowledge accumulated by humans of a certain

period. The complex of certain features of design as well as the geographical information contained in a map allow us to attribute maps.

The third property of the map as a sign is that the map expresses the unity of an objective picture of the world and the personal "experience" of the cartographer who created it. That is, the subjective preferences of a cartographer manifest themselves in the map, its

design and contents, they become apparent in the choice of signs, design, layout, and even in the contents of the map. The different experiences (including social and cultural) of cartographers, their different cartographic skills, result in the creation of slightly different maps even for the same area, of the same contents, and at the same scale. Maps made by different people present the subjective semiotic expression of the objective reality. A man reading a map understands it in his own way. He interprets its contents, compares map signs with the objects they denote in accordance with his social and cultural experience and his skills at working with maps. That is why every person reads a map in his own way, depending on his experience which cannot be totally the same as that of another person. There is no common reading and perception of a map. The vision of the reality and its semiotic perception is individual for each person.

Thus, the semiotic approach to cartography opens new possibilities for the study of map language, its informative and spatial structure. It allows us to reason and use the rules of construction of some map signs or other, and also to reinterpret the process of the cognition of reality with the help of the map.

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