
GEOGRAFICKÝ ČASOPIS

55

2003

4

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CARTOGRAPHY IN THE AGE OF GEOGRAPHIC INFORMATION SCIENCE

M. Wood: Cartography in the age of geographic information science. Geografický časopis, 55, 2003, 4, 19 refs.

Although cartography and GISystems can be regarded as separate disciplines they do overlap and have common roots. This paper traces origins and attempts to identify a more holistic field in which “cartography” and GISystems contribute to the common human requirement to solve spatial problems. The first real maps, traced in sand, were early examples of this. However the growth of the traditional discipline led to classes of expert collecting and transform the data into graphic information as published maps. The result was a map-making/map-use dichotomy which, effectively, separated those having to solve problems from those creating the map tools to help them. The arrival of computers, global communication and multimedia has had a profound effect on cartography. Experts still operate in different areas – from specialised design to the application of maps in research and analysis – but new interactive web-based facilities now offer even general users the possibility to start employing cartography (and not just pre-printed maps) directly. This interactive process of seeking, assembling and modifying maps and data on the Web is leading to a shift from the dichotomy paradigm, and a move back to a more basic situation. Users – expert and novice – can now become involved, more directly in “using cartography”, rather than just “using maps”. So GISystems and GIScience have not isolated themselves from mapping. Mapping (and cartography) are integral to the whole procedure of spatial problem-solving.

Key words: cartography, map, geographic information system, geographic information science

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INTRODUCTION

Although *mapping*¹ is an instinctive awareness and fundamentally cognitive, for centuries it has been known through the paper-based maps which have been used to express geospatial ideas, to store and to communicate spatial information. Paper maps have many qualities but lack the dynamic and interactive flexibility of their cognitive counterparts. More recently, through the innovative technology of GISystems, the process of mapping has been extended more effectively to facilitate the exploration and analysis of increasingly complex spatial problems in science and society.

Our early ancestors had mapping skills which not only made them aware of the environment but enabled them to scratch out simple sketches of their cognitive “maps” in the sand. This ability remains but, as with writing, it took an emerging class of specialists in what became known as the discipline of “Cartography” to develop usable map products. After centuries of gradual change, maps began to increase in status and in their contribution to the understanding of world geography. Cognitive mapping abilities continued but there was also a long period during which the “making” and “using” of real maps were distinct activities. One consequence of recent advances in technology has been to bring them closer. Intelligent access to databases and interactive user support now make it possible to both find suitable maps on the Internet and even to create and modify maps to meet individual needs. Instead of merely “*using maps*” produced by others, these new interactive exploratory facilities allow individuals to truly “*use cartography*” themselves in an admittedly simple but more holistic sense². For a long period the only link between our flexible and responsive cognitive maps and the growing external sources of spatial data were paper maps, designed for broad categories rather than individual users. With parallel developments in GISystems, cartography for the casual user is now maturing into a more personal interactive facility. New technologies offer a “live link” between our instinctive spatial cognition, through vision and direct interaction with a new generation of cartographic visualisations, to the potentially infinite resources of the Internet. Although cartographic visualisations are, by definition, abstractions, new technology (and high resolution data sources) also permits a spectrum of representational possibilities from near-realistic dynamic visualisations, to generalised static map models, all linked directly to the databases from which they were derived. They are “malleable” (Cartwright 2000) and can be transformed in response to the changing demands of the investigation.

Despite remarkable and separate developments in the field of GISystems/GIScience since the 1960s the author attempts to place both cartography and GIS within a broader developmental context. This emphasises the fundamental nature of the subject in humans for problem-solving and marginalizes the narrower definition (sometimes assumed by users of GISystems) of cartography as only the visual *communication* of spatial data.

¹ The ability to construct, internally, a knowledge framework of the spatial environment.

² As one might ‘use mathematics’ rather than just individual mathematical formulae.

CARTOGRAPHY BEFORE THE COMPUTER

By the early years of the 20th century production cartography was well established and widely recognised as a discipline with professionals skilled in artistic craftsmanship and knowledgeable of the science of map making. They worked manually using traditional tools and techniques and were employed in many environments including national and military mapping agencies, commercial map and atlas publishers, local government and in the technical departments of various organisations. They were the latest generation of practitioners whose origins can be traced back many hundreds of years and still acquired their expertise from experience through apprenticeship and work. By the 1950s the more basic pen-and-ink methods were being superseded by new technologies of image production and reproduction (such as scribing on plastic, photostat lettering and photographic and photomechanical procedures) adapted from the mainstream graphics and publishing business.

RESPONDING TO COMPUTER TECHNOLOGIES

During recent decades things have been changing. Professional cartographers still exist but their pens, scribes and photo-lettering have now largely been abandoned. Expertise is now being expressed through computer-based systems. Computing technologies began to impact mapping from the middle of the 20th century (Tomlinson 1988), but the adoption of these technologies was a staged process and involved different groups of people. The first (a), by professional cartographers, was essentially part of the continuing investigation into new ways of developing the “map-drawing” tradition, with the aim of improving maps and accelerating their production. The most notable innovation was digitising, the conversion of analogue maps into digital form to make them available for future computer manipulation. However the best that could be achieved in the 1970s was the automated drafting of selected themes from the digital map data and the preparation of map masters for reproduction. Nevertheless reviewing almost fifteen years of experience of computer mapping Rhind was able to summarise its great potential for the future (Rhind 1977).

The second trend (b), which had already partly contributed to the development of automated mapping in cartography, had different priorities and was led by a different group of professionals. In the 1960s and 1970s spatial researchers, notably in landscape and urban planning, sought ways of applying computing to develop the analytical potential of mapping, a cartographic function which had previously been constrained by the limitations of traditional paper maps³. They used the computer to support measurement, create inventories and separate the map elements from associated attribute data. This trend or movement which was also reflected in the contemporary research activities of many other environmental scientists and managers, and was supported by developments in data capture and methods of data display, eventually led to the emergence of GIS systems.

³ Although Tobler had taken up this cartographic theme (Analytical Cartography) as early as the 1960s (Tobler 1976).

During the past 15 years other important changes have, in some cases, revolutionised the activities within both “trends”. These include the availability of powerful but cheap computers and digital storage, the now all-pervasive information networks, the development of multimedia, standardisation and interoperability, and a growth in uniformity of functionality in both computer graphics and GISystem software.

SUCSESSES AND FAILURES

Cartographers – the (a)-stream – had not only been involved in the development of computer-mapping programs but, more recently, had adopted and adapted graphics packages such as “Freehand” and “Illustrator” to help meet specific needs. This provided a degree of success. But not until they had embraced the animated and interactive possibilities of new software and systems was the established concept of the map as solely a static representation, finally replaced. The (b)-stream on the other hand, through GISystems and the separation of graphic map elements from attribute data, had also made the break from the single map-storage-display concept. This introduced a new flexibility for the use of spatial data and the employment of numerical and cartographic procedures for spatial data exploration and analysis. Initially the focus was on improved spatial and digital processing with less emphasis on output quality, but the latter was regarded as a failure by the contemporary cartographers. However as the use of GISystems increased, their developers responded to demands and improved the nature and quality of graphic output to match the analytical functionality.

CARTOGRAPHY, GISYSTEMS AND GISCIENCE

As GISystems were adopted more extensively and across a wider range of subject fields and applications, their users (and, by implication, their developers) encountered various problems and issues. These related to aspects such as data structure and storage problems, the effectiveness of analytical tools, the quality of output representations and the perceptual and cognitive aspects of user interaction with these maps and images. The latter problem involves image perception and cognition. This has given birth to the new field of GIScience (Goodchild 1992) which studies “the fundamental issues arising from geographic information” (Longley et al. 2001, p. 21).

Are cartography and GISystems/science now quite separate disciplines? Many people working in GIS would support this view. “... GIS have become a worldwide phenomenon ...” (Burrough and McDonnell 1998) with well over one hundred thousand GISystem sites across the world, many hundreds of thousands of users and many million beneficiaries of their use. From within GIS or even cartography the answer may be “yes”, but taking the longer view the author believes it must be “no”. The (a)-stream, described above, reflects only recent cartographic activity and priorities. Cartography can be regarded more holistically, and the instinct from which it derives has prehistoric origins. The (b)-stream account is more specifically about the evolution of GISystems, the origins and important fundamentals of which are significantly cartographic (e.g. maps, computer cartography, cartographic modelling, Boolean overlay map-

ping, cartographic generalisation and design). And, as suggested in a recent textbook, GIScience may well describe a subject “predating GISystems ... and concerned with a much longer historical perspective” (Longley et al. 2001, p. 438). This is confirmed by the fact that map design principles, map projections and perception and cognitive studies relating to human-GISystem interaction, all featuring in cartography’s past, are acknowledged as part of GIScience.

REFLECTIONS ON THE ORIGINS AND FUNDAMENTALS OF CARTOGRAPHY

The human mapping instinct – that ability to construct a supportive knowledge framework of the spatial environment within which we live and move – is basically internal and cognitive. Its existence is confirmed by our survival from day to day as we negotiate our environments, but it has, more conventionally, been recognised for millennia through artefacts such as prehistoric rock drawings and the paper maps of recent centuries. In normal daily life we are constantly facing and solving spatial problems of all types and complexity. But no matter how effective our cognitive maps may seem the ability to externalise at least some of the cognitive ideas and processes through drawings, models and maps can be a positive aid. Although the most highly visible aspect of cartography as a discipline has been the production of such externalised artefacts, cartography is not just about “map-making”. Map creation should be seen more correctly as part of the spatial problem-solving process which also involves the manipulation and use of maps. With appropriate content and design, maps can improve the comprehension and support the analysis of environmental problems and, when appropriate, help communicate this information to others. Interpreted holistically, cartography should be defined as a unique facility for the creation and manipulation of visual (or virtual⁴) representations of geospace – broadly referred to as maps – to permit the exploration, analysis, comprehension and communication of information about that space.

THE MAPPING INSTINCT – IS IT ENOUGH?

Since studies with rats in the 1920s (Tolman 1948) cognitive mapping has become accepted as a “general property of mobile organisms” and “an evolutionary adaptive mechanism necessary for spatial survival” (Downs and Stea 1977). Although some scholars doubted early humans’ ability to engage in such sophisticated cognitive behaviour, Wynn concluded that “hominids had achieved operational intelligence by 300 000 years BP, and perhaps earlier” (Wynn 1989, p. 89).

Cognitive mapping may have been a continuing theme within human evolution, but the visible historical record provides the only basis for what is normally referred to as “cartography”. Its content has been classified into *performance cartography* (mainly non-material, deriving directly from information in our mental “databases”) and *material cartography*, in the form either of fixed artefacts (such as rock art) or “mobile comparable objects” (Woodward and

⁴ e.g. cognitive maps or spatial databases

Lewis 1998, p. 3). Performance cartography may be spontaneous to the need of the moment, but the wider functions of material cartography are more stable but have changed through time. Some communities may still operate without material maps but this cannot apply universally. Groups such as the Pacific Marshall Islanders for instance, living in a uniquely challenging environment, created special maps – the stick charts – to support community survival (Woodward and Lewis 1998). The more complex a spatial problem (and the greater the cognitive information load it presents) the more urgent the need for extensions (such as a map) to the internal cognitive (thinking) space. This process has been referred to as “external cognition” (Scaife and Rogers 1996) and, as printed maps, is the essence of cartography. Spatially-related problems can increase in variety and complexity as communities become more advanced and as the increased quantity of associated information also challenges mental manipulation alone. Maps are also vital for recording land ownership, and provide a framework for planning and development.

Material maps⁵ can be further classified as – *spontaneous (ephemeral)* and *permanent*. Spontaneous maps lie on the boundary of the categories of performance and material cartography and emerge naturally during spatial thinking and dialogue. One person might draw a sketch (map) to represent part of her spatial knowledge. Another participant in the “discussion” might understand only part of it and this could lead to the reconstruction, and, thus, extension of his own knowledge from the map. Mapping and map use are processes of knowledge analysis and construction and not just knowledge transfer or communication (MacEachren 1995). The presentational methods normally adopted in spontaneous mapping are pragmatic, ranging from hand gestures to drawings in the dust (or the modern equivalent, pencil sketches “on the back of an envelope”!). Although there is little early evidence of this category of mapping, it has a critical place within our overall spatial intelligence and represents a direct and personally-externalised part of the spatial thinking process. Even a map drawn on sand can thus become a crude but legitimate interactive tool – easily modified or deleted during use by one or more participants. These spatially discursive procedures could also be summarised as truly “using” simple cartographic procedures to investigate a problem spatially, as one might “use” mathematics to analyse a problem numerically. Indeed the concept of spontaneous mapping and “using” cartography holistically have much in common, and when supported by new technologies, may reflect the instinctive procedures of cognitive mapping.

Externalised personal maps, although frequently essential, are seldom sufficient and represent only one way of fulfilling the potential of our spatio-cognitive skills to resolve problems. Another involves more permanent map artefacts, some examples of which can be traced back for at least 20 000 year⁶. Earlier map themes included the sacred, cosmological, secular and aesthetic (Harley and Woodward 1987), but such figurative cartography was used by quite small sections of the community and in philosophical rather than real

⁵ Also referred to as ‘real’ maps by Moellering (1980).

⁶ The earliest known material map, c.26 000 years old, engraved in a tusk or horn, was discovered in the Pavlov Hills of South Moravia, Czech Republic.

world debate. The output of the last five centuries has been of much greater value in the expansion and application of geographical knowledge. Early examples of partially-customised cartographic tools were the innovative 14th/15th-century Portolani (harbour-finding charts) of the Mediterranean “made by seamen for seamen” (Tooley 1961, p. 15). They contained much of the information required and therefore provided a vital link between the cognitive knowledge/maps of the users and the navigational problems they faced. From the mid-18th century, developments in printing launched the real era of cartographic expansion, bringing maps of all types into the public domain, based increasingly on accurate data collection and with improved image quality. Although not as precisely customised as the Portolani, new navigation charts, topographic and thematic maps were compiled and designed to be optimal for specific user groups in the scientific, military and even leisure (mountaineering) communities.

During the 20th century most changes in the cartographic process were technical, broadly consolidating the trends of previous centuries, and thus maintained the dichotomy between professional map making and both professional and amateur map use. Improved data collection and production methods increased the response rates of map provision to satisfy the increasingly urgent demands of both military and civilian communities. An early example of the convergence of mapmaking and use took place during wartime with the establishment of special in-house map offices. Taking advantage of more user-friendly drawing and production tools a new class of cartographer helped interpret spatial ideas and create specialised maps for soldiers, scientists and planners. In some cases the cartographers were by-passed by investigators anxious to accelerate their research by doing their own data manipulations and spatial analyses. The results were sometimes returned to the technical cartographers if more formal presentation was necessary. Although essentially cartographic in character the map manipulation and analytical processes referred to above would not have been acknowledged in a mid-20th century dictionary definition of cartography, which would have focused more specifically on the art and science of “*map making*”. These analytical methods, however, had been employed regularly by landscape architects and planners and geography researchers who knew that the map was “... not an end in itself; cartographic representation of facts is the graphic means which the geographer employs in studying distributions and their possible causal relationships” (Rudmose Brown 1922, quoted by Board 1984).

A REVOLUTION IN CARTOGRAPHY

Just as enthusiasts had led GISystem developments from the 1960s, so have equally-motivated groups from the cartographic community begun to exploit the possibilities of new systems and dynamic interactivity. This has grown rapidly over the past fifteen years with a new generation of electronic atlases and maps, especially on the Internet. An important development is what is referred to as multimedia cartography. According to Cartwright, multimedia, global communication systems and global publishing offer the opportunity to produce dynamic and interactive visualizations which build on the exciting virtual environments of the computer games business (Cartwright 2000).

Many of the unsatisfactory maps of the printing era resulted from earlier and more restrictive methods of data-gathering and reprographics. These maps generally offered little to support visual thinking and cognitive cartography. When dealing with the specific needs of a single user, neither the maker of the paper map nor even the map searcher herself, might know what is required until it is seen (MacEachren 1995)! The cognitive mapping facility is thus ideally complemented by an open two-way live link between the mind and the data with attendant interfacing tools. This would allow full flexibility for exploratory search through many sources and scenarios. Although such investigations are possible using static maps alone, maximum potential can only be effected by the simultaneous implementation of dynamic, interactive and multimedia facilities. These new cognition-friendly solutions can then be employed in a range of spatial enquiries, from the search for an ideal holiday place, to the identification of areas most prone to earthquakes along an active fault line.

The ICA Commission on Visualisation and Virtual Environments has pioneered this research direction through collaborative work with the Association of Computing Machinery, Special Interest Group on Graphics (ACM SIGGRAPH) and others (URL 1). Building on Scientific Visualisation and Multimedia, it has focused on data representations in environmental science and, in particular, dynamic cartographic visualisation for exploration and analysis to gain understanding and insight into data (URL 2).

A PARADIGM SHIFT OR RETURN TO BASICS?

With the new cartographic facilities of GISystem-based interactive Web maps, a different philosophy is emerging for some users. Whereas previously – when map “making” and “using” were largely separate – the mapper as percipient merely *studied the map* with a view to expanding her knowledge. Now she can truly interact with the map (and with its underlying data sources) and become, in the process, a simple “map-maker” also. No longer restricted by fixed content and symbols or conventional visualisation techniques, she can now create a range of maps or map-related images (such as cross-sections and terrain models) from linked databases as part of a spatial investigation. Cartography in its new more holistic form is a unique and instinctive multi-dimensional *facility* which we can *use* to explore, analyse and communicate geospatial information.

We may now have come full circle, from the experience of our Upper Palaeolithic ancestors trying, through spontaneous gestures (or even map sketches!), to represent and share their spatial cognitive knowledge, to their modern counterparts doing the same, but interactively on the Web. Now, however, the extended dimension of “external cognition” goes far beyond the subjective sketches of the prehistoric (or modern) mapper, or even the superficial map images on paper or screen. The whole networked knowledge-base of the World-wide Web is available, live-linked through eye-and-hand-on-mouse to the interface map. The map is more than a space for image manipulation and design, it can be a graphic window onto infinite possibilities. This new visual-thinking environment which is the joint product of cartographic and GIS research takes maximum advantage of our instinctive cognitive mapping powers which can be used, even more effectively, in a kind of geovisual dialogue with the cartographic/geographic visualisation system.

While this new futuristic vision of “use-it-yourself cartography” (even if only at a simple level) might be characterised as a paradigm-shift from the restricted spatial investigations previously dominated by the maker/user dichotomy, it could equally be described as a return to “basics”. To support the basics of our individual cognitive mapping skills we first created archives of maps directed at broad user categories rather than at individual users with their own specific needs. But with new technology we have now extended the power and scope of what, after all, is at the core of the discipline – the instinctive skills of cognitive mapping and the related abilities of feature identification and comparison during visual data exploration and analysis. The accessibility of these popular new cartographic working environments may also refute the charge that the number of cartographers is decreasing. Some professionals, such as ocean navigators, already interact with electronic charts (e.g. ECDIS⁷). Specialised “super cartographers” will continue to practice⁸, as do specialist architects today. But under the new definition of our subject, the numbers of both cartographers and maps are increasing by orders of magnitude.

Although restricted physically to the production of static, symbolic and optimal⁹ maps to support their investigations, innovative users of cartography in the past imagined much more than they could ever create. Their cognitive realms offered animated visualisations of landscapes or data-sets, realistic or simplified according to the project in hand, but these could not be created externally at that time. The dynamic, detailed, task-centred and interactive facilities of today need not, in the author’s view, represent some radically “new” subject. This is just “cartography” enhanced (yet again) by new technologies and thinking. More importantly it represents a cartographic revolution – the dynamic and interactive convergence of our instinctive cognitive powers with the “outside world” of geospatial data. Current international geovisualization studies include the examination of how visualisation can contribute to all aspects of the geoscientific process¹⁰. The model presented, of “using cartography” holistically, has always been applied by humans in spatial problem-solving. Today, however, technology has broadened its scope and effectiveness.

CONCLUSION

Although, in recent decades, there was some significant divergence of research and development in the field of mapping – between those continuing to create products (the cartographers) and those who were searching for new ways of handling spatial data (the community of GISystems and GIScience, they were both part of a larger field of concern – spatial problem solving. As they have done in the past, cartographers are still seeking to create specialised map

⁷ Electronic Chart Display and Information System (http://www.osl.com/Support/OSL_Support_ECDIS.htm).

⁸ Typically members of organisations such as the Society of Cartographers (SoC).

⁹ Normally compiled and designed for a user category, rather than for a specific user and task.

¹⁰ The paper “Building an open, flexible visualization environment to support GIScience activities”, by Mark Gahegan, GeoVISTA Center, Department of Geography, Penn State University, USA., will appear as a chapter in the forthcoming book (from the ICA Commission on Visualization and Virtual Environments) entitled “Exploring Geovisualization”.

products (static, dynamic, interactive, etc.) which people can use and combine with their own cognitive spatial knowledge (maps) in seeking solutions. The new community of developers and users of GISystems have essentially the same goal, but from their fuller knowledge of spatial data and spatial problems they are able to develop different approaches and tools for the job. The period of separate and parallel development, referred to above, was thus of critical importance in the advancement of spatial science as both branches have had the opportunity to diversify, e.g. “cartography” into new cartographic/geographic visualisation research, and the GISystem users and developers into more advanced spatial data handling. Uninformed observers may be confused by the continuing existence of two apparently unrelated groups – “cartographers” and “geographic information systems/scientists” – but that does not matter. The important thing is that all are acting in the interests of the global population and its environment. There is also growing convergence (or networking) as the participants of the two communities of cartography and GIScience increasingly overlap in knowledge, interests and activities. In the end they are still working towards solutions to the problems of our spatial environment.

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Michael Wood

KARTOGRAFIA V ÉRE GEOGRAFICKEJ INFORMAČNEJ VEDY

Termín „kartografia“ je azda nový, ale jej predmet je prastarý a vznikol vtedy, keď si ľudia začali uvedomovať priestor, pretože si to vyžadoval inštinkt prežitia. Priestorové povedomie i inštinkt prežiť sa nám zachovali až podnes. Priestorové vedomosti o našom okolí, ktoré zhromaždíme, sa ukladajú v čomsi, čo sa neskôr začalo nazývať kognitívne mapy. Ľudia sa spočiatku vyjadrovali externe, prostredníctvom gest, ale keď začali kresliť do piesku, zrodila sa kartografia. Tisíciky rokov trvalo uznanie kartografie ako vedeckej disciplíny. Vynález tlače znamenal pre ňu obrovský impulz.

V posledných storočiach sa kartografia stala významným vydavateľským odvetvím. Odborné vedomosti a zručnosti potrebné na zber priestorových údajov a tvorba čoraz detailnejších a presnejších máp viedli k postupnému oddeleniu procesu tvorby máp od zaužívaných tradičných technológií. V 19. a 20. storočí sa zvyšovala hodnota a praktické využitie máp a mnoho terénnych výskumníkov, odborníkov na vojenské a urbanistické plánovanie, využívalo kartografiu na zber údajov a na skúmanie a analýzu priestorových problémov. Takéto využívanie máp bolo niečo viac ako len používanie úradne vydávaných máp. Podobne ako matematika, aj kartografia sa stala súčasťou výskumného procesu, ktorý zahŕňal aj zakresľovanie a priestorové narábanie s mapovými informáciami samotnými výskumníkmi. Grafická kvalita týchto „pracovných“ máp bola možno niekedy nízka, ale od začiatku 20. storočia začali relevantné organizácie zamestnávať odborne zdatných kartografov, ktorí pomáhali pri dosahovaní odborných výsledkov, najmä ak boli určené na publikovanie.

Počítačová technológia v šesťdesiatych rokoch minulého storočia, podobne ako tlač v minulosti, zvýšila postavenie kartografie. Kartografi primárne zrýchlili a skvalitnili tradičné techniky, ale pritom ignorovali skutočný potenciál počítačov na inovácie ich oblastí. Odborníci na plánovanie si však tento potenciál uvedomili a čoskoro ho využili nielen na vyhotovovanie jednoduchých máp, ale aj na manipulácie s priestorovými údajmi a na ich analýzu. Najvýznamnejším výsledkom tohto nezávislého vývoja v rámci kartografie boli geografické informačné systémy. Aj keď sa v oboch týchto oblastiach dosiahol istý úspech, kartografom sa nepodarilo skvalitniť podstatu a silu máp a priestorovým analytikom spočiatku unikol význam ich vzhľadu. Rôzne komunity si na nich vybudovali svoju identitu a silu, ale sa aj poučili a absorbovali, aj keď v rôznej miere, vývoj modernej multimediálnej techniky a internetu. Pri širšom využívaní geografických informačných systémov s ich mnohorakými aplikáciami sa vynorilo množstvo praktických a teoretických problémov, spojených napríklad so štruktúrou databáz a dizajnom grafického rozhrania. Termín geografická informačná veda sa používa na definovanie oblasti, v ktorej sa tieto problémy skúmajú, pritom je však jasné, že predmet záujmu nie je nový. Kartografi a pracovníci zaoberajúci sa tvorbou, ako aj používaním máp robili po celé storočia podobný výskum (napríklad vývoj mapových zobrazení a aplikácia psychofyziky v používaní máp). Potvrzuje to kontinuitu témy mapovania, ktorá je spoločná tak tradičnej kartografii, ako aj geografickým informačným systémom.

Potenciál kartografie na analýzu a vizuálne zobrazovanie, ktorý čerpá z práce týchto ešte vždy oddelených výskumných oblastí, sa značne rozšíril. Frustrácia spojená s papierovými mapami je už minulosťou. Dnes naše poznávacie mapovacie schopnosti

možno využívať a rozširovať pomocou kartografických rozhraní (príkladom sú elektronické atlasy na internete). Pružné a pohotové stratégie vyhľadávania (umožnené geografickými informačnými systémami), ktoré sú dostupné začiatočníkom i skúseným používateľom internetu, naznačujú posun paradigmy od prechádzajúceho oddeľovania tvorby a využívania vytlačených máp. Možno to však opísať aj ako návrat k úplne základnému interaktívnemu prostrediu našich predkov, ktorí externalizovali svoje kognitívne mapy, bohato vybavené detailmi, pomocou rudimentárnych, a pritom potenciálne interaktívnych mapových nákresov do piesku alebo snehu pri skúmaní a výmene poznatkov a hľadání riešení. Potenciál nových kartografických foriem a prostredí naznačuje, že účel a podstata celej kartografickej činnosti nespočíva len vo vizuálnej komunikácii, ale aj v riešení problémov. Ak je to tak, potom delenie, ktoré v kartografii pretrváva, stáva sa anomáliou a malo by sa prekonať v prospech oboch aktérov (tvorcov máp a ich používateľov), ktorým kartografia ponúka svoje mnohoraké formy.

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