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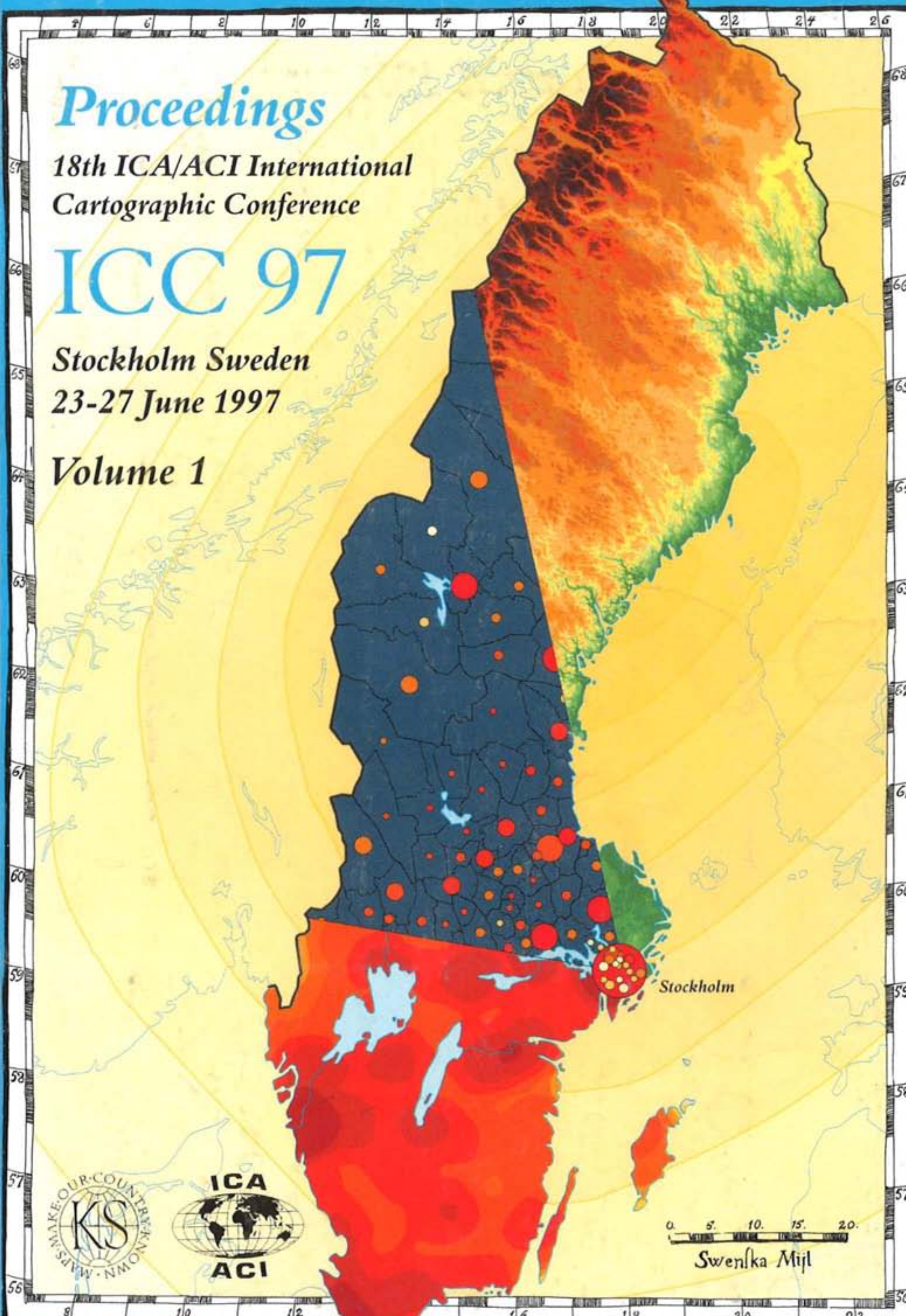

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18th ICA/ACI
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Stockholm, Sweden 23 - 27 June 1997

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PREFACE

The Call for Papers for the 18th ICA/ACI International Cartographic Conference, ICC 97, was met with a very good response. Thus, almost five hundred proposals for presentations to the Conference were submitted to the Scientific Programme Committee for review. The Organisers decided to include 144 oral presentations divided into 24 sessions in the programme as well as a special lunch session for oral presentations of papers prepared by seven ICA/ACI travel awardees. Moreover 8 poster sessions each including presentations of some 25 papers complete the scientific conference programme.

The review of submitted papers has been carried out by members of the Scientific Programme Committee. Committee members also helped organising the oral and poster sessions. I gratefully acknowledge the help rendered by the following members of the Committee: *Wolter Arnberg, Ulla Ehrensvärd, Curt Fredén, Margareta Ihse, Liqui Meng, Ulf Sandgren, Mats Söderberg, Kennert Torlegård* and *Anders Östman*. Grateful acknowledgement is also due to *Alan McEachren, Andrew Tatham* and *Bengt Rystedt* for assisting in paper review.

Special thanks are extended to all authors contributing to the Scientific Programme of ICC 97. Due to the large amount of papers it has been necessary to divide the Proceedings into four volumes. The papers presented in the Proceedings offer a comprehensive review on contemporary cartographic research and development. The Proceedings will hopefully promote discussion and contribute to progress of cartography.

Finally, the Scientific Programme Committee would like to extend a sincere acknowledgement to the Chairpersons of the Plenary Sessions for accepting this important task for the realisation of the 18th International Cartographic Conference.

Lars Ottoson
Chairman Scientific Programme Committee

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PROCEEDINGS

MAPS AND MAPPING IN THE INFORMATION ERA

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Introduction

Throughout history the map has been important to societies all over the world both as an artifact and as a concept. The terms "maps" and "mapping" are used in relation to almost all aspects of societal activities. We map the brain, we map the future, we talk of mental maps, we use maps in an increasing range of socio-economic and scientific activities. Maps have been central to warfare over the centuries, are themselves works of art and have inspired both poetry and literature.Two of my favourite quotations relating to maps come from the great Argentinean writer Borges: *In that Empire, the Art of Cartography reached such Perfection that the map of one Province alone took up the whole of a City, and the map of the empire, the whole of a Province. In time those Unconscionable Maps did not satisfy and the Colleges of Cartographers set up a Map of the Empire which had the size of the Empire itself and coincided with it point by point. Less Addicted to the Study of Cartography, Succeeding Generations understood that this Widespread Map was Useless and not without Impiety they abandoned it to the Inclemancies of the Sun and the Winters. In the deserts of the West some mangled Ruins of the Map lasted on, inhabited by Animals and Beggars; in the whole Country there are no other relics of the Disciplines of Geography [Suarez Miranda Viajes de Varones Prudentes, Book Four, Chapter XLV, Lerida, 1658]".*Andres Suarez de Miranda was indeed a late 17th century Spanish author, but Borges was the real 20th century author and also of this second quotation:*"A man sets himself the task of portraying the world. Through the years he peoples a space with images of provinces, kingdoms, mountains, bogs, ships, islands, fishes, rooms, instruments, stars, horses and people. Shortly before his death, he discovers that that patient labyrinth of lines traces the image of his face.* [Jorge Luis Borges, Buenos Aires, 31 October 1960].

Will maps and mapping retain their importance in the information era?

The central argument of this paper is that mapping as a process and the map as both a concept and a product are already central to the information era and can become more so. This will, however, require a change in the thinking of cartographers and a greater awareness of the opportunities with which the discipline and profession of cartography is presented. It will also require imagination, foresight and effort if the opportunities are to be realized. We must move away from narrow "technologized", normative and formalistic approaches to cartography to a more holistic approach where both mapping as a process and the map as a product are expanded.What I will call "Cybercartography" will be interactive, multi-media, applied to a much wider range of subjects than is currently the case and more widely available through new media forms and telecommunication networks. As we move into the 21st century maps and mapping will be important not only in their own right but could well become core organizing mechanisms for the tidal wave of information threatening to drown us all.

Some Recent Developments in Computer and Telecommunication Technology

The driving forces of the information era are developments in computer technology and related developments in satellites and telecommunications. The pace at which these developments are taking place is staggering and the half life of knowledge in the field is probably down to a matter of months. These technologies are revolutionizing cartography to such an extent that it is no longer necessary to talk about digital cartography or computer cartography as a separate subjects (Morrison, 1995) as we did during the 1970's and 80's. Computer technologies are now so all pervasive that there is now little cartography without them even in fields such as the history of cartography.

At the centre of the technology of the information era is the microchip, a tiny integrated circuit that does much of the actual computing. The first commercial chip, the Intel 4004, which was developed by Marrian Edward Hoff and his colleagues, was released on November 15th, 1971 and could deliver what for that time was the incredible performance of 60,000 instructions per second. At the time Gordon Moore, one of the founders of Intel, predicted that the power and complexity of chips would double every 12 to 15 months and so far what has come to be known as Moore's Law is certainly holding. Modern chips can easily perform 300 million instructions per second, and, in January 1997, Intel released its new Pentium processors with MMX technology which are even faster with double the amount of internal memory allowing the processing of multimedia data including sound and video which will be of special interest to cartographers and to the development of Cybercartography. Chip components are now down to 0.35 of a micron and there is potential to reduce this to 0.18 in the next year. In February, 1997, Plasma Materials and Technology Incorporated (Kalish, 1997) announced that they had developed a better way to apply insulation materials between the millions of tiny wires that connect a chip transistor dramatically reducing the interference between the signals they carry which could quadruple the performance of microprocessor chips. Leonard Shuster of the Computer Museum History Centre in California argues that, *"The same way that the steam engine enabled the industrial revolution, the microprocessor enabled the information revolution."* (Gooderham, 1996).

The result of the developments in chip technology are such that one modern work station has more computer power than all existing computers world wide in the 1960s. An even more astounding comparison is that a modern greetings card which sings *"Happy Birthday"* when it is opened probably contains more computer power than existed in the world prior to 1950!

Powered by new chip technologies, hardware developments increase apace. The Personal Computer is challenged by new Network Computers (Associated Press, 1997) (and by hand held palm-sized machines (Mertl, 1997)) which in turn may be replaced by imbedded or invisible technologies activated by voice, by touch or even by the body's own electromagnetic field (Tauz, 1997). Another interesting development is molecular computing. The

World's first molecular computer using tubes of DNA molecules was developed by Leonard Adleman in November, 1994. (Adleman, 1994,95) and work on DNA computers continues (Friedman, 1997).

Software developments lag behind hardware but progress in massively parallel object-oriented programs continues as does work on neural networks which have been used to develop what has been described as the world's first conscious machine, MAGNUS, by Imperial College, London (Matthews, 1997). Of special interest to cartographers is the development of the computer language JAVA by SUN Microsystems. JAVA is machine and operating system independent and the development of a new JAVA-based code known as BARISTA by Corel Corporation allows much improved production of graphics for the World Wide Web (Chianello, 1997).

Both data gathering and data storage techniques have made rapid advances, especially through the use of much improved satellite and remote sensed imagery such as the Canadian RADARSAT technology and a host of other satellites which seem to be launched almost on a monthly basis. Optical disks as storage devices which only a few years ago were regarded as the ultimate answer to data-storage problems are being replaced by hologram storage devices with much great capacity. High resolution data display devices including High Density TV are increasing the potential for the display of high quality graphics often within a multi-media context with both improved vision and sound and the Digital Video Disc which holds twenty times more date than the CD ROM is already on the market (Krantz, 1997).

Satellite technology and fibre optics networks are the mainstays of telecommunications on the so-called information highway. The Internet is now being expanded by the creation of Intranets which are being developed by businesses and organizations for their own purposes and some have been extended into Extranets to include customers (Arnault, 1997). A major problem at present is limited bandwidth which is the speed at which data can be transmitted but this likely to be a temporary problem although the cost of creating high speed fibre optic networks is still considerable and they tend to be confined to the richer parts of the globe. This may change with the plans of Teledesic Corporation to launch 840 low-level satellites beginning in 2000 AD (Weise, 1997). These are planned to orbit at an altitude of around 700 kms. To get service, a small antenna and signal decoders that plug into computers or telephones will be required. If this plan comes to fruition it will allow high-speed data transfer and video-conferencing anywhere in the world. Existing high orbit satellites are geared for continuous data like TV or weather but do not work for the Internet which uses Transmission Central Protocol - Internet Protocol (TCP-IP). This is a set of standards which allows any Internet message to be read by any computer. Existing high orbit satellites are 35,900 kms above the earth's surface and the half second delay involved in transmitting an Internet signal to them is too great. The low orbiting satellite net planned by Teledesic at a cost of $9 billion could resolve this problem. An added advantage is that areas not now covered by fibre optic cables would be covered by the proposed satellite net.

The Pervasiveness of the Information Era

In the post-industrial societies of North American and Western Europe, the information era has penetrated all aspect of society through the Internet and the World Wide Web. Indeed some have argued that a new Cyberculture is emerging (Rushkoff, 1994) with its own history, language, customs and politics and the term 'netizens' has been coined to describe those who live in cyberspace or in what has been called a new Internet country, Cyberia (Moran, 1997). Internet addiction is now a recognized illness. It is possible to marry by Internet. An American company called Glamorama provides on-line wedding service and, not to be outdone, another company called Cybermourn allows funeral services to be transmitted on line through a secure web site using a multimedia PC, specialized software and a video camera. Cybersex sites are visited by thousands of users each day and the Internet community grows in number each day with some of the latest high profile participants being the British Royal Family and the Pope.

However, the extent of this penetration should not be exaggerated. There are probably well under 100 millions people on the net and the vast majority of these are in North America. One knowledgeable observer, John Mackenzie of Newbridge Networks, commented that the current Internet is not a superhighway 'but a barely beaten path" (Freeze, 1997). A number of important societal issues relating to accessibility, content, freedom of expression, censorship, the uses to which the net is put and who controls information flows arise. I will return to some of these later in the paper but would like to touch on this briefly through a series of humorous graphics appearing in the popular press. At definition of home in the information era can be summed up by the aphorism "Home is where you hang your @"! (Overhead 1). As we struggle to build our web sites do we always know what we expect them to be used for? (Overhead 2). Do we expect everything on disk? (Overhead 3), and will an over-reliance on the current data bases and information sources, especially by the young, lead to a warped sense of an appreciation of both art (Overhead 4) and nature? (Overhead 5).

Despite these concerns, I believe that the information highway is an important element in Cybercartography and it is to this concept the paper will now turn.

Towards Cybercartography: The Canadian Geographic Explorer

I have previously argued that interaction, dynamics and visualization are central to cartography (Taylor, 1994). I have also argued for the importance of electronic mapping and electronic atlases (Taylor, 1991). Arguments have also been made that what were previously independent mapping sciences like remote sensing, surveying and cartography are converging both as a result of technological change and the challenges of common applications such as environmental issues (Taylor, 1994). I should now like to extend these arguments and make a case for Cybercartography.

Cybercartography will see cartography applied to a much wider range of topics than has been traditionally been the case as Hall (1992) and others have argued. It will also utilize an increasing range of emerging media forms and telecommunications networks such as Internet and the World Wide Web. It will be a multi-dimensional cartography utilizing multi-media formats and is more likely to be an integral part of an information package than a stand-alone product. Cybercartography will also be highly interactive and engage the user in new ways. In organizational terms, it will see new partnerships being created between national mapping organizations, the private sector and education institutions and the products of Cybercartography are likely to be compiled by teams of individuals from very different disciplinary and professional perspectives working together.An interesting example of Cybercartography is the Canadian Geographic Explorer. The Canadian Geographic Explorer was produced in 1996 and is the brainchild of an innovative Canadian company called IQ Media Holdings Corporation. Explorer is currently in CD-ROM format with links to the World Wide Web through its own Web page. It has been produced for the mass market and sells for around $60 Canadian. Explorer is an interactive multi-media product using maps, text, photographs, video and remote sensed imagery which was put together by the combined efforts of a number of key actors from both the public and private sectors, including IQ Media, the Canadian Space Agency, the National Film Board of Canada, PCI International, Canadian Geographic Magazine, Natural Resources Canada, Sierra Communications and RADARSAT International. It runs on both IBM and Macintosh platforms and the minimum configuration required includes a 486 or 68040 chip with 8 megs of RAM, a double speed CD-ROM, a colour monitor, a mouse, Windows 3.1, or Windows 95 or, in Mac terms, System 7 or higher (IQ Media Holdings, 1996).

At the core of Explorer are four functional areas: Earth Observation, Compareography, MapMaker and Georiddler. Access to each of these four functional areas is by a graphic interface called a digital device which is a compass-like object with common commands on the right side and commands which change for each of the four sections on the left. At the top of the digital device is a digital readout and at the bottom a tool box which contains various functions and operators which vary from section to section and can be called up on demand. Earth Observation sees Canada from space and a special feature is the interpretation and commentary on the imagery by the Canadian Astronaut Team. Both regular imagery from three different satellites and the first three dimensional satellite images are included which are viewed with special glasses which come with the CD. Digital terrain models and PCI "Fly" software allow simulated flights over different parts of Canada. A comprehensive glossary called RADARSAT Illuminated gives information on satellite platforms and uses. The PCI "Fly" software can be downloaded to individual computers hard drives and comes with a sample digital terrain data set for Southern Ontario. Other data sets can be ordered from PCI interactively through the Web site. The tool drawer functions include magnification of any part of an image and distance measurements between points using cross hairs with the answers appearing in the digital readout on the graphic interface, the digital device. The digital device can itself be moved across the image or reduced in size if required.

The Compareography Section utilizes the extensive thematic mapping archives of the National Atlas Information Service of Natural Resources Canada, mainly at the 1:7.5 million scale. There are ten thematic categories and the user first chooses one of these categories either for the whole country or for a magnified smaller area chosen through a dynamic grid overlay. For each selected theme the user can use the tool box to choose different information formats such as a Canadian Geographic Article in text format on the region, a Canadian Geographic photograph of the same area, a National Film Board video, a Canadian Geographic Regional Map or a simulated fly over. A second option enables the user to change to another of the ten thematic options available for the same magnified area. The Mapmaker section is designed to allow users to make their own customized maps of Canada. The base scale is 1:30 million and the users can either utilize one of the four prebuilt base maps (Ecological, Hydrological, Cultural or Physical) or create individualized base maps from thematic layers, point features or line features. Once the base map is in place users can select up to ten different thematic layers to overlay. In addition, the user can create an individual customized layer for each map created. In theory, almost 500,000 different map combinations could be created. In addition to the overlay function the tool box allows users to measure distances, place label pins, write freehand or magnify any part of Canada. Maps can be customized for printing out with scales, titles and legends or may be saved for future use.The Georiddler section is a fast paced quiz game for 1 to 3 players to compete against time and each other. There are ten built-in questions and points vary randomly from 100-500. There are nine categories including geography, history and politics, art and culture, science and ethnology, sports, weather and natural hazards, Canadian superlatives, industry and transportation, and wildlife. The questions are read, the user buzzes in and the correct answer is again narrated. Cumulative scores are appear on the screen.

The CD-ROM comes with two freeware programs from PCI which can be downloaded. PCI 'FLY" is the software program which creates the 3D perspective scenes and allows the user to take simulated flights utilizing digital terrain models. PCI Image Handler is a tool for viewing, enhancing, and analyzing remote sensed imagery from RADARSAT, LANDSAT, SPOT, ERS, NOAA AVHRR and air photographs.

Purchasers of the CD-ROM are given access to the Explorer Web Site at *www.explorer-cdrom.com*, which is still under development, and can join the Explorers Club. This allows the user to update the disk, and to download new Canadian geographic data sets, new satellite images and elevation models which can be loaded into the "Fly" software included on the CD-ROM. There will, of course, be costs associated with this which have not yet been fully set. The Web site also provides links to major Canadian Web Sites including all Provincial and Federal Government agencies, the Canada Centre for Remote Sensing, the National Atlas Information Service, RADARSAT International and the innovative Canadian Schoolnet.

The following interactive demonstration will illustrate some of the features of the Explorer beginning with an Introductory Flight over Canada, followed by the world's first 3D chrono-stereoscopic satellite imagery. Different elements of the Earth Observations, Compareography and Map Maker elements will follow and I will finally test your knowledge of Canada through selected questions from Georiddler.

Canadian Geographic Explorer has limitations but it is an example of an important step in the development of Cybercartography and I anticipate that further improvements will be made. CD-ROM technology may in fact simply be a transitional stage as we move into a fully- networked Cybercartography.

The Societal Context of Cybercartography

The information revolution is very much a product of the post-industrial societies of North America and Europe, and as outlined earlier, is having a profound effect on these societies. It is also clear that although the reach of the information revolution is global there are widely varying impacts in different parts of the world. It is a cliché to argue that information is power but in the information era there is a distinct possibility that the new technologies will operate largely to the benefit of the rich at the expense of the poor. Well over 70% of the Netizens to whom I referred earlier live in North American and within these societies use of the information highway is restricted to those who have a computer which is still the minority of households.

In June, 1966, the International Data Corporation and World Times Incorporated developed an Information Imperative Index (III) which is described as *"a groundbreaking indicator that measures the ability of individuals in 55 industrial and emerging economies to access, adopt and absorb information and information technology.....the III is the single most useful matrix gauging participation in the Global Information Revolution."* (International Data Corporation, 1996). The Index has been compiled using 20 data elements from three critical infrastructures. Social --school enrollments, press freedom, civil liberties; Information--telephone lines per household, telephone faults per line, cellular phones per capita; and Computer--PC's per capita, percentage of networked PCs, software/hardware spending and Internet costs per capita. I was unable to fully analyze this index as the document describing it on the Web (Bellomy, 1996) came with the interesting message *"This document costs 18, 500 US dollars + tax!"*The index divided the 55 countries selected into four groups as a result of the analysis with scores running from a low of 335 to a high of 5107. At one end of the scale were what were described as the *"Roller Bladers"* with scores of over 4000 of which there were only two--the USA and Sweden-- and at the other end were the *"Joggers"* with scores of under 1000 including countries such as China, Turkey, Saudi Arabia and Brazil. In between were *"Striders"* such as Korea, Israel, Japan, the UK, Canada and Australia, and the *"sprinters"* like Russia, Chile, Spain and Ireland.

Although any macro-index of this type has problems the picture it presents is quite clear. There are only two African nations for which indexes have been calculated, Egypt and South Africa and the world's poorer nations including the developing nations of Africa and to a lesser extent those of Asia do not figure in the information society to any significant extent.

Technologies which could make a significant contribution to the solution of the major problems facing the world today such as poverty, disease, illiteracy and environmental degradation are much more likely to be applied within the rich post-industrial societies for quite different purposes. There are, of course, applications which help decision making, education and environmental management but these are outweighed many times by the entertainment market. Given the scale and nature of development problems it is difficult to accept a situation where a great deal of money is spent on developing an interactive program to allow girls to dress a virtual Barbie doll in 15,000 different outfits when the same technologies could be used to educate the millions of children in the developing world who cannot read or write.

I do not subscribe to conspiracy theories or to the extreme views of countries like Iraq who ban the use of the Internet which Al Jumhuriya, the official Government newspaper described as *"...the end of civilizations, cultures, interests and ethics...one of the American means to enter every home in the world. They want to become the only source for controlling human beings in the new electronic village"* (Al Jumhuriya, February, 1997) but there are important political, economic and military aspects of the information era which have to be addressed including censorship and control which represent in all countries, whether they be post industrial, emerging economies or developing nations. Access to the benefits of the information revolution should not be restricted to those who have the ability to pay or the information revolution will, like its predecessor the industrial revolution, create increasing inequity both within and between nations. Nor should these technologies be solely in the hands of governments, the military of big business or the potential for abuse or misuse will increase.

In developing Cybercartography care will have to be taken to ensure that it is inclusive rather than exclusive and that the uses to which it is put are aimed at benefiting society. Here one of its great potentials is clearly in the field of education. Cybercartography, for example, is an integral part of the Canadian Schoolnet Project. Schoolnet is a Federal/Provincial/Territorial and Industry initiative developed in order to introduce elementary and secondary school students and their teachers to the Internet and to enhance educational opportunities by making national and international resources, including on-line maps, available to them. The project was officially announced in August, 1993 and connected 300 schools in a pilot phase. Canada has now almost completed the goal of connecting all 17,000 secondary and elementary schools in Canada. Through the Internet participants have access to the Schoolnet Gopher and a wide variety of sources and services including the National Atlas Information Service. The initiative is user driven and the National Schoolnet Office in Industry Canada is responsible for the administration and promotion of the network. There is a National Advisory Board with the responsibility to provide operational and strategic direction and guidance for Schoolnet. The Schoolnet Support Group, Ingenia Communications Corp., is responsible for the technical support, development and management of the daily operations of Schoolnet and its various services. The objective of Schoolnet is to electronically network Canadian schools in order to:

• *enhance educational opportunities and achievements in elementary and secondary schools across Canada by making national and international resources available to teachers and students, regardless of geographical location;*
• *foster significant improvements in learning performance by facilitating the development and electronic delivery of the most advanced and proven educational techniques through new software applications and access to electronically based resources*
• *stimulate learning and produce a school graduate population with a strong command of information and telecommunications technologies, which will be key employability skills in a knowledge-based economy;*
• *identify and develop new educationally relevant services from government, industry, universities and colleges, and facilitate their electronic provision to the school, teachers and students;*
• *build shared learning experiences among teachers and students in schools across Canada through the electronically based education projects, and*
• *stimulate the Canadian information technology , software and multimedia business by providing new market opportunities.*
(Industry Canada, 1996).

The concept of Schoolnet is attracting wide attention in a number of nations including developing nations as a means to increase the effectiveness of the education system at relatively low cost.The key to the future of Cybercartography lies not so much in the technologies involved but how people utilize these technologies. What is needed first is an understanding of the societal contexts in which Cybercartography is to be applied and what is appropriate and what is not. Problem identification and priorities must come from within individual nations and then technological solutions appropriate to the problems can be found.For some situations the type of Cybercartography described in the Canadian context will be appropriate whereas for others it will not. Cybercartography is not a replacement for existing cartographies. It is a new and exciting complement which will grow in importance over time. Julius Nyerere of Tanzania has been quoted as saying *"whereas some people try to reach the Moon we try to reach the villages"* but in information terms the same technologies used to reach the moon can be used to reach the villages.

Conclusion

Maps and Mapping are alive and well in the Information Era but what is required is synthesis, balance and responsibility and an imaginative application of Cybercartography to an increasing variety of topics and in an increasing number of countries. Mapping as a process may also take on new functions and could become the key organizing concept and mechanism of the information era by the utilization of graphic interfaces and the organization of data and information in a spatial framework.

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PRODUCTION OF NATIONAL BASE MAPS OF IRAN AT 1:100,000 BY SATELLITE IMAGES

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Abstract

The National Cartographic Center of Iran (NCC) is currently responsible for producing base maps of the whole country at scale of 1:25,000. It is anticipated that production of the maps at this scale be completed in a 10 year period. In addition to that map series, the first revisions of digital topographic base maps at 1:1,000,000 are ready to use. Other map series at different scales are rather old and need to be updated.

Map users at different level need updated maps for different purposes, such as topographic map applications, land-use classification, building a geographic information system. Using maps at 1:1,000,000 for planning prepossess is not possible, meanwhile waiting for maps at 1:25,000 is not wise. Since the speed of image-maps production is relatively more than vector maps, and due to supplying users' requirement for updated maps, the National Council of GIS Users of Iran (NCGU) approved the base image-mapping of entire Iran at 1:100,000 as an intermediate scale.

This paper intends to present some aspects of evaluation steps for possibilities and requirements, establishing the standards and guide directions of base image-mapping at 1:100,000, designing the production line as the main step, building a GIS to response GIS users, cartographic processes, and finally presenting different products as output.

1 Introduction

Presence of updated maps and related information in developing countries, like Iran, is evident. Topographic maps are basis for production of other map products, and topographic mapping is the main function of a national mapping agency.

NCC acts an important role in production of maps and spatial information in Iran. Due to the tasks assigned, NCC is responsible for production of base maps at different scale of whole country and preparation of the National Topographic DataBases (NTDBs) at those different scales to respond the community of maps and Geographic Information Systems (GISs) users.

Two existing base maps at 1:50,000 and 1:250,000 of Iran are rather old and need to be updated. Besides, 1:50,000 maps have not been converted to digital form yet. 1:250,000 maps have already been digitized and available in digital form, but still have to be accompanied by extra up-to-date spatial data layers. Producing of base maps at 1:25,000 is running in NCC. Due to size of the country and variety of terrain, we expect that the NCC complete whole map series in 10 years.

Obviously, lack of maps and information as a base for various projects does not mean stopping and waiting for at least 10 years, but means extra works have to be done to obtain required information. To avoid extra works, and even worse, parallel works, the NCGU approved an intermediate scale of base maps of entire country at 1:100,000 by satellite imagery in 1996. This decision was made upon several reasons:

- Needs of users to up-to-date maps
- High speed of image maps production
- Coverage of entire country by available satellite imagery
- speed of acquiring satellite data
- Ability to use satellite images in various disciplines, such as land-use, land-cover classifications, . . .
- Direct data transfer to GISs

The Council has fixed a period of 3 years for the project, and NCC is performing the preliminary steps now. We have done several pilot projects in different areas, namely, Khozestan in the South, Isfahan in the center, Oroomieh in the north-west, and Hamadan in the West. Problems, deficiencies, and abilities have been met and evaluated during these pilot projects. All source of auxiliary data, such as ground control points (GCPs), digital elevation model (DEM), and vector overlay layers have also examined.

Availability of GPS-driven control points in some areas of Iran is the advantage of the project. Since field surveying groups are measuring GPCs for 1:25,000 maps. While for some areas the acquiring is already done, there is still possibility to coordinate the job for two projects at the same time. Of course, the matter of time must be justified in the case of coordination of GPS-driven GCPs collecting for two projects.

2 Evaluation and The Proposal

2.1 Advantages of Satellite Image Data

In addition to speed of acquiring and availability of satellite images, there are several reasons behind using these sources of spatial data for base mapping at 1:100,000. Some of these reasons are related to the nature of images, in some are sensible in the context of applications (under certain conditions) in Iran. For example, existing of periodic information does not mean that it is decided to update any scene and/or map sheets periodically. However, there will be the chance to do so in case of certain application in parallel with main tasks. Generally, the following reasons can be mentioned for satellite imagery as sources for mapping at that scale:

- Existing of digital form of satellite images
- Ability to process these images by computers directly
- Possibility of producing B/W and color images
- Existing of periodic information in case of map revision and/or multi-temporal analysis
- Possibility of raster-vector overlay
- Ability of DEM extraction from stereo-pair images
- Ability of combining the images with other sources of data, e.g., height information and 3D viewing of terrain
- Various applications of satellite imagery

2.2 Applications of Satellite Image Maps

Diverse applications of image maps at 1:100,000 are taken into consideration, although, the maximum functionality of these maps depends on speed of acquiring the new images for updating. The following applications have been considered for these map series in terms of analysis (measurement, classifications, and estimation analyses) [Aronoff, 1991], in addition to usual applications of topographic maps:

- Cartography and terrain mapping
- Crop studies
- Applications in land-use mapping and planning
- Urban planning and development
- Water management
- Ground water studies
- Forestry
- Coastal zone management
- Geological and geomorphologic studies
- Enhanced GIS applications

2.3 Sources of Satellite Imagery

Despite existence of several satellites which acts as Earth observer, according to the scale of mapping and applications, a few of them are holding the conditions due to the spatial resolution for mapping at 1:100,000 and users' requirements. Satellites and sensors suitable for our purpose amongst others are Landsat, IRS-1C, EarlyBird, SPOT, and MOMS-02. The other important point in required imagery is that the users' community is obliged us not to use panchromatic images because of their applications in multispectral domain, for example, land-cover classifications, change detection, crop studies, and so forth. Table 1 shows the satellite and sensors under studying of the project [Richards, 1993][Euromap, 1996][EOSAT, 1996][EarthWatch, 1996].

Satellite/ Sensor	Number of Spectral Bands	Stereo Capability	Scene Width (km)	Ground Sampling Distance GSD (m)
Landsat 5 TM	7	No	185	30 except for band 6
IRS-1C LISS-III	4	Yes, (panchromatic)	141	23 except for band 4
EarlyBird Multispectral Sensor	3	Yes	15	15
SPOT XS	3	Yes	60	20
MOMS-02	4	Yes, (Modes 1 & 4)	97-105	13.5

Table 1. Specifications of satellites and sensors under studying for the project

In addition to stated sources of imagery, there are some satellite and sensors with higher spatial resolution, already launched or to be launched in near future (for instance, QuickBird Multispectral with GSD of 4m, 4 spectral bands and 27 km x 27 km Scene size). Such an imagery can be used for mapping of urban areas, cities, and the regions with great interest. Of course, for integration in map series and analysis prepossess, we have to cover entire country with the same source of data, but compiling image maps of urban areas and cities may be accomplished in addition to ordinary image mapping at 1:100,000.

2.4 National Users and Their Requirements

NCGU was formed in 1993. The main objectives of NCGU are to determine the national base maps for national-based GISs, feature listing and classification, to agree on timing for map updating, and to coordinate the needs of ministries and organizations in national mapping and GIS, among the other objectives [NCC, 1995]. The following ministries and national organizations are members of NCGU:

- Ministry of Agriculture
- Ministry of Housing and Urban Planning
- Ministry of Interior
- Ministry of Jehad
- Ministry of Mines and Metals
- Ministry of Oil
- Ministry of Power
- Ministry of Roads and Transportation
- Army General Staff
- Plan and Budget Organization
- Statistics Center of Iran
- National Cartographic Center (NCC) of Iran

While the topographic database and maps have a relative stable information contents and serve for as long as 10-20 years without the need for major revisions, the land-cover maps have to be updated more frequently. Their actual update interval depends on the rate of land-cover change and this may differ from map sheet to another [Kalensky, 1996]. For this reason the members of NCGU stated their needs to utilize the updated maps accompanied by land-cover information of any area in the country. This is the exact case of Ministries of Agriculture, Housing and Urban Planning, Jehad, Oil, Mines and Metals, Power, and Road and transportation.

3 Preparation

3.1 Standards

NCC sensed the need to develop new standards that would cover image mapping and GIS at 1:100,000. So, the Standard Committee for Digital Spatial Data (SCDSD) of NCC, formed in 1994, started developing of a standard for national base mapping and topo-database at scale of 1:100,000 in 1996. In order to insure attention to user needs, SCDSD communicates with NCGU through the Director of NCC and participates in their meetings. NCC's Digital Spatial Data Standards will compass the subjects such as data acquisition, coordinate system and projection system, conceptual model, data structure, data format, feature coding, cartographic presentation, meta data, data dictionary and storage media.

After completion of the standards, SCDSD will submit the finalized items to NCGU as a proposal standard. Thereafter, SCDSD will receive the feedback and SCDSD will make the necessary revisions.

3.2 Type and Classification of Information

We have decided three major classes of information in 1:100,000 image maps. These classes are planimetric features (roads, buildings, waterbodies, political boundaries, ...), topographic data (height information, DEM/DTM, points elevations), and land-cover information (urban areas, agricultural lands, range lands, forests, wetlands, etc.). Planimetric features can be acquired whether directly from satellite images or in special cases from other maps (vector maps). Small roads and important buildings are not distinguishable in some images. Political boundaries must be derived from other maps or lists of coordinates. Topographic data may be extracted from stereo-pair of satellite images. Another possibility is using existing maps at 1:50,000 by converting contour lines and other height information (break points, spot heights, ertc.) to Digital Elevation Model (DEM), analyze the data and then convert the results back to topographic features. Land-cover information is matter of users' needs and applications. Since they are supplied with complete geocoded images, they can use their tools to interpret the images. Classification methods and limited fieldwork for collecting ground truth will help users in this respect.

3.3 Equipment and Sources of Data

During the feasibility studies (by performing several pilot projects), we used a certain set of hardware, software, and source of data for some reasons. The most important reasons were possibilities to supply the resources, existing equipment, and sources of data at that time. The equipment and type of data used are not necessarily as same as equipment and data for the main project, but they can lead us to decide the optimum choices in the production line.

3.3.1 hardware and software

The hardware that we used during the pilot projects was based on personal computers (IBM PCs and the compatibles) with 486 and Pentium processors, color inkjet raster plotter, and A2 size digitizer. ILWIS, PCI-EasiPace, Aldus PhotoStyler, Intergraph's Microstation and IRAS/C are the software used in the pilot projects. We also utilized special programs for geometric corrections and removing relief displacement caused by height difference in terrain.

3.3.2 Data

The following data have been use during preliminary studies:

- Landsat TM (7 bands) for Isfahan
- Landsat TM (3 bands) for Ahvaz, Khozestan
- SPOT XS for Oroomieh, West Azarbaijan and Ahvaz, Khozestan
- SPOT PAN for Hamadan and Kabodarahang, Hamadan
- Ground Control Points (GCPs) derived from existing 1:25,000 and 1:50,000 maps
- Digital Elevation Model (DEM) generated from contour lines of existing 1:25,000, 1:50,000, and 1:250,000 maps
- Aerial photographs for distinguishing the areas of interest on old maps

Since there will be a large amount of data in the main project (satellite images of entire country), performing all processes on PC-based systems is not possible. Combination of PCs and workstations looks to be suitable for of production line. Time consuming processes can be done on workstations, while operations like acquiring control points on images may be accomplished on several PCs simultaneously. SPOT XS imagery has been recognized as the suitable choice. It's spatial resolution (20m for GSD), stereo capability, being appropriate for mapping and other disciplines, full coverage of Iran, speed in acquiring, and direct deliveries of images are the most important reasons for this recognition.

3.4 Geography and Nature of terrain in Iran

Iran has a total land area of 1,684,000 square kilometers. It is mostly mountainous terrain (Alborz and Zagross being the main ranges), and has two vast arid zones in the north-east and south-east.

About one-third of Iran is rather flat. So, there is no need to have DEM to remove relief displacement caused by height difference in the flat areas. For the rest having DEM is necessary. It would be the great advantage of using SPOT XS stereo imagery to generate DEM for removing the relief displacements.

Except for the southern Caspian Sea coastal area with annual rainfall of +1000 mm, the rest of the country has below 500 mm of rainfall, therefore the chance of acquiring cloud-free images is high.

4 The Production Line

The main steps for map compilation can be summarized as definition of required information, identification of data sources, data acquisition, process and analysis, inspection of the results of analysis, reporting the results, representing the outputs, and/or dissemination of map sheets [Aronoff, 1991].

For base mapping at 1:100,000 by satellite images in NCC, we have defined the main working steps as diagram 1.

4.1 The Design Stage

Design and setting-up the production line is the most important issue in the project. During the design of the production line, we have contemplated several details, such as requirements, input data, equipment, auxiliary data, software, human resources (specialists, technicians, operators), processes, and output results (digital image map databases). Diagram 2 shows the results of design of the production line in NCC.

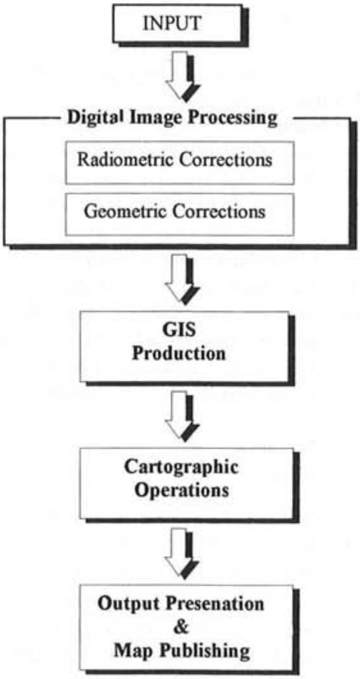

Diagram 1. Main working steps in the production line

4.1.1 Radiometric Corrections and Enhancements

Just parameters of haze correction and histogram stretching are calculated but not applied to each scene. For some applications, there is a need to have the origin values of each pixel, while we need to apply these parameters in cartographic operations to make an enhanced image map.

False color composites must be generated as background of vector layers on digital maps and databases.

4.1.2 Georeferencing

There is two possibilities to derive control points, by help of GPS or from existing maps. We may use GPS in the areas in which there is no updated maps. In those areas that NCC have done production activities, control points can be procured from digital maps. For the rest, we have to use GPS receivers with enough accuracy.

4.1.3 DEM

Digital Elevation Model (DEM) can be generated whether by digitizing the contour lines on existing maps (in the areas in which 1:25,000 digital mapping has been finished) or by use of satellite stereo pairs (for the rest of country). Obviously, there is no need to have DEM for flat regions and areas with small height difference.

DEM can also be presented as a by-product to the users of certain applications, such as slope and aspect analysis.

Another application of DEM may be stereo-vision of areas by combination of images with height information.

4.1.4 Adding Extra Information

Satellite image data are rarely used as the sole data source [Aronoff, 1991]. Field observations and measurements as well as existing information such as maps and reports are used together in the image mapping.

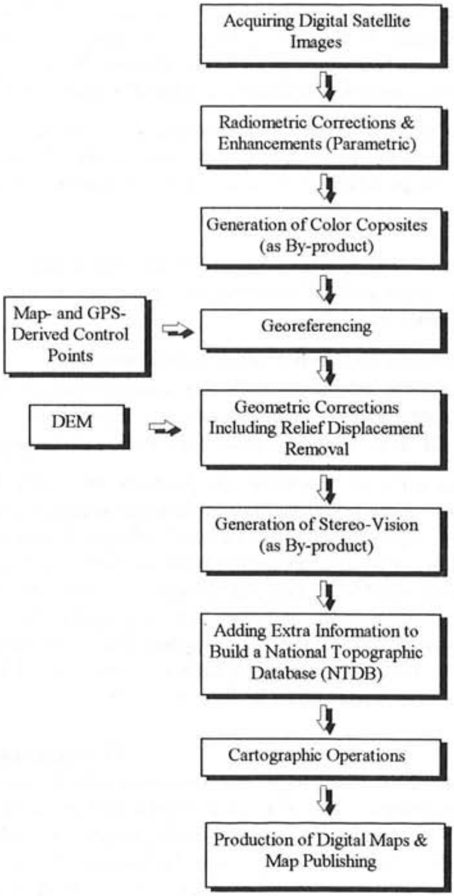

Diagram 2. Deatiled steps of the production line

4.1.5 GIS Database

Often the image data are the most current spatial information available for an area within the country. The use of digital image data offers the additional advantage of a computer compatible format that can be fed in directly into a GIS.

The integrated use of satellite images and GIS methods and technology not only will improve the quality of geographic information, but also will enable information previously available to be economically produced [Aronoff, 1991]

In our design, we plan to use a system capable of display vector and raster data in correct registration simultaneously. This system will enable the raster satellite images to be used as a background overlaid by a vector map. Vector maps will be derived whether from existing maps or directly from satellite images themselves. The vector maps can then be updated or created by interactive drawing over the images. By using the imagery directly as background, the change can be found visually and the GIS database updated as required.

The particular GIS users will be able to classify the images to generate more information. Since the classification methods and spectral are not similar in different in applications, this will be the responsibility of the users to manipulate the dataset to derive the extra information of their own.

4.1.6 Cartographic Operations and Presenting Final Products

The main goal of cartographic operations in our context is to increase map production efficiency by

- creating and editing cartographic symbols;
- creating, editing and archiving custom feature representations;
- adding grids, graticuls, annotations, legends, and other visual information to map images;
- and, associating both raster and vector data to prepare image maps for printing.

Two ways of presenting the products are viable for 1:100,000 image maps: hardcopy and digital output. For the most applications digital products are suitable, as majority of users have been equipped with hardware and software that can operate with digital maps (both raster and vector). For some special applications, there is still need to have hardcopy. Printed image maps and/or satellite images can be made by utilizing accurate printing devices, such as film writers. Since the number of copies for each image may not be so high, we can follow the printing procedures in parallel with another disciplines in other organizations, companies, etc. Since NCC is a national mapping agency, establishing a line for producing of printed copies of raster maps and images is not far from its duties.

5 Conclusions

Existing of base maps in a developing country, like Iran, as a significant part of planning and management tools, is so clear. Producing base maps in a short period of time is also important in development. By use of satellite imagery we will be able to response to need of map users quickly. Maps with images in the background are so useful in many applications. Besides image maps, producing of by-products, such as DEM, slope and aspect maps can be the advantages of using satellite stereo images. Since variation of topography is rather slow, these by-products can be generated once. Therefore just the main products (image maps) will be revised by simple procedures.

Iran is a wide country with all types of terrain. Generally, harmonizing of all national activity to proceed with 1:100,000 project is vital and of great importance. This will be the duty of NCGU to coordinate among different organizations' activity in this case.

6 Recommendation

Utilizing the advanced equipment, such as image processing workstations for handling large amounts of graphic data in combination with PC clusters for operation of normal tasks; a computer network for better communication and data transfer, sharing, and management; advanced output devices, like inkjet raster plotters and film writers for producing checkplots and final products; and large format digitizers and scanners for entering extra data are highly recommended.

Modern image processing and remote sensing software, such as PCI-EasiPace and Erdas Imagine, must be supplied for the project. Modules for mapping, DEM extraction from both aerial photographs and satellite images, format conversion, and linking capabilities with GIS database are necessary for production line.

SPOT XS stereo images have the best potential for producing the first set of maps and generating DEM. For map revisions in the future, we can order SPOT XS single images, because topography of terrain will not be changed rapidly, and DEM generated with the first series may be used in future.

For the areas with no available existing up-to-date map to extract control points(GCPs), GPS is the main source of deriving such points. By establishing DGPS in Iran, hand-held GPS receivers will be the good tools for acquiring GCPs and other map features not be seen in satellite images, for example, pipelines, small roads, power lines, etc.

Mapping of urban areas with high frequency of features is not possible with SPOT XS images. Instead, another satellite imagery may be ordered. EarlyBird panchromatic with 3m GSD, IRS-1C panchromatic with 5.8 m GSD, moms-02 HR with 4.5 m GSD, SPIN-2 panchromatic with 2 m and 10 m GSD, and SPIN-2 IR&NIR with 5 m GSD are the options for being source of data for those regions.

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LANGUAGE ASPECT OF MAP REPRESENTATION

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Introduction

Map is a historical-social phenomenon. It is not a fiction (or construction) of some individual, but it is an intelectual result of yielded by a wide society of people, of the whole human society. A map expression originated both with art expression of a man, i.e. even before writting originated.

Map is a form of reflection, graphical transformation of spatial distribution and correlation between objects and phenomena in this world recognized by a man. It is also a result as well as a source of recognition. A map is to fulfill its historically obtained gnoseological (or cognitive) function, aspects of its expression - map system of expression have to correspond to the function. It is necessary to study the organization of this system.

Map language conception

Language conception of map tries to explain, by means of semiological--linguistic principles, the structural logical as well a graphic-expression aspect of a map representation. It is based on a process of thought and manipulation--operation with notions (concepts).

The following (besides other) reasons caused that we have considered map signs as language signs too:

- Map signs possess practically all properties of natural language signs, of course, except phonic expression. However, they have also some other properties (e.g. two-dimensionality).

- Also different principles of inner organization in a map sign system result of the two-dimensionality of map signs, their high ability to comprehend conceptual content within themselves as well as of other specialities.

- Map (as well as verbal) expression can be adequate or non-adequate. Consequently, the knowledge of reality by means of map depends on a quantity, quality and degree (level) of man (previous and current) knowledge, while knowledge of map language is took for granted.

- Map language was developed as a specific form of human activity and serves as replacement of natural language in situations where natural language is not able (and therefore not the most convenient means) to describe sufficiently certain properties connected with e.g. spatial distribution of objects and phenomena (and their characteristics).

- It is necessary to learn map language (like any language). A lot of concepts can enter into a process of thought also in non-verbal, i.e. in map (cartographical) form, whilst it is also possible to generalize, deduce, induce, analyze, quantify, valorize, diagnoze, prognoze, etc. on their basis.

Map language [1] can be understood as a system of map signs and rules of their use in which there are the four levels: map signics, morphography of map signs, map syntax, map stylistics.

Separate problems there are designation, and expressional errors of maps.

Map signics

Map signics, in a strict sense, is a material (sign) stock of map language, which deals with definition of map sign, classification, collecting and thesauration of map signs. In a broader sense it is a set of knowledge on map designation, i.e. on semiological, logical, lingual (linguistic) and other analogical aspects of map signs and of the map sign system. Accordingly, map signics can be considered as an introduction to the theory (or conception) of map language.

Map sign is trilateral. It is a two-dimensional graphical unit (in two--dimensional map) which has (1) a certain form (shape, appearance), (2) a meaning, and (3) position (location) in a map. The three properties (form, meaning, position) are consiidered also the basic triad of properties of the map sign.

For the needs of map signics the term "map syntagma" was introduced, which is, in other words, a map sign considered without a position in the map. It is graphical or graphic-meaning unit as a potential map sign. This term is convenient as an internal cartographical one also for other levels of the map language, especially for the morphographical (sign-forming) one. As opposed to the linear character of connection within a verbal syntagma (as a categorial notion of natural language), the map syntagma represents a structural two-dimensionally organized connection of its graphic components (morphemes) and elements (graphemes) - see morphography of map signs.

The map syntagmas can be thesaured (gathered) in the form of map sign thesauri so far named sign-book, pattern-book, catalogues, albums and surveys of the map signs or map expression means. Apparently the term "map signicum" or "map signicon" is suitable for them. Any thesaurus, however, requires existence of a suitable classification. For needs of the map signics the classification of map signs (syntagmas) was worked out in which simple and compound map syntagmas are differentiated. Simple are syntagmas indicating one meaning - even if their graphical form is complicated. Simple map syntagmas are divided to figural, linear and areal ones. Compound are syntagmas (named "synsyntagmas") with two or more meanings. Synsyntagmas are divided into discrete and continuous ones. Discrete map synsyntagmas can be figural as well as linear and areal ones. Continuous map synsyntagmas can be illustrated on examples of georelief, geographical network, river network and other networks.

Map legend (in a wide sense) is understood as a form of asignation (joining) of the meaning to map syntagmas. In a strict sense map legend can be considered as a set of translation definitions (as a translation dictionary). There are descriptive, mediate and direct map legends.

To give meaning to the graphical units is mostly an intuitive and empiric process at the present. However, it is an important aspect which can be studied either in the framework of map signics or, if necessary and possible, in the framework of map semantics (cartosemantics).

Morphography of map signs

Morphography of map signs is a level of map language dealing with sign-forming, i.e. with formation, creation, construction of map signs as a map syntagmas.

Map syntagma is defined as a basic unit of morphographic level of map language. It is each graphic map formation with independent meaning. It is composed with map morphemes and map graphemes.

Map morpheme is defined as a part, component of map syntagma with relatively independent partial meaning.

Map grapheme is an graphic element of map morpheme which has a predominantly material function and consists of individual graphic motive and unavoidable graphematic space.

Morphographic operations (manners, ways, modes) are those, through which various forms of map syntagmas (as well as synsyntgmas, morphemes and graphemes) are formed. The aim of these operations is to create such syntagmas that corespond as much as possible to the meaning for which it was determined. Regardless the completeness, the next morphographic operations were separated: consociation (conjunction), composition (with ordination and dividing), connection (connexion), affixation (with sublineation, fringing, mounting), rotation (with conversion and complemention), screening, coloration, modification of dimension (with compression and dilution).

Morphographic analysis of map signs means a decomposition or deconstructing of the individual signs into components (morphemes) and elements (graphemes).

It means that the morphographic analysis starts with the decomposition of the meaning (content) of the sign and ends by the apportion (classification) of the morphemes and graphemes.

The reverse of morphographic analysis of map signs is their morphographic synthesis - creation (forming) that is very important especially when working on complex thematic atlases.

Map syntax

Map syntax is a level of map language dealing with formation (composition) of map as syntactic unit (aggregate, set upon). We are distinguish four kinds of map syntax: typifying, componential, stratifying and compositional.

Typifying syntax is dealing with map syntactic types. Map syntactic types are to be understood as theoretical models, paradigms, principles of sign--composing within the field of map. Each syntactic type of map is divided into subtypes and variants - according to the classificatory attributes.

Classificatory attributes for map syntactic types are the following:

S_F - figural sign,

S_L - linear sign,

S_{AD} - discrete area sign,

S_{AC} - continual area sign

Q - qualitative,

M - quantitative,

Dens - density,

Diagr - diagrammatic,

Curs - directional,

Int - intensity,

Isogr - isogradational,

Anam - anamorphic.

According this attributes, 11 syntactic types may be separated (see Fig. 1):

(1) - type of figural signs: - qualitative,

(2) - density,

(3) - diagrammatic,

(4) - type of linear signs: - qualitative,

(5) - directional,

(6) - diagrammatic,

(7) - type of discrete area signs: - qualitative,

(8) - intensity (cartogram),

(9) - diagrammatic (cartodiagram),

(10) - type of continual area signs (isogradational type),

(11) - anamorphic type.

Most of types correspond meaningfully to the methods of cartographic representation so far separated in cartography. However, their classification and terminology has run into difficulty in the course of time.

Individual syntactic map types are rather minutely divided into syntactic map subtypes on the basis of attributes of the 2nd class classification) and further to syntactic map variants (on the basis of attributes of the 3rd class classification).

Componential syntax is the construction of the map using its syntactic elements and syntactic components. Under the syntactic element each single map sign (as a kind of meaning that is explained in the map legend) and its set in the map field, is understood. By the syntactic component a class (thematic group) of syntactic elements of the map is understood.

Can be discerned:

- analytical componential syntax: monoelemental, bielemental, trielemental and polyelemental,

- complex componential syntax: monocomponental, bicomponental, tri-componental and polycomponental,

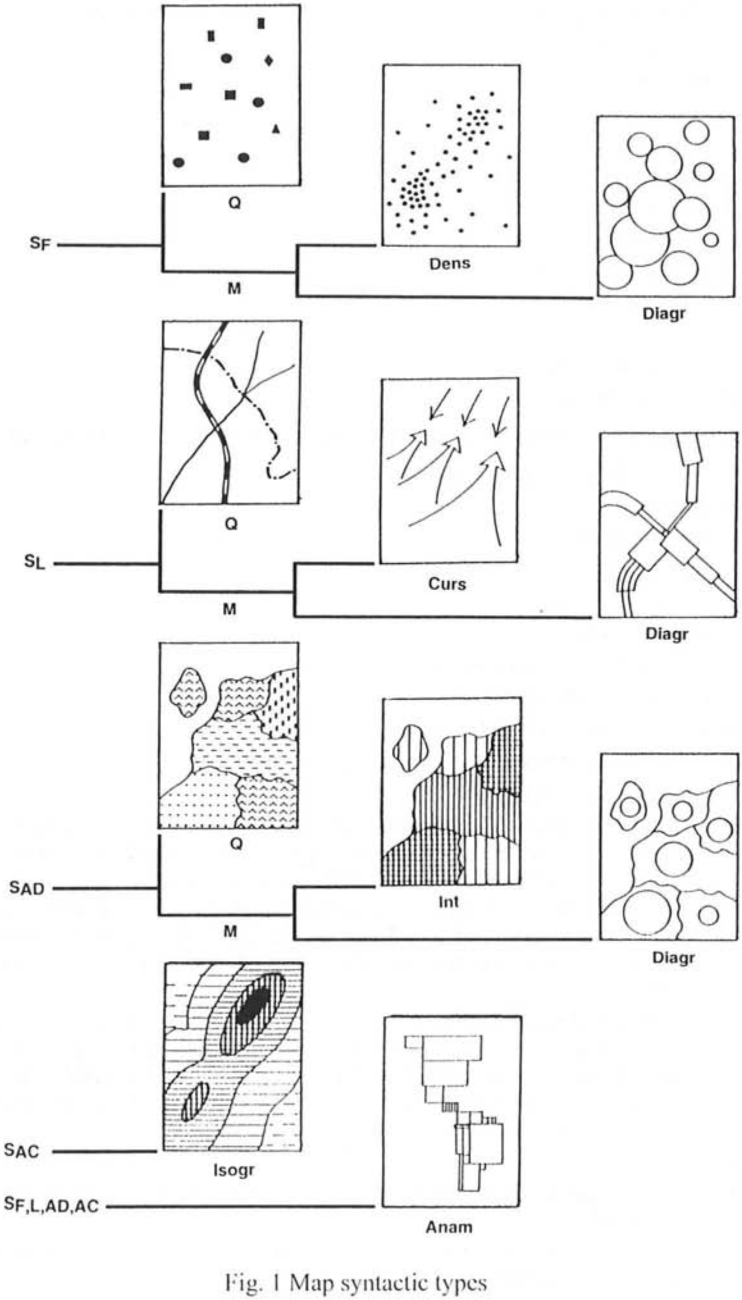

Fig. 1 Map syntactic types

- synthetic componential syntax: regionalization, typification, valorization, diagnostic, prognostic, potential, ... and the like.

Stratifying syntax of map is its construction regarding the differentiation of syntactic levels (horizons, floors, layers). By syntactic level we understand such a grouping of syntactic elements, components and complexes that facilitates perception of the back- and foreground on the map. This phenomenon occurs mainly in thematic maps. Especially geographers register and exploit it. Intentional and immanent map stratification is distinguished.

Compositional syntax of map is an overall distribution and arrangement of its compositional elements. Each syntactic element, component, complex or map layer as well as additional graphical items and map appendices (frame, heading, scale, legend, etc.) is a composition element. Intracompositional and extracompositional elements (elements within the map field and outside the map field) are distinguished. For that reason also map intra- and extra-composition is distinguished.

Besides compositional elements we distinguished also compositional factors like: (graphical) fullness, (graphical) emphasis and (graphical) equipoise of the map. Fullness of the map is the degree of its saturation (load) by compositional elements. Emphasis means differentiation of intracompositional and extra-compositional elements of the map from the view point of their optic (visual) expressivity. Equipoise (balance, harmonization) is attainment of such state when the map is perceived as a harmonious compositional whole. Fullness, emphasis and equipoise of the map are the characteristics that are matter of further investigation.

Map stylistics

Map stylistics is a structural level of map language dealing with the style of maps. However, it can be considered also out of language (linguistic) conception of a map.

Map style is the complex of characteristic map features. It is based on purposeful (sometimes subconscious) choice of stylemes i.e. stylistical--compositional elements chosen to support some map functions. That is why we talk about functional map style (styles).

Since maps, as a rule, fulfill always more than one functions, there cannot be as many styles as there are the functions of maps, since also the style-forming factors (subjective and objective) are taken into consideration. The subjective style-forming factors include: professional erudition, approach to the subject (the theme) of map representation, and individual inclinations of the author (compilers and others participating subjects: reviewers, authorizers and so on). The objective (objectivizing) style-forming factors include: technical equipment (standard), the system of representing means into a map publishing house, the purpose of map and some others.

Three groups of map styles can be distinguished: historical, contemporaneous and individual to regional. Within the framework of historical styles the following can be distinguished: primitive style, antique style, O-T (Orbis Terrarum) style, Arabian style, Chinese style, portolano style, topographic style and hachuring (hatching). In the framework of contemporaneous styles the following are distinguished: utility (usefulness) style (this term is question-able), scientific style, popular style and artistic style. In each of them several style variants and subvariants are distinguished. The third group of map styles is formed by: individual (author or editor) style, publisher (publishing-house) style, national to regional (also subregional) style.

This classification of map styles is preliminary and introductory. The style of maps can be investigated from both the presenting viewpoint (from the viewpoint of linguistic system) and the aesthetic (graphic and artistic) viewpoint. Further investigations will show whether it is sufficient to investigate the map styles of these differentiated aspects, or whether they can be done only one and integrated aspect.

Designation

Designation is an act of denoting the meaning by sign [2]. Cartographic designation did not enjoy sufficient attention so far. Many considered, and still consider it negligible or petty matter in conviction that there are no special rules. An opinion that this act is ruled by only one principle - convention, application of which only requires "common sense" is prevailing.

Implementation of convention in case of map designation is considered an initiative duty of the map creator. Many, especially inexperienced creators of maps, consider this advantage a "victory" where the "winning side" is allowed more than the "loosing" one - the percipient of the map. But the experienced map creator understands it as a demanding task and great responsibility to the supposed anonymous reader of the maps.

In order not to interpret conventionality as an utterly free choice of the sign and its utterly free alignment to any meaning (notion) it is necessary to observe some kind of rule, principle. Conventionality can be used in two varietes: arbitrariness and associativity. It seems that the basic one is the principle of associativity. Associativity in designation means such choice of expressing means on basis of which their formal side (appearance) is discerned as it is done in its contents (concept) aspect in our minds. At the cartographic designation the associativity is ensured by means of agreement of some relevant property with some relevant characteristics of map sign and reversely: certain particular graphic unit can fulfill the function of map sign only if it agrees in some way with object-phenomenon of objective reality it is representing on the map.

Associativity of map sign and its meaning is applied by means of agreement in topology, shape, colour, size, structure and in some other properties (plane accordance, exactness of localization, combinational ability, regularity, priority etc. Minimum associativity can be talked about if the sign and the represented object-phenomenon by it, agree at least in one of associative properties. If the sign and the represented object-phenomenon agree in several properties it is possible to talk about multi-associativity of map expression.

Expressional errors of maps

All failures to keep the rules of associativity are perceived as faults of map expressing and a careful search for the causes shows that they are the faults of designation in the process of map creation. Associativity is a natural property of human expression. With regard to the development of human communication in general and with regard to the development of map expression we can state that in case of map expression it is a primary associativity and not conventionality. It means the associativity does not substitute conventionality, on the contrary, conventionality is used when the associativity is not possible or desirable - for instance when denoting abstract meanings.

Besides that we can distinguish (without factual errors) the errors in signics, in morphography of map signs, in map syntax and in map stylistics. We distinguishe (as minimum) the big errors, technical errors and negligences in map expression.

Conclusion

It is possible to suppose that the outlined foundations of the map language conception will be a sufficient starting-point for the display of various ideas that were too briefly expressed in this paper. So far only four subsystems of the map language (signics, morphographics, syntax, stylistics) and two separate problems (designation and expressional errors of maps) are selected. With the gradual deepening of the knowledge (in cartography but not only there) it can be count on the expansion of these fundamental knowledge into the shape of the developed theoretical conception that in its consequence will not have to be considered language (linguistic) or communicative as model or other interdisciplinary knowledge and approaches can prevail in it.

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GIS-ASSISTED MAPPING OF SNOWPACK ACCUMULATION PATTERNS IN IDAHO, USA

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Introduction

Snowpack is the most important water resource in the western United States. Snowpack has been reported to provide approximately 75 percent of the volume of seasonal streamflow in the West, and to account for more than 60 percent of the annual variability in streamflow. Point snowpack measurements in snow water equivalent (SWE) are typically used in snowpack accumulation variability studies and in water supply forecast models. How to create a SWE surface from these data points is the focus of our research.

A number of methods for interpolating a statistical surface from given point data have been suggested in the cartographic literature: thiessen polygon, linear interpolation, inverse distance weighted, and kriging (Lam 1983, Tabios and Salas 1985, Burrough 1986, DeMers 1997). These methods interpolate the surface by mainly considering distances from known points or spatial dependence models among data points. The reliability of an interpolated surface therefore depends to a large extent on the distribution of data points and the areal coverage of data points relative to the study area.

Snow courses, at which snowpack accumulation data are measured, are located in mountainous areas and typically form a clustered pattern. The traditional methods for interpolating SWE surfaces from clustered snow courses tend to result in surfaces with irregular isoline patterns and island areas, as we found in our preliminary analysis of SWE surfaces in Idaho using the inverse distance squared method and universal kriging. A different approach is therefore needed to construct SWE surfaces. In this paper, we describe the modeling of snowpack accumulation with a geographic information system (GIS) and a multivariate approach to predict values at unknown points.

Data

Snow course data

The Natural Resources Conservation Service (NRCS, used to be the Soil Conservation Service) has conducted snow surveys in western mountainous regions since 1935. Manual survey takes 5 to 10 measurements at regular intervals along a snow course and the average measurement is recorded in SWE. In 1977, the NRCS began developing a network of SNOTELs (SNOwpack TELemetry data stations). Each SNOTEL station is equipped with automatic measuring devices and remote communication devices. Over 250 snow courses are maintained in Idaho. For this study, we removed those snow courses that did not have continuous 30-year (1961-1990) records, and those that had apparent positional errors. We ended with 194 courses. Although clustered, the snow courses covered different elevation zones in Idaho. For each course, we computed the average monthly SWEs from January through May and the average maximum SWE. The maximum SWE referred to the highest SWE during a snow season; the month in which the maximum SWE occurred varied between snow courses.

DEM

We used 3 arcsecond Digital Elevation Models (DEMs) from the U.S. Geological Survey (USGS) to derive locational and topographic variables for our study. After obtaining all the DEMs for Idaho, we projected them into the Lambert map projection, merged them, and removed sinks, or possible data errors, from them. The final single DEM grid measured 5,966 columns and 8,229 rows, with a cell size of 95.154 meters. Of the total 49,000,000 cells, 31,000,000 cells covered the state of Idaho.

Analysis

Locational and topographic variables

Locational variables measured the geographic location of a cell. We used the column number and the row number in the DEM grid as the easting and southing, respectively. Topographic variables covered elevation, slope, and aspect. We had to transform the aspect variable because its circular measure could not be used directly in statistical analysis. To capture the N-S principal direction, we set 0 degree at north, 180 degrees at south, and 90 degrees at both west and east. Similar transformations were applied to capture the E-W, NE-SW, and NW-SE principal directions. We also included secondary or compound variables (Moore et al. 1993), measuring land surface curvature and the combined effect of slope and aspect such as the slope-aspect index and shadow. All the variables were generated using the various functions and commands in the Arc/Info GRID.

Regionalization

A preliminary multiple regression analysis using all 194 snow courses in Idaho resulted in a low R-square value (0.5). We decided to divide the state into different hydrologic units and ran the analysis separately.

Idaho contained 88 basic hydrologic units according to the USGS Water Resource Division. We combined these basic units into 15 regional watersheds, of which eight had a minimum of 13 snow courses. The other seven regional watersheds were smaller in size and had either less than 13 or no snow courses; these watersheds were combined with the neighboring watersheds for data analysis.

Multiple regression analysis

We overlaid the snow courses with the data grids and extracted their locational and topographic values. We then ran separate multiple regression analyses using each monthly SWE and the maximum SWE as the dependent variable and the locational and topographic variables as the independent variables.

Several steps were taken to ensure the validity of our SWE models. We made sure that variables with high inter-correlations would not be included in the same model. We limited the number of independent variables in a model to five or less because of our small sample sizes (13 to 31) in the regional watersheds. The stepwise method was used to initially select independent variables into a model; the level of significance for adding a variable was set at 0.15.

Another measure we took to avoid the overspecification of our SWE models was to run the jackknife resampling method with different subsets of three to five independent variables for those models with sample sizes of less than 15. We chose the subset that had the smallest sum of squares of predicted residual errors as the best-fitting model.

Results

Multiple regression models

There were a total of 48 regression models (6 models x 8 regions). The R-square values ranged from 0.62 to 1.0, with half of the values reaching 0.9. Different monthly models for the same watershed all had the same or similar independent variables. Watershed 6 had the same independent variables (easting, elevation, and the slope-aspect index) for all six models; Watershed 9 had elevation and easting in most models; Watershed 8 included elevation, easting, and southing in every model; and Watershed 5 included easting, southing, and elevation in most models.

This consistency in the selection of independent variables suggested: (1) analysis at the watershed level was crucial, as each watershed was characterized by a set of physical factors that influence its snowpack accumulation; (2) the physical factors that influenced a watershed's snow accumulation remained effective throughout the snow season; and (3) the locational and topographic variables were reliable predictors of snowpack accumulation.

SWE surfaces

Figure 1 shows the SWE surface for the month of April: the bright areas indicate areas of snowpack accumulation. Resampled at the 1 km resolution from the original 95 m grid, each cell in Figure 1 has the average value of about 100 cells in the original grid. Except for elevation, this resampling has blurred the effect of aspect and other topographic variables. Figure 1 corresponds well with a topographic map of Idaho: the high concentrations are in the Salmon River Mountains in Central Idaho, the Clearwater Mountains near the Montana border, and along the Canadian border.

Resampling from the original grid is also required for making isoline maps at the state or watershed level. Figure 2 shows an isoline map at the 5-inch interval for April in Idaho, resampled at the 10 km resolution. The resolution for resampling depends on the size of area for display, the map scale, and the level of detail needed. Certainly, a major advantage of using a GIS is the flexibility in scaling.

Generalization through resampling is required for data display. The 95 m grid, however, can be used directly in data analysis. An example would be to use it for computing the total amount of water storage at the watershed level for water supply forecast. The grid can also be used as a map layer in hydrologic modeling involving snowpack.

Conclusion

Using a cell-based GIS, we have successfully modeled snowpack accumulation in regional watersheds of Idaho with the locational and topographic variables derived from the USGS 3 arcsecond DEMs as the predictor variables in multiple regressions. Regional SWE models can be pieced together to provide a synoptic view at the state level; they can also be displayed at different spatial scales through resampling and isarithmic mapping, or used directly as a map layer in hydrologic modeling. GIS is well suited to multivariate regression modeling because of its capabilities in integrating and analylzing diverse spatial data sets.

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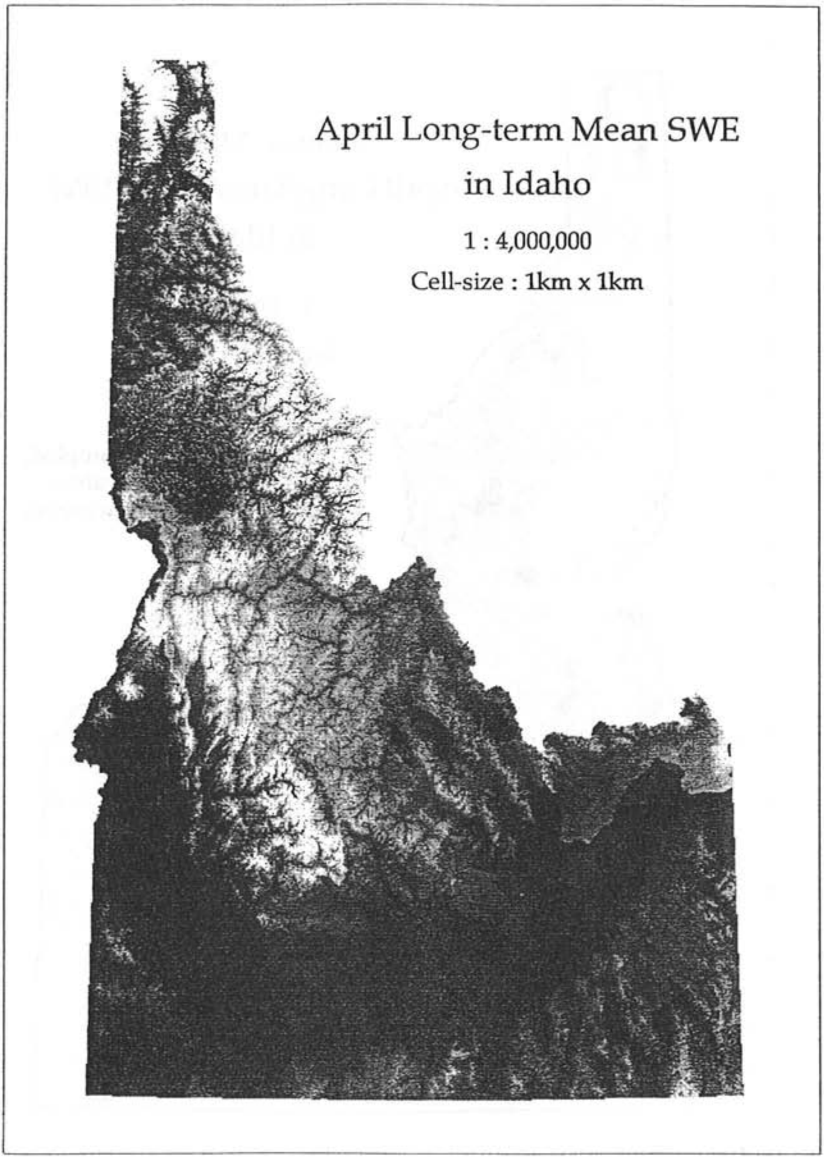

Figure 1. April long-term mean SWE in Idaho

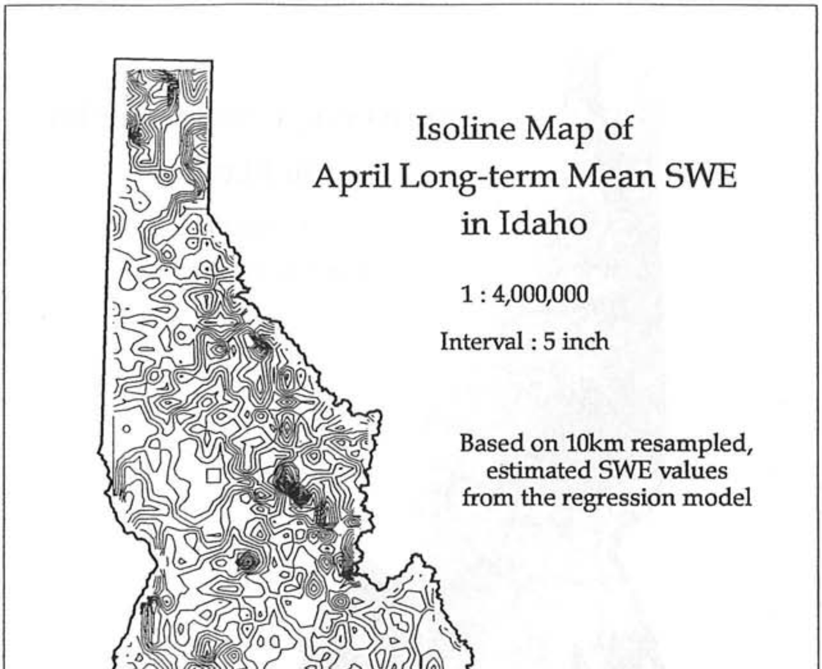

Figure 2. Isoline map of April long-term mean SWE in Idaho

A CARTOGRAPHIC RESEARCH AGENDA FOR ENVIRONMENTAL MANAGEMENT

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Abstract

Throughout history, cartography has been an applied science to meet the spatial information needs of complex navigation, earth science, resource management, and political issues at various scales. As we approach the end of the 20th century, one set of scientific application need is becoming high priority for all levels of government: solving the environmental problems created by changing demographics. Because of increasing population pressure on natural and cultural resources, the cumulative effects of previous human activities, and a better understanding of the natural variation in global and regional ecosystems, cartographers are being asked to portray ever more complex variables. Because of advances in technology, cartographers are being asked to portray those variables in a greater variety of analog and digital media. Because we now better understand the cost of management decisions, cartographers are being asked to incorporate better information about the reliability and accuracy of cartographic data. Also, because decision support systems (DSS) have improved, cartographers are being asked to provide their data more quickly and in formats that can be used by the DSS's. Some of the issues and activities for which these demands are made include global change, environmental security, ecosystem management and restoration, real-time hazard monitoring and response, mitigation of the effects of natural disasters, and earth resource management. Cartographic research is being focused on activities to meet the challenge of these requirements with increased emphasis on conducting research both independently and as part of multidisciplinary cartographic applications projects.

Introduction

The intellectual evolution of a scientific discipline begins with description and follows through phases of monitoring, understanding, modeling, and predicting (Kelmelis, 1996). Topographic maps, for instance, describe the physical features and elevation of the land surface in a generalized manner. Mapping organizations have traditionally concentrated on mapping the status of themes describing various aspects of the land surface. However, modern technology has enabled regular monitoring of various themes and has allowed land surface processes to be more easily studied using geographic information systems and computerized numerical models. Cartography can now help us understand not only what is on the Earth's surface but why it is there and how it will change under various circumstances. Cartographic research must now address these advances in land surface process studies.

For cartography and geography to advance and solve the current and future problems, new techniques to acquire, integrate, analyze, present, and use spatial data will be necessary. Cartographers and geographers have unique experience in integrating multidisciplinary data that will be particularly valuable. However, cartographers will increasingly be required to gain working knowledge of processes in related disciplines such as geomorphology, ecology, biology, forestry, urban studies, and other fields. Although individual research is still important, much work will be conducted in multidisciplinary teams. The knowledge gained and techniques developed as part of land surface process research will be important in conducting applications analysis to address policy and management issues.

Applications

According to the International Institute for Applied Systems Analysis the world's population has quadrupled over the past 80 years and is likely to reach 9.9 billion by the year 2050 before it begins to level off at about 10.4 billion in the year 2100. The large increase and ongoing demand for food, fuel, and an improved living standard will continue to place unprecedented pressures on our natural resources. At the same time we are learning of short- and long-term effects of humans on the environment. Efforts to ameliorate past negative influences and reduce the potential effects of future changes coupled with advances in technology have helped geography and cartography mature from the descriptive to the predictive phases.

Of course, all phases are necessary. Descriptive cartographic information, represented either in printed or digital format, is the basis of understanding. Status must be monitored to determine trends, which leads to an understanding of the system. Conceptual, spatial, and numerical models can be constructed to test our understanding of the system. Once our understanding is sufficiently sophisticated, a forecasting capability can emerge that provides hypotheses about the future. This is a necessary part of decision support systems. These can be tested against the real world with descriptive and monitoring efforts.

The problems and anticipated solutions currently articulated by decision makers are being framed in geographic terms. Their spatial undertone sets the stage for cartographic analysis. There are numerous examples.

Ecosystem Management In recent years there has been an increasing emphasis on using a system approach to managing environmental resources. This is a result of the realization that local actions can have systemic effects. Debates about who is to bear the costs of those effects are taking place. Methods being developed to produce vulnerability and recoverability maps for the Mojave Desert (Gaydos and others, 1997) and ecological response unit maps for the Gunnison River basin (Wheeler, 1996) are major steps toward bringing an understanding of the Earth's response to human and natural changes into the decision making process. By integrating the Earth surface status with conceptual and mathematical models of various components of the Earth system, it will be possible to produce maps of processes as well as variables. This will facilitate a more sustainable approach to ecosystem management (Kelmelis and Watts, 1991).

River Basin Management For many years activities conducted in river basins were done independently. A new ethic has arisen to manage river basins as a whole rather than as a series of independent projects. This new approach is partly because experience has shown that decisions can have long-term costs as well as benefits. Thus, after years of managing the Mississippi River as a series of independent structural projects, the U.S. Army Corps of Engineers has developed an integrated hydraulic model of the main stems of the Mississippi, Missouri, Ohio, and Illinois Rivers, and the major tributaries. This monumental effort is partly the result of recommendations made after the 1993 floods in the Upper Mississippi River Basin (SAST, 1994).

Environmental Restoration Past activities have affected the environment, often with harmful results to both humans and wildlife populations. Current efforts are underway to restore conditions that will support ecosystems with (1) sustainable habitat for wild species, (2) an effectively functioning system, and (3) an adequate environment for sustained human use. For example, the environment in the South Florida ecosystem has been greatly altered by agriculture and urban development resulting in saltwater intrusion, land subsidence, mercury contamination, wildlife population reduction, and reductions in both water quality and quantity. A consortium of Federal, State, local, tribal, and nongovernment organizations are coordinating their scientific research to provide information to policy makers and managers. Because it is impossible to conduct field studies throughout the 2.9 million acres of the Everglades, cartographic data bases are developed using a multiscale approach. Field surveys, airborne videography, aerial photography, and satellite imagery are being used to map variables needed to model hydraulic flows and evapotranspiration (Garster and Desmond, 1995). These data will also be useful for evaluating toxic chemical migration, species distribution, and other variables to restore the viability of the ecosystem.

Disaster Management Natural disasters cost the United States $50 billion per year along with untold human suffering and misery. In developing countries the suffering is even worse. Much of the suffering and economic costs can be reduced by taking proper measures in the mitigation, response, and recovery phases of disaster management and by providing appropriate real or near real-time hazard warning. The actions that must take place include: (1) mapping hazards, that is anticipating the vulnerability of a place to individual and multiple hazards, (2) evaluating the relationship between vulnerability and social fabric, that is, determining the individual, multiple, and comparative risk at a given place, (3) providing timely warnings of the likelihood of an event's occurrence, (4) furnishing the necessary information during and immediately after the event's occurrence to aid in the response, (5) supplying timely information for recovery and redevelopment to minimize future loss, (6) ensuring that information is used in the policy making phase immediately after an event's occurrence while the public sensitivity is high, and (7) using the event as a natural experiment to improve our understanding of the relationship between human and natural systems and their effects on vulnerability and risk.

Environmental Diplomacy and Environmental Security Worldwide interest is high on the environment and the consequences of natural resources degradation and the international community is increasing its focus on the environment as an issue for diplomatic discourse and interaction (Shaw, 1996). Issues for which nations have developed diplomatic instruments include preserving the Antarctic environment, prohibiting military or other hostile uses of environmental modification techniques, air pollution, hazardous waste transport and disposal, biological diversity, climate change, and ozone layer depletion. In addition, nations are examining the relationship between environmental factors and national security. Environmental security can be described as any environmental action or impact that has a potential to directly or indirectly cause a nation to alter its national security activities. To address this, a systems approach to the observation and understanding of environmental factors on global, regional, and local scales is important. This, of course, requires an understanding of the natural system and the relationship of diverse cultures and its economy.

Global Change Although global climate change is the most frequently discussed global change issue, there are others that are significant as well. These include loss of biodiversity, reductions in water quality and availability, population growth, changes in population concentration (both spatially and by age), changes in trace element composition in the atmosphere (for example, chlorofluorocarbon and related compound increases and resultant ozone depletion), and others. All of these require strategies for mitigation and (or) adaptation. Some of these problems may sound relatively straightforward but all are extremely complex and their solutions require a degree of cooperation among interested nations that goes beyond merely the establishment of agreements. The effects of these changes must be clearly understood, portrayed to the population and the decision makers, and adaptation and mitigation strategies developed that will not exacerbate these or other problems. These changes can have negative socioeconomic consequences but they can provide market opportunities as well.

Research Needs

There are several elements common to all of these applications: (1) mapping the status of the landscape and the factors that affect it, (2) developing systems to monitor changes, some of which must be real or near real-time, (3) taking a systems approach to develop an understanding of Earth processes, (4) using a spatial approach to process modeling, such as sensitivity mapping, (5) improving process models so they can incorporate socioeconomic factors and policy changes, as well as biophysical variables and parameters, thus providing nearly immediate forecasts (hypotheses) of outcomes of decisions, and (6) developing methods to display the forecasts in ways that are intuitively understandable. All of these are necessary elements of an advanced decision support capability for natural resources management. The research needs for each element follow. They are cumulative, for example, the research needs for monitoring are built on the research needs for mapping.

Map

- Relate the data provided by new sensing systems to both static variables and processes taking place on the Earth's surface;
- Develop data mining tools, particularly for extracting variables from a variety of data types both historical and current. A variable can be either a feature or a process.
- Integrate disparate data and data types including advancing automated conflation capabilities. This includes conflating different data structures, formats, content, accuracies, reliabilities, representations (projections, geoids, etc.), and scales.
- Develop easy to use metadata tools that are not troublesome to scientists in other fields, while still providing the information necessary for data integration.
- Develop new data structures to meet new analysis needs and computing capabilities. Establish better methods to translate from one data structure to another.
- Design and test data models capable of efficiently storing data in three and four dimensions. This should include capabilities for seamless or virtually seamless data bases to reduce the cost of updating data bases, efficiently store process dynamics information, and effectively explore and mine data.
- Automate generalization capabilities including the ability to: (a) go from large to small scales and visa versa, (b) evaluate statistical and fractal data scale change capabilities, and (c) identify process thresholds for variables.
- Develop data compression capabilities for more efficient data storage, transmission, and manipulation.

Monitor

- Establish monitoring systems for key parameters and develop spatial, temporal, and content thresholds necessary to identify critical changes.
- Develop methods of analyzing existing and new data sources (manual, automated insitu, and remotely sensed) to identify critical information about change or the lack of change; including (a) conducting retrospective analysis to discover critical changes in the past, (b) developing methods to compare actual changes to expected changes, and (c) developing methods to evaluate the data stream, as well as the images to identify change.
- Incorporate existing or new change detection capabilities into operational environments and develop methods to rapidly ingest data into geographic information systems and process models. This includes developing methods to do real and near-real time data transmission and incorporation and transactional data storage.

Understand

- Develop methods to mine data in such a way that processes and their parameters can be identified.
- Use the data to conduct analysis as the data bases are being built. This increases understanding of the variables or processes being mapped, as well as increasing understanding of the effectiveness of the map structure, content, accuracy, and format.
- Develop methods to link subprocesses and subsystem information into overall system maps and to incorporate externalities into spatial data sets for parameterizing models.
- Develop smart maps, in which process information is imbedded and related to spatial location.

Model

- Produce sensitivity maps. These maps incorporate a variety of parameters so that the sensitivity of a piece of ground to a single or group of forcing functions is identified. These include hydrologic response units (Hallam, 1993), ecological response units (Wheeler, 1996), vulnerability and recoverability maps, risk maps (Campbell and Bernknopf, 1993), and similar spatial data.
- Improve methods of linking social, biological, and physical spatial data to produce meaningful results.
- Develop methods to conduct analysis at the metadata level.
- Conduct analysis of the data to define potential reliability of results and identify data that may need modification in content, accuracy, structure, or other category.
- Develop methods to incorporate accuracy and reliability information at the map, category, feature, and process understanding levels, as appropriate, to provide

reliability information on analytical results.
- Develop modular modeling capabilities for a variety of processes and build data sets that are suitable for analyses under conditions to which the modules are applicable.

Forecast
- If models are sufficiently refined and robust they will be able to forecast change due to natural or anthropogenic forcing functions. Mechanisms must be developed to convert natural language queries about variables that may affect the landscape to spatial input that can be used in models to assess "what if" scenarios.
- Develop techniques to integrate the most recent monitoring information, historical information, pseudo data, operator knowledge and input into models to conduct error analysis, and to provide a forecast of results and their reliability as a spatial data set that can be displayed rapidly on a variety of media.

Present results
- A print on demand capability must be developed to provide hard copy results to managers, scientists, and the general public. This capability must include the to production of custom maps as well as standard products.
- The ability to produce intuitively understandable meaningful symbols and automated symbol placement must be included in geographic information systems, visualization systems, and print on demand capabilities. This should include representations of content, reliability, currentness, and so forth.
- Interactive display capabilities must be developed so nonexperts can manipulate spatio-temporal data and obtain results that are meaningful to both scientific audiences and the general public.
- Visualization capabilities must go beyond current animation practices of multiple snapshots and morphed interpolation to scientific visualizations that include snapshots that represent control points for interpolations based on mathematical functions and equations that represent verifiable process dynamics.

All of these research activities must be supported by a robust data management and distribution system capable of serving data in a seamless manner. Therefore, significant improvements are necessary to graphical user interfaces, online server links, online processing and analysis capabilities.

Conclusion

Most of these research needs have been with us for many years. Most of the advances that have been made to solve some specific problems have been incremental, some, however, have been dramatic, motivated by enabling technologies or disciplines.

Most often those solutions are not sufficiently robust to address the increasingly complex issues that are facing us as increasing pressure is being placed on our environment. Solutions to some environmental problems may elude us until these analytical techniques, needed for robust decision support systems, become available to help guide us in modifying our behavior.

To be most useful, the cartographic research must be conducted in a multi disciplinary environment with an emphasis on efforts to make the process models and decision support systems more effective. Therefore, cartographers will need to become more educated in environmental problems and participate as full partners on teams whose objective is to solve those environmental problems.

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APPLICATION OF REMOTE SENSING INTEGRATION WITH GEOGRAPHIC INFORMATION SYSTEMS FOR DISTRICT PLANNING IN VIETNAM

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I. Introduction

During the past many years, new possibilities have been created to collect environmental data on a monitoring basis. Data can be collected over very large areas in a short time. It can be carried out by applying an adequate level of remote sensing technology, ranging from the use of aerial photography to the use of earth resources and meteorological satellites.

In the context of regional planning, for the documentation and analysis of natural resources and some social aspects the following data may be obtained :

- Landuse/landcover stratification and statistical area.
- Soil and Landform structure.
- Hydrology drainage patterns, surface water turbidity.
- Climate related factors.
- Population: density and distribution to a certain extent.
- Infrastructure: transportation networks.
- Existing recreational areas.

The transformation of satellite data into valid information is often carried out through a combination of visual (manual) data interpretation and computer processing. The Landsat-IV and SPOT imageries used in this study have got a good resolution in comparison with others. The time for data capture is mostly in dry season so cloud and haze are absent in photoimages. Theoretically resolutions of SPOT and LANDSAT-TM are 20m and 30m respectively, but many small details can be recognized because of the good quality of imageries.

II. The study area:

The area selected for study is Cam Binh district, Hai Hung province. Cam Binh is located in the Red River delta about 50 kilometers by road from Hanoi. The district is bordered by the Thai Binh river at the North East direction and crossed by its tributary, the Sat river, which offers scope for irrigation, allowing upto 3 crops per year. Naturally agriculture is the mainstay of the district economy, covering 70% of the total area, with rice is the main crop. The topography of Cam Binh is rather even. The average elevation is 1.5 - 2.5m. Some elevated land and depressions are scattered over the district. The soils in the district are also rather similar, the 5 soil categories including

- Annually deposited and recently deposited alluvium.
- Non-glay undeposited alluvium of Thai Binh river.
- Ferralitic alluvium soils of Thai Binh river.
- Glay alluvium soil of Thai Binh river.
- Water-lodged alluvium soils.

Most of soils have medium to heavy structure; the organic content is from medium to rich, suitable for rice growing. Some upland and slightly elevated areas are suitable for subsidiary crops in the spring and winter seasons.

III. Photointerpretation and thematic mapping for planning and development:

The photointerpretation process was carried out on SPOT and LANDSAT-IV imageries flown at different time in the period of 1985-1993. It aimed to identify distribution of natural resources and its dynamic of change over time, to come up with an orientation for further development for the study area. In specific terms, the interpretation aimed to cover following themes:

3.1 Land Use Pattern Interpretation:

Land use/land cover is most suitable information for imagery interpretation. The landscape of study area is fully reflected in the land use picture. Although the dominant form of cultivation is paddy field, the imagery tone and texture of it is not the same because of different growth status, soil types in the open areas and the degree of water logging. Mostly paddy field has a fine imagery texture and regular pattern. On color composite images, a yellowish color ranging from bright to dark reflects growth status or the plant density.The subsidiary crops cover a smaller area than paddy fields and the imagery texture is more coarse. They require not very much water and are mostly grown on the upland areas.

Orchard and residence mixed with orchard have a very characterized red color on the LANDSAT and SPOT false color composite (FCC) images. Usually, they are located along the river and the roads, nearby annually cultivated areas.

Land use pattern is most dynamic one in comparison with other natural resources. According to the interpreted results, the area of spring rice field (which very characterized for waterlogging alluvium soil) has decreased, some times changing to double crop rice. (The spring rice field also called as "floating rice" which is grown in many part of Asia and West Africa. There are extensive areas in Bangladesh, India, Burma, Thailand, Vietnam, Indonesia). The area of subsidiary winter crops has increased, especially corn and potato on the river bank and in the more upland zone. The orchard has enlarged a little too, perhaps for longan cultivation for export. Other types of subsidiary crop such as mulberry and sugarcane have been developed and offer a better land use rotation in recent years.

The secondary data shows that even though the area for paddy cultivation has decreased, the total product of rice remains the same, the reason for this we need to find out from the socioeconomic field survey.

<u>3.2 Soil Types Interpretation</u>.

The soil types can be interpreted through land use pattern and topographic location. There are 5 main types of soil in study area as indicated above. Mostly recent alluvium deposit can be found on the river bank, the ferralitic alluvium soil in upland areas and water logged alluvium soil is located in the lowland and swamp land. The other two types of soils are intermediate of three soil types given above. Almost all the soil is suitable for crops diversification. The interpretation of soil types also based on the direct indicators at time of crops harvest. Brightness of tone shows the water content and the coarseness of soil structure. Recently deposited alluvium soil has a brighter tone than other soils, and waterloging alluvium soil has dark to very dark tone on the images. Soil type is not a very dynamic variable in comparison with land use and land cover relevant, but it requires the series of images for correction of interpreted results.

<u>3.3 Water Bodies Interpretation</u>.

The water bodies are shown in the image by a very dark tone, their linear shape and small size with irregular pattern. River are also characterized by a varied vegetation and residential areas mixed with garden along the bank. The results of SPOT images interpretation shows that irrigation canals slowly developed in some communes may explain the decreasing area of spring rice field.

<u>3.4. Flooded Areas Interpretation</u>.

The flooded areas have been found on the lowland without a very developed irrigation system. These areas always have dark and dark-red tone on the FCC images in comparison with surrounding. For indication of two level of flooding, we have to use images given at different periods of time : in rainy season and in dry season. According to SPOT and LANDSAT-IV imageries the flooded area had been decreased over time, it can be caused by development of irrigation system.

Thematic mapping. Based on the results of the image interpretation, the following thematic maps had been established for further planning and decision making :

- Land use map.
- Soil map.
- Map of water bodies.
- Map of Flooded Areas.

At the same time remote sensing data with support of other secondary data has been used for creation of the following maps:

- Map of population density.
- Map of transportation cost.

Here we have to stress that remote sensing data can give us only a general picture of social feature in qualitative form such as location of human settlement or residential area, road network and some indirect indicator of existing recreational area. Almost the data for compilation of socioeconomic thematic maps have been derived from secondary statistical data such as population density, indication of recreational existing area.

Thanks to the good quality of the photoimages, many details could be interpreted. But field check of office work will always be needed in a strategic planning system for:

- remotely sensed data calibrations
- model and result verifications and modification
- environmental and socioeconomic survey on the most detailed levels.

Results of field check work shows that photointerpretation of SPOT images can indicate many features requiring good resolution such as road networks and drainage patterns, while the LANDSAT-TM image gives good differences of tone and color for general classification of land cover and soil types.

IV. Map overlay analysis.

Environmental information presented in map form is a necessary tool for the planning and management of natural resources, as well as for research on the distribution and allocation of human resources. The map can be seen as a means for communication between researchers, decision makers and planners. To keep pace with the increasing capacity to collect environmental data handling methods must be supplemented by modern computer assisted techniques.

Based on political priorities, the planner can define any combination of data for target areas. That may be suitable annual crops combination with soil qualities, flood hazard; population density and land productivity etc.

It would be a tremendous and practically impossible task to carry out manual operations as combining and comparing map sheets, with different themes, scales and ages. The Geographic Information Systems (GIS) packages had been used for maps storage and analysis, integrate very large amounts of data from different sources and with different themes.

4.1. Factor Analysis for Cultivation.

Paddy fields are the dominant cultivation type in the study area. However there are also other crops mostly which play an important role for economic development in the region such as some types of subsidiary crops: corn, soybean, spring ground-nut, sweet potato, that get more household income and serves for good rotation of land in certain area.

Factors directly influence rice productivity are water logging, fertile soil; the subsidiary crops mostly require deep and fertile soils, mostly grown on the recently deposited alluvium soils.

The topography is rather even so slope and erosion do not need to be taken into account. But elevation will affect the depth of water in the flood season, and this requires a good irrigation system because of the volume of water flowing from Red river through the Thai Binh river system in the period of August - October.

Transportation cost refers to accessibility of each area in term of bringing inputs (fertilizer) and output (yield) from and to market centers or storage areas. Poor accessibility will mean higher production cost and that will affect the productivity of crop cultivation. The rivers in the study area play not only an irrigation role, but also asset in transportation.

The main method for data analysis in map overlay with Boolean logic. The model for identification of profitable areas for cultivation is shown in Fig. 1.

The map of soil suitable for cultivation is a product of the Land use map and soils map. Each combination of soil and initial land use are evaluated with respect to its suitability for growing rice, subsidiary crops and orchard. It is assumed that all fields in private as well as public holdings, and disturbed area are already in use for cultivation. Thus the inherent soil fertility is already deficit, especially in relation to alluvial soil both on natural levee (for upland crop) and hydromophic (for paddy field).

MODEL FOR IDENTIFICATION OF PROFITABLE CULTIVATION AREA

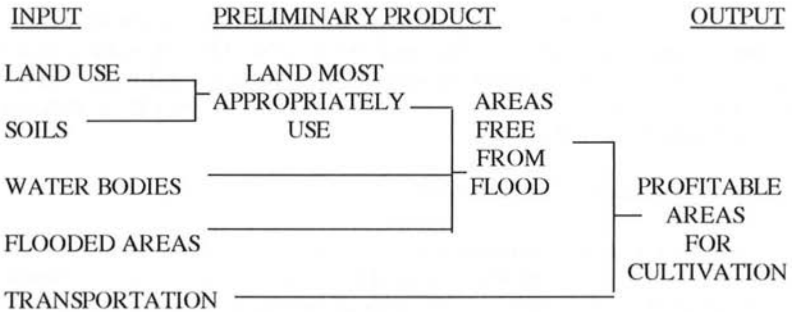

Figure 1

The map of soil suitable for cultivation is a product of the Land use map and soils map. Each combination of soil and initial land use are evaluated with respect to its suitability for growing rice, subsidiary crops and orchard. It is assumed that all fields in private as well as public holdings, and disturbed area are already in use for cultivation. Thus the inherent soil fertility is already deficit, especially in relation to alluvial soil both on natural levee (for upland crop) and hydromophic (for paddy field).

Next step is to combine soil suitability map map with flood map in order to determine which of the available area can be cultivated with limited risk for flood causing.

Given environmental suitability for cultivation, its use for profitable agriculture will be determined by it accessibility. Area that are remote, even though favorable for cultivation will not be extensively planted with the preferred crop due to the high production and transportation costs. Those areas covered by the highway are eliminated from the analysis, as these are supposed to be densely populated.

4.2 Factor Analysis for Handicraft Development.

Handicraft industries need to be set up in such areas where land is not liable to flood, but can not be cultivated intensively, so that it is necessary to seek alternative occupations. However these should be as near as possible to the cultivated land for raw material and the transportation network. The most important factor is, however, population density that indicates the necessity to base economic development not only on agriculture, but also on non-agricultural production. Another factor influencing handicraft development which need to be considered is natural resources endowment which appropriate and profitable for cultivation or for other kind of economic production. That requires combination of agricultural zones with socio-economic data such as population density and transportation cost.

Again the main method for this analysis is map overlay in the GIS packages. The model for identification of the best areas for setting up handicraft development as presented in Fig. 2.

MODEL FOR IDENTIFICATION OF HANDICRAFT DEVELOPMENT

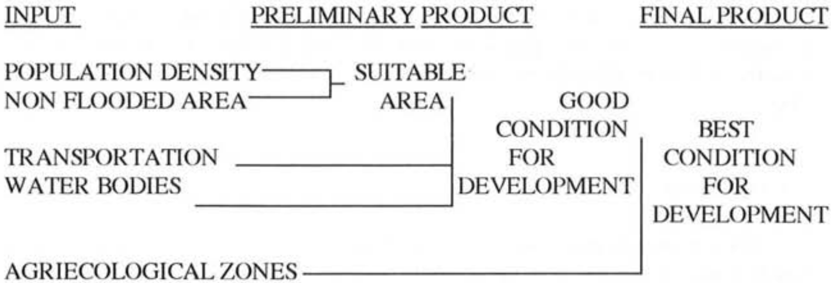

Figure 2

Guiding technique for maps overlay is Boolean logic operations as described above. The cross-tabulator for each combination was also used.

Maps overlay analysis shown that handicraft better to develop in those communes, where population density is high, topography is relatively higher, soils type suitable for subsidiary crops cultivation and very important at all it should near as most as possible to roads and large river.

V. Socio-economic field survey.

Development planning requires not only natural resources base analysis, but analysis of socioeconomic factors also. That includes of leadership in implementation of government policies. In this study two communes were chosen for collection of primary data: an advanced commune and a backward commune. The difference in level of development is reflected in such measure as income, housing standards and level of communal infrastructure development. The comparative advantage method had been used for indication of effective socioeconomic factors. To this end interviews were carry out with a range of commune leaders in an attempt to ascertain the broad characteristics of each commune as Income sources and Household economy, trend in cultivation, their problems and their plans for development.

Such findings seem to suggest that much as remote sensing and GIS techniques can offer important guidelines for the development potential of a district, they must be combined with other factors if we are to fully analyze the situation. The field survey was conducted and confirms that these policies which encourage the development of domestic economy, assessment of the market export, the condition of irrigation network, the capacity of management and services meet the need of production... are very important socioeconomic factors. Agricultural production of the district has changed from self-sufficiency to market orientation. The productivity also reflects the level of skilled labor in the district. All the infrastructure facilities also plays an important role for the overall development planning, and it is appropriate only through conducting of socioeconomic field survey.

VI. Conclusion

The remote sensing analysis help to obtain a general picture of study area on a timely basis. It implies that the Remote Sensing and the information approach, including the computer based information systems, can appropriate the distribution and assessment of the natural resources in time and space on the regional level. The model and technology illustrated in this study is presented as one demonstration of combining natural and human resources assessment simultaneously for district planning purposes. It confirms that Remote Sensing technique is suitable tool for regional planning and development, but that Remote Sensing Data alone can not give a perfect picture for planning studies. The socioeconomic field survey following of Remote sensing Analysis helps to get a more correct picture of social reality and offers a basis for decentralized regional planning. Geographic Information System packages generalize and combine whole natural and socioeconomic data in proposed model which is suitable for given planning purposes. Regional planning based on resources endowment is intermediate step which has to be combined with human environmental factors in order to offer appropriate guidelines for development planning.

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"SPACE METHODS FOR GEOECOLOGY" - RUSSIAN ATLAS OF SATELLITE IMAGES FOR ECOLOGICAL APPLICATIONS

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1. Introduction

In the present time of strong anthropogenic impact on nature and severe ecological problems there is an urgent need in modern methods for monitoring Earth's environment. It greatly benefits from the use of remote sensing methods - the most objective and operative. Special methodological manuals are necessary for deeper and broader utilisation of satellite imagery in ecological investigations and nature management. The methods of remotely-sensed images usage for ecological applications have been developed and presented in the new scientific-methodological atlas "Space Methods of Geoecology", prepared by geographers of Moscow State University.

2. Background and involved organisations

Special manuals on scientific methods in the form of atlases of satellite images are within the best tools for support of the geographical and ecological research and thematic mapping. The team of Moscow State University geographers, in cooperation with other organisations, have developed and edited a series of such atlases. Two fundamental atlases have been published already and the third is being prepared. The first two volumes were devoted to processing of multispectral imagery - a new kind of remote sensing data now widely distributed due to many Earth observation missions. The volumes were prepared in the international cooperation within the frame of the "Intercosmos" initiative and published by "Nauka"(Moscow) and "Academie Verlag"(Berlin) in Russian, German and English. The first volume, called "Atlas of Interpretation of Multispectral Aerospace Photographs. Methods and Results" deals with satellite photographs and is based on high quality materials received by means of MKF-6 camera, presented by specialists of former GDR and USSR. The second volume is based on high-resolution multispectral scanner images from Russian scanner system "Fragment" on board "Meteor-30" satellite. Both atlases illustrate the broad perspectives for thematic interpretation of multispectral images and diversity of methods and processing means used, from visual interpretation up to computer map compilation. The volumes include dozens of images and about 150 thematic maps, with their subjects covering the whole spectrum of Earth sciences. The following triad is the presentation basis in the atlases: satellite images - interpretation techniques - interpretation results. The atlases received approval in the world press and are widely used for training of specialists in remote sensing.

The Laboratory of Aerospace Methods at the Department of Cartography and Geoinformatics, Faculty of Geography, Moscow State University, has taken the initiative of compiling the third - ecologically targeted - volume. The new atlas, called "Space Methods for Geoecology", has been compiled in coöperation with specialists of the other university departments and other organisations. There were 90 specialists involved in its compilation, including 15 doctors of sciences, 55 candidates of sciences, 15 postgraduates and students. The Atlas consist of 112 34x48 cm sheets enclosed in a folder. By now the compiling and editorial works have been finished and the Atlas is awaiting for financial support for printing.

3. Atlas contents

The new atlas includes dozens of colour images, mainly from Russian spacecraft, as well as the results of their interpretation, thematic ecological maps, compiled on the base of the imagery, and short explanation texts on methods of interpretation and possibilities of satellite images usage in investigation of ecological problems and decision making. The issues covered range from global ecological problems, represented in quite a general manner, up to the more specific regional and local problems, characterised in more detail (Table 1). A short section of the Atlas is devoted to the potential of remote sensing methods for global ecological problems investigation: global climate warming, vegetation biomass loss, ozone layer depletion. In the group of regional problems, the common problems for all the geographical zones are presented first, within them sea level fluctuations, air pollution and water contamination. Ecological problems of coastal regions connected with sea level fluctuations are shown through the examples of Caspian sea coastal zone, where they are provoked by sea level rise, and Aral sea area, where they are stipulated by sea receding. Remotely-sensed images usage for water contamination control is examined for sea waters - on the examples of influence of the flood prevention dam in Neva bay, Baltic sea, on the sea water quality, and problem of phytoplankton outbreak in Black sea. Inland water bodies contamination is shown on the examples of Imandra Lake and Angara River. Air pollution revealed by dirty snow cover areas in winter imagery is studied for the industrial central part of the European Russia, Urals, Siberia regions; industrial smoke plumes - for Moscow region.

More detailed description is given for regional ecological problems of Russia and neighbouring territories in different geographical zones - tundra, forests, steppes, and deserts. Problems of deforestation, erosion and desertification are the main subject of this part of the Atlas.
In tundra zone, under technogenic impact on soil and vegetation cover on permafrost, activation of cryogenic processes takes place. Natural tundra landscapes of North-Eastern Siberia, as they appear in satellite images, are

compared with damaged landscapes of Tazovskiy Peninsula in regions of oil and gas extraction, oil pipelines construction and the off-road traffic impact.

Scale and spatial peculiarities of deforestation in boreal forests are investigated in the Atlas by comparison of recent satellite imagery with the old maps, compiled in the mid-XIX century. It was carried out for 15 test sites in European part of Russia and interesting phenomena were discovered. The changes in forest types, due to intensive timber production, that are inevitable without suitable measures for forests restoration, are presented for taiga regions. Within the topics shown are: monitoring the violations of timber felling rules; results of mass forest diseases and pests outbreaks, forests fires, possibilities of post-fire forest restoration and cuttings control on the examples of the European Russia, Eastern Siberia and the Far East. A GIS for the country-wide forests fire monitoring, using remote sensing methods, is represented.

Ecological problems of steppe zone, with its' intensive agricultural land use, causing development of erosion processes - rising linear erosion intensity, soil sheet erosion, humus losses - are characterised using the examples of Central Chernozem area and Northern Caucasus region. Possibilities of soil deflation monitoring are shown for the arid steppes in inner mountain basins of Transbaikal.

Ecological problems, connected with desertification, are shown for Aral area and Kalmykia. For the wide area of Aral impact -Kyzylkum desert - maps of modern landscape, processes of desertification, degree of desertification, recommendations for its prevention, and the map of geoecological assessment of landscapes are compiled using satellite images. For Amudarya delta landscapes in Southern Aral area the dynamics had been analysed using multitemporal satellite images. Then maps of hydrogenic ecosystems for different dates and their dynamics have been compiled. For Tedzhen and Murgab subaeral deltas (Turkmenistan), with irrigated agricultural and pasture land use, the following issues have been studied: processes of secondary soils salinization as the result of irrigation water discharge, marshland formation and salinization under the influence of water percolation from irrigation canals, desertification of water basins. Kalmykya region satellite images reveal types and factors of desertification in this area - overgrazing and pasture digression; sand storms in areas of sand soils ploughing; sand dunes threatening roads and buildings; salinization due to improper melioration and hydro-engineering constructions. Maps of land use, processes of desertification and desertification forecast for 20-30 years ahead are presented.

Technogenic impact in mining and industrial regions, problems, connected with urbanization and nature management, natural hazards and nature conservation are examined in the concluding section of the Atlas. Environmental impact of mining and mineral processing can be seen in images of Kola Peninsula (mining industry) and Central Caucasus (mining of non-ferrous metals). Damage to environment due to coal mining is analysed using images of Southern Yakutia, Neryungri, due to gold mining - for Aldan and Patomskoe mountain plateau.

Much attention is paid to peateries exploration in Moscow region; the model of post-exploration changes at processed sites is developed using multitemporal aerial photos; it can help recultivation works and rational management of these lands. Impact of oil exploration on landscape is shown for some Western Siberia regions and possibilities of oil contamination monitoring using aerial photos are analysed. Severe damage to nature caused by nickel and copper ore processing due to the sulphur dioxide and heavy metals emissions to atmosphere are shown for Monchegorsk area in Kola Peninsula and Norilsk area in North Siberia.

In solving the ecological problems of urbanised areas satellite image can help in estimation and mapping of buildings density, presence and state of green vegetation, settlement recreation resources, dynamics of town land use. Usage of satellite images for these applications is shown on the examples of Moscow and Saint-Petersburg.

In addition to antropogenic ecological problems the Atlas characterises the potential of remote sensing for natural hazards investigations. Monitoring of flooding is described for Lower Volga region. In mountain regions imagery is used for studies of natural catastrophic destructive processes both endogenic (seismic activity, volcanism) and exogenic (landslides, stonefalls, rock falls and surging glaciers). It is illustrated through the examples of earthquakes, rockfalls and landslides at southern slope of Big Caucasus, volcanism in Kamchatka, surging glaciers in Pamir.

The Atlas is concluded by discussion of nature conservation issues. It characterises ecological problems of protected areas - Astrakhanskiy (Volga-delta) Biosphere Reserve, National Park "Prielbrusie", for which a series of thematic maps and a GIS are developed using satellite images.

4. Possibilities of Atlas application

Although the materials of the Atlas are mainly Russian-oriented, the proposed methods can be successfully applied for solution of similar problems in other countries. The atlas will serve for ecological education of people from different fields of Earth sciences and business, as well as for general public. It will become a specialist manual on scientific methods for use of remote sensing information in compilation of ecological maps, environmental impact assessment and solving of ecological problems. The atlas may be used by university teachers, by specialists in Earth sciences, especially geoecologists; it will be also interesting for anyone, who would like to know more about ecological problems and their solutions using remote sensing methods.

Tabl.1. Atlas "Space methods for geoecology".
Contents

MAPPING OF THE DYNAMICS OF THE CASPIAN SEA COASTAL ZONE BY MULTITEMPORAL SPACE IMAGES

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1. Introduction

The mapping problems of dynamics processes are very actual in our inconstant world with its global and regional changes of environments. In the row of changes connected with nature cycles and antropogenic activity there are the sea level fluctuations, due to which serious problems of coastal regions have appeared. In Russia this kinds of problems are connected with Caspian sea level rise, that have required monitoring and mapping of coastal zone dynamics.

Since 1978 the Caspian coastal zone has influence by sea level rise, followed a long period of its fall down. By 1996 the rise has reached 2,34 m. Resulting changes in the coastal environments damaged the surrounding area nature and economy with various effect in different regions: at the sea edge of Volga delta, along Terek-Kuma lowlands and coasts of middle and southern Daghestan. Investigations, mapping and monitoring of these changes are very important for environment management under sea regression-transgression conditions.

2. Materials and methods

The coastal zone changes are seen in space images. Their study was carried out by compare the pictures taken in periods of maximal regression (in the middle of 1970's), of early transgression (in the middle of 1980's) and in our days (beginning and middle of 1990's). The high altitude airphotos in scale 1:100 000-1:200 000 (1977-1978), space photos from Cosmos satellite in scale 1:200 000 and 1:600 000 with 10-15 m resolution (1982-1986, 1991, 1993) and scanner images from Resurs O-1 satellite with resolution of 40 and 170 m were used. The most part of the pictures were taken umder similar seasonal conditions - in June-July; it is very important for this region with considerable seasonal fluctuations of water level.

As a result of multitemporal images interpretation, the shemes of transgressive changes in the coastal zone were compiled for 8 test sites of Kalmykiya and Daghestan. As the first step of their compiling the interpretation of the earlier images was carried out. Then the shemes of interpretation were compared with the later images and changes were investigated and mapped. At shemes of coastal zone dynamics we show: the coastline (outer limit of the reed cover) in 1978 and 1991; submarine and shore landforms (barriers, ridges) eroded by rising sea and formed in new water depth conditions; flooded areas, reed covered mud flats - persisting and newly formed or larged; inner water bodies persisting and newly appeared; waterlogged areas; reed swamps at the land - persisting and newly appeared; agricultural fields, canals, dams, settlements and their changes.

3. Results

The schemes compiled as a result of airspace pictures interpretation show the specific features of nature dynamics in different parts of the Caspian coastal zone of Russia.

Kalmykian coastal plain, characterised by shallow water coasts with mud flats due to wind surges. These mud flats have thick reed vegetation and it is difficult to determine the position of sea border line. But the outer boundary of reed vegetation is seen very clear in space pictures. Migration of this boundary relates to the changes in mud flats and may be used as an indicator of coastal zone dynamics.

Comparison of 1978-1991 remote sensing data shows that reed vegetation boundaries at the northern part of Kalmykian coast have changed very little (fig.1). It is explained by significant influence of adjacent large shallow water platform of Volga prodelta; it's "buffer effect" will be efficient up to sea level rise more than -26,5 m. This is the reason why processes of accumulation have been continued here, especially at upper parts of bays between shore ledges, where land accretion of 0,5-1 km is seen. At the southern part of this test site the influence of sea level rise is increasing. The strip of reed mud flats becomes more wide and it widens in land direction. The lagoon of 1-2 km wide has been appeared behind the mud flats. The growth of land moisture displays in appearing of some swamps and lakes in land depressions and along the Caspian Canal.

Around small town named Lagan' large area of meadows has been flooded due to dams constructed here in the regression period for the wind surge water conservation. This settlement has serious ecological problems with flooding buildings and especially clean-water-constructions because of dangerous possibility of dirty water breaking into pure drinking-water canal.

The southern part of Kalmykian coastal zone between Morskoy Ivan-Karaul Island and Kizlyar Bay (fig.2) - so that far off Volga delta - has more significant influence of sea level rise, seen at space pictures. Flooding of mud flats within the strip of 1-1,5 km wide, wave erosion of old depositional features are prevailed. New series of beach ridges are forming along the changing shoreline. So the earlier existed opinion about passive flooding of the Kalmykian coasts seems to be not correct, the work of sea waves displays here in new form construction. The landward widening of reed mud flats (from 1-2 to 5-10 km) and forming of open lagoon in their backside are seen everywhere in space pictures.

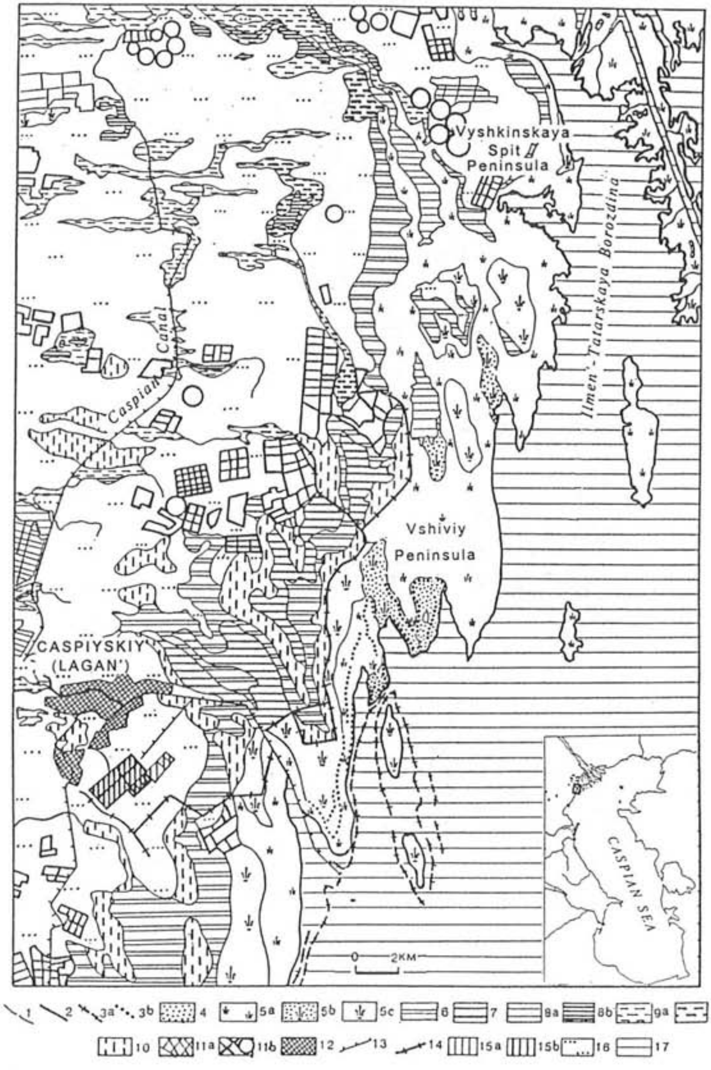


Fig.1. Kalmykian coastal zone, northern part

1 - outer limit of the reed-covered flat and the coastline in 1978: 2 - the same, in 1991; 3 - marine depositional landforms (beach ridges, barriers, etc.) developed: a - on open shallows, b - on the reed covered mud flats; 4 - sand flat, newly appeared (zone of the coast accretion); 5 - reed-covered flat: a - persisting, b - newly formed in bays' heads (zone of the coast accretion), c - developed in place of former land (zone of landward shift of the reed covered flat); 6 - lagoons at the back of reed-covered flats; 7 - land areas flooded by surge water retented by the dam; 8 - inner water bodies: a - persisting, b - newly appeared; 9 - reed swamps on the land: a - persisting, b - newly appeared; 10 - waterlogged area; 11 - agricultural fields: a - persisting, b - newly cultivated; 12 - urban area; 13 - canals; 14 - dams; 15 - sewage treatment sites: a - persisting, b - newly constructed; 16 - land; 17 - sea

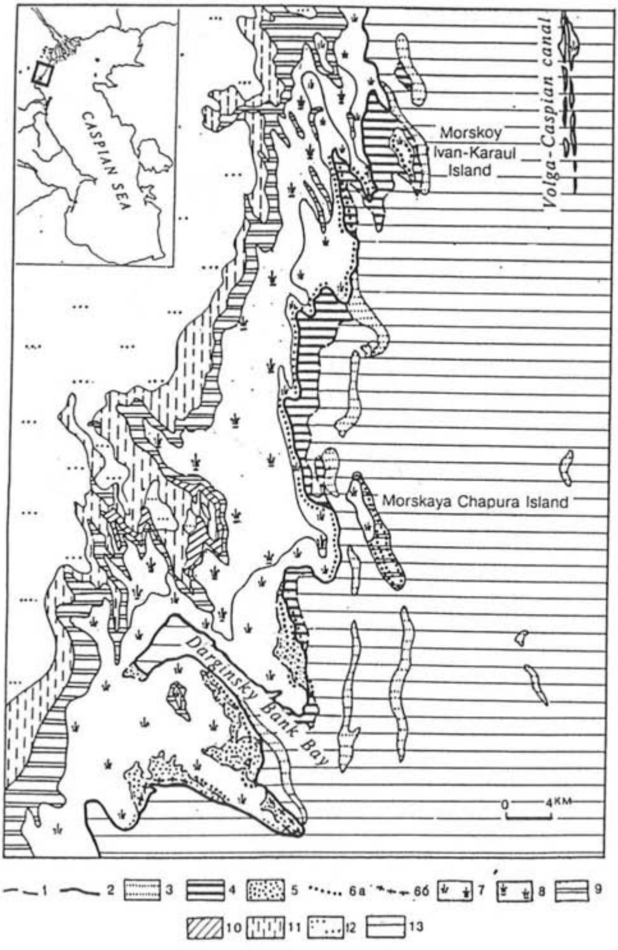


Fig.2. Kalmykian coastal zone, southern part

1 - outer limit of the reed covered and the coastline in 1978; 2 - the same, in 1991; 3 - submarine constructional landforms (barriers, ridges) eroded by the rising sea; 4 - drowned areas of the former reed-covered flat (zone of the coast retreat); 5 - sand flat, newly formed (zone of the coast accretion); 6 - marine constructional landforms (ridges, barriers) formed: a - in place of open shallows, b - in place of the reed-covered flat; 7 - areas of the reed-covered flat persisting; 8 - areas of reed growth on former land surface (zone of the landward shift of the reed-covered flat); 9 - lagoons newly formed at the back of the flat; 10 - areas drying during intervals of the wind-induced low sea level; 11 - waterlogged zone along the lagoons; 12 - land, 13 - sea

Bryanskaya Spit and Suyutkina Spit area. At the area to the south of the Kizlyar Bay (fig.3) erosion-accumulative processes were predominate in the Holocene and modern epoch. Large depositional features - Bryanskaya Spit and Suyutkina Spit - were formed here in the Holocene due to intensive wave erosion of nearest ledges of old Terek delta and transport of sediments to the north by predominant south-eastern waves.

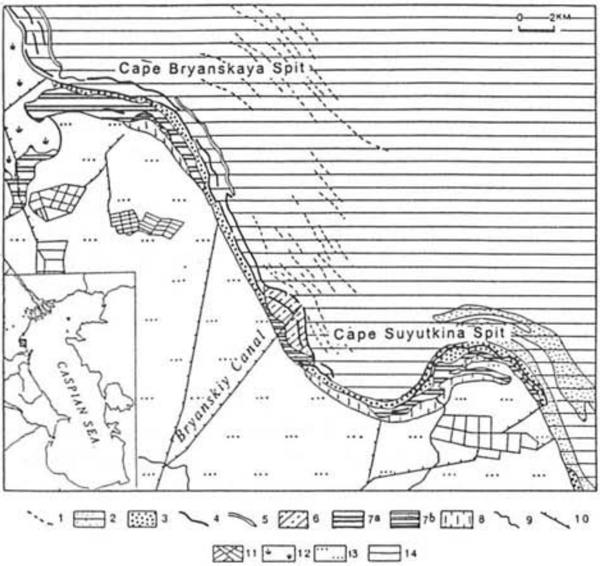
In the end of last sea regression wave erosion of proximal parts of these spits was seen because of sediment lack in the coastal zone due to Terek discharge displacement to the south and behind the Agrakhan Peninsula. Some years later, mud flats of 400 m wide were formed along Bryanskaya Spit and cliff erosion was ceased, but erosion of proximal part of Suyutkina Spit continued, and deposition at it's distal part continued too. Some small deltas were formed at the mouthes of irrigation canals.

Present-day sea level rise lead to flooding of mud flats and cliff activization. Space pictures show that now sea water reached cliffs. Narrow long beach ridges and barriers have been formed at the outer edge of mud flats and at 0,5-1 km distance of it in the sea. The spit's ridge have been breaked with sea water and large lagoon behind it, 10 km long and 1-1,5 km wide, have been flooded. Delta of artificial canal was flooded, too.

Old Terek delta coast to the south of Suyutkina Spit fig.4) was the source of sediment material for Suyutkina Spit building during many decades. In the regression period the shore was smoothed out, only small deltas at artificial canals protruded here. Under present-day sea level rise flooding of these deltas and activization of sea cliffs (that is not seen at space pictures) take place. The system of offshore bars is reconstructed and now up to 4 lines of them are seen at space pictures.

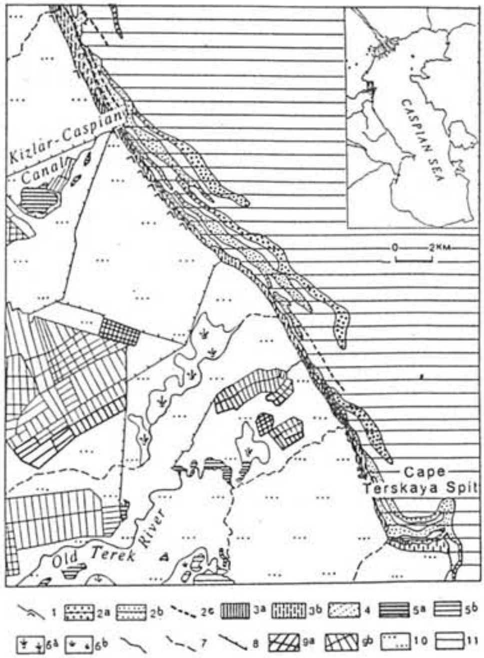
Agrakhan Peninsula. Essential changes are seen in the Agrakhan Peninsula coastal zone (fig.5). Agrakhan is the biggest aggradational feature of the Caspian Sea, generated as a barrier, and then modified as a spit. In the regressive period it had wide fringing beaches with a series of narrow beach ridges. After beginning of sea level rise significant changes have been happend here. Shoreline retreated by 0,5-1 km, mud flats along distal part of Agrakhan Spit were flooded. Narrow sand barriers were constructed along all shores of the peninsula and a lagoon appeared behind them. In 1991 space pictures these lagoones are the most characteristic feature of this area, but now, after continued sea level rise, barriers and lagoones are mostly flooded. Space pictures also show flooding of deflation blowouts at western part of the peninsula.

Sulak delta. In this region (fig.6) strong reducion of the old river delta area is seen. In the middle of our century the delta of Sulak River growthed very quickly - at rate of 100-200 m/year. After artificial erection of river channel in 1957 new delta has begun to form and the northern part of the old delta began to erode by waves far before sea level rise. Long spit growthed at the northern part of the delta due to these erosion processes. Under sea level rise conditions flooding by sea water reduced the old delta area very strongly. As a result, the Caspian water now came just to Sulak settlement. The dam was constructed here to protect this settlement from sea waves. Distal part of



1 - series of developing submarine swells and troughs; 2 - submarine wave-built platform, newly formed; 3 -beach ridges overgrown with reed, formed in place of former coastal flats; 4 - emerged crests of longshore bars, newly formed; 5 - longshore bars persisting since 1978; 6 - persisting parts of the young delta; 7 - lagoons formed: a - at the back of beach ridges belonging to different generations of the spits, b - in the landward part of the delta; 8 - waterlogged areas on the coastal land; 9 - rivers; 10 - canals;, 11 - rice fields; 12 - reed swamps within the limits of the old Terek delta; 13 - land; 14 - sea

Fig.3. Caspian coast near the Bryanskaya and Suyutkina spits



1 - coastal casps formed near mouths of canals, streams and distributaries since 1978; 2 - submarine longshore bars: a - newly formed, b - persisting, c - recorded in 1978 but not found in 1991; 3 - reed growth on shallows: a - persisting, b - recorded in 1978, destroyed by 1991; 4 - plumes of fluvial sediments; 5 - inner water bodies: a - newly formed, b - persisting; 6 - reed swamps in delta: a - newly formed, b - persisting; 7 - rivers, intermittent streams; 8 - canals; 9 - rice fields: a - newly formed, b - persisting; 10 - land; 11 - sea

Fig. 4. The Terek delta coast south of the Suyutkina spit

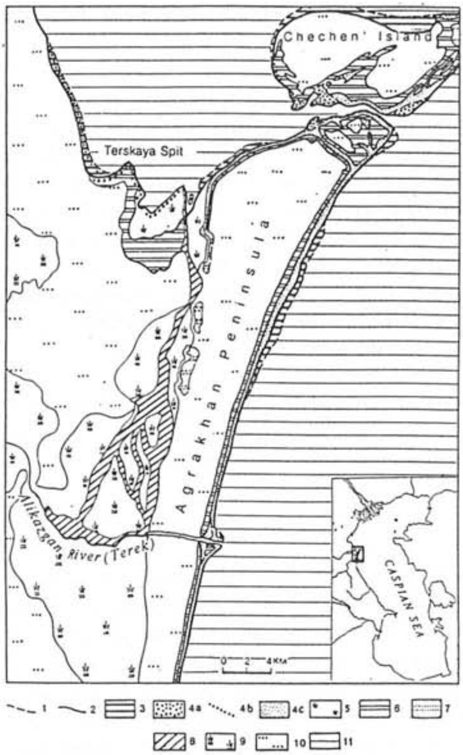


Fig. 5. The Agrakhan Peninsula

1 - coastline in 1978; 2 - coastline in 1991; 3 - drowned areas of the former reed-covered flat (zone of the coast retreat); 4 - beach ridges and barriers overgrown with reed: a- formed on open shallows, b - formed within sectors of the coast retreat, c - on drowned beaches and marine terraces; 5 - reed-covered flat, persisting; 6 - lagoons formed in place of beaches and marine terraces; 7 - wind-blown hollows filled with water; 8 - areas of deltaic deposition along the Terek old channel (reed-covered levees); 9 - reed swamps with small areas of open water within the old delta of the Terek; 10 - land; 11 - sea

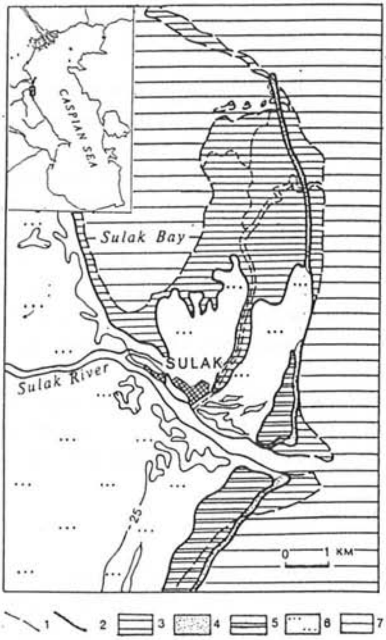
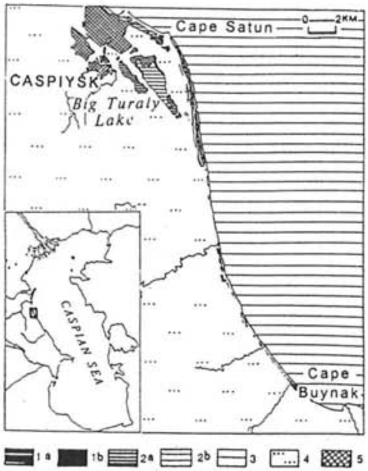


Fig. 6. Delta of the Sulak River

1 - coastline in 1978; 2 - coastline in 1991; 3 - flooded parts of the delta; 4 - constructional landforms (beach ridges, bars) on the flooded delta surface; 5 - the present-day lagoons; 6 - land; 7 - sea



1 - newly formed lagoons: a - filled with water, b - swampy and overgrown with reed ; 2 - a -lakes: newly formed, b - persisting; 3 - sea; 4 - land; 5 - urban area

Fig 7. Daghestan coast near the city of Caspiysk modern Sulak delta is flooding too, narrow barriers and lagoones behind them are formed here.

Along the southern part of the Daghestan coast processes of wave erosion are usual now, but they are not clear seen in space pictures. Along depositional coasts formation of narrow lagoones (up to 0,2-0,5 km wide) is seen everywhere. For example, at Caspyisk area (fig.7), where beaches and young regressive terraces were flooded and cliff erosion began, it is impossible to see these processes at space pictures. But new high beach ridge is seen in photographs very well along depositional coast, as well as lagoones with water behind it. These lagoones appeared because of overwash processes of storm waves across the high beach ridge and due to rise of groundwater table. The big lagoon to the east of Caspyisk stretches for 10 km and has width of 200-300 m. Some swampted lagoones are seen along the shore at Cape Buynak area.

At Lake Adji area the same type of changes is fixed by space pictures - although activization of wave erosion is not seen at them, but everywhere you can see narrow lagoones (100-200 m wide), parallel to the shore, behind the high beach ridge.

4. Conclusion

Comparison of airspace pictures of Caspian coasts of Russia, taken during periods of regression (1978-1979) and transgression (1991-1992), has shown that influence of sea level rise increases from the north to the south along with increase of offshore steepness and transition from predominantly accumulative type of the coast to prevailing erosion one . At the northern part of the area (with exception of the section near the Volga delta with it's "buffer" effect) flooding of mud flats with some wave reconstruction of coastal zone profile, formation of lagoones at backside of mud flats and some landward retreat of all coastal complex are the typical features of coastal zone dynamics.

At the southern part of the Caspian coasts of Russia transgressive transformation displays in more narrow strip. Active wave reconstruction with cliff erosion - at steep slopes and big beach ridge formation with wide lagoon behind it - at more gentle slopes - are the most important features here.

Analysis of multitemporal space pictures shows that airspace monitoring and dynamic processes mapping are a good tool for control of coastal zone state. This is especially necessary for management of coastal zone under sea level rise conditions.

MAPPING OF DYNAMICS OF INDUSTRIAL DAMAGE TO VEGETATION IN MONCHEGORSK REGION BY MULTITEMPORAL SATELLITE IMAGES COMPUTER PROCESSING *

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1. Background

The regular monitoring of environmental changes caused by industrial impact, as well as of the degree and dynamics of the damage in impacted areas is very important in many regions, especially in Arctic. It requires quick acquisition of information and computer technologies for its effective processing and compiling of dynamics maps. The Aerospace Methods Laboratory at Cartography and Geoinformatics Department, Faculty of Geography, Moscow State University, has investigated and mapped the industrial impact on northern taiga and mountain tundra vegetation of Kola Peninsula (Russian Arctic) using remotely sensed images. The work has been carried out in collaboration with University of Cambridge and World Conservation Monitoring Centre. The representative study area of 40x60 km in size surrounds the town of Monchegorsk. It is exposed to strong impact of nickel and copper 'Severonickel' smelter that uses ore with high sulphur content. The emissions reach annually 20-30 tonnes of sulphur and 5-6 tonnes of heavy metals per sq. km in the surroundings of the factory, leading to destruction of natural ecosystems. Technogenic barrens that formed within 5-10 km distance from the smelter are surrounded by 20-30 km belt of dead and damaged forests and mountain tundra. Many scientific organisations held impact studies in the area (Doncheva et al 1992, Krasovskaya, Evseev 1992, Kruchkov 1991, Kruchkov, Makarova 1989, Kryuchkov, Syroid 1984) but only point observations, detailed maps for very small test sites and sketch schemes of the damage for the whole area were obtained, due to ground mapping difficulties in this area of sparse road network, broken terrain, mountain ridges, numerous hills and marshy lowlands. Therefore it was necessary to apply remote sensing techniques. In last years interesting work incorporating satellite images was undertaken by Finnish colleguaes (Mikkola 1996), but without mapping the degree of damage to forests. Our goal was to fill the gap and to compile, using satellite images, the first complete spatial maps of damaged vegetation for the study region.

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2. Data and research methods

Digital LANDSAT Multispectral Scanner images 1978-1992, kindly provided by Scott Polar Research Institute of Cambridge University, were used as the main data source. Multispectral photographs from the Russian COSMOS satellite 1984,1986 were also used. At the initial stage of the project the ground truth information consisted of a schematic map, compiled on the base of a visual interpretation of the LANDSAT 1978 scene and COSMOS photographs of 1984,1986 supported by some route observations. The boundaries from the map were digitised and overlaid on the LANDSAT scene, to choose the locations for sample spectral measurements. Several classification methods were tried to incorporate spectral signature curves (SSC) information as fully as possible. An attempt to use simple 'parallelepiped' approach for non-overlapping spectral brightness values failed to produce a sufficient number of classes. Also, it would be essential to find out individual threshold spectral brightness values for every new satellite image asquired. In theory, if reflectance values, corrected for observation conditions, could be used, it would not be necessary. However, as experience showed, such a correction is extremely difficult without extensive ground data. These were not available for the 1978 image and raw spectral brightness values were used instead of reflectances. Subsequently, it was decided to employ derivative attributes that would reflect the SSC shape and be invariant to observation conditions. At first, NDVI and a simple ratio of second near infrared and red LANDSAT MSS bands were used. The images of these ratios were computed and visually assessed on the screen to find out threshold levels for classification. This resulted in 9 classes, parameters of the classification were published in our report at 17 ICC (Kravtsova, Lourie, 1995).

Following this first classification, detailed summer field works were undertaken in 1994 and 1995, including ground and aerial spectrometry, carried out by researchers from Scott Polar Research Institute and from Institute of Geography (Russian Academy of Science). As a result, it become possible to find spectral differences between several types of mountain tundra and tundra vegetation with various degree of the damage. A complete spatial map of damaged vegetation for the study area (Fig.1), showing 25 separate types of objects, was compiled by interpretation of LANDSAT, COSMOS and aerial images on the ground and from a helicopter. It greatly reinforced 'ground truth' base for subsequent classifications. To discriminate tundra vegetation according to degrees of the damage, a new set of attributes was tried. Along with NDVI, a composite image of the LANDSAT scene principal components was computed and used to find threshold levels. This produced 10 classes described in Table 1. New ground data allowed to refine class descriptions. But, as well as in the first classification, mixing of certain classes occurred, particularly of damaged tundra and significantly damaged forests, healthy tundra and housing. The classifications described above were performed on a PC, using EPPL7 and IDRISI software.

A series of LANDSAT MSS images 1978-1992 were then used to study the dynamics of damage to vegetation for the area. Two of them were chosen at the first step: of 26 June 1986 (taken after maximum of pollution dischardge in 1984-1985) and of 10 June

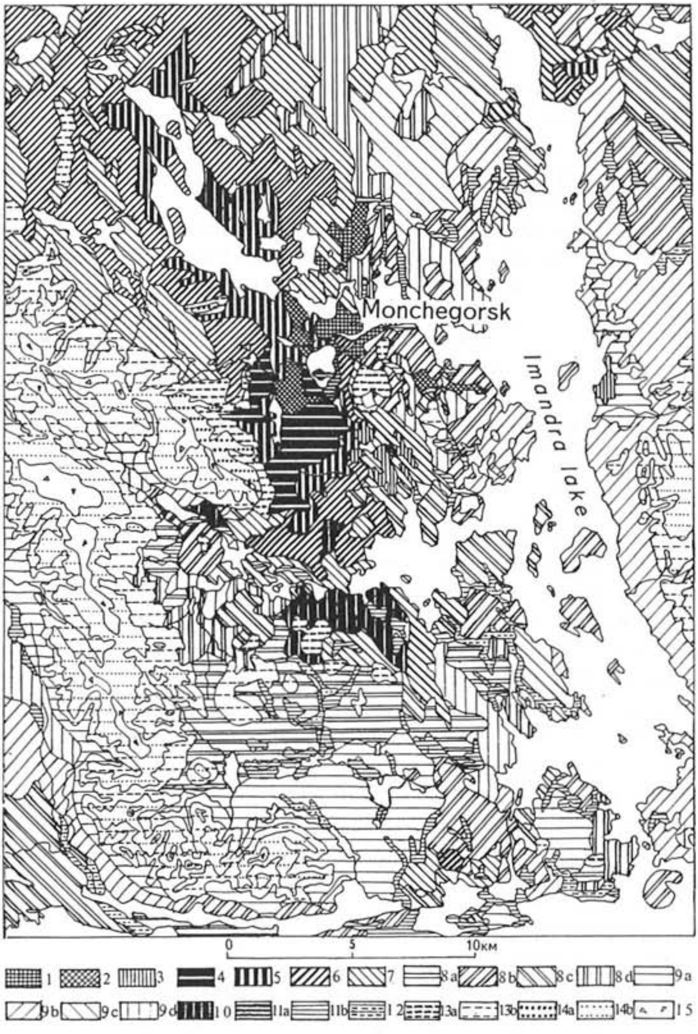

Fig.1. Map of industrial impact to vegetation, compiled by field interpretation of space images

I.Urban areas, settlements and agricultural lands: 1 - housing areas; 2 - industrial areas, quarries, tailing ponds; 3 - agricultural lands. II.Technogenious barrens in the areas of industrial impact: 4 - completely destroyed vegetation cover; 5 - severely damaged vegetation cover. III.Forest affected by industrial pollution and subsequent fires (with shares of damaged and dead trees in %): 6 - severely damaged (80-100%); 7 - significantly damaged (60-80%); 8 - partially damaged (40-60%), including: 8a - spruce, 8b - birch/pine/spruce, 8c - birch/spruce, 8d - spruce/birch; 9 - slightly damaged (up to 40%), including: 9a - spruce, 9b - birch/pine/spruce, 9c - birch/spruce, 9d - spruce/birch. 10 - Fires. IV.Wetlands: 11 - grass and dwarf-shrub/moss, including: 11a - areas damaged by industrial pollution, 11b - not damaged areas. 12 - Combination of moss swamps with spruce forests. V.Mountain tundra: 13 - Stony dwarf-shrub/lichen, including: 13a - areas damaged by industrial pollution, 13b - not damaged areas. 14 - Combination of stony dwarf-shrub/lichen mountain tundra with stony deserts of nival zone, including: 14a - areas damaged by industrial pollution, 14b - not damaged areas. VI.15 - Stony deserts of nival zone.

1992 (the latest image available). The main attention in dynamics investigations was payd to making the images comparable, so that differences could be explained only by changes on the ground. Though the raw brightness values for each image were converted to reflectances using standard NASA correction procedure (Markham, Barker 1986), there was a substantial difference between the corrected images. It may be explained by still uncorrected differences in observation conditions, slight seasonal dynamics, heavy striping on both images and unusually low values in the second infrared band of 1992 image, probably due to sensor malfunction. A new approach was developed to classify multitemporal images. Firstly, both images were destriped using Fast Fourier transform, converted to reflectance values using NASA methodology, and transformed to the projection of 1:200 000 topographical map. Also the haze component was reduced using dark pixel subtraction technique. All processing from this stage onwards was made in ERDAS IMAGINE 8.2 package on SUN SPARCStation 10. After all kinds of corrections, a supervised maximum likelihood classification of 1992 image was made, based on 1994-95 field data and spectral properties of the study objects known from the previous research. To overcome the problem of mixing forest and tundra classes, a mask of tundra areas was created, using scanned 1:200 000 topographical map. Then classification was performed separately for tundra and forest areas and the results combined. Good ground data and new powerful software and hardware helped to distinguish 23 classes. This is very close to the number of classes in the map compiled by field interpretation while the level of detail in the computer classification is higher. In the next stage, the classification of 1986 image was performed. No detailed ground data close to 1986 were available. But it was possible to relay on spatial relationships between the 1992 and 1986 images. The training areas in 1992 image were chosen in places, where, according to the field observations, no significant change took place over the last decade (except for the areas of burnt forest). So, by overlaying 1992 training areas' boundaries on the 1986 image, it became possible to derive correct spectral signatures for the older image. The training area for burnt forests was defined using forest fire maps and statistics of Monchegorsk forestry. Then supervised classification with masking was applied, resulting in the same 23 object classes, as in 1992 image classification, but with their spatial extent of 1986.

3.Results

The derived classifications of 1986 and 1992 were overlaid to produce the map of changes in vegetation state. Prior to this, their 23 classes were generalised into 6 groups according to the degree of damage, to reduce number of possible combinations. Mountain tundra areas were excluded from analysis, because significant seasonal changes in upper zone of mountains were identified. The 36 produced combinations shown in table 2 were examined on screen and merged into 15 classes on the base of spatial and genetic similarity (table 3). Still, the final map is too complex to reproduce in black and white, as well as initial classifications. Fig.2 shows a generalised map of changes in vegetation state, compiled in traditional manner using the computer dynamics classification as a base. Five types of areas with different kind of dynamics can be seen: a - areas without visible changes in the epicentre of the damage; b - areas

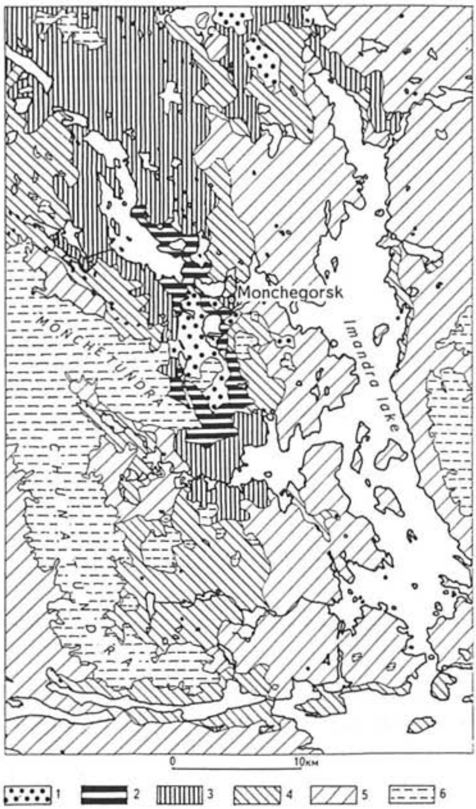

Fig.2. Generalised map of changes in forest vegetation state 1986-1992

1 - areas of nearly unchanged state of vegetation within the technogenic barren; 2 - areas of intensive complex dynamics - dying and reviving vegetation on the edges of technogenic barren; 3 - areas of intensive dynamics with vegetation affected by forest fires and regrowth in place of the old fires in severely and significantly damaged forests (share of dead trees >60%); 4 - areas of moderate changes in partially damaged forests (40-60%); 5 - areas of little changes in slightly damaged forests (<40%); 6 - mountain tundra

Table 1. The NDVI and principal components composite' threshold classification feature levels

Class No	Classification parameters /*	Class definition
1	NDVI=255 and 48<=SINT<=79	completely destroyed vegetation cover / industrial areas
2	NDVI=255 or 0<=NDVI<=48 and 80<=SINT<=107	severely damaged vegetation cover / quarries / stony deserts
3	(NDVI=255 or 0<=NDVI<=48) and (126<=SINT<=143 or 87<=SINT<=215)	severely damaged vegetation cover /quarries/ housing /mixture of stony deserts and tundra vegetation
4	0<=NDVI<=48 and 120<=SINT<=125	damaged tundra vegetation / significantly damaged forests, share of dead trees 80-100%
5	157<=SINT<=175	healthy tundra vegetation / housing
6	49<=NDVI<=72 and (SINT<157 or SINT>175)	significantly damaged forests, share of dead trees 50-80%
		slightly damaged forests:
7	73<=NDVI<=89	predominantly coniferous
8	90<=NDVI<=103	mixed
9	104<=NDVI<=255	predominantly deciduous
10	B4<=12	water bodies

/* KEY : SINT - color composite image of the principal components, NDVI = (B4- B2)*255/(B4+B2), B2 and B4 - brightness values for 0.5-0.6 mkm and 0.8-1.1 mkm bands

Table2. Matrix of changes in vegetation state. 1986-1992
(the area in km^2 and percentage to total area are indicated)

	years			1	9		9		2
SHORT CLASS DEFINITIONS		NN class	1	2	3	4	5	6	Total
technogenic barrens with completely destroyed vegetation cover, housing, industry, quarries, burnt forest		1	60.8 3.2%	14.3 0.8%	12.0 0.6%	13.2 0.7%	29.1 1.5%	78.8 4.2%	208.2 11.1%
technogenic barrens with severely damaged vegetation cover	1	2	4.4 0.2%	18.8 1.0%	4.0 0.2%	12.8 6.8%	11.2 0.6%	11.9 0.6%	63.1 3.4%
severely damaged forests, share of dead trees 80-100 %	9	3	6.8 0.4%	5.3 0.3%	10.6 0.6%	4.1 0.2%	3.7 0.2%	11.7 0.6%	42.2 2.3%
significantly damaged forests, share of dead trees 60-80 %	8	4	6.4 0.3%	6.2 0.3%	7.2 0.4%	23.2 1.2%	13.0 0.7%	15.8 0.8%	71.8 3.8%
partially damaged forests share of dead trees 40-60 %	6	5	11.3 0.6%	2.1 0.1%	2.9 0.1%	27.8 1.5%	239.8 12.8%	266.1 14.2%	550.0 29.4%
slightly damaged forests share of dead trees < 40%, wetlands, agricultural land		6	26.5 1.4%	5.8 0.3%	9.6 0.5%	42.5 2.3%	278.5 14.9%	573.8 30.6%	936.7 50%
Total			116.2 6.2%	52.5 2.8%	46.3 2.5%	123.6 6.6%	575.3 30.7%	958.1 51.2%	1872 100%

Table 3. Generalized matrix of changes in vegetation state. 1986-1992
(the area in km^2, percentage to total area and classes of changes are indicated)

	years			1	9		9	2
SHORT CLASS DEFINITIONS		NN class	1	2	3	4	5	6
technogenic barrens with completely destroyed vegetation cover, housing, industry, quarries, burnt forest		1	**1** 60.8 3.2%					**14** 90.7 4.8%
technogenic barrens with severely damaged vegetation cover	1	2		**2** 18.8 1.0%		**13** 144. 9		
severely damaged forests, share of dead trees 80-100 %	9	3	**7** 17.6	**9**	**3** 10.6 0.6%	7.7 %		
significantly damaged forests, share of dead trees 60-80 %	8	4	0.9%	21. 6 1.1 %		**4** 23.2 1.2%		
partially damaged forests, share of dead trees 40-60 %	6	5	**8**	**10**		**11**	**5** 239.8 12.8%	**15** 266.1 14.2%
slightly damaged forests, share of dead trees < 40%), wetlands, agricultural land		6	37.8 2.0%	17.5 % 0.9		70.3 3.7%	**12** 278.5 14.9%	**6** 573.8 30.6%

of strong complex dynamics around the epicentre of the damage (dying and reviving vegetation on the edges of technogenic barren); particularly areas to the south from Monchegorsk; c - areas of complex dynamics strongly affected by forest fires, where vegetation was partially destroyed but in many places its state improves due to regrowth in place of old fires and loggings; in particular, large areas to the north from Monchegorsk, around Kashkosero Lake; d - areas of moderate damage increase in partially damaged forests (mainly to S and SW from Monchegorsk, in an air 'trap', formed by Chunatundra ridge on the way of prevailing near-meridional winds); e - areas of slight damage increase (in protected positions around damage epicentre and on lake Imandra shores, to where pollution is probably carried by air streams along the water surface).

4. Conclusions

The compiled map of changes in vegetation state covers about 2100 sq. km around town of Monchegorsk. Remote sensing methods, coupled with necessary ground studies, provided a good base for detailed mapping of industrial impact dynamics in the area. Results can be used in local environmental management and planning of restoration activities. The techniques for mutual calibration of multitemporal satellite images are still to be developed and then simpler classification approaches (e.g. using band ratios instead of supervised classifications) may become possible.

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FROM ARMISTICE LINES TO INTERNATIONAL BOUNDARIES

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INTRODUCTION. The peace process brings with it the transition from armistice lines to international boundaries. Armistice agreements usually stress the non-permanency of the lines which separate the parties at the cessation of hostilities. The location of the lines is usually indicated on map or maps, which are annexed or otherwise incorporated into the agreement. There is very seldom a demarcation of the armistice lines except for local demarcations dictated by the needs of modus vivendi.

The international boundary is characterised by its permanency and universal acceptance and in the words of de Lapradellè (1928) "... La Première consèquence politique apparente de la dèlimitation d'une frontière, c'est la paix."

Over the last decade some 600 kilometres of armistice lines between Israel and Egypt (215 kilometres approximately) and between Israel and Jordan (385 kilometrès approximately), became delineated, demarcated and fully documented international boundaries (see fig. 1). This paper presents a brief outline of the mapping contribution to the process in which the cartographers played an essential role, providing a background to political negotiations and transferring the agreements to the terrain and to maps and other information products used by the general public.

ISRAEL-EGYPT BOUNDARY. The boundary between Israel and Egypt stretches from the Mediterranean Sea, near Rafa to the Gulf of Eilat/Aqaba on the Red Sea, near Taba. Historically the line was delimited as a Separating Administrative line, between the Villayet of Hejaz and Governorate of Jerusalem (Turkish Sultanate) and Sinai Peninsula (Egyptian Khedivate), within the framework of the Agreement signed on the 1st October 1906 and commonly referred to as the 1906 Agreement. This line, demarcated by the parties between October 3 and October 18 1906, became later the boundary between Egypt and the former mandated territory of Palestine, and later still the Armistice line between Israel and Egypt, following the hostilities of 1948/49, 1957, 1967 and 1973. The peace treaty signed by the two countries in 1979 states that "The permanent boundary between Egypt and Israel is the recognised international boundary between Egypt and the former mandated territory of Palestine ...".

Fig 1. From armistice lines to international boundaries.

In carrying out the terms of the treaty, a joint team of surveyors discovered that there was a difference in the interpretation of the location of fourteen points along the boundary. This dispute, which became known as the "Taba Case", was eventually submitted to International Arbitration Tribunal, headed by Judge Gunnar Lagergren. During negotiations of the compromise, the cartographic experts of both parties advised their respective diplomats on the choice of a map on which the dispute locations would be marked, as well as on the technical procedures, whithin the arbitration. The Tribunal gave its award some twenty two months after the arbitration compromise was signed, 10 points in favour of Egypt and 4 in favour of Israel. Both parties complied with the award, respecting article VII of the Treaty of Peace.

Subsequent to the re-demarcation, a survey of the boundary took place, each side observing the boundary monuments with its own GPS receivers and using a "boundary datum", referred to by Adler (1995), thus avoiding the sensitive issues of choosing one of the national datums as reference. The datum IEBD92 (Israel-Egypt Boundary Datum 1992) was defined by the WGS-84 ellipsoid and fixing BP36 coordinates. The survey included 97 boundary pillars and 2 permanent markers.

Each side used 6 receivers in measuring the boundary pillars, with an overlap of 2 points between sessions. Each session was measured for 2 hours except the frame session which was measured for 4 hours.
The GPS points were related to the boundary pillars by polar measurements, as eccentric points. The experience which was gathered during the pilot project, including learning from mistakes, brought the parties to create a special bar-type device which allowed simultaneous, eccentric measurements on the same boundary pillar by both parties. In this fashion, the connection of the GPS points to the boundary pillars was carried out in a consistent manner at all points. It was decided to orientate all devices in an East-West direction. The Israeli antenna was mounted on the East side of the device, and the Egyptian antenna was mounted on the West side of it. The antennas were set up at a distance of 1 meter from each boundary pillar (this was how the device was constructed). In order to mount the special bar horizontally, a level was used.
Differences in coordinates were distributed as follows: 33 boundary pillars between 0.0-0.1m, 54 pillars between 0.1 and 0.5 m., 9 pillars between 0.5 and 1.0 m. and one between 1.0 and 1.2 m. Both sides agreed to average the values, understanding that the differences range is acceptable for documentation purposes.

ISRAEL-JORDAN BOUNDARY. There are basic differences in the delimitation of the Israel-Jordan boundary and the Israel-Egypt boundary, although the common point is that both came within the peace agreements after a long period of hostilities. The original delimitation of the boundary between mandatory Palestine and Transjordan was laconic and inadequate: "... line drawn from a point two miles east of the town of Akabah in the Gulf of Akabah up to the centre of Wady Arabah, the Dead Sea and the River Jordan to the junction of the latter with the river Yarmuk, thence up the centre of the River Yarmuk to the Syrian Frontier."*
Between 1922 and 1994, even assuming that it was not necessary to demarcate the river portion of the boundary, some 250 kilometres remained undemarcated, except for a short stretch of less than 4 kilometres demarcated by 5 pillars, at the southern end of the boundary.
It was considered too expensive during the mandatory period to undertake a demarcation campaign in the 180 kilometre stretch of the boundary in the Wadi Araba, a saving which proved to be a source of friction between Israel and Jordan during the period of armistice and cease fire 1949-1994.
The Treaty of Peace between Israel and Jordan was signed on 26th October 1994, with the Joint Team of Experts (STE) acting in an advisory capacity during the negotiations concerning the delimitation of the boundary.
The delimitation was unique in character, an album orthophotos, showing the boundary line, having been attached to the Peace Treaty, as Annex I, appendices I-VI, becoming a directive for demarcation.
Phase I of the demarcation was carried out by three Jordan/Israel field teams working in parallel. Every point was located on the ground, using the orthophoto maps for identification, and marked temporarily, with witness marks and ground measurements describing the location.

* Lord Herbert Samuel, Palestine Order in Council, 1st September 1922.

In Phase II, the monumentation took place, pillars replacing the temporary markers, 124 in all. An IJBD'94 boundary datum was established, observing 6 points in Israel and 6 in Jordan and choosing one of them as the main point. Ten joint teams carried out GPS static mode observations, measuring each boundary point twice. Holding the frame coordinates fixed, the boundary pillar coordinates were computed, achieving a uniform accuracy, estimated at sub-decimeter level, for the 124 boundary pillars located between the Dead Sea and the Red Sea.

SUMMARY AND CONCLUSIONS. The delimitation and demarcation, including a survey record of the boundaries between Egypt and Israel and between Jordan and Israel can serve as a model for modern delimitations and demarcations. The general pattern of mapping services to international land boundary creation is shown in figure 2. The delimitation and demarcation are carried out in sequence conforming to circumstances. A preliminary demarcation can be made to facilitate delimitation, which is usually followed by final demarcation and survey record.

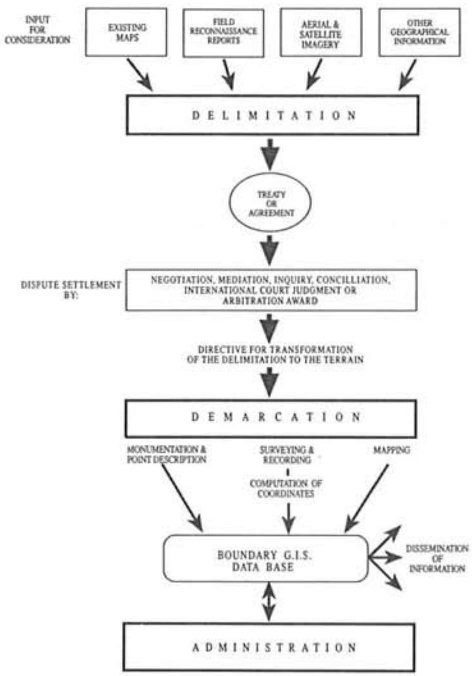

Fig 2. General pattern of Boundary making.

The following points should be mentioned.

- The professional cooperation between the experts of the countries involved.
- All disputes, big and small were solved by patient negotiation and by peaceful means.
- Orthophoto maps are an excellent aid to delimitation and a means to avoid the many disputes which arose world wide due to faulty delimitations.
- GPS observations, joint and simultaneous, are the best way to define the location of boundary points within a very acceptable accuracy and reasonable time.
- A boundary datum not only avoids problems of connecting the boundary points to national datums, but provides an excellent opportunity for the parties concerned to develop mutual confidence and cooperation.

It is hoped that the approach and procedures described here will be applied in converting the remaining armistice lines to international boundaries on the basis of peace treaties.

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GIS AND GEOSPATIAL METADATA

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Every scientific theory has its own subject of investigation, and all the research activities and thoughts should be directed toward this subject. So the indispensable condition of developing the GIS theory is the crisp definition of its subject as well as of trends and methods for its investigation.

On the current stage of development, GIS theory is a relatively independent area of knowledge based on its own regularities and principles. Its subject can be defined only by means of deep comprehension of substance and intent of GIS, matter of the tasks being solved and conditions for their implementation, including technical and technological ones.

The substance of GIS consists in the activities of geographers, cartographers, geodetists, mathematicians, programmers and users in area of acquisition, system processing, modeling and analysis of spatial data, its displaying and using in solving tasks, preparing and adopting decisions.

As the main intent of GIS one can consider the formation of knowledge about the Earth, separate regions, terrain, as well as in-time supplying users with spatial data in order to reach the utmost efficiency of their work, especially in GIS-mapping.

GIS-mapping is intended to create the united geoinformatic space and correspondent geoinformatic structure. The content of GIS-mapping consists in preparation and carrying out the whole of measures oriented to develop normative documents and methodological basis, standards of metadata for the geodetic, gravimetric, photogrammetric and cartographic information, standards of electronic topographic and special maps, electronic photomaps and city plans, spatial (3-D) terrain models. It also involves the development and implementation of hard- and software, methods and technologies for the acquisition, collecting, processing, analysis and transfer of spatial data (digital cartographic information), creating usual (paper) and electronic maps, as well as the creation of bases of metadata, databanks and GIS of various purpose.

The achievement of the goal of GIS-mapping can be carried out by means of solving the following tasks:

- generalization of the experience in area of providing users with spatial data;

- development of the key notions and definitions, revelation and investigation of the rules of geoinformatic maintenance of users, formation of the main principles of creating the Base of metadata, databanks and GIS of various purpose, and networks for the transfer of spatial data;
- investigation and development of the common Concept of creation and implementation of the Electronic maps system, hard- and software, technologies of the acquisition, collection, processing, analysis and transfer of spatial data (digital cartographic information), technologies of automated producing and delivering usual (paper) and electronic maps;
- development of methods for modeling and displaying cartographic and special information, solving informational and computational tasks;
- development of criteria and methods for the evaluation of GIS effectiveness, measures on GIS improvement and practical recommendations on its implementation.

The successful solution of these tasks becomes possible only under the condition of working out the general Concept of GIS-mapping that is necessary for effective organization of researches, understanding and rational use of the rules of informatization, development and application of scientific-proven principles of designing and functioning of the whole System.

The general Concept of GIS-mapping appears as its philosophy. It must contain: main terms and definitions; basis for choosing or designing the Base of metadata, Banks of spatial data, their informational, mathematical, linguistic and technical maintenance; requirements to the electronic and digital maps, spatial (3-D) terrain models, principles and methods of their projecting and designing, methods of the acquisition, collection, processing, analysis, displaying and transfer of spatial data (digital cartographic information); methods of modeling and displaying cartographic and special information, solving the informational and computational tasks; system recommendations for its implementation; normative documents, standards of metadata and electronic maps; information about terms of development and implementation, bulks and sources of investments.

So, the subject of GIS theory consists of the rules for the geoinformatic maintenance of users, principles and methods of designing the System of acquisition, collection, processing, analysis and transfer of spatial data (digital cartographic information), technologies of automated producing and delivering usual (paper) and electronic maps, methods and technologies of modeling and displaying the situation, solving the informational and computational tasks, related organization structures.

The subject of GIS theory appears in the key notions and definitions of this new area of knowledge. The conceptual system must reflect the substance of GIS, rules of geoinformatic maintenance and GIS-mapping, investigate and show the mechanism of their action. It allows to reveal the most essential dependencies and relations between GIS and its environment (i.e. users), as well as to learn the relations inside GIS itself, between its related subsystems. Inexact interpretation of definitions, imperfection of terminology embarrasses the unity of expounding and understanding GIS theory.

Principles of designing and functioning of the System link GIS theory with practice. They translate the objective rules of geoinformatic maintenance into the language of practice. Guiding by these rules, it is possible to formulate some general principles that concern the System in the whole, and some special principles that concern its certain subsystems.

At the initial stage, the determination of GIS intent and principles of developing GIS appear as the main problem of GIS design. The most important of these problems is the principle of correspondence between the intent and structure of GIS, its characteristics and users' requirements. According to this principle, GIS must comply to the main requirements not only to its possibilities and structure, but also to the basic informational maintenance (system of classification of cartographic information, rules of digital data description, spatial data format, symbolization library), and to the electronic map itself.

System approach is considered as one of the fundamental principles in creating and implementing GIS. It lies in representing the object of investigation as whole complex system that consists of set of subsystems and characterized by certain relations and dependencies between these subsystems. System approach provides the informational, mathematical, linguistic, and technical compatibility of GIS subsystems, and determines methods of research and designing the system, its structure.

The key factor in designing GIS, its structure and user interface, as well as in choosing the system, is its functional intent. There are two groups of GIS according to their functional potentialities. First group includes powerful universal multi-functional GIS that are oriented to be used on workstations with highly developed software, that can process large bulk of information in various formats from various sources. These GIS create the vast range of cartographic production, solve many informational and computational tasks. Second group includes special and less powerful GIS based on personal computers and certain hard- and software, that provide the solution of problem-oriented tasks.

As an example of multi-functional GIS, one can take up a system that processes and synthesizes spatial geodetic, gravimetric, photogrammetric and cartographic information, and solves informational and computational tasks. Such GIS usually includes three subsystems: geodetic, photogrammetric and cartographic one. Each of these subsystems can be used separately. But, as a mandatory parts of the system, there must be the Base of metadata and Bank of spatial data.

The Base of metadata must contain information about all created, creating and planned to be created electronic and digital maps, problem-oriented models and their characteristics (author, production date, lineage, accuracy and complexity, projection and coordinate system, geodetic basis, available training materials and instructions). Bank of spatial data is provided for creating and conducting cartographic databases, input, check-up, storage and output of all kinds of electronic and digital maps. The main info-logical unit of electronic and digital maps is an object of image or terrain, which keeps constant values of its quantitative and qualitative attributes. Information about an object includes its semantics and metrics.

Geodetic subsystem is intended to form the united coordinate space of GIS and to obtain data about figure and physical fields of Earth. This subsystem includes acquisition of data of satellite and surface geodetic measurements, its processing and transforming into geodetic parameters of Earth, coordinates of points of geodetic networks, global and local models of gravitation field, digital maps of deflections of plumb line and geodetic basis of electronic maps.

Photogrammetric subsystem conducts an automated recognition of satellite images, creating and updating topographic maps, creating orthophotomaps in analogue and digital form, electronic maps and spatial (3-D) terrain models.

Cartographic subsystem carries out input (scanning) of cartographic materials, processing (recognition and generalization) of cartographic information, and its output by means of laser recording technique in the form of publishing originals of topographic and special maps, photo maps, electronic maps and spatial (3-D) terrain models.

Hence, a multi-functional GIS must contain not only cartographic, but also geodetic, gravimetric and photogrammetric metadata. Just such an approach to the Base of metadata can provide the most effective application of GIS.

THE MAPPING OF TAIWAN

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The earliest known Chinese map regarding Taiwan is found in a book written in 1555.[1] This may be the beginning of Taiwan's mapping history of nearly four and a half centuries. By the following century, a few more maps concerning Taiwan were drawn by the Chinese.[2] Unfortunately, none are extant today. Considering features that distinguish mapping activities, the history of mapping of Taiwan can be divided into four characteristic periods.

Firstly, it is the European Period, 1554-1680. By the mid-sixteenth century, Taiwan started to appear on European maps. On a world map prepared by Portuguese cartographer Lopo Homem in 1554, Taiwan was portrayed possibly for the first time as a small island off southeast China's seacoast and was named I. Fermosa.[3] On the world map by Bartholomeo Velho in 1561, Taiwan was presented as two separate islands, the northern one was named Fermosa while the southern Legueo Pequeno(lesser Liuqiu). Of Lazaro Luiz's 1563 atlas, which contained thirteen maps, Taiwan was portrayed as three separate islands on its seventh map. The northern island was named Lequeo Pequeno, while the middle and southern islands remained unnamed.[4] Portuguese cartographer Fernao Vaz Durado's atlas of 1568 also portrayed Taiwan as three separate islands, like those in Luiz's atlas.[5] On a map entitled *Asiae Nova Descriptio* which was from

Abraham Ortelius' atlas engraved in 1570, Taiwan was named I. Fermosa.[6] In the 1584 edition of Abraham Ortelius' atlas, there was, for the first time in an European atlas, a separate map of China on which Taiwan was represented as two separate islands. The northern island was named Fermosa and the southern Lequeo Pequeno.[7] In ca. 1590, Bartholomeo Lasso produced a portolan atlas consisting of eight maps. Taiwan was portrayed as three separate islands like those on the above-mentioned Velho's map. The northern island was named Fermosa and the southern Lequeo Pequeno. The size of later is larger than that of the former.[8]

Flemish cartographer Petrus Plancius (1552-1622) made a world map first published in 1590 and subsequently in 1592, 1596, 1604 and 1607. On 1592 edition, Taiwan was also portrayed as three separate islands like those on Lasso's map.[9]

In 1597, Captain Hernando de los Rios enclosed in a letter to the Spanish king a map entitled *Mapa de las Islas Filipianas y Fermosa y Parte de la Costa de China.* This manuscript map was the best map of Taiwan at that time. The main island of Taiwan was portrayed as an elongated island off China's seacoast. Between them were the the Pescadores. The coastal area around Danshui (Tamshui) and Jilong (Keelung) were of especially high accuracy.[10]

During the sixteenth century, the main island of Taiwan was mapped as one, two or even three islands. Some European map makers who saw the heavily forested river mouth areas mistook these rivers as sea channels separating Taiwan into two or three separate islands. This peculiar error also appeared on a number of early European maps of Southeast Asia.[11] By the seventeenth century, the Europeans were more familiar with Taiwan. Taiwan was then more accurately mapped by Dutch and Spanish cartographers. This can be attested by several maps. These include Jacob Noordelloo's manuscript map of Taiwan in 1625, a Spanish map of the Jilong port, and Johannes van Keulen's map of the Pescadores entitled *De Eylanden van Pehou* completed in 1680 (see Figure 1).[12] On all these European maps, the Pescadores and the coastal area around Anping and that around Jilong were comparatively more accurately portrayed.

The second is the Manchu Period, starting from 1684, when

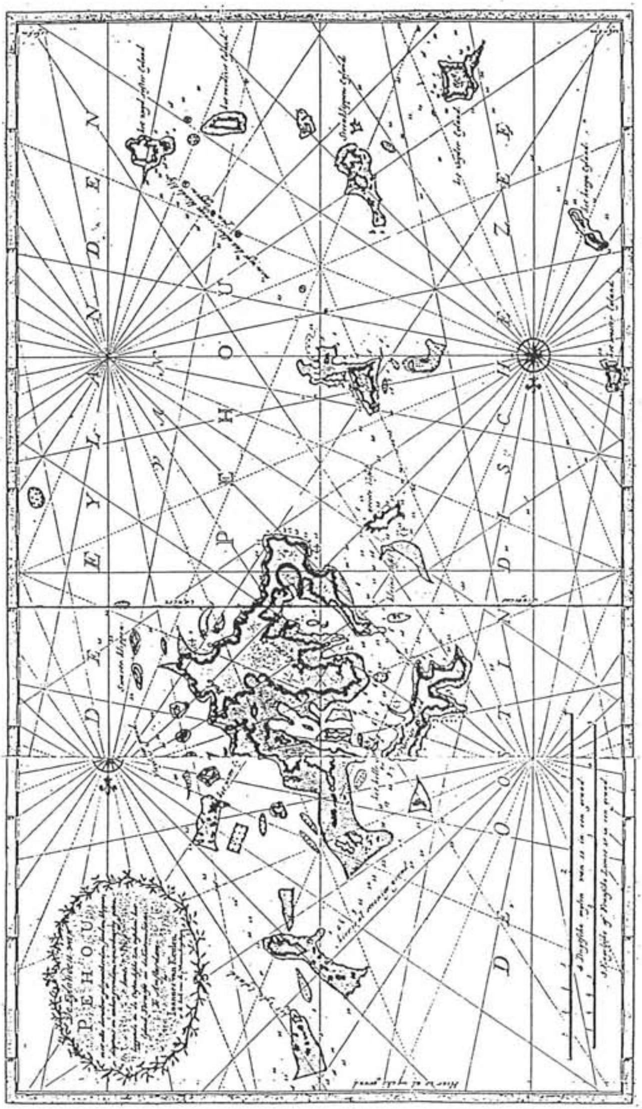

Figure 1 Johannes van Keulen's *De Eylanden van Pehou*(Source: Christine Vertente *et al., op. cit.*, pp. 34-35).

the Manchu government took over Taiwan, and ending in 1895 when Taiwan was ceded to Japan. In 1714, Emperior Kangxi sent a team led by three French catholic priests Jean-Baptiste Regis, Joseph-Anne-Marie de Mailla, and Romain Hinderer to survey Taiwan using contemporary scientific surveying methods. This is the beginning of modern survey of Taiwan organized by the Chinese. This team surveyed the Pescadores and the entire main island of Taiwan except for its eastern part because much of that part was underdeveloped and inhabited by aborigines. Seven longitudinal and latitudinal points were first determined to serve as a base for the subsequent surveys (see Figure 2). This thus resulted in a map of higher accuracy than before. However, after completion, the map was secretly kept in the court, only available to the Emperor and higher government officials.[13] Consequently, it had little influence on the development of any subsequent mapping of Taiwan. The other maps of this period are of the landscape painting or the Chinese grid types (see Figure 3). Both are traditional Chinese maps, mainly found in local gazetteers.[14]

The third is the Japanese period commencing in 1895 when Taiwan was ceded to Japan and ending in 1945. In 1899 the Japanese commenced large scale modern survey projects to map the main island of Taiwan and its offshore islands. By 1903, a total of 37,869 cadastral maps of various scales and 466 administrative maps of 1:10,000 scale were completed. One year later, based on the administrative maps, a series of topographic maps of an 1:20,000 scale were also completed. For the first time, Taiwan had modern cadastral and topographic maps. The former was for civil administrative purpose while the latter was for military purpose. Prior to this, the Survey Department of the Japanese Army carried out topographic survey as early as 1895. A series of topographic maps with scales of 1:20,000 and 1:50,000 were completed. Later in 1926, another survey project was carried out and a new series of topographic maps of 1:25,000 were completed. These maps were of high standard, forming a good base for future mapping.[15]

After the defeat of Japan in World War II, Taiwan was restored to China in 1945. This ushered the fourth period of map making of Taiwan: the Nationalist period. There have been

Figure 2 *Qian-long Nei-fu Di-tu Tai-wan-tu, 1760* (Map of Taiwan, Qianlong Imperial Map, 1760)(Source: Taipei: Guo-fang Yan-jiu-yuan, 1966).

Figure 3 *Tai-wan-fu Zong-tu, 1696* (General Map of Taiwan Prefecture, 1696)(Source: *Tai-wan Fu-zhi* [Gazetteer of Taiwan Prefecture], completed in 1696).

five categories of map making activities. First was the large-scaletopographic mapping conducted by the civil and military agencies. Over seven thousand triangulation points were fixed. Several series of topographic maps were completed, with scales of 1:25,000, 1:50,000, 1:100,000 and 1:250,000. A series of national basic airphoto-topographic maps were completed by the National Agricultural and Forestry Air Survey Bureau. The scale of this series was 1:5,000 for areas below 1,000 meters above M.S.L. and for the rest 1:10,000. Second was the mapping of administrative divisions. Third was the mapping of other thematic features. These included cadastral maps,[16] economic maps, maps of drainage basins, and sea charts for coastalTaiwan.[17] Fourth was the completion of various atlases.

Several general and thematic atlases were made. Fifth was the mapping engaged by commercial firms, producing general maps and atlases, road maps and atlases, tourist maps and atlases, maps and atlases for schools, and school globes. From 1957 to 1994, a total of 940 maps, atlases and globes were produced. In addition, various thematic maps of small and medium scales could be found in unpublished original master and doctoral theses submitted to local universities. These form a valuable source for thematic maps of Taiwan. From 1981 onward, Taiwan has carried out an active computerization project of its mapping programs. Cadastral maps have been prepared by computer, map data banks in digital form have been established, and GIS have been applied to a number of government mapping projects.[18]

In conclusion, the earliest Chinese maps of Taiwan were only rough sketches while the European maps were of small scale, portraying mainly the Pescadores and the coastal areas of western Taiwan. When Taiwan became a province of the Manchu Empire, the western half of the main island of Taiwan and of the Pescadores were surveyed and large scale maps were thus prepared. These were of high standard, but were unavailable to the public. Therefore, maps of the landscape painting and the Chinese grid types continued to prevail, particularly in local gazetteers. During the Japanese period, the Japanese colonial government actively carried out mapping projects. Several series of large-scale topographic and cadastral maps of high standard were made. These maps formed a good base for future mapping. Since 1945, the Nationalists also carried out active mapping projects, i.e. large-scale topographic, administrative divisions, and other thematic mapping. In addition, thematic maps of small and medium scales could be found in unpublished theses submitted to local universities. They form a valuable source for thematic maps of Taiwan. The latest mapping projects are the computer mapping and the application of GIS.

Notes

1. Zheng Shun-gong, *Ri-ben Yi-jian* (Japan as a Mirror) (Completed in 1555).

2. Shen Guang-wen, *Tai-wan Yu-di-tu Kao* (On Taiwan

Maps)(ca. 1652).

3. Lopo Homem, *World, 1554* (a manuscript map) in Chen Zheng-xiang, "Tai-wan di-tu zhi yan-jin(Progress of Taiwan maps)," *Di-li Yu Chan-yen* (Geography and Industries), Vol. 2(1962), p. 1.

4. Cao Yong-he, "Ou-zhou gu-di-tu shang zhi Tai-wan(Taiwan on ancient European maps)," *Tai-wen Wen-xian* (Historio-Geographical Records of Taiwan), No. 1(1962), p. 4.

5. Cao, *op. cit.*, p. 5.

6. Cao, *op. cit.* pp. 7-8. A copy of *Asiae Nova Descriptio* is in the possession of Mr. Ye Zhong-xun, a Taiwan map collector.

7. A copy of *Asiae Nova Descriptio* is in the possession of Mr. Ye Zhong-xun.

8. Cao, *op. cit.*, pp. 5-6.

9. Cao, *op. cit.*, pp. 9-10.

10. Chen, *op. cit.*, p. 3.

11. Paul Wheatley, "A curious feature on early maps of Malaya," *Imago Mundi*, Vol. 11 (1954), pp. 67-72.

12. See Johannes van Keulen's map entitled De Eylanden van Pehou in Christine Vertente *et al.*, *The Authentic Story of Taiwan: An Illustrated History, based on Ancient Maps, Manuscripts and Prints* (Taipei: Mappamundi Co., Ltd. Taiwan, 1991), pp. 34-35.

13. Weng Wen-hao, "Qing chu ce-hui di-tu kao(On the mapping of China during the early Qing)," *Di-xue Za-zhi* (Geographical Journal), Vol. 18, No. 3(1930), pp. 405-438.

14. Xia Liming, *Qing-dai Tai-wan di-tu yan-bian shi* (A History of the Mapping of Taiwan during the Qing Dynasty)(Taipei: Zhi-shu-fang, 1996).

15. Zhong Mei-shu, *Tai-wan Di-tu Ce-hui Shi* (A History of the Mapping of Taiwan)(unpublished M.A. thesis, Chinese Culture University, 1995), pp. 114-124; Jack F. Williams, *China in Maps, 1890-1960: A Selective and Annotated Cartobibliography* (East Lansing: Asian Studies Center, Michigan State University, 1974), *passim.*

16. Zhang Yu, "Ti-ji ce-liang zai Tai-wan(Cadastral survey in Taiwan)," *Ti-ji Ce-liang* (Cadastral Survey), No. 12(1993), p. 1.

17. Lin Xi *et al.*, *Hai-tu de Ying-yong* (The Application of Sea Charts)(Gaoxiong: Hai-jun Hai-dao Ce-liang-ju, 1988), p. 46.

18. Zhong Mei-shu, *op. cit.*, pp. 125-188.

TWENTIETH-CENTURY CHINESE STUDIES OF THE HISTORY OF CHINESE CARTOGRAPHY

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The development of a science is affected by the external environment. Research has to be generously financed. Different fields need different materials for research. Maps are of prime importance to the study of the history of Chinese cartography. The discovery of ancient maps by archaeologists has had a positive impact on the study of this subject. The establishment of the Institute of Geography and the Institute of the History of Natural Sciences in the Academia Sinica has also been helpful in promoting the study of the history of Chinese cartography. Academic journals such as the *Studies in the History of Natural Sciences* (Zi-ran Ke-xue-shi Yan-jiu) among others have provided a publication outlet for research results. Since 1911, Chinese scholars have contributed more than three hundred articles and monographs on this subject. The productivity of publications started to increase in the 1930s and was reduced during both the Second Sino-Japanese War (1937-1945) and the Chinese Cultural Revolution (1966-1976).

At the turn of the twentieth century, three scholars published three separate articles in French, Japanese and Chinese, respectively. In 1903, Chavannes published his fundamental paper in the *Bulletin de l'Ecole Francaise de l'Extreme Orient.*[1] Ogawa published a paper on the history of Chinese cartography prior to China's contact with Europe in recent centuries in *The Journal of Geo-Sciences* (in Japanese) in 1910.[2] Tao published an article discussing the origin and progress of Chinese cartography.[3] These ushered in the modern studies of the history of Chinese cartography.

In two decades following 1910, five more articles were published. Two are worthy of mention. In 1926, Zhu discussed Shen Gua's contributions to geography. Shen was credited with these three inventions: a prototype level instrument to measure altitude, a method termed Fei-niao zhi-da (the Chinese equivalent of "as the crow flies") to measure the distance between two points, and a method of making a three-dimensional topographical model using sawdust and wax.[4] In 1930, Weng published an article discussing the mapping of China during the early eighteenth century. Results of this mapping formed the foundation of the modern geography in China.[5]

Wang was the most productive scholar in this field. In the 1930s, Wang's studies concentrated on the introduction of Chinese source materials concerning the history of Chinese cartography. His lifelong study resulted in a book entitled *The Outline History of Chinese Cartography* (Zhong-guo Di-tu-shi Gang) published posthumously in 1958, two years after his death.[6] This is a well documented and highly accurate work. Wang concluded that four different types of ancient geographical works had the same origin. They all evolved from the prototype map of ancient China. He analyzed the relationship between three different forms of ancient Chinese publications: maps with annotation (Tu-jin), gazetteers (Di-zhi) and maps (Di-tu). In addition, he discussed the contribution of ancient Chinese cartographers, including Pei Xiu, Jia Dan, Zhu Shi-ben, and Lo Hung-xian. In summary, Wang provided a solid foundation for the study of the history of Chinese cartography for future scholars.[7]

From 1933 to 1944, a number of scholars made significant contributions. Liang studied the fish-scale maps.[8] Jing prepared a chronological table of the history of Chinese cartography.[9] Chen Guan-sheng and Hong examined Matteo Ricci's world maps.[10] Zhu and Rong described Yang Shou-jing's contribution to Chinese cartography.[11] Fang prepared a report on the determination of 114 longitudinal and latitudinal control points in ten Chinese provinces in the early 1930s.[12] Finally, Ge published a substantial article on the general historical development of Chinese cartography.[13]

The establishment of the People's Republic of China in 1949 commenced a new period in the study of Chinese cartography. Roughly starting from 1954, there had been gradually more scholars who published their research results. This trend reached its peak in 1990. Related to this trend, four circumstances need to be elaborated. The first was the publication of Wang's *The Outline History of Chinese Cartography* in 1958. The second was the discovery of a number ancient maps by Chinese archaeologists. These include a city map imprinted on brick from the Han dynasty that was discovered at Xinfan, Sichuan province in 1965, three other Han maps discovered at Mawangdui, Hunan province in 1973, a tomb plan discovered at Pingshan, Hebei province in 1974, and several Qin maps drawn on wood discovered at Fangmatan, Kansu province in 1986. The third was the publication of Needham and Wang's *Science and Civilisation in China*, Vol. 3, *Mathematics and the Sciences of the Heavens and the Earth*. in 1959.[14] This volume contains a lengthy section on Chinese cartography. Finally, it was the open policy of the Chinese government after the Cultural Revolution. All these have either helped or stimulated the interest of scholars in studying the history of Chinese cartography.

Many scholars have contributed to studies of the history of Chinese cartography, but only some can be mentioned in the following paragraphs. In roughly four decades until her death in 1996, Cao had been the most productive Chinese scholar in the field. Her publications include numerous articles and chapters in books. She is a leading co-author of the magnificent *Atlas of Ancient Chinese Maps*[15] and has contributed three major articles and numerous short map notes to the atlas. She was a co-author of at least two books.[16] She had also written several papers in English.[17]

In her study of *Map of China and the Barbarians* (Hua Yi Tu) and *Map of the Tracks of Yu* (Yu Ji Tu), her conclusions contain three main points. Firstly, the date of *Map of China and the*

Barbarians should be between 1081 and 1094; secondly, *Map of the Tracks of Yu* is the earliest Chinese grid map (Hua-fang di-tu). But this cannot prove that Pei Xiu's map is of the grid type.[18] Regarding Shen Gua's contributions to cartography, she inferred that *Map of the Tracks of Yu* was Shen Gua's work.[19] After careful examination, she pointed out that the contents of *Map of China and the Barbarians* and *Handy Geographical Maps, Chronologically Organized* (Li-da Di-li Zhi-zhang Tu) were quite similar.[20] In 1983, she published a major article on the methodology of Chinese cartography. There were four main points. Firstly, she proposed that it is the theory of a round heaven and a square earth (Tien-yuan di-fang) that suggested the surface of the earth is flat. Additional observations of the North China terrain, which appears flat, further influenced ancient Chinese cartographers to believe the earth was indeed flat. Therefore, the grid map was invented instead of map projection. The ancient Greeks being a sea-faring people would more easily feel the spherical nature of the earth's surface. Therefore, they invented map projections, not the ancient Chinese. Secondly, Pei Xiu's six cartographical principles formed the mainstream of Chinese cartographical thoughts until the Ming dynasty. Thirdly, ancient Chinese maps had already rich abstract symbols. Fourthly, a new explanation of Pei Xiu's six principles was proposed.[21] In another article, she and her co-authors accounted for the origin, content, and collection of Matteo Ricci's world maps. The astronomical and geographical materials contained in these maps were also analyzed.[22] In 1984, she and two other scholars studied the exchange of maps between Chinese and Europeans. They concluded that the exchange of maps between China and Europe commenced in the second half of the sixteenth century. Chinese maps were brought to Europe at least as early as 1575, while European maps were brought to China seven years later in 1582.[23] In 1985, she studied the Han city map that was imprinted on brick. The drawing on the brick discovered was only a part of a map, not the entire map. She suggested that the map was a city plan. The format was a square. The upper side of the plan pointed to the north. There were symbols representing streets and the city wall, and the plan could be considered a good sample of urban maps of the Eastern Han dynasty.[24] In the same year, she with co-author Zheng published an article on the Taoist's maps of the five sacred mountains. Their conclusion consists of four points. First, the early Taoist's maps of the five sacred mountains were actually based on field observation. Second, the symbols that portray topography on the maps are different from those on the Han topographic map from Mawangdui. Ancient Chinese maps rarely had two dimensional symbols portraying three dimensional topography. This made the Taoist's maps rather valuable. Third, the symbols could be considered as somewhat a prototype of modern contours. Fourthly, the Taoist's maps were used as omen symbols rather than as true maps. This usage as omen symbols hindered its mountain symbols from developing into modern contours. The contours on modern Chinese maps are imported, not being Chinese in origin.[25] In 1978, she analyzed the relationship between the Han maps from Mawangdui and Pei Xiu's six cartographical principles.[26]

Zheng was the second most productive scholar. Between 1982 and 1995, he contributed at least ten articles and chapters in books. He was also one of the co-authors of *Atlas of Ancient Chinese Maps* and prepared two comprehensive chronological tables of the history of Chinese cartography and nine short map notes for the atlas. In 1982, he published an article on *Jiu-yu Shou-ling Tu*, which is a map from the Northern dynasty that was inscribed on slate. He studied the date of the map, its characteristics, and its significance in the history of Chinese cartography.[27] In the same year, he and Tang wrote a review article on the studies of the history of geography in China. They briefly reviewed the contributions of Chinese scholars.[28] In 1984, he contributed a lengthy chapter on surveying and map-making in ancient China to a volume on the history of geography in ancient China. In that chapter, he discussed the origin of prototype maps of ancient China, the establishment of theory of traditional Chinese cartography, the continuing development of Chinese cartography, and the contribution of European priests.[29]

Chen Shu-peng has been one of the most productive Chinese geographers. Among his publications on cartography is a book entitled *The Story of Maps* (Di-tu de Gu-shi) in which there were three chapters on Chinese cartography.[30] In 1957, he published a substantial article pointing out future directions and tasks of cartographical research in China in the leading Chinese geographical journal *Chinese Geographical Review* (Di-li Xue-bao). He advocated ten tasks that needed to be done. One of these was studies of the history of Chinese cartography. His advocacy must have had a strong influence on the studies of the history of Chinese cartography thereafter.[31]

Ren published numerous articles and short notes. He was also one of the co-authors of *The Atlas of Ancient Chinese Maps*. In 1987, he wrote an article describing six Ming maps in foreign countries.[32] In 1992, he published an article discussing the scholarly value of the Enlarged Map of the Territory of China and briefly describing the existing eight different versions of it published between the mid-sixteenth and the late eighteenth centuries.[33]

Until 1990 Hu had written several articles and short notes on the history of Chinese cartography. He was also a co-editor of *The Atlas of Ancient Chinese Maps.* In 1990, he published an article on the maps in *Zhi-zheng New Jinling Gazetteer* (*Zhi-zheng Jin-ling Xin-zhi*) and concluded that firstly, the quality of the maps in *Zhi-zheng New Jinling Gazetteer* were much better than those in *Jing-ding Jian-kang Gazetteer* (*Jing-ding Jian-kang Zhi*) and secondly, the former indicated that a prototype of cartographical symbols had developed.[34]

Niu published at least five articles between 1980 and 1991. He was also a co-editor of *The Atlas of Ancient Chinese Maps* and wrote one article and five short notes for the atlas. In 1991, he wrote an article on the development and achievement of sea-chart in ancient China. He concluded that there were several types of sea charts in ancient China. One of these types is the compass direction map (Zhen-lu tu), of which *Zheng-he's Sea Chart* (Zheng-he hang-hai tu) is a prime example. Based on his work, we see that these sea charts were then not only useful to the ancient Chinee for navigation, but also valuable to the modern Chinese for scholarly research, especially in historical geography, place name studies, cartography and history of geography.[35]

Wang Qian-jin published at least seven articles between 1987 and 1994. He completed his doctoral dissertation entitled *A*

Study of the Surveying of The Map of a Comprehensive View of Imperial Territory (Huang-yu Quan-lan Tu Ce-hui Yan-jiu).[36] In addition, he was a co-author of two articles and three short map notes in the above-mentioned *The Atlas of Ancient Chinese Maps.* In 1989, he published an article on the cartographical study of the City Plan of Ping-jiang. He accounted for and analyzed the date, authorship, mathematical base, symbols, notes, and errors of the map.[37] In 1994, he published another article on the exchange of knowledge in the field of cartography between China and Korea in ancient times. He concluded the following three points. Chinese cartographical knowledge had been transmitted to Korea in the first century BC. Chinese maps were brought to Korea before the Tang dynasty. Traditional Chinese cartographical theories and survey methods were transmitted to Korea at least as early as during the Tang dynasty. The development of cartography in ancient Korea was dominated by Chinese cartography.[38]

Wang Jia-jun is the most productive scholar with reference to the history of Chinese sea charts. He has published numerous articles and two monographs on historical sea charts of the Qing dynasty.[3] Zhang published at least six articles between 1984 and 1992. His work included studies on these two important topics: restoration problems of the Han topographical map discovered at Mawangdui and the Fangmatan maps which are the oldest Chinese maps discovered by archaeologists to date.[40] In 1980, Li published on the origin of the longitudinal concept in China. He proposed that Yeluchucai (1189-1244) of the Yuan dynasty first suggested this concept of longitudes. At that time the term for longitudes was called li-cha, meaning literally mileage difference.[41] In his preface to explanation of Zheng-he's Sailing Chart, Yan suggested that Zheng-he's Sailing Chart was highly accurate for a small area, making them extremely useful for practical purposes.[42]

The publication of *The Atlas of Ancient Chinese Maps* is a landmark in the study of the history of Chinese cartography. The first two volumes of a trilogy, a national research project, have been published. They contains nearly four hundred black-and-white and color maps. Many of these maps are kept in libraries throughout China and throughout other foreign countries. Many have not been available to the public. This collection is very valuable to scholars of the history of Chinese cartography. There are forty articles and more than one hundred short map notes. In addition, there are two comprehensive chronological tables of the history of Chinese cartography, one for the long period pre-1368 and another for the period from 1368 to 1644.[43]

In summary, several characteristics can be generalized. In terms of contents, five areas received more attention than others. They are (1) treatises of the general history of Chinese cartography, (2) discussions of individual maps, (3) inquiries of methodology, (4) studies of sea charts, and (5) compilations of bibliographies and source materials. Individual maps that have attracted more discussions than others include Mawangdui's Han maps, Fangmatan's Qin maps, Matteo Ricci's world maps, Zheng He's sailing chart, *The Map of a Comprehensive View of Imperial Territory, Map of China and the Barbarians, Map of the Tracks of Yu, and the Enlarged Map of the Territory of China.* These choices reflect two preconditions. Firstly, it is the availability of these ancient maps. Secondly, it is the availability of source materials related to these maps.

There are also other areas worthy of mention. A common weakness of most studies has been an overemphasis on descriptive material and a deficiency of analytical discussion. These studies also lack both a global perspective and examinations of a comparative nature between Chinese and European cartography. In general, the study of the history of Chinese cartography has been among the most active subfields under the history of geography in China. Scholars in China have been able to make especially significant contribution to the study of the history of Chinese cartography in the past thirty years because of important recent discoveries of ancient maps by Chinese archaeologists. In addition, the establishment of the Institute of History and Natural Sciences in the Academia Sinica has also helped promote the study of the history of Chinese cartography. (Note: Five pages of footnotes can be obtained from the author)

THE MAP OF SOIL CONTAMINATION AS A SPATIAL IMAGE OF GASEOUS AIR POLLUTION

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1. Introduction.

The patterns of air pollution in large industrial cities are very complicated. It is impossible to describe them adequately by monitoring stations data or plume models only. Some attempts were made in to find a medium for mapping pollution. Possible medium are: plants and animals, soil, snow. Organisms and snow are suitable for the study of short-term pollution (some months or years); soil is a long-time medium. Previous research usually concerned correlations between concentrations of the same pollutants in different mediums: lead, copper and mercury in soil and/or snow and air (Voloch, 1992); lead, zinc and other metals in air and cortex of Black Poplar (Tyutyunnik, 1993); lead in some kinds of Spiders and Lichens (Clausen, 1984). Voloch (1992) established linear correlations between concentrations of these heavy metals in the air and in the dust deposits. Different pollutants often come from the same sources, i.e. soil pollution by lead and air pollution by carbon oxide are caused by motor vehicles exhausts. J. Sayet et al (1990) showed areas of deposit of heavy metals near large industrial enterprises to be the same as areas of air pollution by fluorine, ammonium hydrate, nitric and sulphuric oxides. The aim of this study is to establish equations in order to calculate indexes of air pollution by indexes of soil pollution.

2. Materials and methods

The laboratory data on soil pollution were obtained as a results of geochemist surveys carried out in some cities. The techniques of geochemist survey of urban territories was elaborated by the Institute of Mineralogy and Cristallochemistry of Scattered Elements, Russian Academy of Sciences (Sayet et al.1990). The techniques includes: sampling of the upper layer of soil and/or snow; spectral, X-ray-spectral or atom-absorbic analysis of samples; calculation of pollution indexes and drawing of maps; health and toxicological investigations. The pollution indexes includes concentration index of separate elements (Kc) and total pollution index (Zc):

$$Kc = \frac{Ci}{Cn},$$

where Ci is the concentration of element in sample number i;
Cn is the natural (background) concentration of the same element in the same kind of soil, deposit or snow in the country-side or forest, outside polluted areas.

The total pollution index Zc is calculated as:

$$Zc = \sum Kc - (n-1),$$

were n is the number of detected elements for these Kc indexes (Saet et al.1990).

The set of detected elements usually includes 20 ones: Cu, Zn, Pb, Ni, Cr, V, Co, Mn, Ag, Mn, Sn, Ti, Li, Nb, Y, Zr, Ga; some elements were detected not in all cities but only in few samples: Ba, W, Sr, Sc. The sensitivity of spectral analysis is 0,00001% for Ag and Mo and 0,001 % for other elements; it is conventional method, used by Russian geologic service. Some elements, such as As, Cd, Hg, Sb, Bi, Be, Ta, Ge, Tl, In, etc. were not detected with such sensitivity. The background concentrations of elements depend on geological formations. There are some pollutants spread in all cities, such as Pb, Zn, Cu; concentrations of other elements differ sharply from one city to another, and even within one urban territory. For example, in Izhevsk the largest contribution to the total index Zc gives Mo, Pb, Zn within all the city; W, V, Cr, Ag, etc. in separate localities.

The laboratory data on air pollution were obtained from Year-book statistics of air pollution (1984-1987): the mean annual concentrations (mg/m^3) of carbon monoxide, sulphuric dioxide, nitric dioxide and dust. The total indexes of air pollution were calculated for dust and nitric, sulphuric, carbon oxides only, because the control of other pollutants concentrations is selective. The total pollution index (J) was calculated by the formula:

$$J = \sum \left(\frac{Qi}{Qp}\right)^{r},$$

where:
Qi is the mean annual concentration of pollutant number i (mg/m^3); Qp is the maximum permitted concentration of the same pollutant (mg/m^3); r is the risk estimation constant: 1,7 for pollutants of class 1 of toxicity; 1,3 for class 2 of toxicity (includes NO_2); 1,0 for class 3 of toxicity (includes SO_2 and dust); 0,9 for class 4 of toxicity (includes CO) (Manual...,1991).

The index J and constants r are recommended by Manual on air pollution control (1991), Russian air monitoring service. An analogous linear index I:

$$I = \sum \left(\frac{Qi}{Qp}\right)$$

was used too. The difference of correlation turned out to be insignificant. The use of an air indexes based on background concentrations in stead of Qp would be more correct, but it demands long-term measurements. There are only few suitable air monitoring stations within former USSR (near Moscow, in the Caucasus, in Byelorussia and Kazakhstan), located at long distances from the investigated cities.

53 sampling points of geochemist surveys were selected, located near air monitoring stations in 9 cities of Russia and Ukraine: Moscow, Kazan, Voronezh, Jaroslavl, Lipetsk, Uljanovsk, Izhevsk, Voskresensk, Odessa. The data of the different cities were collected in order to obtain statistically significant results.

3. Results

We carried out the geochemist survey (soil mapping by 1400 samples and snow one by 50 samples) of Izhevsk, according to the above mentioned techniques. The urban territory was regionalized into areas of permissible pollution ($Zc<16$); moderate pollution (Zc 16-32); dangerous pollution (Zc 32-128); extremely dangerous pollution ($Zc>128$), according to classification by Russian Ministry of Public Health. 68 geochemist anomalies were described and mapped; most of those (47) are caused by atmospheric input.

There are some sources of soil contamination: atmospheric input, deposition from water, dumping of waste, use of fertilisers and pesticides (Sayet et al. 1990). It is obviously, that the index J may be calculated for the first kind of geochemist anomalies only. Anomalies of this kind are at the soil's surface (pollutants are concentrated in upper layer, its thickness not more than some cm) and of diffused outlines. Other kinds of anomalies have a specific dislocation and chemical composition. The study of anomalies genesis includes: a) chemical composition of anomaly, its dislocation and outline as compared to the dislocation and waste composition of neighbouring plants; b) past land-tenure is also taken into account; c) sampling of vertical section of anomaly by excavation or drilling is a way to elucidate the origin in most difficult cases.

The correlation analysis of laboratory data on soil and air pollution was carried out. The results of the analysis are presented in the Table 1. The correlation ratio between the indexes J and Zc (soil) for neighbouring cities is greater: 0,625 for 14 points in Izhevsk, Kazan and Ulyanovsk; but for Moscow it is 0,150 only (16 points), because of very completed territorial and historical structure of pollution. The multiple correlation ratio between air, snow and soil pollution indexes is too greater: 0,723 for 25 points in Moscow, Kazan and Ulyanovsk.

The equations for calculation of indexes J were obtained for the same cities, expect Moscow (37 points):

$$\mathbf{J=3{,}466\ Zc^{0{,}123}}; \qquad r=0{,}556 \qquad (1)$$

Calculation of indexes J in Izhevsk were carried out within 47 anomalies caused by atmospheric input only. So, the map of indexes Zc (the fragment of the map at the Fig. 1a) had been transformed into map of calculated indexes J (the same fragment of the map at the Fig. 1b). The map of calculated indexes J permits to distinguish zones of impact in the vicinity of industrial enterprises, main streets more exactly and without accidental distortions.

Table 1

The ratios of correlation between indexes of air and soil pollution. The number of samples are presented in brackets.

Pollution indexes: of air, mg/m^3 | of soils and snow	Zc, soil	Zc, snow	Kc, lead in soil
Mean annual concentration of dust	-0,170(53)	-0,207(27)	
Mean annual concentration of SO_2	0,130(53)	0,237(27)	
Mean annual concentration of CO	0,282(53)	0,594(27)	0,318(26)
Mean annual concentration of NO_2	0,455(53)	0,632(27)	0,180(26)
Mean annual index J (dust $+SO_2+NO_2$ +CO)	0,515(53)	0,581(27)	
Mean annual index I (dust $+SO_2+NO_2$ +CO)	0,497(53)	0,539(27)	

We compared this maps with the territorial distribution of children's sick rate. The correlation is positive, but not close: ratio 0,05-0,33 for Kc of separate elements, 0,26 for index Zc; 0,37 for calculated index J. The closest relationship were obtained for indexes of extreme air pollution, measured in special monitoring sampling points, during unfavourable meteorological situations (r=0,54); the minimal correlation were obtained for indexes of water pollution (r=0,07). The mentioned correlation ratios were used as coefficient of significance of the kinds of the pollution. It permitted to calculate and to map the complex indexes of pollution (Fig. 2). The relationship between complex indexes of pollution and children's sick rate is more close than for any kind of pollution (air, soil, etc.): 0,65.

4.Discussion and conclusions

This paper presents an attempt to correlate indexes of air and soil contamination. The significance of equation (1) may be estimated by comparing with results of analogous experiments in other regions. There are obviously may be established different correlations for different geographical and social conditions. As homogeneity of data increases, closeness of relationship increases too. The calculated indexes of air pollution may used for **relative** estimation, in order to map pattern of air pollution in more details.

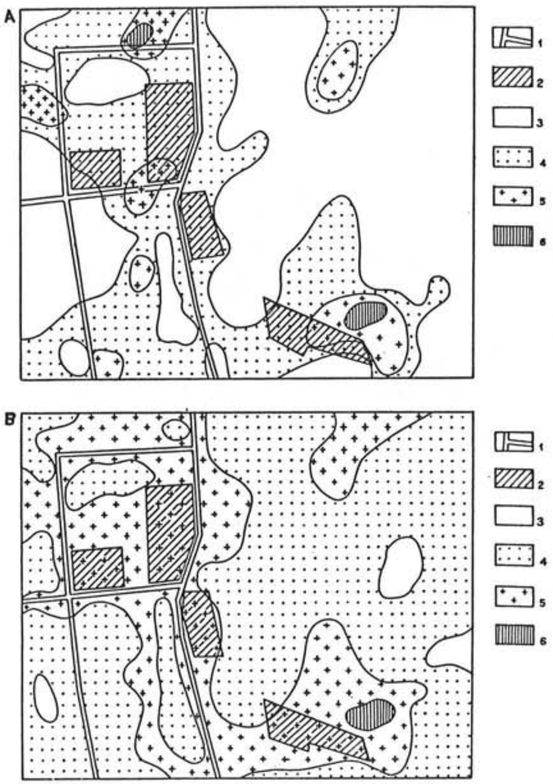

Figure 1. Fragments of map of pollution indexes: A- total soil pollution (Zc); B- calculated air pollution (J). Legend: **A** 1.Main streets 2.Industrial enterprises 3-6. Gradations of Zc: 3. Permissible, Zc<16 4. Moderate dangerous, Zc 16-32 5. Dangerous, Zc 32-128 6. Extremal dangerous, Zc>128. **B** 1.Main streets 2.Industrial enterprises 3-6. Indexes J: 3. J<4 4. J 4-5 5. J 5-6. J>6

Pollution levels of Environmental components are closely connected by migration of pollutants within biogeochemistric cycles. Mobile components of the Environment (air, water) are of most importance for the life processes, but stable components are sediment mediums for the mapping of pollution; the most universal medium is soil. Correlations and equations permits to estimate and to map one kind of pollution by another.

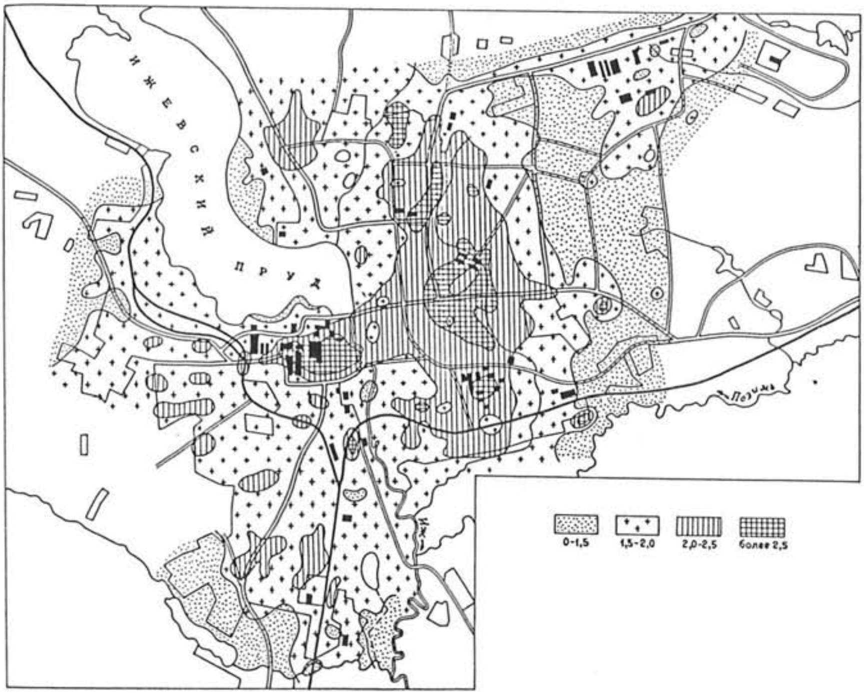

Figure 2. The schematic map of the complex index of air (extreme and mean annual), soil and water pollution in Izhevsk urban territory.

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THE EDUCATIONAL SUBJECT OF THE ENVIRONMENTAL MAPPING

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1. Introduction

There are 2 schools exist traditionally in Russian Cartography: technological and geographical ones. The last few years this two schools develop two different approaches to the Environmental mapping. We try to combine this approaches in the training of students of the geographical department. Technologic aspects predominant for students of cartographic specialization; while geographic ones are of most importance for students of environmentologic specialization. The Environmental mapping is one among 20-30 special disciplines, but it is a significant part of the professional education.

2. The technological approach

The technological approach to the Environmental mapping is being developed mainly by cartographers of special collages and technical universities. The Environmental mapping is being explored to be technological discipline on the production of this kind of maps. It includes primary the design and application of adequate cartographic symbols. It means similarity between symbols and appropriate natural objects, convenient scales (for example, "light signal" color scale of grades of pollution). Territorial units for applications of information and estimations are geometric: squares, hexagons, etc. The application of GIS-technologies is being emphasised. This technologies permits to map dynamic processes, such as spreading and dissipation of pollutants by cartofilms [1]. Main information sources are previous maps, data bases, aerial and space photographs, but not special field investigations [2].

We use software in courses of GIS ARC/INFO and MAP/INFO. The educational discipline contains short theoretical course and more practical classes; it is not original program.

3. The geographic approach

The geographic approach to the Environmental mapping is being elaborated by geographers of academic institutions and universities [2,3], includes author [4]. This approach implies Environmental mapping to be the integrative scientific discipline, rather theoretic than practice. It's aim is to unite knowledge on Ecology principles of ecosystems evolution with wide geographical view, which includes the territorial survey and the research methodology. Main parts of this approach are: peculiarities of information sources; the analysis of geographical features; the applied technologies of mapping.

The sources of information about Environmental situations are: Remote Sensing, pollution sources parameters, measurement of pollutants concentrations? bioindicators. Aerial and space photographs are most effective for investigations jf Land? Water and Vegetable resources. Emission parameters is the object of control. Plume models (based to Gauss's equation, for example) permits to transform this data into computer maps of calculated concentrations, but authenticity of results depends on emission data, so the external control is necessary. The measurement of pollutants concentrations is the most reliable, but expensive method of monitoring. Moreover, results of sampling are expose to discreteness in time, territory, set of ingredients. The state of bioindicators organisms is the concluding index of Environmental situations, but reactions of organisms can be definite in cases of genetic and life conditions uniformity only. So, there is no universal information sources. The most complete information may be obtained through complex of these sources. The complex approach include taking into account advantages and limitations of information sources.

The analysis of geographical features contains the division of territories into landscape units and the estimations of natural boundaries as barriers for pollutants migration. The pattern of landscape units must be used in cases of distribution of monitoring and/or sampling points and interpretation of results. The information, obtained by the above mentioned sources, is quite differ in all components of data quality: positional accuracy, attribute accuracy, logical consistency, completeness, lineage [5].

The applied technology of mapping includes a lot of specific analytical and modeling methods and the cartographic presentation of results. Technologies of air and water quality mapping are mainly based to pollutants dissipation (plume) models, controlled by monitoring data. Soils pollution mapping include some field and laboratory methods. The set of methods depends on the matter of local or regional Air, Water and Land problems.

4. The matter of educational process

The course of Environmental mapping is based to previous education subjects, such as: the Landscape science, the Geochemistry, the Remote Sensing, the Environmental science, GIS science and so on. We train students to extract information on air, water, soils, vegetation quality from statistic tables, special maps and to attribute estimations of Environmental quality to territorial units These territorial units are mainly landscapes, guarded by geomorphic and/or geochemictric barriers. So, we also teach students to find such barriers by topographic maps. The information obtained by the above mentioned sources can be discrepant: for example, emission of pollutants decrease, while concentrations and/or morbidity rate increase. The student's task is to discover and explain spatio-temporal trends.

The theoretical part of the course of Environmental mapping is presented in the form of lectures. Main chapters are:

1. The Theoretical fundamentals of Environmental mapping
1.1. The part of the Environmental mapping in the Environmental strategy
1.2. The Laws of Ecology and mapping
1.3. The principles and lows of Qualimetry and those significance for mapping
2. Sources of information on Environmental conditions
2.1. Remote sensing
2.2. Parameters of sources of pollution
2.3. Measurements of concentrations of pollutants
2.4. Bioindicators
2.5. Relations between sources of information
3. Principles of composition of environmental maps
3.1. Anthropocentricism and/or biocentricism
3.2. Documentalism
3.3. Complexness
3.4. Dynamicness
3.5. Concordance of scales
3.6. Priority of specific information
4. Cartographic analysis of Environmental information
4.1. Kinds of anthropogenic influences
4.2. Indexes of Environmental situations
4.3. Territorial interpretation of Environmental information
4.4. Relationships between different kinds of pollution
4.5. The succession of Environmental mapping
5. Applied technologies of Environmental mapping
5.1 Approaches to mapping of stability of geosystems
5.2 The middle-scale mapping, based to indexes of dissipation
5.3 The large-scale mapping, based to measurements of concentrations of pollutants and correlations
5.4 Bioecological aspects of Environmental mapping
5.5 The mapping of geological and geomorphologic pollution
5.6 The analysis of pattern of pollution

The complete version of this course of lectures has been published in Russian in the author's book [4]. The theoretical study is supplemented by classes on analysis of published Environmental maps and composition of training maps based to training data bases. As the linear interpolation were studied by students during course of GIS, here students master the geographical interpolation.

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SWISS MAP TROPHY - a new way to teach map reading

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The Swiss and their maps

The first map of what is today known as Switzerland was drawn around the year 1497. During the following centuries, local governments tried to get a general view of their territory. Under the direction of General G.H. Dufour, the first accurate map of the country was published between 1845 and 1864 at the scale of 1:100'000. Scientists and alpinists soon pushed for the publication of the original surveys, with contour lines (instead of hachures) and scales of 1:25'000 for the lowlands and 1:50'000 for the mountains. In fact, the published topographic data allowed the "conquest of the Alps" and the development of tourism.

Today, the national map series 1:25'000, 1:50'000, 1:100'000 and 1:200'000 are widely used in the army, for business purposes and for getting around. Hikers, alpinists, bikers, motorists and pilots plan their trips and orient themselves en route using detailed topographic information. Planners and technicians rely on up-to-date (and historical) maps – for the past few years also on cartographic information in digital form. Military planning and operations have usually required a large amount of printed maps.

Education in map reading

In the past cartography used to be part of the curriculum of geography courses in the 5th year of basic schools. Nearly every Swiss child pasted a list of the conventional signs in his/her geography book. Map reading is part of the training programme for the boy scouts, and the knowledge of how to use maps is essential for military leaders. But – amazingly enough – no educational standards have ever been set in this field.

In a recent book called "Karten lesen" or "Lecture de carte", published in co-operation by the Swiss Alpine Club and the Federal Office of Topography, detailed hints for a training programme are provided: **what** has to be taught and **how** can it be presented and applied:

1) How to switch from the horizontal **view** (that's what we are used to) to the vertical **projection** of the map – and vice versa.
2) Every map user should know what the **scale** means, by how much a **distance** in nature is reduced on the map, and how many details have to be left aside, **generalised**, because there is not enough space to present everything.
3) **Co-ordinates** are an important means of communicating to another person a certain place and by which to calculate distances.

4) Just as the reader of a book needs to know all the letters, map reading includes the meaning of all **conventional signs.**
5) Because of the vertical projection, map makers use different methods for terrain **representation**. In a country like Switzerland, it is most important to realise what is behind that.
6) Fog, snowfall or darkness in a dense forest mean severely limited visibility. A **compass** can show the way to a destination, but the user should also know about its limitations.
7) In the mountains an **altimeter** can be of even greater importance in a case where visible landmarks are missing.
8) More and more **GPS** receivers are used for navigation on land and on water. If DGPS correction signals can be received, the accuracy is sufficient for many users.
9) If a group leader wants to **prepare a trip**, he/she ought to know which information can be extracted from the map and what other sources have to be consulted.
10) Once the map user is on his/her way, the **actual position** should be tracked continuously on the map. If there is a difference between what is expected ("mental map") and what can be seen, one should stop immediately, maybe even retreat to the last known position.

Training documents

The Federal Office of Topography started printing a separate list of conventional signs soon after the war. In recent years a few pages were added, making it a useful tool at school and for courses. A (horizontal) view, a vertical photograph and map extracts at 1:25'000, 1:50'000 and 1:100'000 of the same area offer many possibilities. 20 years ago an illustrated supplement was published with a photograph and a short description of the most important map symbols or of those which can easily be confused.

The Swiss Orienteering Federation edited a folder for beginners with many hints for the use of maps. Based on this the army produced a similar folder (for topographic maps only) called "Sicheres Kartenlesen". A small pocket book "Map and compass" was very popular until the publication of the complete handbook for the national map series "Karten lesen".

History of the project

In the army computer-assisted training is becoming more and more important. It has a lot of advantages: saving time, adapting to the knowledge of each trainee, protecting the environment. Every base is equipped with a number of workstations, trainees often continue with one of the programme steps in their spare time. Contacts between the army's service for computer-assisted training, the transport troops and the Federal Office of Topography soon showed that the field of map reading and map use lends itself very well for use on a computer.

At the first meeting of the working group, map producers and map users (civilian and military) as well as computer specialists brought forth their ideas. They all agreed that the above-mentioned 10 items should form the basis of the programme and that a kind of game involving these items should invite a user to actually look into the maps and test him on his way. Basically, a version for civilian use should be written which could also be used by the military. The programme should be designed for all map users, starting from children aged 10 years.

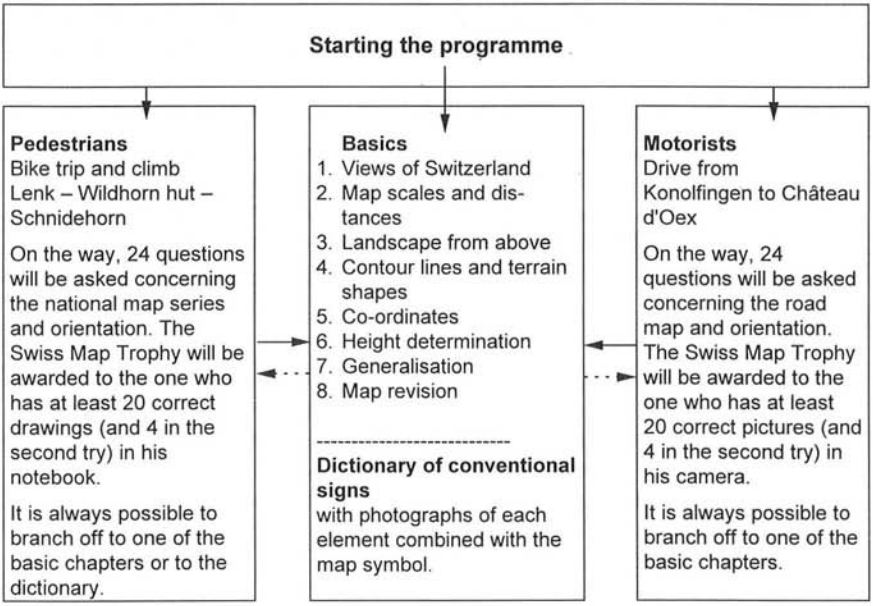
According to the two main user groups, two scales were selected:

1:25'000 for pedestrians: they travel shorter distances, have many details by which to orient themselves, they can stop and look around and are exposed to the weather;

1:200'000 for motorists: they cover larger areas, have to decide quickly when coming to a crossroad or have to know which roads are suitable for their vehicle...

The story board

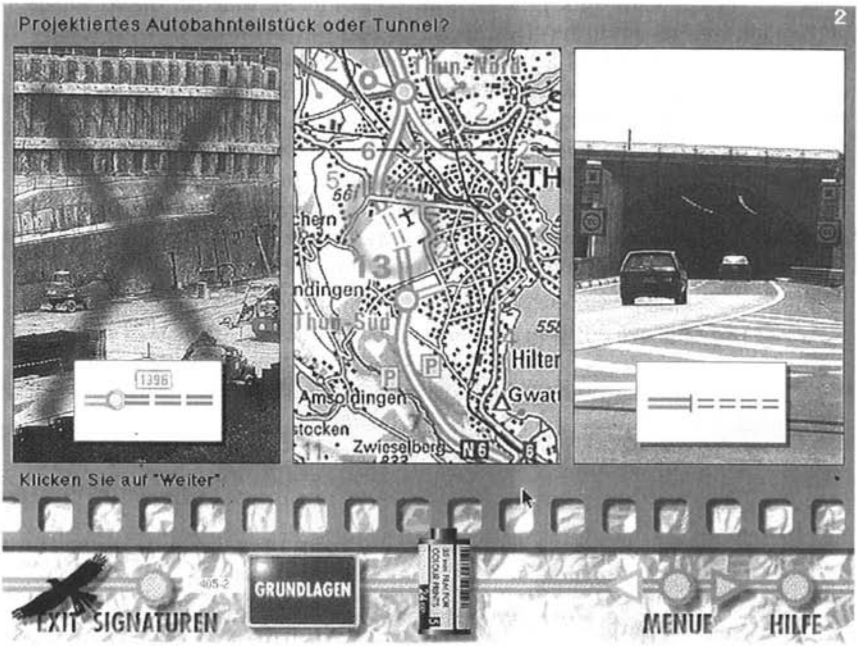
The first decision has to be made at the beginning: an expert might start with one of the two trophies right away, whereas those with little or no knowledge will be guided through the basic chapters: scales and distances, the landscape from above, contour lines and terrain shapes, co-ordinates, generalisation, map revision. A complete dictionary with all the conventional signs proves to be a useful tool; access is provided



through an alphabetical list, group headlines or by scrolling. With a second click of the mouse, a photograph of a typical element is presented with the symbol incorporated. It can be accessed from any part of the programme.

The **pedestrian** climbs a mountain using a bicycle for the first leg. How long is the distance? Then he starts walking: what is the symbol for the waterfall ahead? Which photograph corresponds to the landscape of the next part on the track? What is the meaning of the black dots? The next task: to draw a profile along the path. Which terrain model shows the area around the lake? How long will it take to get to the hut? At what altitude is the hut? Identify three summits in the panorama from the top! What's the safest way to cross the glacier? How do you use compass and altimeter if the visibility is reduced because of fog? Each answer is written in a notebook, at each stage the player can check his score or branch off to a basic chapter to find out or brush up on something. At the end the "Swiss Map Trophy" will be awarded to the one who has answered all 24 questions correctly in the first attempt (or a maximum of 4 in the second).

The **motorist** prepares for a longer drive: which is the best access to the highway? Does the interrupted symbol mean a tunnel or a highway under construction? Approaching a highway intersection, which lane do we have to take (15 seconds for the answer)? Can we use the small road with a truck? Where is the spot with the rocks on the right hand side? How long will the drive to the next town take? Which aerial photograph shows the hairpin turns of the road up to the pass? What is the name of the pass? What does a small black circle mean? On which summit can we meet Roger Moore (alias James Bond), given the height difference from the railway station? On the balloon flight, the different views have to be put in the right order. Each question requires a photograph. At least 20 focused and 4 blurred pictures are needed to obtain the "Swiss Map Trophy".



Programming

An audio-visual computer is ideal for this task: sound, text, photographs and maps can be presented and connected. A private company was engaged for the programming. From their experience they proposed many interesting suggestions. All of the programming was first done on Macs and later on converted to Windows. The main tool for programming was MacroMedia®. By coincidence the QuickTime VR was released at that time and it was used to present 360° panoramic views from the summits reached on foot or by aerial cable car.

For a map specialist, it was a very interesting and welcome experience to work together with specialists in education and computer programming.

The package

The CD-ROM is available in a book-like cassette. Of course there is a booklet with the necessary instructions, including a hot-line phone number. Two special maps were printed for the "Swiss Map Trophy": the eastern half of the sheet 1266 Lenk at

1:25'000 and a section of the national road map 1:200'000. A list of all the conventional signs is in the package as well as the "rapex"®, the new co-ordinate ruler which allows the measurement of angles as well as slopes. The silhouette of an eagle was chosen as the trade mark, suggesting an easy way of travelling, keen eyesight and the vertical view of the landscape presented on the maps.

Edutainment

The goal was to produce a programme which should be inviting to the user and provide him/her with several ways of working through it. The whole thing should not only be educational but also entertaining. For this reason, the solution with the two games was developed.

Field test

The beta test was done with 100 provisional copies by troops, schools and interested individuals. Nearly all of the questionnaires were returned, most of them with very positive general comments,.and quite a few pointing out errors or possible improvements as well. It took some time to sift through all of the information, however, it was worthwhile going through it very carefully – even though the launch on the market had to be postponed. In addition, the possibility of saving the current state was installed, which was also a popular wish.

First reactions

The "Swiss Map Trophy" was presented at several fairs. Visitors were attracted by a picture on the screen or by the sound, and they started playing spontaneously. The presence of skilled staff was not necessary. Most of the visitors enjoyed their first contact. One frequent question was: "Does this programme also exist for my home town?"

Most of the people tested said that once they had started, they would keep on going, even if it took them up to 2½ or 3 hours to work their way through! Teachers said that is was a very useful tool for their geography lessons, the only restriction being the limited number of PCs available. Surveying students at the Federal Institute of Technology use it to test their knowledge, and one professor failed to get the trophy in his first try...

At the computer fair "orbit 96" in Basle, the "Swiss Map Trophy" was awarded the "Golden Mouse" by the Milton Ray Hartmann Foundation for being Switzerland's best multi-media production of the year.

Marketing

The price of the Swiss Map Trophy is SFr. 79.-, which is within the range of educational programmes. All of the sales outlets of the Swiss maps were contacted as well as a few specialised CD shops. A wholesaler was sought to deal with the schools. 5000 copies were made. Right from the beginning the military ordered 1000 copies for its own purposes.

MAPPING SNOW AND GLACIER PHENOMENA CHANGE IN MOUNTAIN REGIONS

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Abstract

The authors used the method of mapping to analyse the snow and glaciers space and temporal variability in mountain areas. The data of glacier fluctuations and records of snow cover in Alps and Caucasus meteostations are the main information for this analysis. This data was used to construct the isoline maps.

In the report the method for mountain climate temporate monitoring with isolinean maps is discussed. These are maps of glacier front shift annual change. We demonstrate the results of these maps creation used annual front shift data (from August to August) of 72 Alpine and 13 Caucasus glaciers through 1986-1990. The maps were created with the computer program "Surfer" help. The method of creating with first power polinom was chosen. These maps show the most power of space data generalization. That is why we could detect, that the glacier front shift spreading repulsed climatic characteristics changes from year to year and didn't depend of selected glaciers size. We have compared average in the map glacier front shift data with the data of summer air temperature (it is thawing condition) and the data of winter precipitation (it is accumulation condition). The conclusion is: glacier front shift value reflects the conditions of glacier accumulation. That is why the glacier front shift maps show was preceding winter snowy or not. These maps have shown, that snowy and minor snowy winters were in the same years in the Caucasus and in the Alps and in the plain between them.

There is the main model to answer the question how snow conditions change in mountains areas

Introduction

Mountains and high plateaus occupy approximately 20 percent of the global land surface. Mountain areas are the source of significant water resources. Some 25 million people reside permanently at elevations of 3 km or more and millions more visit high elevations for summer and winter tourism and sports. Knowledge of present climate regimes of mountain regions keeps abreast of the times. It is very difficult indeed to measure presipitation in high mountains and especially snowfall precipitation. But we can use glaciers in mountain regions as a nature eqiupment for precipitation measurement. Glaciologists have data of precipitation in hundreds glaciers in all moutain regions. Isoline maps have costructed using these data reflect best spatial distribution of precipitation in this areas.

In view of its enormous economic importance for winter tourism as well as for water supply, records of snow cover and glaciers in mountain areas have begun to recieve considerable attention.
The authors used the method of isoline mapping to analyse the snow and glaciers space and temporal variability in mountain areas.
Knowledge of the present climate regimes of mountain regions, and understanding of their variability and sensitivity to change are the main aim of this presentation.

Data and methods

The authors actively use cartographic-statistical methods to research modern glaciarization[4,8,9,] and in particular a method of drawing up and the comparison isoline maps, showing spatial distribution of mountain glaciers characteristic [5,11] .The isoline maps of terminus variations of mountain glaciers were constructed [7]. These maps were made by a method of statistical integration of spatial - distributed data of front shift of each of several tens glaciers in a determined year (from August on August) and have shown, that the distribution of fluctuations of the glacier fronts in the mountain country submits to peculiarities of climate in a greater degree, than peculiarities of individual sliding of each glacier. Thus the glacier system changes from a year to a year as a unit in dependence, mainly, on accumulation conditions. Maps of distribution of glacier fluctuations correlate well with maps of solid precipitation distribution in the mountain country (correlation coefficient for example, for the Alps 0,8) and practically do not correlate with maps of distribution of average summer air temperatures, i.e. ablation conditions [15].
Besides, this approach (using information about glacier front shifts) allows to reveal not only glaciers transition from retreat to advance, but also to answer a question, whether there was the delay or acceleration of glacier front moving in the given year.
Till now for determination the state of mountain glacier system a method of calculation of a percentage glaciers observed retreating, advancing and stationary usually was applied, for example, in the Alps [19].Unfortunately, it gives good results only at the account of plenty glaciers. For example, only for the last 25 years there are thousands annual measurements and hundred of estimations of glaciers front fluctuations of the Alps received by different ways [10]. When we have compared these data with data on annual front shift of 72 Alps glaciers (Tabl.2), the results have coincided.
For former USSR glaciers there are only tens of similar measurements [1, 2, 3,12]. There are only a few long-term observations on some glaciers necessary for drawing up series of maps of spatial distribution of glacier fluctuations in each year. So, for Caucasus such long-term annual observation for 1986-1990 yy [16], is published. (Tabl.1)

Table 1. Annual fluctuations of the Caucasus glaciers, m..

name	longitude	latitude	1986	1987	1988	1989	1990	8690
Marukh	41.17	43.35	-3	-3	-4	-4	-5	-4
Alibek	41.50	43.17	-1	-1	-8	4	-1	-1
Khakel	41.67	43.17	-5	-1	-1	-1	-6	-3
Kvishi	42.50	43.15	-15	-8	-6	-1	-2	-6
Dzankuat	42.77	43.2	0	3	-2	1	2	1
№ 462	42.97	43.13	0	-8	5	-15	-12	-6
Bezengi	43.00	43.17	9	3	2	-2	-1	2
Tseja	43.67	42.92	-1	-6	-5	-8	-4	-5
Skazka	43.67	42.83	-9	14	-2	-1	0	0

Devdoraki	44.53	42.72	2	2	2	-1	-1	1
Abano	44.53	42.70	-1	1	1	-1	-1	0
Chachi	44.55	42.70	-1	-1	-4	-1	-1	-2
Kibisha	44.73	42.47	-4	-4	-6	-1	-2	-3

Таблица 2. Annual fluctuations of the Alps glaciers, m.

№	name	longitude	latitude	1986	1987	1988	1989	1990	8690
1	Suretta	9.38	46.52	29	-78	-33	-16	-32	-26
2	Rhone	8.4	46.62	1	9	-19	-5	-16	-6
3.	Mutt	8.42	46.55	4	0	2	-2	4	2
4.	Gries(Aegina)	8.33	46.43	-13	1	-5	-11	-6	-7
5.	Fiesher	8.15	46.5	0	-11	17	-17	-1	-2
6.	Grosser Aletsch	8.03	46.5	-25	-22	-12	-14	-19	-18
7.	Mittelaletsch	8.03	46.45	-22	-10	-10	-10	-56	-22
8.	Oberaletsch	7.97	46.42	-13	-6	-6	-39	4	-12
9.	Schwarzberg	7.93	46.02	2	-1	0	6	2	2
10.	Allalin	7.88	46.05	-53	-8	22	-49	-57	-29
11.	Fee North	7.88	46.08	10	80	87	-51	-10	23
12.	Zmutt	7.63	46	2	-3	10	-2	7	3
13.	Ried	7.85	46.13	4	0	5	-16	-8	-3
14.	Turtmann(West)	7.68	46.13	4	-3	2	-6	-10	-3
15.	Brunegg	7.7	46.15	4	4	0	3	3	3
16.	Bella Tola	7.65	46.25	-4	-2	-8	-38	-1	-11
17.	Zinal	7.63	46.07	-19	-25	4	0	-82	-24
18.	Moiry	7.6	46.08	-1	-2	-7	-1	-3	-3
19.	Ferpecle	7.68	46.02	5	4	6	3	-8	2
20.	Arolla(Bas)	7.6	45.98	10	4	-3	-6	-10	-1
21	Tsidjiory Nouve	7.45	46	12	5	7	5	6	7
22.	Cheillon	7.42	46	-7	-24	-3	-3	-71	-22
23.	Tsanfleuron	7.23	46.42	-10	-5	0	-22	-9	-9
24.	Otemma	7.45	45.95	-25	0	-50	-25	-28	-26
25.	Mont Durand	7.33	45.92	-6	-5	-28	-24	-15	-16
26.	Breney	7.42	45.97	-3	0	-10	-8	-12	-7
27.	Gierto	7.38	46	-4	-4	-2	-18	-4	-6
28.	Corbassiere	7.3	45.98	12	18	0	7	8	9
29.	Valsorey	7.27	45.9	-10	0	-1	-10	8	-3
30.	Tseudet	7.25	45.9	1	0	-1	-5	0	-1
31.	Boveyre	7.27	45.97	14	6	4	1	-2	5
32.	Saleina	7.07	45.98	12	5	5	0	-15	1
33.	Trient	7.03	46	7	4	-10	-5	-13	-3
34.	Sex rouge	7.22	46.33	-6	6	-8	-14	-14	-7
35.	Oberaar	8.22	46.53	-21	-5	-21	-5	2	-11
36.	Unteraar	8.22	46.57	-24	-12	-10	-17	-41	-21
37.	Gauli	8.18	46.62	-4	8	-6	0	-38	-8
38.	Stein	8.43	46.7	9	5	6	3	-2	4
39.	Steinlimmy	8.4	46.7	-3	-2	-2	-8	-4	-4
40.	Ob.Grindelwald	8.07	46.58	-15	16	-2	-20	-9	-6
41.	Elger	7.98	46.57	-9	-6	-11	-15	-16	-11
42.	Tshingel	7.85	46.5	-2	6	-2	0	-2	0
43.	Gamchi	7.8	46.52	5	2	-4	4	-2	1
44.	Alpetli(Kander)	7.8	46.48	0	-1	4	-2	-7	-18

45.	Schwarz	7.67	46.42	-10	-38	-8	-13	-17	-17
46.	Laemmern	7.55	46.4	-10	0	-5	-6	-6	-5
47.	Raetly	7.52	46.38	-19	-16	-34	-30	-22	-24
48.	Tiefen	8.43	46.62	-3	-4	-6	-10	-12	-7
49.	Sankt Anna	8.6	46.6	0	0	-2	-3	0	-1
50.	Kehlen	8.42	46.68	20	10	-2	-1	-6	4
51.	Rotfirn nord	8.43	46.67	0	-4	-1	-6	-7	-4
52.	Damma	8.45	46.63	28	2	6	8	2	9
53.	Wallenbur	8.47	46.72	-7	6	0	-2	-2	-1
54.	Huefi	8.85	46.82	6	-23	24	-21	-4	-4
55.	Griess(Klausen)	8.83	46.83	6	11	0	-14	-16	-3
56.	Biferten	8.95	46.82	-3	0	-1	-10	-5	-4
57.	Limmern	8.98	46.82	3	-1	0	5	0	1
58.	Paradies	9.07	46.5	-11	-8	-21	-21	-12	-15
59.	Porchabella	9.88	46.63	-8	-7	-7	-4	-7	-7
60.	Silvretta	10.08	46.86	-6	-3	-8	-9	-18	-9
61.	Roseg	9.83	46.38	-40	-13	-9	-1	-7	-14
62.	Rossdoden	8.02	46.18	12	7	16	3	3	8
63.	Morterach	9.93	46.4	-6	-9	2	-7	-11	-6
64.	Tiatscha	10.01	46.83	-2	-2	4	1	0	0
65.	Sisvenna	10.42	46.72	-6	-6	-6	-2	-4	-5
66.	Forno	9.7	46.3	-8	0	-56	-13	-18	-19
67.	Corno	8.02	46.18	6	2	-2	-5	-4	-1
68.	Klosteraler N.	10.07	46.87	2	-7	0	-1	-4	-2
69.	Klosteraler M.	10.07	46.87	-5	1	-3	0	-3	-2
70	Klosteraler S.	10.07	46.87	-7	-4	-18	-23	-2	-11
71.	Ochsentalergl.	10.1	46.85	-1	1	-3	3	-2	0
72.	Vermuntgl.	10.13	46.85	-7	-7	-9	-10	-8	-8

The comparison retreating, advancing and stationary glaciers using data on 50 in 1500 glaciers of Caucasus in 60-80 years led the American scientists D.P.Bedford and R.G.Barry [16] to a conclusion that there are no synchronous glaciers fluctuations in Caucasus and the Alps in these years. The conclusion looks like paradoxical one, as both mountain countries get a moisture of Atlantic, are located at close latitudes and have similar mean

intensity of glacier mass balance- 190 g/sm^2 in Caucasus and 160 g/sm^2 in the Alps [6].

The fact is, that all 50 investigated glaciers in Caucasus were retreating in these years while among hundreds investigated Alps glaciers there were retreating, advancing and stationary ones. Involving into an investigation only ten Caucasus glaciers, which were observed by V.S.Tzomaja these years[13], changes a picture a lot: half of these glaciers has increased, half has decreased these years. A method developed by the authors, as was shown in the Alps example , allows to get a correct picture, using data on a few glaciers.

Information on the Alps(Tabl. 2) and the Caucasus (Tab. 1) glaciers were put into database to compare their dynamics. This data was transformed in GRID format, and then the isoline maps of annual glacier fluctuations of both mountain countries were constructed (Fig. 1,2). A way to create a statistical surface with the help of the polynomial of the first power was chosen. This method enables to receive a background surface of the first power as the most generalized image of values distribution in space. The received picture of glaciers front distribution does not depend on the glaciers sizes: in 1986 in both mountain countries the glacier retreat was increased by south, in 1987 - in Caucasus by the north, in the Alps - by the east.

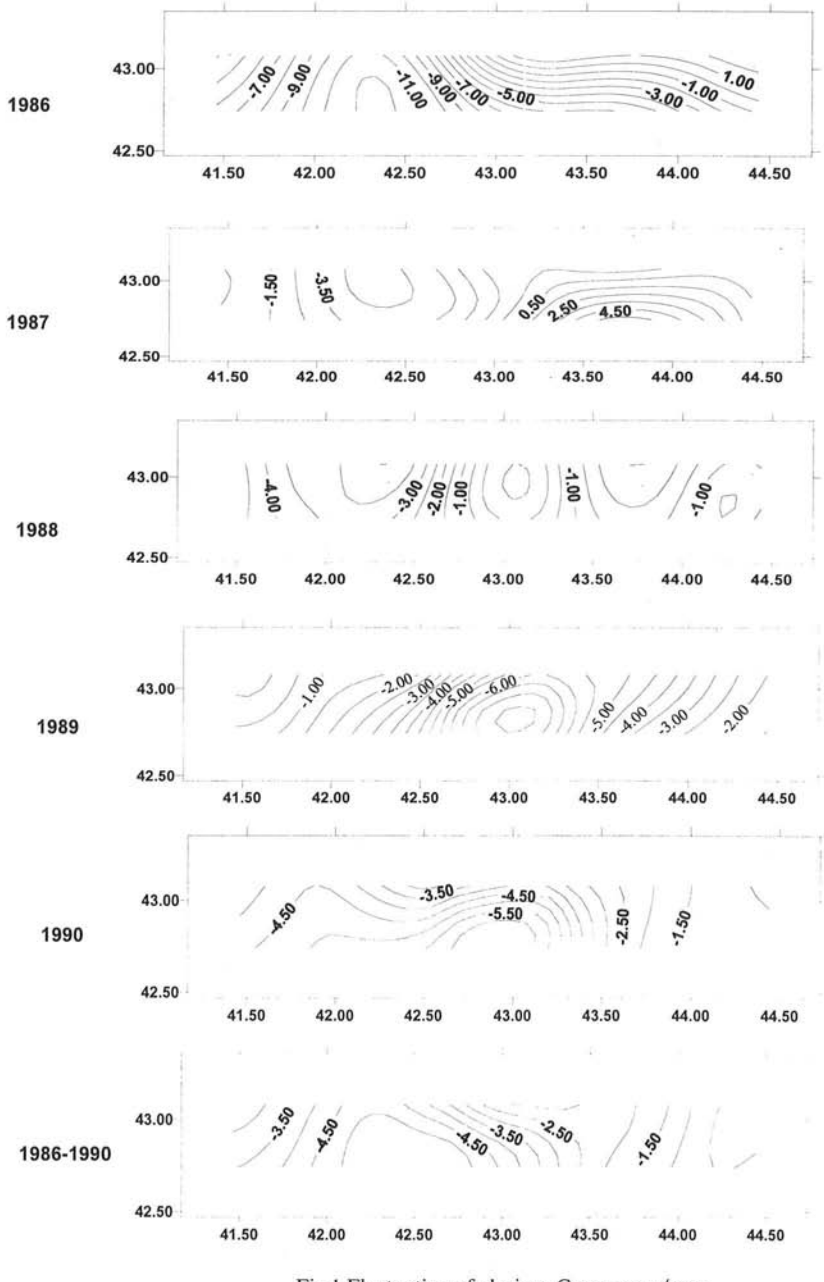

Fig.1 Fluctuation of glaciers. Caucasus,m/year

the axis X- longidude, grad. E
the axis Y - latitude, grad. N

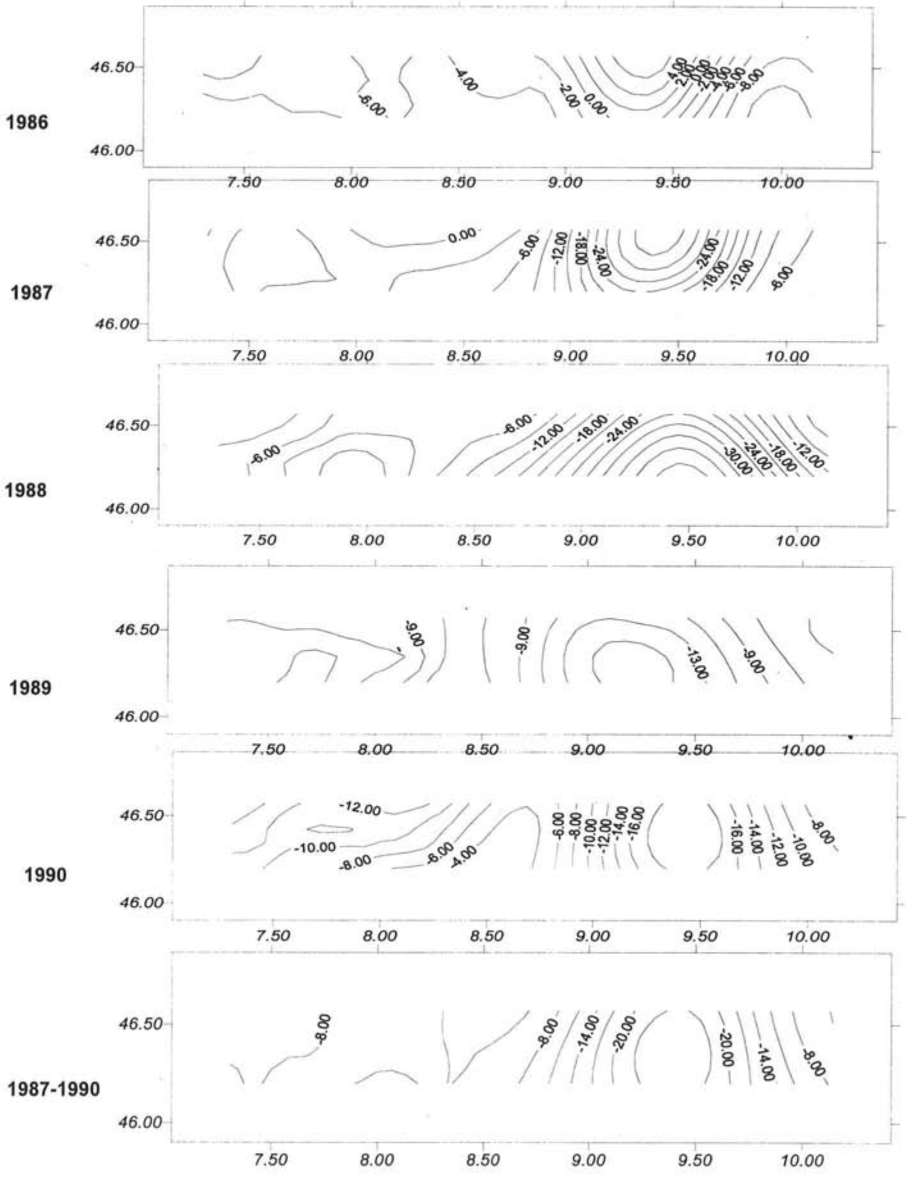

Fig.2. Fluctuation of glaciers.Alps, m/year

the axis X- longidude, grad. E

the axis Y - latitude, grad. N

Now let's to analyse the mean value of each map (Fig. 3). The similarity of value changes from a year by a year is obviously: decrease of retreat in snowy 1987 - as in the Caucasus , and in the Alps - and its increase in next unsnowy years. The mean summer air temperatures in these years were practically constant.

The similarity between snow data of each of these years in the plane territory between the Alps and the Caucasus (in an interval 45-50° N and 30-45° E. (A.N. Krenke personal communication, 1996) and fluctuations of glaciers front are more striking. We should notice, that all analysed 13 glaciers of Caucasus are taken from the list of 50-th ones, used Bedford and Barry, simply applying a less exact method. The analysis of annual changes is extremely important, that in mountains of a moderate belt only the trend of winter precipitation - annual or 10-year moving average [7] - are not similar the summer temperatures trend. It means that the main climatic factor, affecting glaciers behaviour - solid precipitation.

A comparison of the trends of mean values of annual glacier fluctuation maps for the period from1975 to 1990yy and winter precipitation for 9 mountain stations in the Alps [14] confirms this fact.In Fig. 2 is shown mean value of each our maps in 1975-1990 yy It is possible to notice sharp increase of mean value of the glacier fluctuation field in 1975 y. after snowy winter and the same sharp decrease in 1976y after unsnowy winter. In case of small positive digression of solid precipitation in 1977-1985 years the mean values of a glacier fluctuation field are the positive, negative digression of solid precipitation in 1986-1990 years are accompanied by negative mean values of a glacier fluctuations field.

The phenomenon of summer ablation regression and display of positive mass balance of glaciers was marked in 1982 by O.P.Chizov as a result of the analysis of the data for 1959-1975yy. [16]. Now it is safe to say about immediate reaction to solid precipitation of previous winter not only glacier mass balance, but also glaciers terminus. Thus it becomes clear, that alongside with other glaciological borders, the fluctuations of glacier terminus reflect well annual solid precipitation trend and can serve their indicator.

Conclusions

As our previous researches have shown [18], the picture of spatial distribution of annual glaciers fluctuations is unstable when we compared fields averaged over two and three years. When we compared the fields averaged over four years, we have got correlation coefficients between them 0,7-0,9. The maps become to be geometrically similar one another. The values in the maps increase in the direction of the feeding source, reflect the ways of main moisture streams.. Thus, maps (Fig. 2) show, that the main moisture, feeding glaciers in the Alps comes from S-E, and in the Caucasus - from S-W(Fig.1), i.e. in both cases from a Mediterranean part of polar front.

Our researches of average over four years maps of glacier fluctuations [16] have shown general improvement of glaciers state from 1969 to 1985 (mean values :-5,-4,+1,+2 m), and aggravation of that in 1986-1989yy (-6m). Comparison of these data and trends of mean summer air temperature for meteostation Vent in Alps [17] in 1969-1982 yy has shown that the glaciers condition is improved contrary to increase of mean summer air temperatures, and the correlation with the trends of winter solid precipitation..

We can compare (use data [1,2,16]) mean annual glaciers retreating in the Alps and in the Caucasus. For Caucasus glaciers it is -6 m/year in 1966-1969yy and only -3m/year in 1986-1989 yy, for the Alps glaciers -6m/year in 1969-1973yy and -4m/year in 1986-1989yy.

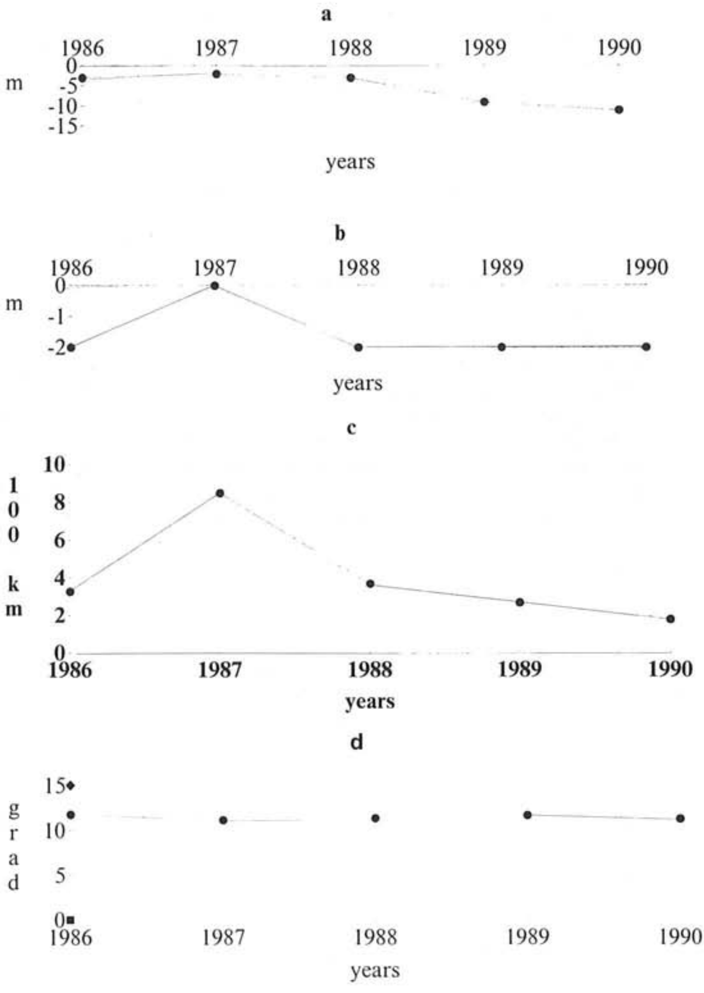

Fig.3 Glaciers and climate changes in 1985-1990yy
a)Glaciers front shift, mean values, the Alps
b)Glaciers front shift, mean values, the Caucasus
c)Solid precipitation, Terskol meteostation (the Caucasus)
d)Average summer air temperature, Terskol meteostation

By other words, the trends of glacier fluctuation in the Alps and in the Caucasus were similar and in last five, and in last 20 years.
We can coclude that mapping of annual snow and ice changing is the real instrument for study mountain climat variability.

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LANDPLAN™ - AUTOMATED GENERALISATION COMES OF AGE

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Abstract

This paper describes one of the exciting developments at Ordnance Survey® which has enabled an innovative solution to map generalising from 1:1250 to 1:10 000 scale. It describes developments in technology which have been harnessed to deliver a new product to our customers, and outlines the processes from data creation to product delivery.

BACKGROUND

Ordnance Survey (OS) has been producing 1:10 560 / 1:10 000 mapping for over 150 years. It is one of the oldest published map series and is the largest scale of British National mapping to a single specification. There are 10,577 maps in the series which are derived from the three basic scales of survey (1:10 000 in mountain & moorland areas, 1:2500 in rural areas, and 1:1250 in urban areas).

Many traditional methods of production have been used over the years, including the manual generalisation of map detail by highly skilled cartographers and subsequent printing by lithographic offset techniques. These processes are both expensive and time consuming. It has long been an objective of OS to automatically derive smaller scale mapping from the basic scales of data with the aim of:

- developing a specification that fully meets the needs of the customer;
- reducing production process times and thereby improving currency;
- reducing production costs;
- ensuring consistency between OS products by direct derivation;

- improving consistency of detail across OS sheet lines;
- providing seamless, site-centred mapping;
- investigating onward generalisation to further smaller scale map series.

Most of this has now been achieved by combining the power of OS data with the functionality of Intergraph® software and hardware, and the marketing flexibility of the Superplan™ Agents Network. As a result, one of the first largely automated generalising production systems has been created in which base data is used to derive mapping at a significantly smaller scale. OS is using this production system to replace its conventionally produced 1:10 560 / 1:10 000 mapping with the Landplan product range.

BRIEF HISTORY

Since the early 1980s, OS has been involved with ongoing research and development into production methods for derived 1:10 000 series mapping. This work gathered pace in the early 1990s with the creation of an experimental generalising system which was targeted specifically at deriving 1:10 000 mapping from OS basic-scales source data. This work was supported by continuous technology tracking of automated generalising techniques, and the evaluation of new and emerging tools for map generalising which included Geographic Information Systems and Expert Systems technology.

DEVELOPMENT APPROACH

A prototype system was created and a number of 1:10 000 test sheets of contrasting content were produced and used to:

- determine comprehensive customer requirements through an extensive market research exercise (Landplan is a mapping product which has been designed by its customers);
- test the feasibility of existing technologies to create the product;
- produce metrics on which to build a Business Plan.

The system development process involved Open Tender Procurement which was advertised through the European Journal. This confirmed our technology tracking findings that there was no complete off-the-shelf solution available at that time, and that the existing technology was relatively unproven.

OS has therefore taken a pragmatic approach to system design by utilising existing technology where it is sufficiently mature and adding custom code where feasible; or relying on manual editing where it is currently more cost effective to do so. A modular design will allow components to be added or replaced as better approaches or technologies are identified.

The development work has involved dedicated, highly skilled technicians from many areas of OS working as a team. Development has been guided by the OS Quality

Management System which has enabled ISO9001 accreditation at Ordnance Survey, and also by the PRINCE project management methodology.

LANDPLAN SPECIFICATION

The data specification is designed to meet the requirements of a graphical output and includes:

- area patterns and tints such as water tint and tree symbols;
- complex line styles such as hachure symbols for slope features;
- digitally reproduced ornament such as flat rock features;
- high-quality text fonts (Univers and Lutheran) and a hold-out effect;
- visual edge-matching across sheet edges.

The data specification will support a Landplan product range which includes:

- colour or monochrome plots on paper or film;
- site-centred output indexed by postal address or grid referencing;
- 1:10 000 (5km by 5km) or 1:5 000 (3km by 3km) scale sheet formats;
- colour and monochrome raster on CD-ROM.

OVERVIEW OF THE PRODUCTION PROCESS

Landplan is derived from existing OS datasets from which the following OS products are produced:

- Land-Line® - basic-scales mapping (point and line data);
- OSCAR® Asset Manager - road centre line data (link and node data);
- Land-Form PROFILE™ - contours and spot heights (point and line data).

Landform ornamentation from 1:10 000 archive drawings is also incorporated into Landplan. These drawings are scanned, vectorised and included in the production process.

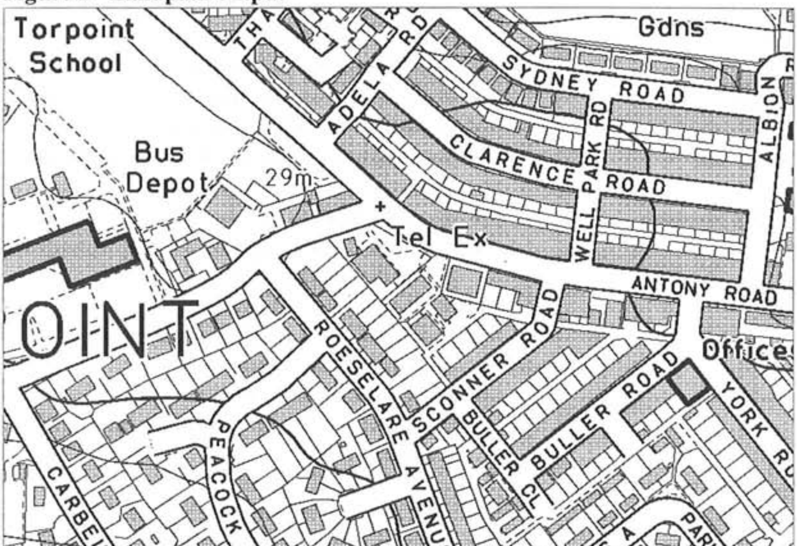
Landplan production involves two main stages. The source datasets are fed into a batch generalising sub-system which is a 'black box' process in which around 80% of the data manipulation is performed. This is followed by an interactive edit process where skilled operators inspect and edit the data to fully meet the specification.

MAP GENERALISING PROCESSES

In addition to the system creating explicit polygons for buildings, water, vegetation and landform features; map generalising processes are applied to many map features. Some processes are automatic, some interactive and in some cases (where automatic generalising is difficult) features are flagged to aid interactive editing. Full use is made of the feature coding in the source data as a means of helping the selection / omission process. Figures 1 and 2 show an example of 1:1250 source data, and the generalised Landplan output.

Figure 1 OS 1:1250 basic-scales mapping

Figure 2 Landplan output



The main generalising processes are listed in the following table:

feature	process
Buildings and garden fences	• omit small buildings. • remove internal building divisions by aggregating adjoining buildings. • simplify building outlines by removing small juts and recesses. • omit some garden fences & re-join where connected to generalised buildings. • identify and symbolise important buildings.
Vegetation	• delete small areas of vegetation. *using a rule base which identifies priorities*: • classify non-overlapping vegetation polygons by calculating valid combinations from the hundreds of possible combinations.
Landforms	• omit small extents of cliff & inland slopes.
Text	*using a rule base:* • select, classify, resize, reformat, reposition, remove duplicates from adjoining basic-scales source components.
Water	• omit small areas of water. • identify and symbolise water point symbols.
Railways	• collapse double lines to single. • classify as multi-track, single track, siding.
Minor Detail	• select line and point features, depending on type of geographical area.
Complex linework	• filter linework to remove redundant data points. • construct continuous links for line features with a complex output style.
Roads	*using the OSCAR input data:* • exaggerate road widths and remove the underlying basic-scales data. • place road names centrally to extent. • place Department of Transport road numbers at each road end.
Height information	*using the Land-Form PROFILE data:* • select 25% of source scale spot heights. • add text labels for contour lines and spot heights.

THE LANDPLAN PRODUCTION SYSTEM

Batch and Edit sub-systems

The system is based on Intergraph's Modular GIS Environment (MGE) and Bentley Systems' MicroStation®. MGE supplies the overall user-interface to the applications and file/database management facilities. MGMAP and Map Generaliser are Intergraph applications which are built on top of MGE and provide structuring and generalising facilities. MicroStation provides the editing capability, and is also the basis for the custom batch processing.

The Intergraph environment is a toolkit around which we have written many software routines in order to provide a complete and effective solution for OS.

The production system involves the following key processes:

Import source datasets
Convert to Intergraph's Design File (DGN) format.

Structure Basic-scales data
Build each basic-scales Digital Map Unit (DMU) into link and node structure and form polygons by using facilities within MGMAP. Basic-scales DMUs are then merged ready for generalising processes to be applied.

Generalise datasets
Apply generalising processes using a combination of custom routines and some tools from Map Generaliser. Experience has shown that the sequence in which processes are performed is a vital part of effective map generalising.

Interactive edit
Use custom-made tools in a MicroStation editing environment to bring the batch processed data to the required specification. Edit tools include a facility to view and copy from any of the basic-scales source data files during the editing session.

Export to storage format
Convert from DGN to the final storage format ready for customer supply.

System configuration

The Landplan production system is a large and complex system where the generalising and editing sub-systems are incorporated into a set of automated production flowlines which are controlled by an OS-customised application of Staffware® workflow software. This software routes all files through a central flowline production server. Production metadata is stored in an Oracle® database and, with the help of a Map Info® user interface, is used for production control and monitoring purposes.

The Landplan flowlines include facilities for:

- visual edge-matching of adjacent tiles;
- error-handling, corrective action;
- data validation checks;
- creation of plots to aid editing and to allow Quality Control and Assurance checks of the data;

- Production Control activities.

The system involves integration across four operating systems:

- Batch processing - CLIX™ on Intergraph's Interpro machines;
- Editing - Windows NT™ on Intergraph's TD30 pentium PCs;
- Production server - Sun Ultraserver running Solaris™;
- Production Control PCs - for MS-Windows™ (Staffware and Map Info).

Staff
The most important part of the production process is the highly motivated Ordnance Survey staff. Although the batch processing is successful, there is still the requirement for expert cartographic skill and judgement in order to complete the process. The interactive editing is proving to be a fulfilling task which utilises existing cartographic skills along with the new skills and techniques that are being acquired by creating a totally new product within a customised editing environment.

STORAGE, DELIVERY, UPDATE

The Landplan System is not only about creation of the data, but also storage, delivery, and maintenance of this data. Figure 3 shows an overview of the Landplan System.

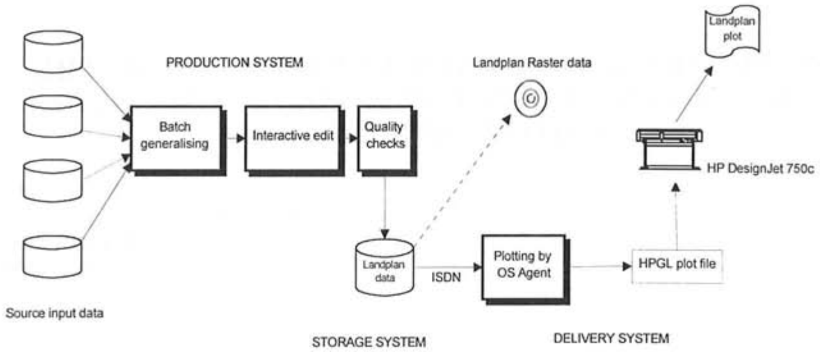
Storage
We have utilised the generic storage facility of the OS national topographic database; enabling efficient storage and retrieval, access control, and backup & recovery.

Delivery
The Landplan graphic product is delivered through the existing network of 35 OS Superplan Agents which incorporates the Agents Plotting System (APS). This system is the most advanced of its type and uses computer and communications technology with the world's first database of national seamless mapping to produce large-scale graphic map products. These products are supplied on demand according to customer specification in terms of content and coverage.

APS is a powerful tool, but is flexible and simple to use. Each system, located on the retail premises of each of the Superplan Agents, is linked by network communications to the database at our Southampton HQ. Maps in an Agent's 'in cover' area reflect the most up-to-date mapping available. Any map not held locally can be ordered directly from HQ via the Wide Area Network using ISDN. APS includes graphic output on HP DesignJet 750C colour plotters using OSPLOT (the OS plotting program). The system provides a cost-effective and flexible mechanism for servicing our customers' needs.

Superplan and the APS won the overall 1996 British Telecommunications Award for Innovation in Electronic Commerce for the year's most outstanding and innovative entry. Landplan is being supplied through the APS. This has presented many technical challenges; mainly concerned with the handling of large data volumes and the output of complex linework and pattern fillings which are part of the Landplan graphical output.

Figure 3 Overview diagram of the Landplan system



Maintenance of Landplan data

Major change such as that affecting road networks and large areas of buildings must appear on Landplan within one year of construction. High-level design work has been completed for the Landplan Update System. Field intelligence for Landplan is currently being gathered when the source data is updated, with OS Field Surveyors in 100 locations across Great Britain flagging basic-scales data files which contain change that is relevant to Landplan. This metadata will be used to guide the update process.

SUMMARY OF TECHNOLOGIES DEVELOPED FOR LANDPLAN

- map generalising techniques;
- automated workflow software;
- user-defined graphic outputs;
- plot-on-demand supply;
- sophisticated plotting program;
- on-line access for Agents to Ordnance Survey databases;
- extensive use of WAN technology using ISDN;
- raster to vector conversion software;
- vector to colour raster conversion software.

THE FUTURE

OS will continue to enhance the Landplan production flowlines - the highly modular design of the system will enable emerging technologies to be incorporated if appropriate.

Landplan is a strategic programme for OS. We have created a practical solution to map generalising from 1:1250 scale to 1:10 000 scale. The technological advances not only support a completely new OS product range but also have significant implications for the future of derived mapping. OS is actively investigating ways of exploiting this technological breakthrough for the provision of innovative products and services in the area of medium and smaller scales mapping.

EARLY FRENCH COLONIAL CARTOGRAPHY OF THE INDIAN OCEAN: THE *DÉPOT DE FORTIFICATIONS DES COLONIES* COLLECTION

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The map collection from the 'Dépôt des Fortifications des Colonies' (the Colonial Fortifications Dépôt) now kept by the French national Archives at the Centre des Archives d'Outre-mer in Aix-en-Provence, gives a fair account of the progress of the French in the Indian Ocean since the end of the XVIIth century. The 5 000 or so documents concerned inform us of the commercial, political and military motivations of the European settlement in this region. The establishment of this map collection, decided by the royal authority, in itself reveals the political representation of its progress and achievements overseas that was prevalent in France at the time. The maps themselves, depicting the various areas where the French settled, express different approaches to this settlement. Mainly nautical maps, constructed on a mercantile logic, looking for new ports of call on the route to India, were then replaced by exploration works of the interior of the newly conquered lands, and then, plans of the first trading posts, or early forts. The XVIIIth century has seen a number of maps that were specifically colonial - a vast inventory task preparing the division of those territories in the next century, between England and France. Military maps though (battlefield sketches or engineers' plans for new fortifications) are by the end of the period the most numerous. These maps appear *a posteriori* as a premonition of the disaster inherent in their object itself.

If one considers the Dépôt as a documentary collection for administrative use, and as a tool in the extension of the royal enterprises in India, the study of its making is very interesting. The gathering of these documents was first made with the special concern of building a useful, geographical and informative base. The more the French establishments grew during the XVIIIth century, the more the administrative concern prevailed in the choice of the information to be witheld, instead of the sole interest for scientific knowledge. After 1776, when the Dépôt was created, this documentary collection was also associated to ruling bodies, watching over the various fortification projects going on overseas. Its goal was then to allow a comparison between what already existed and what was newly planned, but also, to give an evaluation, discussed in advisory commissions, of the military projects that were submitted for approval. From then on, the map was valued not so much for itself, whatever the quality of the information it gave, but rather as one part of a larger set, whose volume was precisely a visible guarantee of its accuracy. The D.F.C. adjusted itself to the progress it had to give an account of. So, the more maps there were, the more neatly the documentary tool distinguished what was pure geography from what was administrative information, separating the nautical maps from the colonial ones. The development of this archival institution gives, in a way, a sort of parallel chronology, which could be useful when one wants to evaluate the '' mental frame '', the perception the royal administration had of its progress in distant lands.

Colbert the founder of the 'Compagnie des Indes' (East India Company, in 1664), had had gathered as soon as 1680 a primary collection of nautical papers. Around 1720, administrative papers were first sorted out, and sent to the 'Bureau des Colonies', created in 1710 within the 'ministère de la Marine' (Naval Ministry). Nautical maps, plans, hydrographic surveys, navy officers' reports and ship logs remained at the 'Dépôt des Cartes et Plans de la Marine'. Among those papers were a few maps specially devoted to the first establishments overseas.

In 1776, two royal decisions prepared the creation of the D.F.C.: on the 7th of June, the king, finding that only '' shreds '' of the engineers' works ever reached France, called upon the governor-generals, governors and commanding officers in the colonies to '' have all the plans gathered, and to have the complete collections passed '' to France, either the originals or duplicates. Eight to nine months of perilous navigation were then necessary for them to reach Lorient (in Britany) from Pondicherry, and this passage was often complicated by the political conditions and the cruising fleets of the enemy. In the Mascarenhas, hurricanes and rats (especially in Mauritius) would make the conservation of papers over a year highly unlikely. On the 4th of February 1731, in Mauritius, a hurricane totally destroyed the office of the Provincial Council, where the island archives had been stocked since 1723. The fortune of war had no mercy for the archives either, and least for the maps, since these were considered secret documents. In 1761, in Pondicherry, the town's papers escaped the city's destruction, only to be captured by the English army. The circular acompanying the edict of the 31st of July 1776 creating the Public Papers of the Colonies Depôt, clearly specifies those numerous dangers. The precautions that had been taken in the colonies until then couldn't protect the public papers from the destructive effect of the climate. The king had acknowledged that ''the best precautions taken on site would have no effect against the climate, fires, earthquakes and hurried transfers in wartime''

In 1778 the 'Dépôt des Cartes et Plans des Colonies' was thus created in Versailles, gathering colonial maps from the Naval Dépôt and from the governors'dispatches. It was planned that every year duplicates of the documents would be sent, and that each engineer-in-chief would have two draftsmen at his disposal, in order to have copies of the ''maps of the surroundings of all the towns, *bourgs*, gun batteries, forts, king's buildings and public works'' sent to Versailles with a « detailled report on the utility of each kind of work ».

The documents we keep show that this disposition was respected - since they often bear close dates, sometimes separated by only a few days, as they were especially written not to miss the departure of the ship to France. When they were received, the documents were then given a reception date, and sometimes even the name of the ship that carried them was mentioned. Most often enginneers would send the tracings, with the main lines of their work, which would be completed by draftsmen in Versailles. Besides, in 1784 a circular prescribed to the governors to have the plans of the ports drawn on a scale of two inches for one hundred *toises*, and also to have maps made of the places where « new establishments for the service of the fleet could be located ». After the Revolution, the Dépôt would experience many changes, additions and removals, before it would finally rejoin the archives of the 'Ministère des Colonies' in 1914 (the fortification plans and sketches having been added as soon as 1899 by the Direction of military engineering).

Documents relating to the Indian Ocean.

The plans and maps kept have a great variety: one can find there the defining of specific sea routes, the progressive search for a better access to the new territories, through compilations and comparisons of the reports of travellers, and then, the delimitation of the land properties, etc. During the XVIIIth century, the need was more marked for an exact topographical information, that would serve military uses, notably in the engineers' works in India. This necessity for a better cartography caused by war would greatly help the European exploration of the peninsula. This typology of the sources made after their use could match up with a geographical typology of the same set: general maps of the Mascarenhas are rather nautical, especially for the Mauritian coast; maps of Bourbon had a more " agricultural " use, whereas Indian maps are mostly from military origins. Those different cartographies have of course grown up of different paces.

The problem of ports of call.

" As soon as the French started trading with India, the question of the ports of call arose imperiously in front of them". Paul Kaeppelin had once demonstrated how sailing conditions ruled the French presence in the Indian Ocean. After long weeks of navigation, the Cape of Good Hope was the ideal stop for sailing ships, having more or less covered half of the distance to India. The Cape also allowed the captains to verify their location, and, according to the season, to choose between two major routes, either through the Mozambique Channel, or going farther down south, to take advantage of the dominating west winds. This latter option was favored by the French, and, since war often forbade stopping there, Madagascar was the first safe landing point in view. The French naturally foresaw the *Grande Ile* as the main base of operations in the Indian Ocean trade. The Mascarenhas were located too far east, and were too far to reach from Europe to be valued as a stop *en route*.

During the whole of the XVIIth century, the French cartography of the region was built on the Portuguese and Dutch patterns, merely adding a few details. Nautical ways, especially, were still elaborated on schemes inherited from the Great Discoveries period. Their objective was to mark routes towards the riches of India; they had to facilitate the access to ports of call and trading posts. Eventually, maps took aim at the domination of a space that was still under definition. Research on new ways of projection, and the new system of skeleton maps designed by Sanson d'Abbeville for a map of Madagascar (1655), with parrallels in a straight line and curveous meridians, allowed to reduce the distortions caused by the impossibility till then to fix the exact meridian for some location. The *Oriental Neptune* published in 1746 is the epitome of all the studies for mastering the navigation in the Indian Ocean. Basing his work on a meticulous critic of the ships'logs kept by the Royal Navy in Versailles, and with the help of the astronomy, D'Après de Manevillette, an hydrographer, built a collection of seventy seven maps, that remained an authority until the middle of the next century. The hydrographer completed his previous observations in two scientific expeditions: in 1750, the Company sent him, with the astronomer Lacaille, to chek the exact location of the Cape of Good Hope; D'Après de Manevillette later left the astronomer in Bourbon, to extend his journey along the coasts of Madagascar and East Africa. In 1758, he went back to India, passing along both the Malabar and Coromandel coasts. Some *Instructions pour la navigation de la France aux Indes*, published in 1768 came after the *Routier des côtes des Indes orientales et de la Chine* (1745). The English translation given by T. Jefferys is additional proof of its success (*Directions for navigating from the Channel to East Indies*). And the next edition of the *Neptune* in 1777, also translated in English, as *The East India pilot*, gives its almost definite aspect to the maritime space so coveted. D'Après de Manevillette's nautical maps will be used for the revival of the french colonial politics, lead by the Choiseul clan. After the sea expeditions, came the land explorations. The second half of the XVIIIth century is the moment when these territories, which were only used at that point as ports of call, are more carefully listed. This survey, in which topography is the most important, will be later used, in the distribution between the colonial powers.

Madagascar.

The 'Dépôt des Fortifications des Colonies' has hardly any recollection of the early french endeavours in Madagascar, since there are no XVIIth century maps of the island kept. It is well known that the failure of the settlement in Madagascar has forced the French to move to the Mascarenhas, some historians even mentionning those islands as ''resignation colonies''. In 1774, survivors from Fort Dauphin, where settlers had been slaughtered by the natives, came to Bourbon and formed the nucleus of the colony. The D.F.C., a colonial creation after all, reflects exactly this situation, since the first map it has to offer is a map of Sainte-Marie, in 1733, and the rest of the set is dated on and after 1760. Moreover these maps moreover are for the most part anchoring surveys and soundings. It's then striking to see how little the exact knowledge of the island mattered. For instance, the anonymous author of a remarquable plan of Sainte Marie's port, undated, point out that this plan was made up ''from memory only, but, to within more or less a few *toises*, it is an exact representation''. For this island, he states that this kind of map, however imprecise, is ''enough to know how it is possible to defend oneself there, by land or by sea''. Most of the maps we have are maps of parts of the coast and surveys of the arrangements for shielding the first establishments roughly settled there; more maps, by the end of the century, are still nautical works, very technical, and in fact, simply depict the coast lines. One has to wait for Maudave's attempts, and particularly Benyowsky's, to have better informed maps of the interior of the island. The Russian adventurer's settlement is especially well described, with over thirty maps, that show what Benyowsky brought to the geographic reconnoissance of the island. The " Discovery map of the channel between Antongil Bay and Morungana Bay " is a perfect example of it. As for the vast and impressive " Map of Madagascar after various writings and travels accomplished by the Baron of Benyowsky ", it stands more as a sort of political proclamation. This empire that was for a time dreamed of, would finally vanish with its dreamer, and Benyowsky's works would have no immediate followings. It's only during the first half of the next century that the French would throw themselves into the systematic exploration of the interior, after Owen's works gave its almost definite contour lines to the island.

Mauritius (l'île de France).

On the contrary, there are plenty of maps that have been kept for the *île de France*. The island cartography has known three distincts periods, and follows the colony's progress to the detriment of Bourbon.

From 1721, when the French regained possession of the island, to the arrival of La Bourdonnais, hydrographic interest came first: cartographers merely pointed out the most interesting spots for anchoring, and at that time, Bourbon was still the most favored port of call for vessels on their way to India. It's not until 1795 that the hydrography of the islands would be finished, since, even with D'Après de Manevillette's works, " the multiplicity of the observations made " wouldn't prevent the " difficulties met by all of those who continually sail between île de France and Bourbon ". In 1722, the engineer De Nyon landed in Mauritius, freshly promoted governor and engineer-in-chief, a double attribution which indicated what was then the royal authority's priority there. As a matter of fact, Nyon's charge was to settle a new port - his work would found the ground cartography of the island for the next thirty years. In three months, he went all around the island and set the projects of two ports, North-West and North-East. He also left a special plan of Port-louis, with the proposed fortifications. Nyon left the island in 1725, driven out by the rats and the hurricanes. Cossigny's assignment in 1731 marked the beginning of the second period in the history of the island's geography. The latter had been promoted engineer-in-chief of the island, specially commissioned to explore the interior and make a report to the king about its ressources. This report was so positive that it seemed necessary to promote a talented man as the next governor: it would be La Bourdonnais. His energetic work will change the fate of the Mascarenhas. Ile de France became the center of government and the center of administration and commercial influence. During the war with England, it also served as the main base for naval operations. Mahé is a sailor, so his vision of the future of the island was mainly nautical. It's the expedition he had sent for a new route towards India that discovered the Seychelles archipelago, whose main island would later bear his name. He took no further interest in Madagascar's colonization, but favoured the Indian trade. Its extension made the arranging of a suitable port necessary; it would be Port-Louis, whose building would obsess Mahé's successors.

These successors though prefered to apply themselves to the agricultural development of the colony. Lacaille's astronomical reckonings in 1753 would later be used as references for many cartographic works, which would make the first exact maps available. In 1773, Cossigny will still use those numbers to give a new map of the island. It's not before the end of the century that there will be definite works though. The engineer-in-chief of Pondicherry, Bourcet, for instance, took advantage of a call at Port-Louis in may 1765 to draw a map of the town. In a letter to the Secretary of State for the Navy, he regrets that only " very bad " maps of the island are still available. This reproach constantly came back in the letters the engineers wrote to Versailles, during the whole french period. In fact, there was no energy, and even less money, for such undertakings. In 1786, Rambaud, another engineer, gave an estimation in a "Memoir for the topographic and military map of Bourbon", of four to five years of work to draw the general map of the island, "with only four engineers" and for a cost of nearly 200 000 pounds. The neverending war with England for the domination of India would give only a secondary importance to this. It's the third period of the île de France cartography that then began, more martial.The great venture of the last years of the century was the developing of Port-Louis' haven into a vast seaport. Tromelin, navy captain and engineer, undertook the the task in 1768, and many are the plans testifying of his efforts for the cleaning out of the harbour obstructed by ship wrecks and invaded by the mud coming down from the neighbouring hills. Besides, a new safety port was to be set up at the *Trou Fanfaron*. The portefolios are filled, a few years later, by the projects of Querenet and Des Roys to fortify the town. That's the dominant feature of the french cartography of this age, to be moving on to military tasks only indirectly helpful to the geography. The number of engineers on duty is even reduced after the completion of the fortifications : in 1782, there were only two engineers left in Mauritius, and one land surveyor; in Bourbon, only one engineer and one surveyor. There still were, besides them, the geographer and the drawer appointed to the general topographic map of the island begun under Canaple's direction, but the latter, with his assistant, the enginner Malavois, had both been sent to India, to follow the military expedition against the British. For now on, geographic works would be kept at a standstill, and the governor Souillac could only send back to France the map of the first part drawn.

La Réunion.

The Réunion portefolios, even if quite bulky, have only a few XVIIIth century maps, and except some coastal surveys, barely none from the XVIIth century. Most of the thousand and five hundred or so pieces kept deal with the Department of Civil Engineering works, roads, barracks, warehouses in Saint-Denis and Saint-Paul. For the XVIIIth century, all we have is a modest set of maps drawn by chevalier de Nyon, Sornay and Cossingy - a series which ends in the years 1738-1740. This mysterious deficit could find part of its explanation in the preference La Bourdonnais marked for the île de France, new center of the French government in the Indian Ocean [1]. It's now Port-Louis, and not Port-Bourbon anymore, which hosts since 1738 trading vessels for India. The main calling for Bourbon was then to be île de France's granary, a colony mainly agricultural. Civil works, surveys and land demarcation had then a significant importance. The treaty Guyomar wrote about the "necessary operations for the practice of land surveying in the isle Bourbon" is in this respect a fascinating document, showing the cartographers' complex working conditions. Guyomar was appointed engineer surveyor in 1734, in the city of Saint-Paul. Four years later, he wrote to the island's Superior Council, asking to be commissioned as the royal surveyor for Bourbon, whose newly created position would be highly profitable to the Company, since it would be possible to know exactly what the extent of its properties were, with all the related taxes. Guyomar had also made plans for a general map of Bourbon. "I will gather all my own plans, in order to put a general plan together, and I will do my best to finish it off, going all around the island by land, which will be no easy matter (...) Further more, my lords, I will do all the astronomical reckonings that I'm able to". Besides, the surveyor asked for two assistants, a drawer and a clerk, though he then estimated that five or six would be necessary to make the map of the major part of the cultivable land. In this case as well, surveying is done by compiling limited studies and informations. It is an archivist's cartography, so to speak, whose best results could have been the *terrier* made by the engineer geographer Selhausen in 1817. It was a compilation "bearing the first concessions, their dimensions, and the owners' names, according to the title deeds, contracts, maps and surveying statements kept by the Archives".

India.

Maps and plans of the Indian portefolios are probably among the finest from the whole collection, for their quality, age and diversity. Maps of forteresses in India were used to appreciate the ennemy's potential, on a global scale; they then often had a better collective worth, gathered in portefolios or in atlas. Their aim in fact was not to give away the weakness of such or such citadel at some precise moment, but rather to give an estimation of the global opposing forces. This concern, about a possible military panorama, is quite obvious in manifold maps, where details about various forteresses are given in marginal inset maps. One example for this kind of work would be the anonymous *Divers plans du Carnate, côte de Coromandel*, which gives in 1770 plans of nine places, each with a specific scale. Engineers' maps are strategic tools, not a spatial representation, but a spatial reconnoissance for future action. Such maps don't give the description of a place, with signs or figures, but, rather, the examination of the general state of the place. They anticipate the object they depict, since their author has to

[1] Maps of the National Library in Paris reveal the same deficit from 1740 to 1815. Cf. Monique de la Roncière, *Les sources cartographiques de l'histoire des Mascareignes et des Seychelles à la Bibliothèque nationale*, in "Mouvements de populations dans l'Océan Indien", p. 337-346, Paris, 1979

make out, through the landscape, what doesn't yet exist, profitable possibilities for an offensive action, for instance. The cartographer's reconnoissance is both a strategic and subjective choice.

Battlefield scale drawings were devised on a different perspective, for they were, in a way, the military drawer's "purple passage". These reports of the attacks against some fortified town were dedicated to the victorious general, and sometimes even payed tribute to the defeated one. The very impressive set about Pondicherry's siege in 1778, dedicated to Bellecombe, paradoxically celebrates the destruction of the grandiose dream of a French India, its capital shown in its full vigour, at the precise moment of its capture by its arch enemy. Maps of besieged Madras in 1746, or the first siege of Pondicherry in 1748, provided the same ambivalent nostalgia, showing both French success and the failure of the "imperial dream"

Military engineers' work were considered top secret. Surveys for the exclusive use of European nations officers involved in the peninsula's conflicts were constantly updated, but wouldn't appear in geographers' books, which were most often general and late compilation works. Southern India, this great "theater", as it was written in fashionable engraved maps of the time, of wars between England and France, was then criss-crossed by cartographers, but the country remained this "great extent of land we have no knowledge of" that D'Anville describes. On the English side, it's only after the battle of Plassey that the cartography of Bengal and northern India would begin, thanks to the vast surveys encouraged by the Local Council in Calcutta. Those works were also the result of amazing individual adventures, that it would take too long to fully expose here. The best example could be marquis de Valory's career. An aventurer and a cartographer, this military officer in Mauritius took advantge of a leave and deserted Port Louis barracks for eight years of eventful peregrinations. His only wealth, when he came back to France, were some twenty maps that he drew up in India, which he would use when he had to negociate his reinstatement in the ranks. Valory was claiming that his works were invaluable, for all the information it gave about regions still barely known, and specially about citadels that were there. Consequently, the fact that he has left his command in Mauritius is of secondary importance, he says, compared with the outstanding interest of the work he had done in India. One could hold up as an example, among others, Lafitte de Brassier, French engineer and geographer, prisonner of the English in Madras in 1778, who managed to draw sketches of their citadel without his jailers knowing. Another example would be artillery officer Gérard, who took part in all the battles of the Lally Tollendal's expedition, and who, back in France in 1762, presented all the maps he had done, to the Naval Secretary of State. These documents were not, for this officer, just the concrete evidence of military facts, but the facts themselves, for which he asked the Saint-Louis Cross as a reward.

The loss of French India, reduced to a handful of trading posts after 1783, the taking over of the île de France in 1811, would restrict the French cartographers sphere of activity. Besides, the Geographic Engineers Corps was suppressed in 1784. Bourbon was thereafter the only French colony remaining, its map almost totally drawn up at the beginning of the XIXth century. Strictly speaking, the colonization era had begun, and the development works replaced the exploration and inventory studies. An adventurous chapter of the history of the geographic progress in this part of the world was by then closed.

Source materials:

Centre des Archives d'Outre-mer, Aix-en-Provence. Dépôt des Fortifications des Colonies:

IV. - Ile de France, cartons 11-15, portefeuille 6-8.
V. - Réunion, cartons 16-25, portefeuille 9.
XVII. - Sainte-Marie de Madagascar, cartons 88-89, portefeuille 28.
XX. - Pondichéry, cartons 98-102, portefeuille 32-34.

TOPOGRAPHIC DATA PROCESSING

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ABSTRACT

In a spatial information system such as topographic information system, two basic types of data are used to describe topographic features: spatial and non-spatial data. Spatial information is always related to geographic space. Geographic information system technology involves objects and their relations in geographic space. Therefore, all spatial data must be structured to make possible the concise and logical definition of spatial relationship between objects.

This paper presents the practical methods for making a vector based data structure, and how spatial data can be produced and related to each other by topological relationships.

The proposed approach is used to establish the National Topographic Database of Iran at scale of 1:25000

Introduction

The spatial data structure allows the digital representation of the conceptual data model inside a computer. There are two basic ways of representation of spatial data namely, Vector based data structures and Tessellation based data structures. [Raper and Maguire (1992)]

Topological data structure is the most widely used class of vector based data structures. One particular form of topological model is termed the Arc-Node data structure. In this model the Nodes, Arcs and Polygons form a hierarchy of topological elements upon which topological structures are built.

In a Topographic Data Base (TDB), use of topological elements is a fundamental approach to express spatial relationships among the features. The procedures of forming the above mentioned topological elements from photogrammetric data for establishing the National Topographic Data Base (NTDB) of Iran are discussed in this paper.

Input Data

The information needed come from a wide range of resources. Surveying and photogrammetry are two of the most widely used methods for collecting GIS data.

At the NCC, photogrammetric data is collected by applying of upgraded analogue stereoplotters. This method is used to capture coordinate data for desirable map features by observation in a stereo model. Finally, digital graphic files are obtained via the Intergraph MicroStation System.

Pre-Processings

After opening graphic models in MicroStation graphic environment, all the models which make a map sheet at scale of 1:25000 must be selected, and merged together subsequently. To form a sheet, some processings are performed automatically by running a software developed at the topographic data processing section. This software consists of the following programs:

1. UTMLCC Program

Iran is covered by about 132 blocks of map sheets. There are 96 map sheets per block at scale of 1:25000.

This program provides the geodetic and Cartesian coordinates for all corners of the map sheets by a certain algorithm. The Cartesian coordinates can be obtained from the geodetic coordinates in two map projection systems : Universal Transverse Mercator and Lambert Conformal Conic. This program accepts several input formats such as blocks, data files or single data. For example, in the single mode we can enter a geodetic coordinate and get a Cartesian coordinate as an on-line output , whereas in data file mode we must write geodetic coordinates in an ASCII text file and enter the name and path of the file and so, we can get the results as an output file.

2. TAFLN Program

This program separates the coordinates of a map sheet from a master data file and writes them into an ASCII text file by a appropriate input format.

3. CHKSTN1 Program

When the stereo models are merged in the graphic environment of MicroStation some settings like view, level, working units, global origin, depth and... have to be adjusted.

Two merged Models

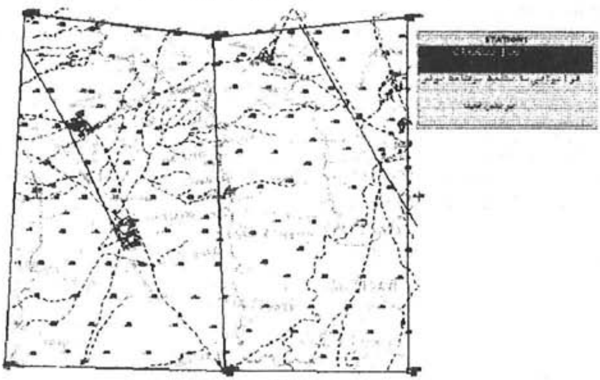

Fig.1

4. CUTSTN1 Program

This program reads the coordinates which located in an external data file. The border of sheet is placed in the design file and then the map sheet will be cut in the standard size at scale of 1:25000.

It's necessary for digitized line work that to be cleaned. Therefore, the operator uses Intergraph Modular GIS Environment (MGE PC-1) applications which let him/her manipulate existing graphic data. At first, the elements are selected by Selection Set Maker tool of this software. Then the Line Cleaner tools process the elements in the selection set and copy all error flags into a given level. These errors include undershoots, overshoots, intersections and duplicate line segments. After processing, the error flags are placed in the map around free-endpoints and intersections.

Generalization of spatial information

Generalization in the context of this paper defines the process of geometric line thinning for linear objects and deletion of specific internal boundaries for surface features.

At the NCC a program has been written in MicroStation Development Language (MDL) for line simplification. The users run the program on two layers : contour lines and water courses. This program will reduce the redundant points of linear objects within a given tolerance. On the other hand, the concept of generalization contains removing the internal boundaries from vegetation polygons. The external boundaries of vegetation areas must be closed with certain man-made or natural linear features. This work is performed related to viewpoint of the operator. Running these processings improves screen update time, plot-stroking performance, spatial analysis processing time and reduces disk space requirements.

Cleaning and Node Creation

Semi-automatic editing of intersection & free-endpoints such as cleaning because of under/overshoots is performed by a software that has been developed at the GIS department. This software developed so far consists of a set of programs for cleaning and Node creating :

1. Automatic Retreivation Program

The aim of this program is :

Selection set of all error flags in a specific level and display flags by a suitable zoom of view.

2. Three Ways Intersection (T) Correction Program

At first, the element that must be extended or shorten will be selected and then the other element will be choosed (see fig. 2). Now the overshoots or undershooots will be resolved and the Node will be created as a topological tool in the intersections. This program is performed only on special types of elements such as line and line-strings.

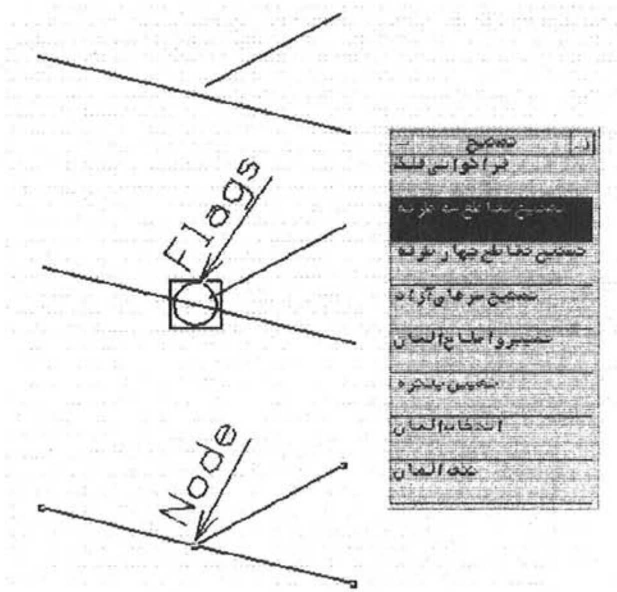

Fig.2

3. Four Ways Intersection Correction Program

When a flag is selected, it will be removed and the Node will be created (As shown in figure 3).

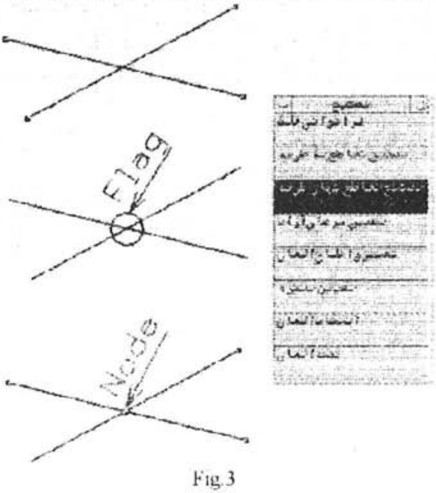

Fig.3

Advantages of Cleaning & Node Creation Program

The speed and precision of the operation will be increased due to :

- Several operations of some tools or icons are combined.
- Some of additional procedures are reduced.
- In order to create a Node, we don't need to snap a tentative point on elements; this problem will be solved with getting the coordinates of free-end or intersection points of elements.

Arc Making

Arc is the basic logical entity in Arc-Node data model. Arc processing contains the linear object layers such as transportation networks and linear water bodies. Using the Create Complex Chain tool of MicroStation,operator chains the line segments and makes an arc which is terminated by two nodes.

The features in table 1 should be structured as arcs.

Level	Features	Level	Features
36	Stream & ditch	59	Pipe line
37	Stream + trees	29	Fence
38	Water course	30	
39	Canal	4	Trench
43	Qanat	40	Dam
50	Road	58	Power line
53	Railways	35	Floodway
54		33	Boundary
57	Tel. line	34	River
3	Pit & Pile	31	

Table 1

Polygon Making

A polygon is comprised of a closed chain of arcs that represents the boundaries of an area. Areas such as vegetation covers or major structures are stored in polygon data layer. For polygon making, these areas are closed by Create Complex Shape tool of MicroStation. Although, polygons are made by manual method, some softwares provide operator's comfort

The features in the table 2 should be structured as polygons .

Level	Features	Level	Features
25	Building block	6	Sand area
26	Industrial center	13	Marsh
28	Ruined place	14	Forest
34	River (wide)	15	Meadow
35	Floodway (wide)	16	Orchard
39	Canal (wide)	17	Bush Covered area
44	Pool	18	Cultivation
45	Lake	19	Cultivation +Trees
46	Pond	20	Palm tree area
50	Square (big)	21	Vineyard
3	Pit & Pile (wide)	22	Rice paddy
48	Cemetery	23	Tea plantation
5	Rock	24	Salt flat
27	Building	40	Dam (wide)

Table 2

Feature Forming

One of the important processings is referred to feature forming. In this step, all the arcs of a linear object which have common properties will be associated. For example in conceptual model we define "Main roads" subclass that contains "Asphalt road 1" & "Asphalt road 2". While in a road network, all the extensions that have a numeric code with the same number (i.e 1 or 2) will be associated.

Edge-matching

Features along the map edges differ in the degree of position discrepancy. For matching the features that exceed the edge of map sheets, one of the map sheets should be opened as active design file and another as reference file and so the discrepancies of features would be reconciled on active file to produce a continuous map coverage.

Other Processings

1.Control of omitted or deleted features in the design file with a check plot or an original file. If the operator finds out an deleted element he can retrieve it from primary design file.

2.Control of the appropriate levels for different features.

3.Setting the accurate symbology on each level. For this purpose, some programs such as "PREAG" have been developed.

4.Automatic deletion of duplications.

5.Quality control of the design file and providing quality report by executing MicroStation Edit Graphics (EDG) programs.

6.Controlling the point symboles.

All the topographic data processings will be done by the field completion of arial photos.

Conclusion

Topographic data processing is an important task of GIS department which is performed in a quick, and flexible method.

This paper concludes that most of processings are performed via programs developed under Intergraph MicroStation or MGE softwares. These softwares provide powerful graphic environments which enable us to do more widely manipulating and handling of topographic data.

As considered, the main aim of topographic data processing is definition of data structure. We selected a vector based data structure because it provides the precise positioning of features in space. The approach used is a topological model as termed Arc-Node data structure. This data structure is a form better suited for spatial analysis such as adjacency, connectivity and etc. This model increases the speed of spatial data retrieving, processing and other graphic studies. Another advantage of this structure is that the spatial analysis can be done without using the coordinate data. As result, many spatial operations performed much more efficiently and largely by a topologically-based GIS.

Although, line of operations has been developed based on the available equipments, but it is not fixed and may be improved from one period to the next.

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USAGE OF NATURAL OBJECT GENERALIZATION PHENOMENON IN SATELLITE IMAGES IN GEOLOGIC CARTOGRAPHY

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Abstract

Natural generalization when passing from large scale images (with high resolution) to small scale images (medium and low resolution) manifests itself in two ways: the intergration of several contours into one or relative increase (or decrease) of an area of some types deposits observed in images.

1. Introduction

Images ofGeological bodies on satellite survey materials (providing the deciphering of images is good) possess higer geometrical similarity to the real form of bodies then in initial large- and medium- scale maps used for compiling small-scale geological maps. This may be explain by interpolation of ground observations which stimulates an appearance of mistakes as a consequence of subjective generalization. That is why in geological map compilation satellite survey materials provide a choice of in optimum version of contours of geological objects shown in the map most close to truth contours. In this case the effect named "a phenomenon of natural generalization" is used. This effect appears when comparing the images with different resolution.

2. Analysis of images of different scale

Study of natural generalization in geological map compilation was made on the example of a well outcroped region of the Pitniakskaya Upland in the north-western part of the Turkmenia [1].
On the basis of interpretation of satellite images with high and medium resolution the sketch maps of geological structure on 1:200,000 and 1:1,000,000 scale were composed (Fig.1) and their comparison was made with the aim of determining the generalization character in transition from larger scales to smaller ones. A published geological map on 1:200,000 scale was used as a geological basis. Age dating of geological bodies revealed by the images was made using this map.
In the geological map Upper Pleistocene sands and marls up to 25 m thick are shown as discordant bedding on Upper Cretaceous sediments on the left bank of the Amudaria river. On the chart of geological structure on 1:200,000 scale (Fig.1A) Upper Pleistocene sediments are represented in form of separate stains as they are deciphered in satellite images of high resolution. In the chart on 1:1,000,000 scale (Fig.1B) areas of distribution of these sediments revealed on a basis of chararacteristic signs are even more increasing.

Upper Eocene sediments, represented by shales and marls are almost completely covered with modern sands and may be rather clearly revealed only in satellite images

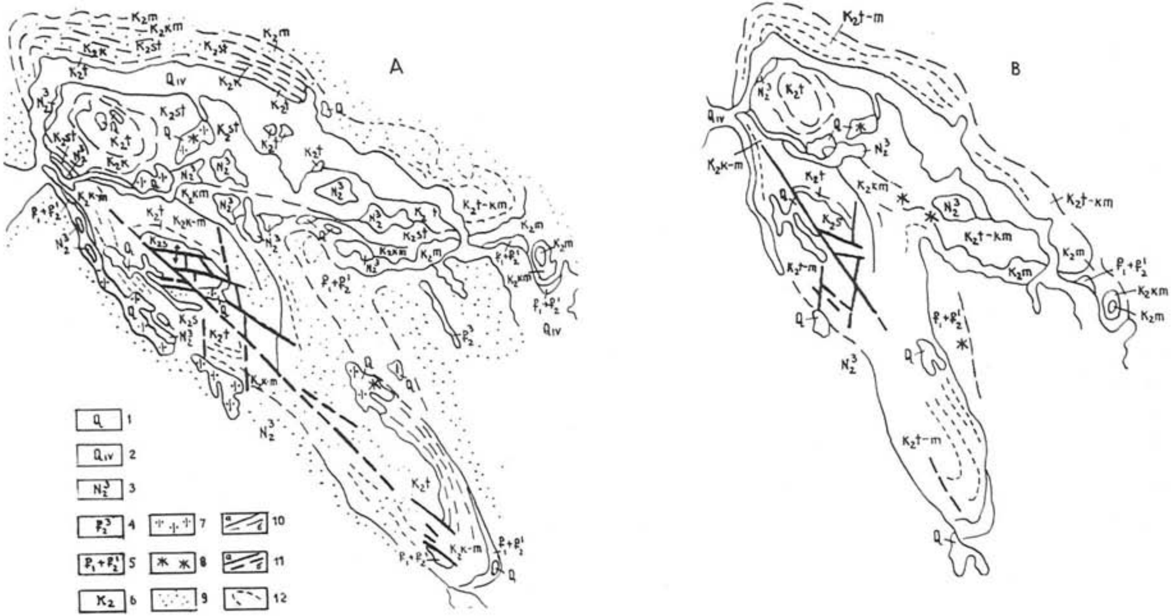

Fig.1. Chart of geological structure of the Pitniakskaya Upland (South-Western Turkmenia):

A: Chart on 1:200,000 scale, compiled from satellite images of high resolution;
B: Chart on 1:1,000,000 scale, compiled from satellite images of medium resolution;
1, Undifferentiated Quaternary sediments; loans, sand loams, sands; 2, Modern sediments: river sands; 3, Upper Pliocene; sands, marls; 4, Upper Eocene; shales,marls; 5, Pliocene - Upper Eocene; marls; 6, Upper Cretaceous sediments (K2 km - Maastrichten, K2 km - Campanian, K2 st - Santonian, K2 k - Coniacian, K2 s - Senomanian), undifferentiated or partly differentiated; sandstones, shales, marls, aleurolites; 7, saline soil; 8, takyrs; 9, eolian sands; 10, geological boundaries deciphered to a different degree (a,

with high resolution as shown in the chart on 1:200,000 scale. In the small-scale chart these sediments are not shown because of small sizes of their outcrops, but they may be revealed from tone contrasts in the used images on 1:1,000,000 scale.
Undifferentiated sediments of Paleocene and Upper Eocene age in the south of the Pitniakskaya anticline are also completely covered with Quaternary sands of small thickness. Moreover, marker horizons are clearly traced on the images and they allow geological bodies shown in the map to be manifested. Complexes of these sediments may be interpreted with more confidence in the images of smaller scale. This fact may be obviously explained in that in transition to smaller scale of the image Quaternary sands of small thickness are not alredy a screen for manifestation of underlying sediments.
The area of Upper Cretaceous sediments spreading on the whole is equally determined both in medium- and small- scale images. Moreover, in the satellite images of high resolution sediments of all stages may be revealed owing to clearly manifested marker horizons and character interpretation sings. In transition to small scales capability of mapping the complexes included in stages is sharply reduced. Only in some cases contoures of Turonian, Maastrichtian and Cenomanian sediments may be determined as independent subdivisions. In most cases in small scale satellite images lithological complexes are revealed which on the whole correspond to the Upper Cretaceous.

3. Resume

Comparison of geological charts compiled from images of different scale has shown that natural generalization of representation of geological objects in transition from medium to small scale is manifested by two ways: a) integration of several contours into one; b) relative increase in the area of some types of geological bodies observed in satellite images because the mellow cover to certain thickness is not an obstacle for manifestation of interpretation signs characteristic of buried rocks.

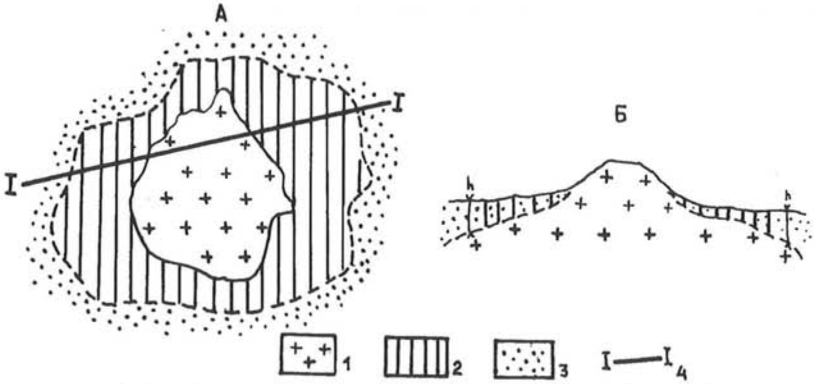

Fig.2. Principal chart showing subsurface parts of a granite massif.

A, Plane image: 1, outcroped part of a granite massif mapped by ground study; 2, part of the granite massif covered by mellow sediments (thickness "h" and less), whose deciphering sings are similar to those of the outcroped part of the massif; 3, area of distribution of mellow sediments (thickness more then "h") where deciphering signs of granite do not appear; 4, a line of cross section, shown on fig.2B.
B, schematic cross section of the granite massif. Shaded part of mellow sediments (thickness "h" and less) is not a screen for the manifestation of deciphering signs of granite.

The first way of generalization leads to revealing in small-scale satellite images and maps compiled on their basis of such subdivisions which correspond to really mapped geological bodies of certain composition and age.
In the second case the area of interpreted contoure of sediments which are visible through covering sediments increases. Therefore, if in map compilation contoures observed in small-scale images are used in some cases areas of certain types of rocks shown in the map would be larger then those mapped by ground works. In a addition to the above mentioned example the same picture is often observed in the study of intrusive massifs and other massifs of rocks stable to weathering (carboniferous, metamorphic, etc.), partly covered by mellow and weakly lithified sediments (Fig.2). In such way information truthful for the given scale necessary to be shown in the compiled map is selected.

4. Conclusion

Usage of "natural generalization" phenomenon is the most effective when images the scale from 3 to 5 times are employed. Interpretation charts compiled from these images aid to make optime generalization of structural framework and geological contours that provides the objectivity, well reading, reliability and space-time similarity of mapped reality. All these factors in the whole give high quality of the map [2].

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PRINCIPLES OF REMOTELY SENSED BASIS CREATION FOR GEOLOGIC MAPS OF RUSSIA ON 1:200,000 AND 1:1,000,000 SCALE

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Abstract

Remotely sensed basis (RSB) of modern geological maps is optimally presenting the totality of remote sensing data and results of its processing, needed for solution of the main tasks of geological cartography. It is necessary to distinguish the factual and interpretation parts of remotely sensed basis. Normalized remote sensing materials and the results of formalized processing of these materials make a factual part of RSB. Interpretation part is presented as the result of visual and interactive analysis of the factual part. Application of RSD in geological cartography and stage by stage processing based on GIS technology provide the creation of modern geological-cartographic information system.

1. Introduction

The main type of regional geological mapping in Russia is the compilation of map sets on 1:200,000 and 1:1,000,000 scale, which have a status of State Geological Maps of the Russian Federation. Every map set consists of three obligatory maps (map of pre-Quaternary formations, map of Quaternary formations and map of mineral resources) and of supplementary maps (firstly geoecological map). The compilation of the latter is regulated by requirement of economy and protection of environment. With the aim of improvement of maps quality and informativity relative instructive documents the obligatory employment of Remote Sensed Data (RSD) in geological mapping is envisaged. The optimally presented totality of these materials and results of their interpretation composes the remotely sensed basis (RSB) of modern geological maps.

2. Tasks solved by RSB

Purposeful processing and analysis of RSD allow to reveal the geological information and solve the fundamental tasks in the geological mapping process:
- determination of the position of mapping area in the regional geological structure;
- clarifying of existing conceptions on geological structure of mapped area, distiguishing of new geological objects;
- analysis of regularities in location and prediction of mineral resources;

- geoecological investigations, evaluation of ecological situation and prediction of its development, evaluation of geological hazards.
The geological objects revealed by RSD are shown on geological maps which are included into map set.
In geological map compilation, the main objects are areal stratified and unstratified geological bodies, their boundaries; linear objects - faults, folded and fracture zones, dykes and veins, marker horizons; subsurface geological objects and buried parts of outcropping bodies.
The main function of RSD in the compilation of the map of mineral resources is the mineragenic zonation, revealing of regularities in mineral resources location and manifestation of the prospective areas. In geoecological investigations the remotely sensed basis is used mainly for distiguishing of the geological phenomena, processes and objects, potentially dangerous for human life and activity, as well as prospecting of its possible changes.
Depending on geological and landscape conditions the capability of solution of certain tasks changes. For example, in mapping of regions with widespread Quaternary complexes on the surface the remotely sensed basis is first used for compilation of the map of Quaternary formations (revealing of areal, linear and extra-scale objects and their boundaries, analysis of geomorphological elements). If the sedimenray, volcanogenic or folded pre-Qaternary complexes have a wide distribution on the surface the geological map of pre-Quaternary formations and map of mineral resources are compiled and the whole scope of above mentioned tasks are solved by RSD. In the zones of land-sea transition in water areas, such tasks, as study of bottom sediments, landscape and ecological characteristics of sea bottom, revealing and retracing of tectonic structures and other objects from land into water areas are additionally solved.

2. Content of RSB

2.1. General principles

Remotely sensed basis of the sets of State Geological Maps of the Russian Federation on 1:200,000 and 1:1,000,000 scale is the optimal totality of aerial and satellite survey materials and results of its processing and interpretation, presented in digital and analog forms and necessary for the compilation of geological and other maps included into the set.
Remotely sensed basis is formed at the stage of preparatory period of the compilation process and is obligatory for the whole territory of mapping and for all types of geological and landscape situations.
Remote sensed basis includs factual and interpretation parts.

2.2. Factual part of RSB

Components of factual part are normalized RSD in digital and analog forms and results of formalized processing of these materials, as a rule, in digital form (sometimes in analog form also).
Normalization includes transition of both digital and analog forms to cartographical projection and geodetic system of the compiled map topographic basis, photogrammetric corrections, assembling of images in a united image (photografic mosaic). For digital material geocoding is needed and for analog material - transition to a certain scale.
Formalized processing includes transformation of normalized image by computer-based methods and it is directed at emphasizing those elements of image which can be used for revealing information about geological structure and ecological state of enviroment. Formalized processing consists of different types of spatial-frequency filtration, convolution, operations with different spectral bands, etc. The composition

of formalized transformations is determined by landscape and geological conditions of the work and type of compiled map.

2.3. Requirements to initial materials

General requirement to initial RSD is necessary and sufficient resolution, as well as the presence of informative spectral bands. These parameters have to ensure revealing of mapping objects and retracing of its boundaries.
Necessity and sufficiency are determined by two rules:
1. *Rule of detailing*. Minimum in size objects, which are subject to mapping, as well as possible extra-scale objects, having the important meaning to understanding of the regional geological structure, mineral resources prospecting and solution of ecological problems, must be distinguished by usage of RSD.
In most cases, the mapping objects are manifested on RSD by natural indicators totality. The size of each of natural indicators is one order less than the observed object. A capability of efficient distinguishing of indicators in deciphering process is provided at spatial resolution 8-10 line/mm that correspond to ground resolution of 20-30 m for the 1:200,000 scale and 100-150 m for the 1:1,000,000 scale. These RSD characteristics ought to be accepted as the necessary requirements to initial remote sensing materials. Taking into account the necessity of revealing of important extra-scale objects, these characteristics are reduced twice. Therefore, the optimal spatial resolution of remote sensed basis for the maps on 1:200,000 scale must be up to 10-15 m, and on 1:1,000,000 scale - 50-80 m.
2. *Rule of review character*. Images must provide such scope of area to show position of mapping territory in the regional geological structure. This stipulates a necessity to use, besides that, the materials of higher generalization level (on 2.5-5 times lesser scale than basic materials), which cover areas, adjacent with mapped territory. Such scale range provides (the other conditions being equal) the receipt of qualitatively new information.
RSD of long-wave length band of visible and near infrared band of spectrum are more informative for revealing the basic objects of mapping.
Geological informativeness of RSD depends on total combination of endogenetic, exogenetic and technical factors. For the outcropped regions these factors are relief character (firstly, its differentiation) and outcropping, physical properties of objects. In deciphering of buried objects, becides peculiarities of their structure (size of geological bodies, degree of dislocation, etc.) it is also necessary to take into account peculiarites of sedimentary cover (differentiation of it surface, thickness and composition of sediments, degree of lithification and age). In all cases, it is necessary to take into consideration the regional climate (for selection of the season and time for survey), weather conditions and transparency of atmosphere, degree of economic development, etc. Account of these factors allows to chose the most informative materials. In the most cases, RSD acquired in spring, before full drying of soils, or in autumn, after fall of the leaves are the most informative. The height of Sun elevation at the survey moment is important also. In the plaine regions the survey has to be executed in the early morning or in the evening, when the height of Sun elevation is minimum, that provides a particularly contrasting image of microrelief details and reduction of noise level under variations of soil and vegetation cover brightness. Under strong differentiated relief, on the contrary, daily survey is needed, which gives the minimum of shadowed sites.
Materials in thermal band are used for revealing of thermal polluted territories by technogenic objects and specific natural ecologically unfavourable objects (such as zones of modern volcanic and solfatar-fumarol activity, etc.). In the compilation of the maps on 1:1,000,000 scale data of satellite surveys in the termal band may be used also to manifest some elements of deep structure by peculiarities of thermal flow. Under utilization of thermal surveys materials account should be taken of some specific requirements to conditions of data acquisition aimed at providing the maximum geological informativeness.

Taking into consideration the above-mentioned requirements and scope of solving the tasks, RSD, forming the factual part of remotely sensed basis of the geological maps, are subdivided into obligatory, providing the execution of necessary investigations and fulfilment of mapping tasks, and supplementary, allowing to obtain data which add and/or clarify the basic information, as well as solve some specialized tasks.
Both obligatory, and supplementary RSD consist of three scale levels: viewing, basic and detail. Moreover, detail scale level of factual part of RSB is not obligatory for using in all cases. They are used in a case of necessity to interprete the most complicated sites of mapping territory and solution of local tasks of Quaternary sedimentary geology.

2.4. Interpretation part of RSB

Interpretation part of remotely sensed basis (interpretations charts) are presented as the results of expert analysis of the factual part of basis taking into account the acquired geological, geophysical and other information. For each map of a set (on 1:200,000 or 1:1,000,000 scale) an independent interpretation chart is compiled.
Analog form of factual part of RSB is processed by two or three experts independently, then these charts are compared and different charts (geological boundaries, structural lines, lineaments, folded, block and circular structures, structural-geomorphological, etc.) are composed.
Digital form is processed and analyzed by GIS technologies support. As a rule interactive regime of processing has to be used.
GIS technology requires integration of heterogenous data (presented both in raster and vector forms): quantitative, qualitative, expert, results of computer-based processing, etc. At the beginning data processing is made in accordance with groups of information, i.e. geology, geophysics, lineaments, etc., and then results of each group are integrated and used alone or in complex as a basis of different maps. Besides, it is possible to combine different thematic layers, additionally to analyze the joint of images pattern, geological and geophysical data to clarify earlier composed geological maps and confirm the geological nature of elements detected by RSD interpretation.
These capabilities may be efficiently used for solution of the following tasks in the compilation of geological map:
1. Revealing of structural framework by initial geological maps and RSD with attraction in some cases of primary observation materials. The methods of these tasks solution foresee:
- computer-based lineament analysis including determination of lineaments, analysis of lineament field by rose-diagrams and different integrated statistic characteristics;
- composition of revealed lineament systems with faults distinguished by geological methods; clarifying of faults orientation, which are coincided with lineaments;
- analysis of new information: definition of geological nature of lineaments non coincided with known faults; for this purpose additional analysis of geological and geophysical materials is made, as well as revealing of lineaments coincided to faults;
- compilation of initial summarizad chart of faults, its ordering of size and generalization; one of criterium at this must be the results of analysis of different scale images;
- compilation of final chart of faults over mapping territory.
2. Detection of geological bodies contours. At the well outcropped areas diciphered contours ought to draw on geological map directly from images and give them indexes in accordance with legend. However, such landscape and geological situation is not typical for Russia and as usually more complicated investigations are executed:
- compilation of the chart of geological boundaries by RSD; therefore such methods as formalized transformations of initial image, synthesis of colour composits and different spacial-frequency filtration are used;
- analysis of acquired cartographic materials and clarifying of geological boundaries draw based on RSD interpretation;

- selection and generalization of contours taking into account phenomenon of natural generalization of image at the transition from large to small scales (Please, see here paper by S.I.Strelnikov "Usage of natural object generalization...").
On the final geological map the results of integrared analysis of remotely sensed basis and geological ana geophysical data are shown in accepted geological symbols. The objects which were firstly distinguished by RSD and confirmed by geological and geophysical data are considered as reliable and shown in the map by accepted legend. Other objects, which are confirmed inccertainly, are shown by special signs as supposed.
Usage of RSD at different levels of generalization provides consequent detailing, starting from the most review-type scales. At each following level the depth of obtained information reduces, but its detailing increases.On the other hand, the information of more high level of generalization must be considered under compilation of charts, created by materials of lower level. It is used for revealing low contrast geological boundaries and aimed search of small objects which might clear up the geological essence of large structures distinguished in analysis of materials of preceding lower levels. Final interpretation chart of basic scale (1:200,000 or 1:1,000,000) has to be the result of gradual compilation of structural framework obtained using materials of lower level of generalization, data on structure of small objects distinguished by more detailed RSD.

3. Technological support of creation and usage of RSB

As the basic software for creation of the factual part of RSB in digital form a specialized parcel for processing of remotely sensed data must be used (for example, ERDAS IMAGINE), providing all necessary function and sufficient productivity on INTELL platform. Materials of remotely sensed basis in digital form are transferred to consumer in .tif or .lan formats.
As the main program means to support deciphering process parcel ARC/VIEW GIS v.3 is recommended. This parcel is completely compatible on raster formats with ERDAS and on vector formats - with ARC/INFO, basic software accepted in Russian Geological Survey.
Different layers of remotely sensed basis in digital form are used by consumers under comparative analysis of interpretation data with geological, geophysical and other materials and also as "lining" under compilation of the contour version of the geological map.
Application of these program means provides full compatibility and continuity of cartographic data, saving of RSD geocoding, capability of interpretation data integration into geological- cartographic information systems.

4. Conclusion

Creation of remotely sensed basis for State Geological Maps of Russia on 1:200,000 and 1:1,000,000 scales a necessary stage of forming geological-cartographic information systems based on GIS technologies which foresees an obligatory application of remotely sensed materials both in analog and digital forms. Moreover, RSD must be considered among used the geological, geophysical and other data as the necessary initial material, which allows to obtain in some cases principally different or new information in comparison with materials of geological and geophysical surveys. RSD analysis has to be aimed at distinguishing of those objects which should be shown in final maps in accordance with existing instructive documents. Integrated processing of RSD and geological and other data by GIS technology ensure the preparation of up-to-day information product - geological map.

A CONSTRUCTIVIST APPROACH TO CHILDREN'S RELIEF MAPS

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Introduction

Understanding the shape of landforms and how they are represented on maps is a challenging task for children, yet both are fundamental to an understanding of geography. Children often have a weak grasp of physical landscape concepts and may be unable to apply correct terms to common features. Milburn (1972) demonstrated that only 30% of a sample of 500 8-11 year olds could correctly define simple features such as rivers, valleys and mountains. Common landscapes are, however, difficult to · define and landscape terminology can be confusing (Wiegand, 1993). Some features are identified by their form (e.g. *island*) but can vary substantially in size. Other features (e.g. *volcano*) are described by their process of formation but can vary in their appearance. Regional variations in terminology to describes features on the Earth's surface may add to the difficulties. Harwood and Jackson (1993) assessed children's understanding of nine common vernacular physical landscape features using oral interviews, picture recognition and picture drawing and revealed many significant misconceptions. However, the concept *hill* was found to be one of the more securely established notions and this was thought to be related to their relevant prior experience. This would include both direct experience (e.g. through walks in the countryside) and indirect (e.g. through pictures, video and stories).

This paper describes part of a larger investigation into young children's *cartographic* interpretation of relief (Wiegand and Stiell, 1997). It adopts a *constructivist* perspective, i.e. that knowledge is not directly transmitted from one knower to another, but is actively built up by the learner (Driver, *et al.* 1994). Constructivists argue that knowledge is symbolic in nature and socially negotiated. Maps and their sign systems are socially created and subject to recognised rules. Certain phenomena are selected from the real world and represented on maps in ways that are generally widely agreed. Learning about maps therefore involves not only attempting to understand cartographic concepts but also undergoing a process of socialisation by which individuals are introduced to a cartographic culture by its more skilled members. In the *geographic visualisation* paradigm (MacEachren, 1995) maps are characterised by high focus on individual needs, the revelation of unknowns and high user-map interaction. The underlying assumption in this view is that the process of representation results in knowledge that did not exist prior to the representation. Mapping and map use become process of actively constructing knowledge rather than transferring knowledge passively. As the potential for electronic user interaction with maps increases, it becomes more and more important to understand the ways in which children make meaning from maps. The constructivist approach considers children as young cartographers and examines their response to cartographic problem solving. The problem considered in this paper is that of how to represent a hill on a map.

Children as cartographers

One hundred and eleven children aged between 5 and 11 participated, from a primary school on the outskirts of Leeds, England. Mid-range ability children were chosen on the basis of an informal assessment made by their teachers. None of the children involved had received any direct teaching about maps and/or contours in the 6 months prior to the investigation. An oval shaped hill was formed from fine, damp sand in a rectangular box measuring approximately 45cm x 30cm x 20cm. A contour map of the hill is shown in Figure 1.

Figure 1.

Contour map of the model hill.

A clear, rigid perspex sheet was placed over the top of the box so that the hill could be clearly seen from above. Children were shown the model one at a time, sitting on the carpeted floor so that they could look down easily into the box. They were initially asked to describe what they saw. Most referred to the sand model as 'a hill' and it was commonly described as 'oval'. Almost all children could describe the shape of the hill by reference to some (more or less accurate) analogy, e.g. 'like an egg', 'like a camel's hump' or 'like a rugby ball'. Older children generally had little difficulty identifying the steep slope but few children could adequately describe the gentler slope. Attempts included: 'it's got a long and a short side' and 'one end is higher than the other'.

The children were then asked to 'look down at the model through the glass and draw the hill as you see it from above' with an overhead projector pen on a sheet of clear acetate film on top of the perspex box lid. When they had finished their drawing they were asked to mark the highest point of the hill with a dot. The maps were then classified as shown in Figure 2. Drawings classified as 'elevation' were generally either discrete, closed hill forms (as in 1a) or open forms, drawn to show some continuity with the adjacent landscape (as 1b). 'Plan' drawings were of two broad types. Some children, on completing their plan, marked the highest point of the hill at the top edge of their drawing (2a). Others marked it within the plan, usually offset from the centre (2b), as in the model. 2b is, of course, also an accurate contour representation of the hill but its simple reliance on one contour line only seemed to require its inclusion as a separate category. Maps were classified as 'hachures' if they used lines drawn parallel to the direction of slope. None of the children's maps showed true hachures in the sense of utilising thicker strokes to indicate slope steepness, but most differentiated between contrasting slope lengths as in 3a. Some

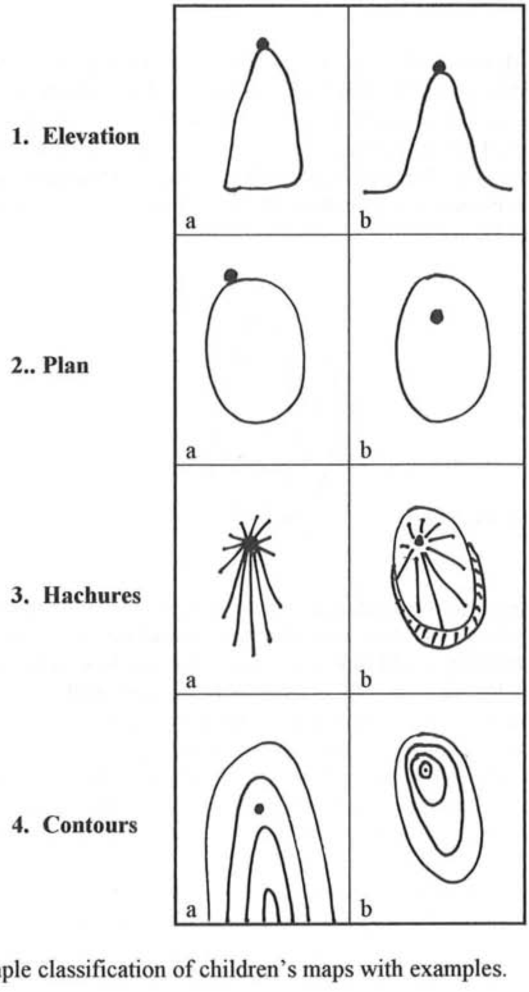

Figure 2. A simple classification of children's maps with examples.

'hachures' were combined with other attempts to differentiate between slope facets, including attempts to give a three-dimensional effect to the hill (3b). Contours, where used, were often drawn partially, or with inaccurate location of the highest point. Both instances are illustrated in the example presented as 4a. Example 4b illustrates an accurate contour representation, although no child numbered the contours so that the resultant map could equally well have represented an oval-shaped depression.

Age	**Map types**				
	1	**2**	**3**	**4**	**Total**
5-7	20	12	3	0	35
7-9	10	11	6	11	38
9-11	1	2	14	21	38
Total	**31**	**25**	**23**	**32**	**111**

Table 1. Number of primary school children, by age, drawing each type of map.

The number of children producing drawings of each type is shown in Table 1. There is a highly significant association of drawing type with age (χ^2=63.45, df=6, p=<0.01). Twenty-nine percent of 5-6 year olds drew the hill in elevation whereas 55% of 10-11 year olds used contours. Thirty percent of all participating children used contours with a further 22% drawing the simple 'plan' view employing one contour only. Only 3 children (8%) aged 7-9 used contours correctly (4b).

The exercise was repeated in a large secondary school, involving a sample of 80 pupils aged 11-15 years. Approximately equal numbers of boys and girls were selected from 3 ability bands. Although the older, more able children showed a marked improvement in their ability to describe the shape of the sand hill, pupils from the lower ability bands up to the age of 15 were still unable to adequately describe shape and steepness of slope. Pupils' maps were classified on the same basis as those for the primary school sample and the number of pupils in each age group drawing each type of map is shown in Table 2. There is no significant association between age and type of map.

All pupils aged 11-12 had been taught explicitly about contours in the previous 6 months and yet fewer than half used type 4 maps to represent the hill. It is also noticeable that pupils in later years appear in their maps to revert to a simpler form of relief representation. None of the pupils in the lowest ability group used contours for representing the hill. All the pupils who drew type 1 maps (i.e. the hill drawn in elevation) were girls.

Age	Map types				
	1	**2**	**3**	**4**	**Total**
11-12	2	6	5	10	23
12-13	1	5	5	5	16
13-14	3	7	4	10	24
14-15	1	4	10	2	17
Total	**7**	**22**	**24**	**27**	**80**

Table 2. Number of secondary school children, by age, drawing each type of map.

Discussion

The evidence presented above appears to confirm Wood's (1993) view that 'the sequence in which children acquire hillsigns parallels that in which they were acquired in our history of mapmaking' (p.158). The youngest children in primary school (and the least able in secondary school) drew their hill in profile. There is much evidence in the literature relating to the psychology of drawing to suggest that children up to the age of 8 years draw what they know rather than what they see. Freeman and Janikoun's (1972) study, for example, demonstrated that when children made a drawing of a cup they included the handle even though it could not be seen from their viewpoint. The most distinguishing feature of the sand hill is its height and thus this is what is emphasised in the drawing.

The children in this study showed themselves to be remarkably inventive in the way in which they attempted to solve the problem of representing a three-dimensional feature in map form. One child experimented later with alternative methods of mapping, drawing a new, conical, hill as a spiral, beginning in the centre and working outwards with ever increasing circles. When challenged with the task of representing a *depression* in the sand of equal dimensions he replied that it was easy and made a spiral by beginning at the outer edge and working inwards. On recognising that the two drawings were identical he added a note: 'Start here' to each drawing.

Some primary school children as young as 9 were able to draw accurate contour maps of the sand hill. Some pupils in secondary school, however, were still struggling with the concept by the age of 15. Indeed, many pupils aged 14-15 in this test appear to have reverted to a less sophisticated mode of representation. In the secondary school in question there is a programme of map skills undertaken in the first year (age 11-12) and, although maps are commonly used in geography lessons throughout the following three years, there is no ongoing and systematic review of associated skill development. Anecdotal evidence suggests that this may be typical of much geography teaching in the UK. Skills are practised when the perceived need arises and it may be that attention needs to be paid to more systematic practice of map skills in curriculum planning. Attention may also need to be paid to the relationship between language development and relief mapping. In order to help broaden their thinking about how to show landscape on a map, children need to have a vocabulary of simple, vernacular concepts (*top*, *steep*, *gentle*), more complex ones (*convex* and *concave* slopes) and more technical terminology (*knoll*, *summit*).

There is much evidence to suggest that children are generally capable of more advanced mapping behaviour than is readily recognised (see, for example, the review by Matthews, 1992), but they need opportunities to see for themselves how maps work. Few geography and map teaching materials in the UK appear to acknowledge that there exist alternative hillsigns to the contour, yet it seems that children's thinking about mapping might be assisted by working with examples of historical maps using hill pictures and hachures. It is suggested that teachers can support children's understanding of the conventions of relief mapping by acknowledging children's own attempts to be cartographers and ascertaining what perspectives the pupils themselves bring to the map making task.

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THE MAPPING OF AGRICULTURAL LAND IN POLAND

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Introduction

Because of its spatial character, agriculture as a branch of national economy demands various and possibly full information concerning agricultural productive land: its quality and quantity, spatial differentiation, existing barriers and stimulants of rural development.

The paper presents a review of agricultural land mapping in Poland in the last 50 years - mainly in the range of environmental conditions. The majority of maps in use are products of traditional cartography. The next category includes computer maps (which appeared in the last 15 years) presenting information graphically. The newest generation consists of numerical maps whose production has recently started.

From the thematic point of view maps of agricultural land concern such problems as:

- cadastre (cadastral maps)
- soil quality (pedological, soil classification, soil - agricultural maps)
- productive land evaluation (maps of land valorization)
- natural factors of agriculture (maps of: soil erosion, agroclimate, relief, water conditions, soil stoniness etc.)
- environment contamination (maps of: sulphur, heavy metals in soils and plants etc.)
- land topography (basic maps, village maps)
- other problems (maps of: mean farm area, land utilization, irrigation and drainage devices, state of crops etc.).

Data sources for the needs of agricultural land mapping comprise: photogrammetric, remote sensing, statistical and descriptive materials, as well as databases and information contained in existing cartographic works [4].

The paper deals with examples of agricultural and environmental maps in various scales - from general to large-scale images.

Cartographic publishers

The main cartographic publishing companies in Poland producing maps and atlases, concerning also agricultural problems, are:

- State Cartographic Publishers (PPWK): maps and atlases of general and special use;
- Military Cartographic Enterprises (WZK): topographic maps;
- Geological Publishers (WG): some pedological maps;
- Polish Academy of Sciences (PAN) and universities: various thematic maps;
- Branch institutes e. g: Institute of Soil Science and Cultivation of Plants (IUNG) in Puławy: maps concerning soils and agricultural environment, Institute of Land Reclamation and Grasslands (IMUZ) in Falenty: maps of water conditions and land reclamation, Institute of Meteorology and Water Mangement (IMGW): hydrological and climatic maps, Institute of Environmental Shaping (IKŚ): ecological maps;
- Regional administrative authorities and geodetic bureaus: topographic and thematic maps for agricultural development.

Maps review

<u>Traditional maps</u>

The cadastral maps in the scale 1 : 1000 and 1 : 2000 comprise the whole territory of Poland. These maps present the state of land use and ownership status.

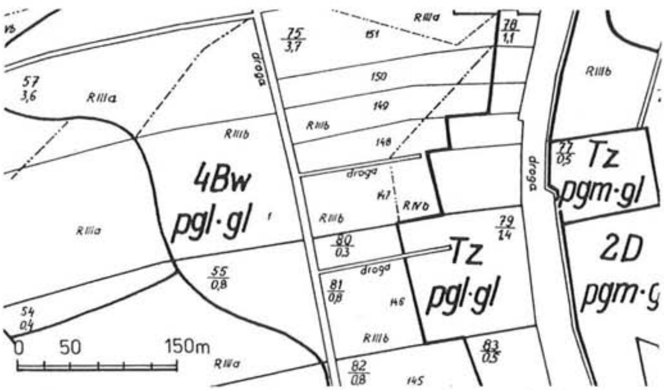
In Poland as well as in many other countries, general pedological maps (soil genetic maps) are the ones that have been most frequently produced. Independently of these - the soil classification maps have been made.

The soil classification which was carried out on the area of the whole country in the years 1956 -1965 is still being used for fiscal purposes. The eight valuation classes (I, II, IIIa, IIIb, IVa, IVb, V, VI)have been attributed mainly with regard to the studies of soils and also local relief, climate and water conditions.

The next stage in recognition of arable lands was the natural - agricultural evaluation which distinguished 14 soil - agricultural complexes grouping lands of similar usefulness for plants [7, 3].

This evaluation has been based on the folloving criteria: soil properties, morphological situation, agroclimate and water conditions. The complexes constitute thus the site types of agricultural productive areas.

The contents of the soil agricultural maps comprises the contours of: soil - agricultural complexes as well as the constituting them soil units, agriculturally useless soil (for afforestation), forests, built up areas, roads, inland waters and also village borders, location of the investigated soil pits etc [Fig. 1].



——plot border 146 plot number —— border of soil-agricultural complexes
No. from 1 - 14 denote soil agricultural complexes, soil kinds are denoted by capital letters (A, B, Bw etc) , soil texture - by small letters (pl, gl, pgm etc). Roman numbers denote soil classes (I - VI)

Fig. 1. Fragment of soil - agricultural map

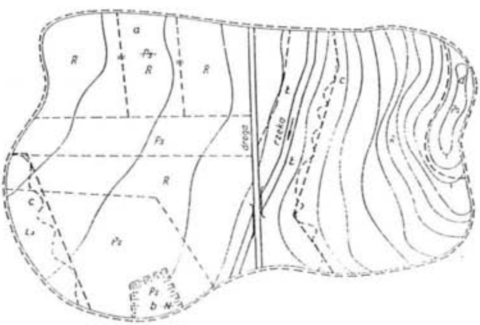
All the contours are marked by respective symbols and their areas are given with the accuracy up to 0,1 ha. The contours of complexes or soil units smaller than 0,5 ha are basically not drawn on maps [5].

The soil - agricultural maps (basic scale 1:5000) and the descriptive annexes accomplished for the whole area of Poland between 1965 and 1981 give the detailed information concerning geographical environment, agricultural properties and cllassification registers of soils.

Maps of productive land evaluation according to the IUNG method in the 100 - point scale present all territory of Poland mainly in the scales 1:1 000 000 and 1:500 000 (c.f. poster presentation).

Numerous, regional or all - country maps presenting natural factors and limitations of agricultural production concern such problems as: agroclimate in the 10 - point scale, relief in the 5 - point scale, water conditions in soils in the 5 - point scale according to the IUNG method, soil stoniness, water and wind erosion in the 5 - degree scale etc. (c. f. poster presentation).

Problems of soil erosion hazard and its control are presented on various maps dealing with water and wind erosion intensity,results of excessive rains and winds in soils and relief, development of gullies, land transformation etc. [Fig. 2].



Types of transformation:
a - basic, b - correcting, c - equalizing, d - preventive

Fig. 2. Scheme of land transformation

Maps of climatic hazards to agriculture take into consideration, among others: rainless spells of longer duration, zones of high risk to the principal crops posed by rainy days and heavy rains, hail, as well as spring and autumn frost. For example the Atlas of Geographical Environment of Poland [2] contains such review maps as: climatic hazards and climatic valuation for agriculture, soils protected for agriculture, reclamation of agricultural and forest land, evaluation of agricultural productive space etc. The basic maps and village maps (both in the scale 1:5000) give detailed information concerning topography and land use [Fig. 3].

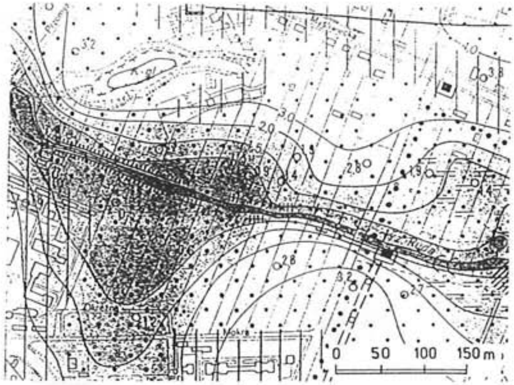
Fig. 3. Basic map

The fragment of large-scale map presenting irrigation and drainage devices is shown in Fig. 4.

The examples of maps (generalized from the scale 1 :50 000 to the scale 1 : 300 000) worked out by the author for the needs of regional planning of agriculture in Kraków voivodship are presented in the poster session [6].

Computer maps

Sozological problems in general and contamination of environment especially in the last years are the subject of numerous maps concerning: sulphlur and heavy metals content in soils (c. f. poster presentation) and plants [Fig. 5] etc.



area with the drainage and irrigation devices
hydroisobath
drilling points and wells
depth to ground water table
surface waters divide
border of sewage area
water intake and pipe
permeable, medium- permeable, non- perm̜eable rocks and non- permeable built up areas

Fig. 4. Land reclamation map

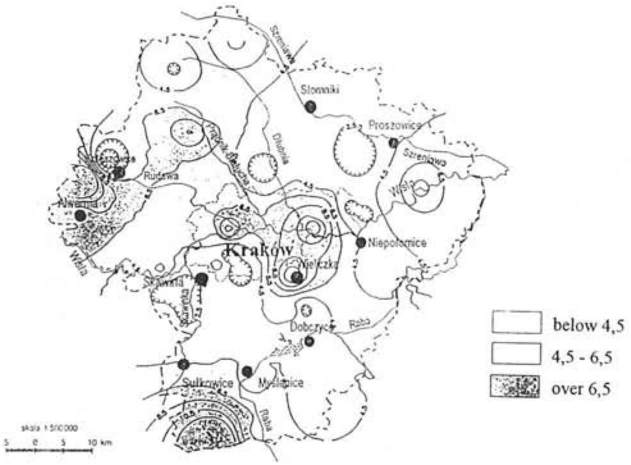


Fig. 5. Lead content in luttuce in 1993 [mg/kg of dry matter]. Voivodship of Kraków

Maps of this character are produced by the use of computer steered plotters. Computer maps presenting the state of agricultural crops, forest areas, soil wetness are made on the basis of digital analyses of aerial or satelite images. An example of a land use map of this type is shown on Fig. 6.

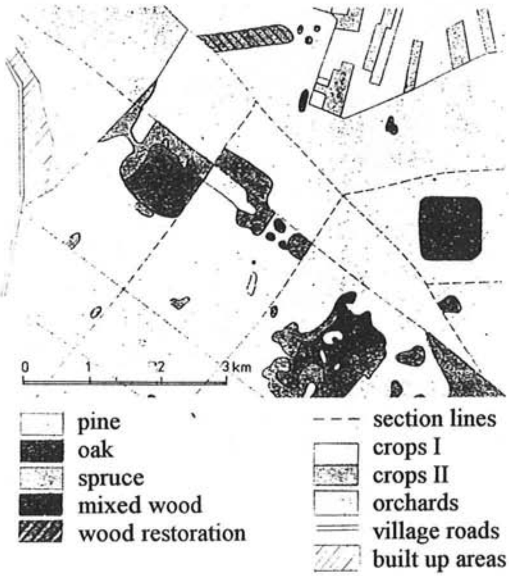


Fig 6. Fragment of land use map produced on the basis of spectral aerial photographs

Numerical maps

Numerical maps are the collection of digital information creating their own information system. For example, the new basic map in the numerical version which contains first - hand information in the range of points of geodetic network, topography, cadastre and infrastructure is very useful also for agricultural purposes. This map, of the object character, according to the SWING standards will be gradually introduced in Poland in the next years [1].

The information contained in various agricultural maps is very useful for the completion of many tasks connected with rural land development in the range of planning and programming. In order to enable the full usability of these maps for rural land development, this information must be of course, adequately updated [4].

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CARTOGRAPHIC SUPPORT OF FOREST MONITORING IN THE LAKE BAIKAL WATERSHED

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The forest managers, scientists as the government administration and the people have recognized that future of lake Baikal which contains 20 per cent of world's fresh water and harbors for more endemic species of plants and animals those found nowhere else on this planet is figuratively in their hands.

The major part of the Baikal basin (20.6 mln.ha, or 72 per cent from 24 mln.ha total area) is occupied by forests, 18 mln.ha of this zone being under the authority of Federal bodies. Specific features of forest management here region is determined by the fact that 52 per cent of forests in the Baikal basin performed a diverse protective functions (mainly, water-protective, erosion preventing and soil-preventive functions) are managed in a special way.

The establishing and maintaining of the resource & ecological forest sustainability in the Baikal region is the obligatory condition of preserving the unique lake proposed include in the world heritage list. The main factors detrimental to forest sustainability are fires, unfavorable meteorological phenomena (stormy winds, hails, heavy snowfalls), unreasonable utilization of forest resources, industrial emissions, unorganized tourism. Coupled with unfavorable meteorological conditions and technogenic pollution, impacts caused by dendrophilous insects, fungi's infections and soil drought lead to weakening and perishing of forests. The main management activity to take place in the Baikal region is associated with harvesting.

To maintain ecological sustainability of forests, it's necessary to establish a monitoring system for organizing timely detection of unfavorable impacts, as well as for optimizing management activities. The forest monitoring system peculiar to the Baikal region, considered to be a unique natural feature, lies in the following tasks to be solved:

- to obtain data about forests that occupy considerable areas (more than 18 mln. ha);

- to describe state of forests in terms of generalized ecological indices that define forest sustainability;
- to analyze disturbances of spatial structure of forest lands and to assess how such disturbances have an effect upon the protective functions of forests.

Water protective zone of Baikal is the first test territory where strategy and main elements of information system for forest monitoring including the methods of data collection by RS means and the methods of data storage and interpretation by GIS application were developed. An information system is the system included some components intending for collection, storage, retrieval, analyzing, processing, manipulating and displaying of spatially distributed forest information.

Such information system developed in the All-Russian Scientific Research & Information Centre for Forest Resources.

The system is aimed at the application of the data derived from satellite images and selective aerial photography in combination with some ground observations as well as from employment of forest management and cartographic materials, reference statistical data.

The establishment of the monitoring system can be roughly subdivided into 4 phases:

- system design;
- individual modules formation;
- integrating modules into a common system;
- test exploitation of system.

A proper cartographic support is required at each phase of organizing of forest monitoring.

System design phase

System design comprises the collection of the cartographic materials, the "base mapping" and selection of territorial units meant for systematizing of monitoring data.

The aim of "base mapping" consists in registration of forest state at the fixed moment to be considered as a "reference point" in order to observe the dynamic of forest composition and other features as well as in registration of the level at which forests of the region are managed. According to tasks mentioned above, two directions can be discerned in the "base mapping": mapping of forest ecosystems and reference mapping.

<u>Mapping of the forest ecosystems</u> envisages compiling set of maps on the common scale 1:1000000 in order to follow the sustainability of forests. Such maps are based on forest inventory data as well as on information derived from ground observation to have been done before. The map set includes the following thematic maps: regional landscapes, forest types, forest fuel materials, damages caused by forest fires, regional hydrologic division, river runoff, etc.

A forest map is to be considered as a main thematic map within the set of maps. So far, there was no such a map available on the scale 1:1000000 to depict the current state of forest vegetation. That is why it turned out to be necessary to develop methods for compiling this map according to up-to-date sources (space photographs) as well as to prepare the map's original.

The forest map on the scale 1:1000000 within the framework of the regional information system is intended for observing changes in forest boundaries, their updating by repeated interpretation of materials derived from newest observations, registering changes in species composition of forests in the course of primary coniferous stands being substituted for derivative deciduous ones.

Special content of the map is the following:

— Dominant tree species and shrubs (common and Siberian pines, spruce, fir, Siberian larch, birch, aspen, elfin wood, and other shrubs) to prevail over the area;

— Associated tree species to be shown within generalized heterogeneous contours where it takes alternation of sites featured by different dominant species;

— Forests disturbed by fires and cuttings of different years;

— Nonforested lands (clear-cuttings or burned areas);

— Nonstocked area including arable lands, pastures, bogs, subalpine meadows, rocky barring, stone-placers' sands, saline lands.

Special content of the map is derived, first of all from CIR space photographs on the scale 1:270000 and 1:1000000 that were taken from "Kosmos" and "Resurs-F" satellites and "Mir" orbital station.

One important issue more is believed to be a natural and territorial division of Baikal region in order to single out long-term reference monitoring units (natural & territorial observation units — NTOU) and to localize subsequently the generalized indices of ecological sustainability. Taking into account the forest monitoring system peculiar to the unique region a basin wide approach is assumed as a basis of the natural and territorial division. The main principle to be kept when dividing basins or their joining up is to find areas with their natural complexes constituting a functional unity and being similar as regard conditions of runoff forming. Boundaries of these observation units are fixed at topographic map on the scale 1:1000000 that is to be used to create a digital cartographic data base.

Reference mapping. The updating statistical information proceeding from results of the operational investigations by applying remote sensing is one of the tasks of forest monitoring. Statistical data are now generalized according to units of administrative and management division, updated every 5 year and submitted to Federal Forestry Service. All the generalized statistical information derived from such periodical forest account is subject to storing in the data bank. Changes in statistical data can be introduced on the basis of results obtained while investigating the territory with the aid of remote sensing during inter-account periods. As regards statistical information itself it can be presented for users not only as tabular but also and cartographic form.

Reference maps served for the resource inventory and recognition of the level of forest management utilization in the region. The set of reference maps highlights the utilization of forest resources and specific features of their reproduction as well as realization of measures aimed at protection of forests against fires, pests and diseases.

The system individual modules formation phase

The task of paramount importance at this phase consists in the development of data acquisition methods for estimating the forest sustainability and obtaining detailed information about forest state at the local sites. The local sites highlight risk zones susceptibility to industrial emission, damaged by forest pests and diseases, forest fires and other calamities, disturbed by logging).

Space photographs serve as sources of the initial data describing the forest state in the region as a whole. Multi-purpose method while orientating not towards one or another set of specific indices but taking into account special features and interpretability of space survey has been developed for collecting the initial data from space photos.

Set of selected indices makes it possible to obtain generalized estimates of ecological sustainability of forests within the territorial observation units to be singled out at preceding phase. The following indices were chosen for evaluation of forest sustainability:

— percentage of forested lands, i.e. forested area as compared to total area of observation unit (%);
— integrity, i.e. forested area as compared to timber area (%);
— share of land covered by coniferous stands (%);
— share of mature coniferous stands (%).
— share of understocked stands (%);

Dynamic of these indices stipulated by natural and anthropogenic factors have a harmful effect on forest ecosystems.

Determination of the mentioned indices consists in identification of land categories and calculation of their percentages. Identification of land categories is based upon utilizing interpretative indicators. Interpretation is carried out according to CIR or multispectral space photographs.

The indices' value to be obtained while interpretation within the framework of hydrological regions and natural & territorial observation units (NTOU) has been loaded and stored into landscape-ecological data base (LEDB).

Apart from the developed method for assessing sustainability of forests in the region on the whole, the following methods have been developed to collect the detailed information:

— method of forest health assessment within area of technogenic pollution according to large scale aerial CIR photographs;

— method of reforestation dynamic's assessment at cutting and burnt-over area according to space and aerial photographs.

The integrating modules into a common system

Landscape and ecological digital data base (LEDB) being the analytical "core" of information system is intended for loading, storage, updating and analysis the data accumulated by forest monitoring of Baikal basin.

Up to now LEDB encompass the reference ecological information about Baikal basin on the whole and interpretation indices describing the ecological and resources' forest sustainability. Climatic data, correlation between temperature and water balance elements, hydrological features tightly connected with climatic condition, generalized vegetation data about Baikal basin, altitudinal zonality of vegetation and its hydrologic importance are included in reference information. Interpretation indices are collected for 206 observation units and 12 hydrological regions inside Baikal watershed basin.

The IBM compatible computers running under MS DOS and printer for producing tables, reports and maps as required for user activities are available for LEDB operation. The CLARION package is selected for LEDB managing and developing the "friendly" interface.

The georelational structure of data base supports the data storage and the one-to-one correspondence between attribute data records and maintains the searching of records in files using identification codes. Data have been recorded in DBF format.

The main functions of LEDB are the following:

— to create generic management action record tool such as initial data input, expire records, modifying records, data updating, current changes data input, processing the current changes data, updating initial indices describing ecological and resource forest sustainability by recalculation;

— to generate tabular and text report available for query;

— to generate map captions and tables.(Software module DOTPLOT from EPPL-7 soft tools produce the data as ad-hoc maps on screen or print it.)

LEDB with soft tool need 6 Mb memory.

The interpretation indices detected by space survey materials interesting for forest management are: percentage of forested land, percentage of forest cover, share of coniferous stands, share of mature coniferous stands, share of understocked coniferous stands.

The digital data base application and GIS advantages allow to analyze mentioned indices and it's dynamic within forest enterprises, national parks, reserves as it is traditionally evaluated.

For such analysis ARC/INFO version 7.0 for WS is applied. System has been installed on SUNSPARCstation 10 under UNIX. The digital cartographic data base consists of topographical basis and graphical information such as boundaries of natural & territorial division units and forest management division units. 44 forest enterprises, 3 national parks, 2 reserves are located within Baikal water protective zone.

Digital cartographic data base needs more than 1 Mb memory. 5 sheets of topographic maps were chosen for creation the digital cartographic data base as initial informational sources. Digitizing and editing the information carried out with the help of VECTEDIT 1.0 software package developed by ARICFR employers. As a result the multilayer structures of digital maps with network of rivers and roads, boundaries of administrative regions, forest enterprises, reserves, national parks, state border and boundary of watershed basin were produced for every sheet of map. The sheets of maps were linked and transformed for building united map spatial extension.

The objective of ARC/INFO application was the counting down of interpretation indices for administrative and management units within Baikal basin. As in general boundaries of NTOU and forest enterprises do not coincide it is necessary to evaluate share of river basin area within one forest enterprise or another for recounting of indices. This square will corresponds share of index value from its general value within forest management unit. For solving this problem two polygon coverages with NTOU (river basins) boundaries and forest enterprise boundaries were combined using overlay techniques. As a result new coverage and corresponding it new attribute table, combining information about united objects were generated. Accordingly the square of NTOU area parts divided by forest enterprise boundaries were estimated automatically. According with share of river basin square inside forest enterprises the interpretation indices were counted down inside latest.

The spatial ad-hoc queries are realized for every coverage by ARCPLOT module also as searching and selection NTOU with critical values of indices and extracting the ecological risk zones.

The colored maps, visualizing indices and describing ecological & resource sustainability of forests inside river basins and forest enterprises were composed.

Applied investigations allow to develop the GIS for spatial analysis and selection the ecological risk zone. One should provide the special detail observation within these detected risk zones when forest monitoring system test exploitation put to use.

DETERMINING AND USING GRAPHIC COMPLEXITY AS A CARTOGRAPHIC METRIC

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Introduction

This paper considers possible reasons for undertaking the measurement of map complexity and the applications for a complexity measure which can summarise the structure and appearance of a map image. By using contemporary software tools to handle and assess scanned digital map data it proposes that raster graphics offer a potentially effective means of measuring of the complexity of maps as perceived by human eyes.

Can complexity be of use to practical cartographers?

Cartographers appreciate that different map use tasks and varying map users mean that, however they are created, the resultant maps will themselves vary in a number of ways. The production of such maps and their eventual appearance are still activities worthy of investigation. The justification for studying the role of complexity in the presentation of spatial data in map form is based on the following factors:

Variation in map type

Most parts of the earth's surface are covered by mapping which varies in its scale, theme, purpose, intended audience and appearance. Each map possesses a different level of quantitative complexity: the small scale geological map having a different complexity value to a large scale cadastral plan covering part of the same area; the tourist map of the area having a different value to a school atlas map at the same scale. If detailed knowledge of the nature of complexity can be ascertained, indices of complexity could be used as guidelines in the preparation of these subject-specific maps.

Despite some evidence which suggests that it is not necessarily appropriate (Castner, 1990), the practice of introducing younger and/or inexperienced map users to 'simpler' maps (in terms of their visual appearance) seems likely to remain standard. If indices of map complexity were available we might be able to use them as guidelines in map preparation to ensure the matching of 'progression' in our map products to map use task and map user.

The task of map generalisation

Summarising the graphical appearance of the map face using metrics such as counts, densities, fractal dimension, line lengths, sinuosity etc. is often a precursor to the implementation of computer-assisted generalisation procedures. The investigation of the behaviour of such generalisation procedures could reveal some fixed yardstick that would determine the target map complexity of a set of spatial data for any given scale. It is likely that such an index would be comparative (e.g. a map at scale 1:50,000 should have a complexity index of 25 (or 5 or 1.0 or 0.5) times a map of the same area at 1:250,000 scale) rather than precise and prescriptive.

A fundamental concern is that there is little guidance in the cartographic literature which explicitly states that maps should become more (or, perhaps, less) intricate as scale decreases and generalisation is applied. It is clear that *mappable data* becomes palpably more complex as its scale of representation is reduced. That is, even although the image *may* become simpler (e.g. in the coarser re-classification of categorical maps or in the simplification of intricacy of drainage patterns on topographical maps) the data, preparatory to generalisation, is likely to be more voluminous, potentially more perplexing and, perhaps, confusing. By examining contemporary practice in generalisation (a method used by the few who have examined *how well* automated processes of generalisation work e.g. Joao, 1995) we could come up with a firm view on the comparative complexity values expected at differing scales.

The requirement to measure reality
One reason why the use of a complexity index cannot necessarily give an absolute value to aim for when generalising is that the areas of reality which maps cover obviously vary enormously. The complexity of a map will inevitably be affected by the nature of the information it is portraying - a standard topographic map of a peri-glacial area will reveal considerably larger numbers of representable landscape features (in a standard topographic map specification) than a similar specification map of a prairie environment, whilst a thematic map of population migration over a one year period will appear sparser than one portraying such flows over a ten year time span.

It is clear, however, that a measure of map complexity could act as a surrogate measure for characteristics of such data and ultimately for reality itself, in the same way that other measurements from maps (e.g. densities, line lengths) are readily used by landscape- and geo-scientists to characterise the 'real world'.

Using information approaches to characterise a map
The traditional communication model of cartography has used the fundamentals of information theory to characterise the role and working of map products. In it there is a distinct reliance on the information embedded in the map and its progressive dilution (or, possibly, enhancement) as it is transmitted from one component to another. A potential method of calibrating such models would be to quantify the information component of the map. Data complexity would intuitively seem to be one possible measure of the 'amount of information' on the map. We do have, however, to ensure that we distinguish between sheer randomness, which can be extremely complex without revealing any structured information, and complexity which does 'add value'.

The process of map data conversion
Measures of map content and complexity could be of substantial use in developing cost functions for, and assessing the efficiency of, the data conversion (digitizing) of

various types of mapping (e.g. with differing densities of detail). In effect, one could predict the resources required to digitize a paper map sheet and thus assist the mass conversion programmes currently being undertaken by many large mapping agencies.

Map and dataset revision
In a similar manner, assessment of the nature of data on the map face or in the dataset tile could help in predicting the effort involved in map and database revision. The content of a 'complex' map or spatial dataset may change more quickly and more comprehensively than that of a 'less complex' one. Accurate predictions of future workload in map and dataset revision would result from a measure of such complexity.

The avoidance of clutter and ease of understanding
Approaches to optimising map design and addressing cartographic clutter may be helped by an index of level of complexity, such that an 'optimal' amount of detail can be portrayed on the map.

The comparison of maps and images
Using complexity measures, differences between maps and images can be determined: if such maps and images were the result of human subjectivity (e.g. two different geomorphological maps created from two different human photo-interpretations) or automated algorithm application (e.g. satellite remote sensing scenes classified using different methods), we could summarise, identify and exemplify 'best practices' in · practical map-making or algorithm choice.

It is therefore suggested that there is value in attempting to determine some form of metric which would summarise the complexity of the graphical document and ease the specific tasks of map design, map generalisation, map compilation and map use.

What is map complexity?

An immediate problem confronted by cartographers investigating complexity has been the use of the term to describe both the intrinsic complexity of the subject matter of the map and the graphical complexity of the marks on the piece of paper or on the computer screen. An initial consideration might conclude that the former is related to the *cognitive* processes of understanding the map, whilst graphical complexity is more closely related to the visual impact of the map and to the *perceptual* processes of viewing it. The uncertain separation between cognitive and perceptual activities makes the distinction between these, and the consequent unambiguous determination of complexity, extremely difficult.

A further problem is that a focus on complexity assumes that it is somehow an inherent or intrinsic property of the system itself i.e. "that the complexity of a system is independent of any other system that the target system is interacting with." (Casti, 1992, p.21). In particular, it may be felt that any observer/controller may be felt to be influencing the system (e.g. a map user may bring their own interpretation and prejudice to the map viewing task). Perhaps the best we can hope for is to "arrive at (a) relativistic view of system complexity" (ibid.): obtaining a comparative metric which can indicate that a certain arrangement (of pixels or landscape elements) is less or more complex than another.

Serra (1988) explores this point further, but whilst indicating that complexity refers to a given description of the system (i.e. "to the relationship between the observer and the observed" (p.142)), he indicates that it is feasible to apply complexity measures to any system *as long as it is adequately described.*

Many disciplines, such as pattern recognition, would regard such a 'top-down' approach as the only sensible way of tackling the concept of complexity: i.e. the definition of complexity resides external to the visual stimulus and is applied from outside using a pre-determined set of parameters or templates. It is just as clear, however, that other disciplines, such as software engineering, have successfully managed to develop ideas of complexity from a 'bottom-up' approach: i.e. the physical structure of the stimulus is quantified and made to equate with complexity. The study described in this paper has taken the latter view, that certain descriptors of complexity can be determined from measurements of the map data itself.

Previous studies of map complexity

The distinction between graphical and intellectual complexity has been made in previous studies on complexity by cartographers. MacEachren (1982) quotes a dictionary definition of 'complex' which stresses these two aspects, described respectively as 'the interconnectedness of parts' and 'the ease of understanding'. They have also been specifically applied to maps by Brophy (1980) who introduced the terms 'visual complexity' ("a direct consequence of the spatial differentiation of the graphic content of the map") and 'intellectual complexity' ("due to the meanings or significations contained in or ascribed to the map symbolism", p.345) as their cartographic equivalents. The former affects and is affected by map reading and map perception, the latter deals with the meaning of symbols and is related to map interpretation and analysis, including cognition. Olson (1975) has also noted such a distinction between the complexity of the mapped distribution and the complexity of the visual nature of the map.

Further discussion by Brophy indicates that the two complexities are not independent of one another as the intellectual content of the map achieves expression through the graphic symbols. In considering the possibilities of quantifying complexity he suggests that " a continuum of map complexity exists which ranges from near zero to near infinite. Moreover, different maps, i.e. different symbols depicting different data, may have a similar level of complexity on a graphic and/or an intellectual basis." (p.344). These comments reflect similar conclusions by software engineers (e.g. Weyucker, 1988) who suggest that a value for complexity can be determined and assigned to each construct (map or computer program) examined.

Castner and Eastman (1985) took a slightly different approach to complexity, acknowledging more clearly the role of the map percipient and the variation in complexity which is *perceived* by each user. They proposed three types of map complexity: *stimulus complexity* which measured the informational content of the map; *functional complexity* related to the map use task and the user's experience; and *perceived complexity* reflecting the visual complexity and its effect on the user.

These considerations of map complexity resulted, in certain cases, in empirical testing of maps to determine how they vary in complexity and what the reaction of map users to such variation is. Relatively simple mathematical functions were used, usually derived from graph theory. This study addressed map complexity using alternative measures, chosen with reference to a detailed study of theories of complexity in a number of disciplines, ranging from management science, where 'causal maps' are used to explain inter-personal and organisational relationships, to landscape ecology, where complexity is a fundamental concept in determining ecological characteristics.

Possible indices to act as complexity metrics

The examination of other subjects revealed a certain common consideration of metrics such as fractal dimension, shape indices, diversity and entropy measures. Experiments have been done using the Fragstats and the IDRISI software packages which have allowed for the calculation of such measures, assessing their variation in maps of differing scale, content and appearance. The measures listed in *Table 1* are presented as characteristic of those which can be used to help determine complexity. Most are straighforward to apply to the data tested (McGarrigal and Marks, 1994) and are also easy to interpret. A preliminary attempt is also made to determine whether these complexity measures can be used in the assessment of map generalisation: does graphic complexity change significantly when scale reduction is undertaken?

Practical testing of these indices with real maps

Preliminary tests have been carried out on a number of maps to ascertain the behaviour of the indices chosen as representative of complexity. Examples of the maps chosen for study are shown in *Figure 1*. This forms a sub-set of a wider range of products which varied in scale (small scale atlas maps to large scale plans), in intended audience (reference maps and school maps), in media (digital and analogue products), in design (monochrome, single component maps to coloured maps with a range of text, point, line and area symbols), in source (maps varying only in their publisher) and in type of geographical area covered (developed flat landscapes and remote mountainous areas). Each of the images in *Figure 1* comes from a publication devoted to cartographic generalisation (Swiss Cartographic Society, 1977). The *berne* images are of an intricate urban area; the *gen* images exemplify building and street generalisation at a very large scale (the scale being maintained to demonstrate differing levels of generalisation); the *wood* images are smaller scale maps showing only area patches; and the *delta* images are line maps consisting entirely of contours (but which have been raster-scanned).

Conclusions

A range of measurements have been undertaken for a small number of particular map products (monochrome, raster, topographic maps of large/medium scale). The results indicated in *Table 1* reveal some differences in the behaviour of the metrics assessed.

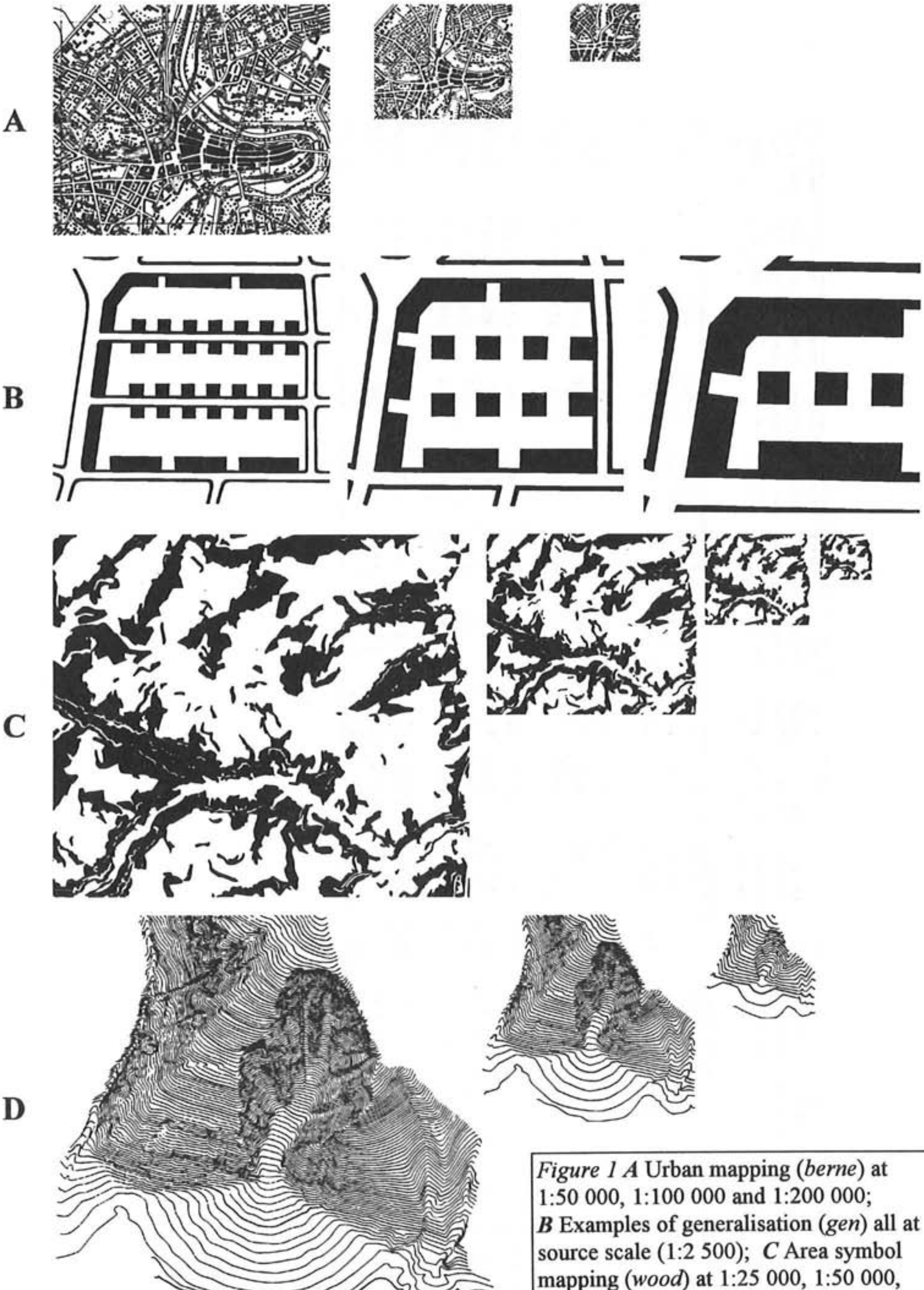

Figure 1 ***A*** Urban mapping (*berne*) at 1:50 000, 1:100 000 and 1:200 000; ***B*** Examples of generalisation (*gen*) all at source scale (1:2 500); ***C*** Area symbol mapping (*wood*) at 1:25 000, 1:50 000, 1:100 000 and 1:200 000; ***D*** Line symbol mapping (*delta*) at 1:25 000, 1:50 000 and 1:100 000

	Reduction using run length encoding (%) [var. #1]	"Black / White Ratio" [var. #2]	Mean Patch Size (hectares) [var. #3]	Mean Patch Size (pixels) [var. #4]	Patch Size Standard Deviation (hectares) [var. #5]	Patch Size Standard Deviation (pixels) [var. #6]	Land-scape Shape Index [var. #7]	Double Log Fractal Dimension [var. #8]	Shannon's Diversity Index [var. #9]	Simpson's Diversity Index [var. #10]	Shannon's Evenness Index [var. #11]	Simpson's Evenness Index [var. #12]	Moran's I (king case) Spatial Auto-correlation [var. #13]	Moran's I (rook case) Spatial Auto-correlation [var. #14]
berne1	84.80	0.590	0.524	292	10.141	5659	46.909	1.452	0.660	0.467	0.952	0.934	0.610	0.667
berne2	83.45	0.517	0.827	115	14.846	2071	25.410	1.420	0.641	0.449	0.925	0.898	0.575	0.629
berne3	82.43	0.723	4.185	146	29.212	1019	14.064	1.557	0.680	0.487	0.981	0.974	0.575	0.633
gen1	98.56	0.342	0.134	30385	0.224	50793	6.987	1.440	0.567	0.380	0.819	0.759	0.931	0.961
gen2	98.79	0.433	0.141	31973	0.282	63946	5.250	1.357	0.613	0.422	0.884	0.844	0.958	0.977
gen3	99.23	0.589	0.244	55329	0.346	78458	3.756	1.403	0.659	0.467	0.951	0.933	0.959	0.981
wood1	98.46	0.599	5.264	11749	51.273	114442	14.171	1.276	0.661	0.469	0.954	0.937	0.995	0.949
wood2	97.61	0.651	6.050	3376	51.264	28605	11.687	1.291	0.671	0.478	0.967	0.955	0.934	0.953
wood3	96.72	0.662	18.693	2608	89.192	12442	8.379	1.270	0.672	0.479	0.970	0.959	0.915	0.929
wood4	96.00	0.821	60.754	2119	142.804	4980	5.404	1.296	0.688	0.495	0.993	0.990	0.907	0.920
delta1	91.73	0.197	1.330	2969	24.650	55019	59.613	1.684	0.447	0.275	0.645	0.550	0.624	0.660
delta2	91.88	0.226	13.256	7397	76.079	42452	30.274	1.681	0.478	0.301	0.690	0.601	0.621	0.682
delta3	93.49	0.197	27.619	3853	112.129	15642	12.764	1.576	0.447	0.275	0.645	0.550	0.675	0.726

Table 1

The more varied appearance of *berne* and *delta* is reflected in their less effective compression compared to *gen* and *wood* (variable 1 in Table 1). The larger the mean size of uniform areas, the bigger the level of reduction with such compression techniques (although the nature of the patches is also important - the linear features in *delta* have a similar mean size to some in *wood*, but their lack of compactness leads to less efficient run length encoding). As is to be expected, the successive generalisations of maps of similar areas leads to an overall coarsening of the image *at real world scale* (var 3) along with more variation (var 5), but *at map scale* the actual pixel count for mean patch size (var 4) is less predictable, although generally becoming smaller and more uniform (var 6). Maintaining the 'black/white ratio' (var 2), a central tenet of topographic map generalisation, has limited success, but it has a strong relationship with the diversity indices (var 8 to 12) which are comparative (rather than absolute) descriptions of the composition of the graphic. The landscape shape index (var 7), which refers to the irregularity of the image along an "intuitive gradient from least to most heterogeneous" (McGarrigal and Marks, 1994, p.42), brings out the reduction in complexity and simplification of the map as scale decreases. Finally, spatial auto-correlation has been calculated to examine the 'roughness' of the pixel distribution, further confirming the more diverse and complex nature of *berne* and *delta* but also, in the case of area data decreasing in scale (*berne* and *wood*), decreasing uniformity.

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PRINCIPLES OF ENVIRONMENTAL MAPPING OF SHELF AREAS

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Compiling of environmental (geoecological) maps of off shore areas is a very complicated task, because of necessity to map numerous and various parameters. To solve this problem we advise to take as base 3 main principles: 1) lithology of bottom sediments is an integral characteristic of physical-chemical features of marine environment, 2) pollutants in off shore areas migratate by the same laws as natural sediments, 3) data on benthos on population and communities level fully present integral information on environmental situation and reflect total effect of anthropogenic impact.

If to take into account that lithological facies of bottom sediments reflect a number of factors: dynamics of their formation, chemical features of water media, source substratum and represent integral characteristics of all the totality of physical-chemical properties of marine environment the problems of showing many parameters at once can be solved by mapping lithological facies of the bottom sediments, namely: bathymetry, grain size of surficial sediments, lithological-genetic facies (including edafogenic and palimpsestic), accumulations of thin-grained material and sub-aqueous slumping. This information, summarized in the map of lithological facies, plays basic role in elucidating and predicting the ways of pollutants migration, places of their possible accumulations, distinguishing of sorptive properties of bottom soil. This map works as a base for final environmental map and can be drawn in black and white.

Spots with anomalous content of pollutants:

$$X_i \geq \bar{X} + S,$$

(where X_i - anomalous content, $\bar{X}$ - mean content, S - standard deviation) is recommended to be shown on the map by red marks, which is similar to geochemical map compilation. Selection of chemical component (pollutants) to be mapped depends on real environmental situation.

Nowdays numerous toxins get into the water by different ways, and it is not easy to evaluate influence of some concrete areas. Under these circumstances the only criteria of ecological situation could be estimation of state of ecosystem and its development. For estimation of ecological state of marine environment different groups of organisms are used: plankton, nekton, benthos. The last group should be recognized as prior due to its advantages: benthos is stable in time, characterized local situation in space, is capable to represent retrospective ecosystem changes.

Close relation of benthos to abiotic factors and to components of the underwater landscape make it possible to judge by its cartographic image on average annual and perennial variations of such parameters as: transparency, illumination, temperature, oxygenous regime, hydrogen sulphide appearing. For these parameters it is very difficult to get continuous variations by other techniques.

Universal model of the state of ecosystem, which can be used under any circumstances is hardly possible. Only criterias which take into consideration original nature of the studied ecosystems can be regarded as trustworthy. Quantitative methods of estimation of the benthic organisms state, which can be used as simple, only now have got into investigation. Method of V.B. Pogrebov based on field experiments and studies in Russian Northern Seas, is on of them (Pogrebov, 1993). According to his scale each bottom station can be characterized by ball estimation incorporating several biological parameters. For final presentation of the results on geological maps bottom areas which differ by their deviation degree from the mean normal regional value can be delineated. This deviation scale can be outlined by colours from green to red (from satisfactory to catastrophic).

Joint representation on the geoecological map the above mentioned lithological information, anomalous contents of pollutants and characteristics of biota state, which is expressed by deviation from normal value (in percent) allows to predict the future tendencies in environmental behavior of the system.

The described methodic were realized in compiling geoecological map of the Cola area of Southern Barents sea. Results of the statistical calculating of several years changing of the Barents Sea biota (Antipova, 1984) show that total benthos biomass nowdays does not differ significantly from the values of 20-30-th years of this century.

Benthic communities have natural undisturbed character, except benthic community in the Cola bay, where the number of species has decreased by 1.5-2 times during last decade in its northern part and by 6-10 times in its middle part. By Pogrebov's index equal "2" and "1" ecological situation in Cola bay is close to catastrophic (Pogrebov et al, 1995).

Contents of chlororganic matter, radionuclides and heavy metals in bottom sediments in Cola bay dramatically exceed their background level (Biologicheskie resursy, 1995).

Considerable accumulation of pollutants in Cola bay, and in consequence of this, catastrophic state of biota there undoubtedly is connected with accumulation regime of sedimentation in this bay, which is obvious from the lithological data. Cola bay apparently plays a role of a natural barrier for the pollutants migrating to the open parts of the Barents sea. Besides, the anthropogenic impact in Cola Bay is very high, because of intensive industrial waste products. A combination of natural and anthropogenic unfavourable factors leads to catastrophic situation in Cola bay. This conclusion is easily read from the geoecological map compiled by the described methodics.

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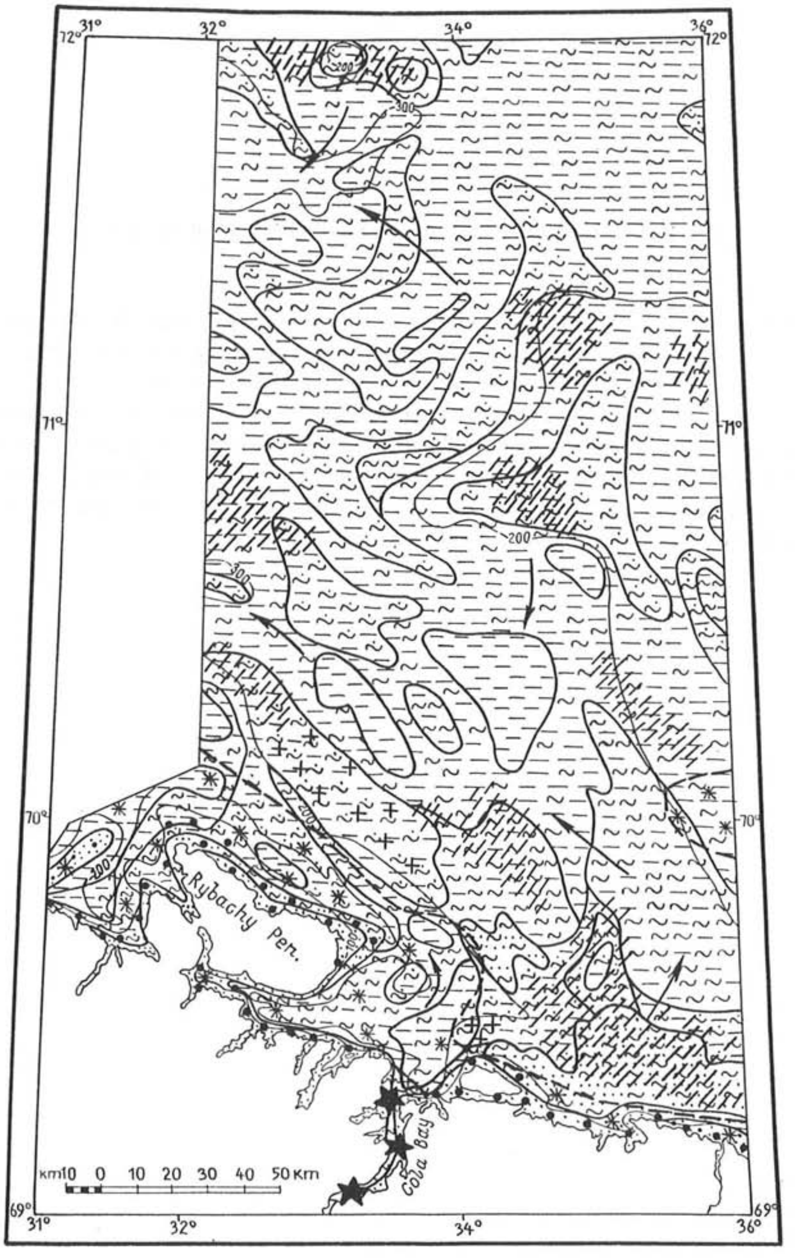

72° 31°
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Rybachy Pen.
Cola Bay
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300
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32°
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15

Fig. 1. Geoecological map of the Southern part of the Barents Sea

1-8 - grain size: 1 - sand, 2 - sand with rare gravel, 3 - pelite, 4 - silty sand, 5 - sandy silt, 6 - pelitic silt, 7 - silty pelite, 8 - sand and silt with pelite; 9-11 - genetic types of bottom sediments: 9 - gravitational sediments (abrasional products), 10 - palimpsestic sediments (products of washed out pleistocene sediments), 11 - edaphogenic sediments (products of washed out hard rocks); 12 - transite ways of sediments; 13 - isobathic line; 14 - content of polychlorbiphenils: 0.5-42.6 ng/g; 15 - content of polychlorbiphenils: 42.7-380 ng/g and Cs-137 activity - up to 30 bk/kg.

PECULIARITIES OF GEOLOGICAL CARTOGRAPHY OF THE SHELF AREAS

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Geological cartography of shelf areas is based on all available geophysical data, direct extrapolation of geological features from the land, boreholes section, and on the interpretation of the bottom topography and sediments data. Depending on the prevailing source of the information the ways of geological map compilation and trustworthy of the maps are different. On the whole it is possible to distinguish and to map rather large litho-stratigraphic rock complexes, having relatively uniform composition and specific physical properties. Unconformity surfaces dividing these complexes correspond usually to geophysical borders with definite magnetic, density, and seismic velocity gradients.

The major role in off shore geological mapping (stratification, estimation of units thickness, tectonic structure) belongs to combined seismic survey, including: 1) seismic reflection profiling (multychannel common deep point, deep sounding), 2) low-frequency seismo-acoustic profiling (100-1000 H), 3) high-frequency seismo-acoustic profiling (1-10 kH). Supported by rare marine boreholes the joint seismic data give all the necessary information for the mapping of preQuaternary and Quaternary strata. Seismic reflection profiling allows to stratify sedimentary and volcanic-sedimentary complexes deeper than 400-500 m under sea bottom up to 12-15 km. To elucidate stratigraphy of the upper part of the sedimentary cover and to trace main reflectors to the surface we need records of low-frequency sparker-type profiling with 3-5 m resolution in the Q-400 m layer. And to study and map Quaternary sediments high-frequency modification should be used with 0.5-1.0 m resolution (Lopatin, Musatov, 1992; Lopatin, 1995).

The first stage of joint interpretation of the obtained seismographic records is resulted in correlation charts of prominent reflectors, in tracing of these reflectors to the bottom surface and in composing of seismic sections in time scale along all the made profiles. The second stage of seismostratigraphy analysis is to identify seismostratigraphical complexes, to map their lateral distribution, and to estimate their geological age.

To stratify and to map Upper Cenozoic sedimentary units seismoacoustic profiling supported by shallow drilling and bottom sampling is the most effective. At the first stage of interpretation seismo-geological section of the Upper Cenozoic strata are divided upon relatively large complexes bounded at their floor and roof by unconformities. Then within these complexes different seismofacies are distinguished, which is very important for polygenetic formation. Mottled chaotic pattern of records is typical of continental (mainly glacial) origin, and bedded type of records - of marine sediments.

For seismostratigraphic analysis it is very important to study a character of relative changing of paleosea levels. Transgressive facies are distinguished by evidences of shoal adjoining in seismographic records. Regressive regime is characterized by stratigraphic hiatus when reflectors cannot be traced at disconformity boundary, in consequence of erosional or tectonic shear or lack of sedimentation. Epochs of sea level stability are recognized by dislpacement of shoal top adjoining of near-shore marine and alluvial-marine sediments to the sea direction (Vail, Mitchum, Thomson, 1977)

Volcanics formation are usually recognized by specific magnetic anomalies. Tectonic faults are mapped by geophysical data, bottom topography features and direct extrapolation from the land. If geophysical study in off shore areas is limited by gravimetric-magnetic data, maps of structure contour lines of basement surface or floor of sedimentary cover serve as a basic material for geological mapping. According to the structural plan of the area younger complexes are shown in depression and older ones are shown in uplifts.

To have complete cartographic data base for the studied shelf area it is necessary to compile a set of maps, including: geological map of preQuaternary level, map of bottom surface, geomorfological map, tectonic map.

As has been mentioned above a geological map is based on recognized quazisynchronous sedimentary seismic complexes tied to the general chronostratigraphic scale. It shows:

- distribution of stratified sedimentary, volcanic-sedimentary complexes divided by their age and composition into units, corresponding to systems, series, rare stages;
- faults of different morphology;
- metamorphic and igneous rocks in near-shore zones, where they occure directly under Quaternary sediments;
- structure contours of the acoustic basement surface and of the main reflectors.

To give some information on the deep structure geological maps are supplemented by series of seismogeological sections. When seismic study is sufficient it is recommended to show by special striation a distribution of old rock complexes buried under the young ones, to make geological maps more informative. It permits to reveal geological structure in oil potential areas. It is recommended to draw off shore and on shore parts of the map in the same legend but to distinguish coast lines by narrow (1 mm) white stripe.

Map of Quaternary deposits is compiled on genetic, stratigraphy and lithology principles. Genesis (marine, glacial and so on) is shown by different colours, the age of units - by symbols and by shades of the colour, and lithology - by black marks. Some geomorphological elements, relevant to Quaternary geology, such as glacial topography features, old shore lines, recent tectonic elements are recommended to be shown. If there are enough seismoacoustic data it is desirable to show iso-pachous lines of Quaternary sediments.

Maps of surficial bottom lithology are composed of by mainly bottom sampling and echo-sounding data. Fields of different grain-sized varieties of sediments are shown by colours (pelite, silt, sand, gravel, pebble). Bigranular and polygranular sediments are shown by alternating stripes of the main colours. Genetical types (terrigenous, biogenetic, chemogenic, volcanogenetic) are distinguished by black marks.

On geomorphological maps the following elements are shown:

- large morphostructures (plains, rising bottom, depressions, troughs, slopes, ridges), by colour;
- degree of rugged topography and dippings of slopes, by shadows of the main colours;

- genetic types of bottom topography (tectonic, denudational, abrasional-accumulative, and so on), by black marks;

- typical small topographic forms (benches, scarps, buried valleys, hills).

For successful realization of the described recommendations of geological cartography the whole scope of computer technology at the all stages of work is absolutely necessary.

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A UNIVERSAL DYNAMIC STRUCTURE OF MAP BASED ON VECTOR DATA

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ABSTRACT

Dynamic processing of electronic map is an urgent and necessary task in many applicational fields.Similarly,the research on basic dynamic data structure is also very important. Based on the analysis of linked and sequence structure , we have found that when they are used independently, there are some disadvantages in representing map .Low level of expressive method leads to inconvenient map operation . In this paper, the author presents, in combination of the advantages of the linked and sequence structure , a universal dynamic structure contributing to high-level representative which makes it simple and easy to manage all kinds of map elements, such as extracting, merging,inserting and deleting and so on. The most important and valuable characteristic is that any node could be located by only one formula. Making use of the powerful function of C-language, the algorithms concerned have been established.

Key words: Dynamic Structure,Vector Data, Map

1. INTRODUCTION

Nowadays, electronic map has found wide application in many fileds,such as navigation ,tourism and cadastral management and so on. Especially in the filed of cadastral management,a great many daily work needs to be finished on it, like the parcels alteration and other dynamic operations. Many advanced data models , such as mixtural model of raster and vector structure,object-oriented data model and so on, have .been applied into it. But a good abstract data model also needs a good corresponding storage structure on which it can do its best.

Generally, in the view of the smallest unit of data structure, i.e., node, there are two major types of node, one, i.e. linked node,needs at least one filed of pointer with which the connection can be made,the other has only one information field which can be divided into more intensive cells and can be organized in a sequential order like arrays of single dimension. With reference to dynamic operations, linear and linked data structure accommodates good performance , but there are some shortcomings as follows:

a) the field of pointer in node will take up additional storage space;

b) the efficiency of some algorithms especially in searching approach is low;

c) it is difficult to locate any node directly, in other words, we can only find and express a node by the action of pointer indirectly.

In this paper, a universal dynamic data structure is dedicated to solving these problems as mentioned above. In combination of the advantages of linked and sequence structure, the basic unit is built and based on it, the organizing principle of universal dynamic structure will be given. With the aid of C language,the powerful functions of type definition and redefinition, memory allocation and reallocation, as well as macro definition are used to implement the principle into practical algorithms.

2. THE PRINCIPLE OF UNIVERSAL DYNAMIC STRUCTURE

2.1 Node and Concerned linear Structure

Node is called the basic unit of expressing the characteristic and linking relationship of data structure.In the universal dynamic structure, the node also needs to be designed. Two kinds of node forms included are linked node which has information filed and pointer field in which the pointer points to another linkage node,and sequential node which has only information fields.The universal dynamic structure organically organize them into one entity. Let's see how it is applied in linear structure.

Commonly,storing a linear data structure can use either sequential structure or linked structure,the main shortages have been mentioned above.Using universal dynamic structure , can store the linear structure as shown in (fig. 1).

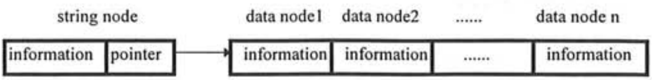

fig. 1 - linear structure expressed by string node and data node

Here, for convenience's sake, we call the node with one pointer filed string node SN, the node without pointer filed data node DN. From fig. 1,we can see the difference from common linear structure in that:a) for one linear string, there is one string node including one pointer filed;b) the elements among linear string consist of data nodes;c) the direction of pointer in string node points to the first element in linear string rather than other string node;d) all the data nodes are in the sequential order.Taking into consideration the combination of string node and data node, we can take full advantages of them, for example, linked structure is suitable for handling complex structure, the algorithms of inserting, deleting, merging and splitting ,etc.; and sequential structure is suitable for the locating node position, and it need less storage space.

2.2 Tree structure

Based on the analysis of the mentioned above, the tree structure can also be expressed by the combination of string node and data node. Tree structure is a very important and widely used non-linear data structure in map data management and other fields.Figure 2 shows the tree structure expressed by the linked node including more than one pointer filed , and figure 3 shows the tree structure expressed by string nodes and data nodes.On regard of the storage space, fig.3 is more efficient than fig.2, the more detailed advantages of fig.3 will be given in the following section.

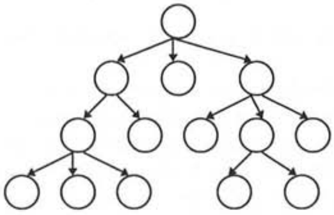

Fig.2 Tree expressed by linkage node

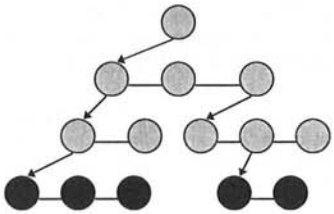

Fig.3 Tree expressed by string node and data node

legend: linked node string node data node
linked node sequential relationship

2.3 Performance of C-language

There is an important characteristic in C-language, i.e.,allowing the conversion of data type.The conversion of the data type pointed by pointer has been used most widely. Using the structure definition, we can add data filed variable of "currlen" to represent the length of string pointed by string node;add pointer filed variable of "index" pointing to "void" type,in other words, the data type pointed by "index" is undefinable and it will be strongly converted into another type according to the practical need. In the same way,the dynamic memory allocation function "calloc", the reallocation function "realloc", the memory block movement function "memmove", and the capability of macro definition are all combined to formulate the basic algorithms of universal dynamic data structure.

3. THE DEFINITION AND ALGORITHMS ON VECTOR MAP

Generally, the information on map fall into certain categories according to the some classified standards.Like cadastral map,although all the elements are in the same plane, they can be divided into parcel layer, map grid layer, character and string layer and others. So we take the tree structure organized by universal dynamic structure to express map elements.

3.1 Classification of map elements and structure definition

In general sense, we divide the map elements into line,symbol, character and other layers in accordance with the graphical feature. And node structure concerned can be defined. In order to elaborate the principle clearly,we assume that the tree structure only has four levels, from top to bottom, the corresponding names are "map", "layer", "string" and "element". So the nodes structure of "map","layer","string" consist of pointer field and information field, but the node tructure of "element" has only information field rather than pointer field.

We define "vm" as the structure name of "map", "cover" as the structural name of "layer", "vstr" as the structure name of "string" , "elem" as the structure name of "element" . The C-code definition are given as follows:

```
typedef struct vstr_stru {
 int currlen;      /* current length */
 int esize;        /*  byte of  data node */
 void *index;      /*  pointer */
 }vstr,vm,cover
```

```
typedef struct elem_stru{
 float x;      /* x  coordinate */
 float y;      /* y  coordinate */
 float z;      /* z  coordinate */
 }elem;
```

In fact, some field variables can be added to the definetd structure to express more etailed nformation, for instance, by adding a variable to"vstr_stru" to define the geometric feature of some layer, or by adding a variable to "elem_stru" to define the character information,etc.

3.2 Representation of relationship of map elements

Sub-structure is very suitable to express the large and complex object.To realize the representation of multi-hierarchical assembling relationship, the first thing needed to be taken into consideration is how to express and how to illustrate the ulti-hiearchical relationship among sub-structures.

Apparently, the relationship consists of the form of multi-layer and multi-branch, and it is in non-linear form.Also,there exists a tree structure among "map","layer","string" and "element", which are used to express the non-linear relationship of map elements.

Utilizing the structure definition as defined above and the organizing principle, we could define the multiple hierarchical relationship very concisely and conveniently. Now that "vm.index" points to the structure "cover","cover.index"points to the structure "vstr", and "vstr.index"points to the structure "elem", the relationship between every two adjacent levels can be concluded firstly. After that, the relationship of every three or up to three levels can be concluded adopting the mosaic definition. The functions of macro definition of C-language are used to define the representative formula as follows:

```
the relationship between "string" and "element" is:
#define iav(v)             ((elem *)(v.index))
the relationship between "cover" and "string" is:
#define lav(v)             ((vstr *)(v.index))
the relationship between "map" and "cover" is:
#define mav(v)             ((cover *)(v.index))
the relationship among  "cover","string" and "element" is:
#define   llaxy(v)(i,j)   (iav(lav(v)[i])[j])     /* "i" is the number of
string,"j" is the number of element*/
the relationship among "map","cover","string" is:
#define   mllv(v)(i,j)    (lav(mav(v)[i])[j])   /* "i" is the number of
layer,"j" is the number of string */
the relationship  among "map","cover","string","element" is:
#define mapxy(v)(i,j,k)   (iav(lav(mav(v)[i])[j])[k])
/* "i" is the  number of  layer, "j" is the number of string,"k" is the
number of element. */
```

For example, "iav(v)[1].x" is used to express the x coordinate of the first element; "mllv(v)(2,3) is used to express the string in the second level and the third position;"mapxy(v)(3,4,5)" is used to express the element located in the third level , the fourth string and the fifth position.

3.3 Basic algorithms

The basic operational algorithms are based on the structure definition and relationship formula,and they are memory allocation and reallocation,memory clearance, deleting, moving, merging,spliting,copying and so on. By these fundamental algorithms,more complex and specialized algorithms then can be created. In this paper, only searching algorithm and deleting algorithm are given. They are put as follows:

3.3.1 Searching algorithm

Here, the C-coded program is given:

```
for(i=0;i<=vm.currlen;i++)
  for(j=0;j<=mav(v)[i].currlen;j++)
     for(k=0;k<=mllv(v)(i,j).currlen;k++)
       printf("%f %f%f",mapxy(i,j,k).x,mapxy(i,j,k).y,mapxy(i,j,k).z);
```

This approach could search all the map elements.The most important advantage of this method is that any map elements could be expressed only by one formula. As compared with common approach, it finds map element in the linear form much efficiently,and the time complexity is O(vm.currlen*mav(v).currlrn*mllv(v).currlen). Contrary to it, if the tree structure is assembled all by linked nodes, the transformation of element path is under the action of pointer exchange, , and the executive efficiency is obviously low. In the practical application, grid index is advised to be created so that the searched object be located quickly in a rectangle area.

3.3.2 Deleting algorithm

The steps of deleting algorithm are given as follows:
a) Judging whether the curren string is in void state,i.e.,having no son node. If it is in void state,then exit;
b)If the node needed to be deleted is not inside the current string, then exit. "t" express the starting address of current string;
c) If the node needed to be deleted in inside the current,then the position "k" of the node needed deleting is "k=p+n", "p" is the starting position, "n" is the number of nodes.
d) With the aid of block movement function "memmove", transform the "n" node data to " p " position.

The corresponding C-coded sub-program is dedicated below:

```
int vstrdel(vstr_stru *v,int p,int n) {
  int k,l;char *t;                    /* define variables */
  l=sizeof(struct vstr_stru);         /* the bytes of snode */
  if(p>=0 && n>0)
    t=(char *)v->data;
    memmove(t+p*l;t+k*l,n*l);   /* movement of the remainder node */
    return 1;
    } return 0;
}
```

Seemingly, the movement of node is more difficult and the step is more complex,whereas in linked data structure,this operation can be finished by the transmission of pointer, so much simply.But nowadays, the computer technology has made much progress,the so-called time-problem becomes less important compared with that five or ten years ago.Practically, the function "memmove" has the same high efficiency as pointer transmission[9].

3.4 Expressing topologic map

Spatial data are used to create the connection and characteristic representation of object on the earth surface in the form of point, line and area feature. Among them,one of the most important character is their inner topologic relationship. The polygon topologic structure is the most popular method used to express the map object based on vector data. The linked polygon topologic structure serves as the example to illustrate the application of universal dynamic structure.It is well known that in common sense, vector map can be organized by root, layer, polygon,line and point. These data are stored in disk media,here, we call it outer data. Generally,many attribute data may be included in outer database too. If we manipulate data directly on outer data stored in disk, any small alteration may cause big movement, and the low efficiency is difficult to tolerate. Compared with outer data,we call the data organized by universal dynamic structure as inner data. For the sake of memory, ordinarily, the attribute information needs not be read into inner structure,when the node has been located,the attribute information related to it then can be directly found in disk.

The conversion steps of outer data into inner data are given as follows:
a) First, initialize the inner structure. I.e., define the structure of root, layer, polygon, line and point ,then make definition of the pointer direction and allocate memory space. For example,vm.index=calloc(vm.currlen,sizeof(struct cover)) means that the "map" pointer point to "cover",and the bytes of vm.currlen*sizeof(struct cover) are allocated .
b) secondly, assemble the muilple hierarchical relationship from top to bottom. Assuming that there are three layers under "map", add "cover" structure to the space pointed by "vm.index" with the function of "memmove".Maybe the initial distributed space is less enough to store it, the function of "realloc" in C-language need to be used to adjust the space distribution.
c) At last, maybe there are islands and hanging lines included in polygon,so the outer boundary of polygon must be organized in clockwise or anti-clockwise direction .

When all operations on universal dynamic structure have been done,the changed information can be rewritten to outer disk media, i.e.,outer topologic data structure, in the order from top to bottom.

4. CONCLUSION

Through the performed discussion and verification, it was found that :
(1) the universal dynamic structure can be regarded as a useful basic alternative for possessing the relationships among all kinds of data type. In the domain of map science,GIS, computer science and so on, it can find widespread application.

(2) as for the dynamic processing of vector map information, we can see that universal dynamic structure is very suitable to express the vector map data structure,such as linked data structure, polygon data structure and other more complex data structure, then the basic operation based on it becomes easier and more concise.

(3) the most important and aluable characteristic is that only one expressive formula could directly locate the node you want to find in any way, and this kind of concept cannot be seen in any other concerned papers ever before.

The principle and algorithms as discussed in this paper have been applied in a practical cadastral information system which is developed by my colleagues and me,and it has been applied in many counties in China.

With the same principle and concept, universal dynamic structure has also been applied to express raster data structure ,such as qudatree structure. Aided by the recurrence function, the definition of quadtree and some basic algorithm is easy to realize,the detailed discussion could be seen in [2].

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THE ROLE OF THINKING IN IMAGES IN MAP DESIGN

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Abstract

An organic combination thinking in images with abstract thought is one of the characteristics of map design experts' thought. It is significant for Artificial Intelligence(AI) to study the expression of image knowledge. It is also the key to make a breakthrough in map design expert system. This paper introduces basic concepts of thinking in images and abstract thought, and presents the role and the process of thinking in images in map design. By initially inquiring into the relationship between thinking in images and map design expert system, the authors think that it is helpful for the development of map design expert system to study thinking in images.

1 Introduction

The thought science is a subject studying the rules and the ways how human beings think. Professor Qian Xuesen, a famous Chinese scientist, has published the papers about thought science successively in recent years, and put forward many precious views on establishing the thought science. Professor Qian divides the individual's thought into three parts: abstract thought, thinking in images, and inspiration thought. He presented that it should be regarded as a breakthrough for the researching into the thought science to study thinking in images.

Abstract thought is the thought taking abstract concept and inference as its form. Thinking in images mainly summarizes by way of typification and thinking with imaginal materials, which imagery is the cell of thinking in images. In the process of thinking, if abstract thought is chiefly made by means of the abstract concept, then, thinking in images principally accompanies concrete image. Thinking in images is thinking through imagery, and the mental process is summarization. Thinking in images is identical with neither perceptual knowledge nor abstract thought, but a kind of vivid rational knowledge activity.

The image in thinking in images is the mental imagery. The mental imagery may be defined as an internal representation similar to sensory experience but arising from memory[1]. It is said that many discoveries in scientific history were made by means of mental imagery. Scientists and inventors, many people think, do not carry on thinking with abstract concept but mental imagery.

The mental imagery plays an important role in problem solving. Like other representations of problem solving, mental imagery is a way of thinking. It is a set of symbol structures, and may be dealt with operation, getting new information from it.

Map design is an important link in the process of map-making, and determines the quality and the appearance of maps. The practicality of map design is very strong, and it reflects the perfect combination between science and art. Because map is the product of visual thinking, and visual thinking is a form of thinking in images, thinking in images plays an important role in map design. Map design experts' thought is mainly characterized by the organic combination between thinking in images and abstract thought. Therefore, it is important in AI to study the representation of image knowledge, also the key to get a breakthrough development in map design expert system.

2 The role of thinking in images in map design

The area of scientific investigation chiefly makes use of abstract thought but thinking in images also plays an important role in it. The area of artistic creation mainly applies thinking in images, but actually it does not exclude abstract thought. Designing map is a kind of scientific and artistic creation, therefore, map design needs the organic combination between abstract thought and thinking in images.

A map is a scientific work characterized by visual images. A map should be imbued with artistic value as well as practical value. At the time of seeking map scientific content, people are pursuing higher level of artistic aesthetics. As a way of thinking, thinking in images is helpful for map designer to create a map work. Applying thinking in images to map design, which is characterized by spatiality and entirety, will be of advantage in enlarging the scope of time and space of map designer's thinking, giving play to his subjective initiative, revitalizing map design's thought, and increasing the interest of map.

The roles of thinking in images in map design are:
Firstly, when a map designer is designing a new map, he has to read various cartographic information, then through perceptual selection, forming some internal images in his mind, namely "mental imagery", and this mental imagery is "mental map". A mental map is not only the result which map designer obtains in thinking in images activity, but also the medium which

thinking in images is dealt with. It is a map that creates a visual image, and this activity of mental imagery is indispensable for transforming cartographic information into visual image. The reason why the map symbol can realize its symbol's function is that people have great ability of image recognition and they are able to make a response to map symbol, through thinking activity like imagination, association and emotion sympathy, to get their concepts. So we can say the characteristics of map image specially need elaboration of thinking in images and they are also specially suitable to it.

Secondly, a person who has great ability of visual mental imagery and has some cartographic knowledge, can "see" in his mind the geographic imagery constructed by the map symbols which he designs. Map design is a process in which its scheme should be compared and perfected gradually. All kinds of middle scheme are stored in the map designer's head in way of mental image through thinking in images, by constantly modifying and perfecting, forming a scheme of new map in the end. Therefore, it is indispensable for thinking in images in the process of map design.

Thirdly, a map designer increases his artistic interest of mental activity, widens his train of thought, and strengthens ability of experiencing harmonious beauty and of intuition selection in the abundant imagination provided by thinking in images. It is easier to smash the bonds of tradition, acquire optimum formal model which expresses rational knowledge for objective world. Different map quality designed by different designers may be explained as divergence presented in their ability of thinking in images and their different mental maps produced in the process of designing maps. To sum up, thinking in images plays an important role in the process of map design.

3 The process of thinking in images in map design

When a map designer is designing a new map, he should firstly "design map" in his head. Designing a map in mind needs neither pen nor ink nor the concepts, but can only use the mental map. The formation of mental map was obtained after mental perceiving objective world or reading plenty of map information through the process of analysis, comparison, selection and synthesis etc. Only changing external map images into mental map images can objective map images be thought, operated and designed in the mind. The actual map is physical design thought in the map designer's mind, and mental map is its internal form of expression. Of course, apart from concept images, cartographer's designing map in his mind needs abstract map design theory and various map design data, such as map scale, size and the scale level of geographic data.

The process of thinking in images which a cartographer goes through in designing a map, generally speaking, is shown as two ways. The first is learning. A map designer should regard himself as a map reader. When he is designing a new map, he should refer to and read a lot of map information, literature and diagram about designed area, and he should use learning ability of mind, and the experience of his predecessors for reference, carry forward strong points, and avoid weak points, to guide his map design practice. The mental map built in this way is the basis of constructing new design map scheme. The second is practical creation. Map designer should be good at using images reflected by objective world in his mind, through thoroughgoing and painstaking thinking in images activity, recalling his successful and failing experiences of designing map. According to map design demands, he should absorb and cast these experiences in practice, surpass the present level and create new methods of expression. These are all the results of bringing thinking in images into full play.

4 Thinking in images and map design expert system

Map design process is a mixture of graphics, art, cognitive science, color science, expertise, etc. It embodies high-level human intelligent behaviors, and cannot be easily simulated with traditional computing methods. Therefore, most researchers in the area of automated mapping have focused on the use of AI techniques, in particular, expert system. The key to such an application is the acquisition and formalisation of domain knowledge[2].

The application of expert system is a popular subject in cartography. Since 1980, there is cartographic scholars who attempt to realize the automation of map design and production using expert system techniques. It must firstly formalize map design procedure in order to develop map design expert system, and the basis of knowledge formalisation is the method of knowledge expression. There are two types of knowledge in the domain of map design. One is the knowledge about the fact and relation in the domain of map design, such as the fact written in teaching books or professional journals. The other is the knowledge used to problem solving. It is often a process that explain how to operate existed data and knowledge in order to solve problems, and this kind of knowledge is called procedural knowledge or heuristic knowledge which is gained by experience. Only combining experience with reasoning can it function, so it must apply thinking in images.

Though cartography has been developing for a very long time, people have as yet known little about the process of thinking decision in map design, in particular, the process of producing design scheme which takes place in human's mind. Up till now, many map design expert systems have been presented, but they have only realized a small part of the intelligence. There is still a long distance to leave true automated map design. It will certainly require using a series of laws of thinking in images to delve further into the production of intelligent design scheme along with the perfect function of computer image processing.

The study of AI often gets frustrated because it is difficult to express "procedural knowledge", and most of them are stored in human's memory in form of images. These images may either be transformed into judgments to take part in abstract thought or directly join thinking in images. If someone wants to substitute abstract logic for images, there are certainly many difficulties. Therefore, it is an important job for AI to study the expression of image knowledge, and it is a key for map design expert system to make a breakthrough progress. The achievements in thought science, for example, the solving of the problems how to combine the experience with reasoning, will play a guidance role during the development of map design expert system.

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THEORETICAL CARTOGRAPHY IN CHINA

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Abstract

As a science, cartography can be divided into two parts: theoretical cartography and practical cartography. Like numerous natural and technical sciences, theoretical cartography is indispensable part of cartography. Theoretical cartography provides the theoretical basis for cartography, which determines the direction of subject, and its importance should be emphasized. This paper presents the origin, analyses the status, and points out the developmental trends of theoretical cartography research in China.

1 Introduction

In China, research on theoretical cartography may be separated as two stages. The first stage was the study of the traditional cartographic theories such as mathematical cartography and map decoration theory from 1950s to 1970s; the second stage began in 1980s when modern cartographic theories, such as map perception theory, map communication theory and map information theory, were introduced into China by some cartographic experts from abroad. From then on, theoretical cartography was emphasized in the field of cartography in China.

Research on the theoretical characteristics and scientific structure of cartography, the system of modern cartography, the nature of the map and pattern of cartographic communication are being dealt with in several different ways. Some cartographers have also put forward the concept of map spatial cognition theory, and some have proposed the concept of comparative theoretical cartography etc. It is quite evident that research on cartographic theory has become a part of Chinese cartographers' work.

At present, the theoretical cartography course has been set up in the department of cartography and geography in China's universities.

2 The status of cartographic theory research in China

In the past, theoretical cartography study was made by only a few cartographic experts in China, but now, more and more younger cartographers join this rank of researching on the cartographic theory.

Due to the introduction of the electronic technology, cartography has been greatly changed. The scope of mapping has been enlarged, and means of mapping has been also altered. Many new concepts arose such as virtual map, real map, mental map, dynamic map, screen map, animated map and interactive map. All these impel cartographers to reconsider the definition of map and cartography. That is the reason why definition and concept of cartography are of interest to cartographers worldwide. More than ten definitions and concepts have been proposed, but there is still no unified recognition on any of them. Chinese cartographers deal with a lot of discussion about these.

Research on modern cartographic theories, especially, on map information theory, map communication theory, map language, map perception theory and map model theory, are going on in China. Quite a few papers are published in the professional journal in China-CARTOGRAPHY. All of these push Chinese theoretical cartographic research forward.

The theoretical cartography research in China has made a good few achievements in several aspects in 90s. At present, some Chinese scholars put forward the concept of map spatial cognition theory, some presented the basic concept of comparative cartography.

Map spatial cognition theory, in Chinese scholars' opinion, is the combination between cartography and cognitive science, which was once studied for the map use in analog map era in 1960s. Map spatial cognition theory mainly studies cartographic cognitive process under computer mapping. Mental map, cognitive mapping, map spatial cognitive model and computer simulation of human spatial cognitive ability are its basic concepts. Since people have as yet known little about the spatial cognitive process of map-making and map use, they have been beset with difficulties in the development of GIS and cartographic expert system. Therefore, it is helpful to study map spatial cognition theory for establishing spatial cognitive model of GIS and cartographic expert system.

The basic concept of comparative cartography was put forward by Chinese scholars for the first time in 1987.Later on, a special paper entitled "Methods of Comparison in Cartography, It's Embodiment, Contents and Significance" was published in CARTOGRAPHY (1988).Since then, the study of practical use of the methods of comparison in different cartographic disciplines has being carried on, and quite a few achievements in comparative study in various fields of cartography have been made, which constitute the essential contents of comparative cartography. In 1989, the term "Comparative Cartography" was adopted in the special publication on natural science and technology terms for Surveying and Mapping Branch. This is a strong indication that comparative cartography has been confirmed in China's cartographic academic circle. At present, the study of comparative cartography has been spreading widely in map use, cartographic set models, map classification, etc. , and its methodological superiority is gradually manifested, and the theory and practice of comparative cartography may be expected to develop more rapidly in the years to come.

3 Problems in theoretical cartographic research

Theoretical cartographic research in China has only a short history, and the author thinks that the following problems exist in the research on theoretical cartography in China:

1) Most Chinese researchers have only put forward their viewpoints according to international acceptable theories, being more literal introduction, and less their own experiments. Some theories like map perception theory should be psychologically tested, but not be just literally described. It must be explained by test data how people to perceive in using a map.

2) Although having made great achievements, theoretical cartography still remains academic, and can hardly guide practical map design and production.

3) Entering into 1990s, most Chinese cartographers are fond of research on GIS, digital mapping and cartographic expert system, but they pay little attention to basic theoretical research of cartography. Some theoretical concepts in cartography like map language, are studied by only a few Chinese scholars, which was selected as one of five Main Theoretical Issues on Cartography in 16th ICC.

4) The lack of information, experimental conditions and international cooperation hinders the development of Chinese theoretical cartography research.

4 Developmental trends in China

The trend in theoretical cartography is a direction in which some, already known, branch of cartographic knowledge is being developed or in which a new branch is arising[1]. As forecasting the theoretical developmental trends is rather subjective-intuitive, the author can only distinguish the following developmental trends according to the present theoretical cartography research in China and abroad:

-theoretical aspects of computer(digital) cartographic modelling,
-various theories about geoinformatics, GIS-technology, remote sensing data-processing etc.,
-map spatial cognition theory,
--map language or map semeiology,
-research on comparative cartography,
-the definition of map and cartography.

5 Conclusion

Theoretical cartography can be regarded as a spiritual wealth of cartographers, and its importance should be emphasized. Any negligence to theory research will lead to the backwardness of subject, even to the destruction.

Cartography has now entered the era of information along with developments in information technology. As an engineering-type subject, cartography is characterized by digital information and digital tools, as well as for the tasks of map design and communication. Therefore, the research on theoretical cartography must keep abreast of the times, and study the theory in relation to information technology and guide practical map design and production.

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ON THEORETICAL GROUNDS OF DESIGNING NATIONAL STANDARD FOR DIGITAL AND ELECTRONIC MAPS IN RUSSIA

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1 General

The most common and significant features and relations that are typical for standardization have found their reflection in terms and definitions developed in the new area of knowledge - geoinformatic mapping [4,5].

The notion of standardization is the basic category that can be defined as an activity oriented to reach an optimal regulation in certain domain by means of establishing some rules intended for the most global use with respect to real or potential tasks. In particular, this activity appears in developing, publishing and implementing standards and technical terms for the cartographic production. The most important results of standardization activity is improving the correspondence between production, processes and services to their intent, elimination of barriers in trade, and assistance in scientific and economic cooperation.

In the area of geoinformatic mapping, the subject of standardization is spatial data, digital and electronic maps (production), processes and services related to the technologies of acquisition, storage, analysis, processing, retrieving and application of cartographic information, as well as to the hard- and software and their mutual compatibility. Standardization also may be limited by certain aspects (properties) of any object. For instance, as applied to the electronic maps, their accuracy and complexity could be standardized separately.

The theoretical basis of developing the National Standard of digital and electronic maps in Russia rests upon the State System for Standardization of Russian Federation that had been put into operation since 1993 by the State Standard of Russian Federation GOST R 1.0-92 [1]. This Standard determines purposes and tasks of the standardization process, main principles of standardization in Russia, categories of normative documents and types of standards, main theses on the international cooperation in area of standardization, application of standards and technical terms, and state supervision of the observance of standards.

The regulations of the State System for Standardization of Russian Federation are obligatory to be guided by for all enterprises, unions, joint-stock ventures, etc. (irrespectively of their forms of property and subjection), private business, technical committees on standardization, ministries (departments) and other authorities of the Russian Federation, scientific societies.

2 Main goals and tasks of standardization

The main goals of standardization are:

- protection of interests of customer and state in area of nomenclature and quality of production, processes and services, i.e. providing their safety for life and health of people as well as the protection of property and environment;
- increasing the quality of production correspondingly to the development of science and technics and necessities of life and business;
- providing the compatibility and interchangeability of production;
- saving efforts and stuff, increasing the efficiency of production;
- elimination of technical barriers in industry and trade, providing the competitiveness of production and effective participation in the international division of labour;
- providing the security of industrial objects taking into account the risk of natural and technogeneous disasters and other extraordinary situations;
- assistance to the state defence.

The main tasks of standardization are:

- providing mutual understanding between developers, manufacturers, sellers and customers;
- establishing optimal requirements to the nomenclature and quality of production;
- establishing requirements to the compatibility (structural, information, software one) as well as interchangeability of production;
- coordination of showings and characteristics of production, its elements, spares, raw materials;
- unification on the base of installing and applying parametrical series, base designs, structurally - unified block-modular constituents of products;
- establishing the metrological rules, conditions and requirements;
- normative and technical maintenance of control (trials, analysis, measurements), certification and evaluation of quality of the production;
- establishing the requirements to the technological procedures;
- creation and maintenance of the system of classification and encoding of the digital information;
- normative maintenance of international and national socio-economical and scientific programs (projects) and infra-structural complexes (transportation, communications, defence, protection of environment etc.);

• creation of the catalogue system in order to provide customers with information about the nomenclature and main parameters of production (metadata);

• assistance to the observance of law by means of standardization tools and methods.

Standard is a normative document that is developed, as a rule, on the basis of an agreement where almost all involved parties have no objections in essential points, and that is adopted by certain authority or business. Standard can establish the most common global-use rules, principles, characteristics, requirements and methods for certain subjects of standardization.

3 Types of standards

The State Standard of Russian Federation is the National standard adopted by State Committee on Standardization, Metrology and Certification of Russian Federation (Gosstandart of Russia). Branch Standard is the standard that has been adopted by some ministry (department) of Russian Federation. Standard of enterprise is the standard that has been adopted and used only within certain enterprise. Technical terms is a kind of a normative document on certain production or service adopted by the developing organization, as a rule, in cooperation with organization-customer. International Standard is the standard adopted by International Standardization Organization (ISO). Regional Standard is one that has been adopted by a regional international organization, for example, some inter-state standards. Such standards are adopted by the states that joined the agreement on coordinated policy of standardization, metrology and certification, and they are used by these states immediately. National Standard is the standard adopted by national standardization authority of a certain country. Complex of standards is a community of interrelated standards that have the same purpose and establish coordinated requirements to the interrelated subjects of standardization.

4 Procedure for developing standards

All standards are based on generalized results obtained from scientific, technical and practical investigations, and they are intended to reach the optimal public benefit. In geoinformatic mapping, the development of standards involves the methodology, theoretical basis (concepts, methods), technologies of creating and using electronic maps and GIS [7]. It also involves the practical experience of standardization accumulated in Australia, Canada, Finland, France, Germany, Great Britain, Netherlands, Norway, Spain, Sweden, USA etc. that has been summarized by ICA Commission on Standards for the Transfer of Spatial Data under chairmanship of Prof. H. Moellering [6].

In Russia, the development of State Standards is being carried out by the Technical Committees (TC) in accordance with assignments of state standardization plans of Russian Federation, TC working plans and contracts on the development of standards [2,3]. The development of standards is guided by the legislation of Russia, State

System for Standardization of Russian Federation, other normative documents. It also takes into account the documents of international and regional standardization organizations, results of scientific and practical researches, patent investigations and other information about the achievements of home and foreign science and technics. Then TC sets the deadline of whole work and determines a sub-committee in which the standard is to be developed, or the working group for developing the project of standard. For instance, the development of standards for geoinformatic mapping is being carried out by TC 22 «Informational Technologies» that includes Sub-committee 051 «Geoinformational Technologies» (Chairman A. Martynenko). This Sub-committee deals with standardization in area of creating and implementing geoinformatic technologies based on methods of acquisition, storage, analysis, displaying, processing and retrieving spatial data for the electronic mapping.

5 Methods of evaluating the standard

The process of designing the National Standard of Russia for representing and exchange of spatial data, digital and electronic maps rests upon some certain principles and methods which reflect the intent and functions of the mathematical, linguistic and informational tools being created.

The main purpose of designing this standard is the most complete and effective implementation of all requirements to the cartographic information to be represented. So it becomes necessary to determine the set of the most important criteria to which the standard must comply. When it is done, some purpose function (or set of such functions) can be constructed on the basis of those criteria, and this function must reflect an integral value of effectivity of the standard.

The process of criteria selection is proposed to be based on the following main principles:

- every selected criterion must reflect the general purpose of correspondent tool being investigated;
- every parameter used as a part of some criterion must be critical to the features defining its value;
- every parameter of the criterion must be clearly and as possible easily defined.

The criteria selected on the principles listed above, and the purpose function(s) compose the sort of evaluation system that can compare the effectivity of standard in whole as well as partially. In practice, such system usually includes a set of criteria where every criterion has its own weight coefficient. Some criteria can be combined in groups (subsets) called generalized criteria. Generalized criteria also can have their weight coefficients depending of their importance in evaluation process. So the most common value of the effectivity of standard can be expressed by the following formula:

$$E = \sum_{i=1}^{n} a_i \sum_{j=1}^{m_i} b_{ij} g_{ij} \quad (1)$$

where a_i – weight coefficient of i -th generalized criterion;

b_{ij} – weight coefficient of j -th single criterion in i -th group;

g_{ij} – evaluation of j -th parameter in i -th group.

If there exists a possibility to provide a simultaneous evaluation of the standard by several independent experts, formula (1) looks as follows:

$$E = \frac{1}{k}\sum_{l=1}^{k} \sum_{i=1}^{n} a_i^l \sum_{j=1}^{m_i} b_{ij}^l g_{ij}^l \qquad (2)$$

where k – quantity of independent expert evaluations of investigated standard;

a_i^l, b_{ij}^l, g_{ij}^l - are the same as in formula (1), but concerned to l -th expert evaluation.

6 International scientific cooperation

International cooperation in the area of standardization is being carried out in the line of international and regional standardization organizations, as well as on the base of bi- and multilateral agreements with correspondent foreign authorities. Such cooperation is being regulated by the edicts of the President of Russian Federation and decisions of the Government of Russia, international commissions on economic and scientific cooperation, Russia's liabilities of participation in the activities of regional and international standardization organizations. The international cooperation between Russia and international organizations on standardization includes immediate collaboration in the development of international and regional standards and implementation of these standards in business and interrelations with partner countries. The cooperation in the area of standardization, both bi- and multilateral, includes joint development of standards, fulfillment of joint scientific researches, information interchange, mutual consultations, education etc.

7 Results

The practical results of research on creating and implementing the system of electronic maps have found their scientific and normative completion in the recently developed State Standard of Russian Federation known as GOST R 50828-95 «Geoinformatic mapping. Spatial data, digital and electronic maps. General requirements». This Standard establishes the most common requirements to the creation and maintenance of the System of classification and encoding of cartographic information, the Rules for digital description of spatial data, exchange formats, and the System of symbolization for digital and electronic maps. According to the law, all regulations of this Standard are obligatory for all businesses that deal with acquisition, systematization, analysis, processing and transfer of digital and electronic maps in Russia.

The Standard has been developed on the base of normative documents adopted in 1978-1993, taking into account the experience of developing some foreign standards, such as: A2260 (Austria), SAIF (Canada), EdiGeo (France), ATKIS (Germany), IEF91 (Israel), MT (Japan), STFGI (Netherlands), SOSI (Norway), NES (South Africa), NTF (Great Britain), SDTS (USA), DX-90 (International Hydrographic Organization), and DIGEST (NATO).

The Standard also contains detailed Technical description as a separate enclosure. It includes the Classifier of technological parameters (list of parameters, codes of their semantic values, types of spatial relations), the Classifier of topographic information (definitions, structure and list of classified objects, their designations, lists of valid attributes), Rules for the digital description of cartographic information (structure and features of digital description for the various elements of map contents - mathematical base, relief, hydrography, settlements, industrial, agricultural and socio-cultural objects, roads, vegetation and soils, borders), exchange format for digital and electronic maps, media requirements, and symbolization system for the electronic maps.

The contents of the Standard in whole reflects the following main theses of the electronic maps system:

- conceptual and logical models of various types of digital and electronic maps and methods of representing digital data;
- list of types of digital and electronic maps, necessary terms and definitions, row of scales, projections, grids, coordinate systems;
- rules of classification and encoding of digital cartographic data;
- description and encoding of spatial and non-spatial primitives;
- description of data and structures of exchange files;
- list of media types and protocol of data exchange.

This Standard had become effective since July 1, 1996. Its implementation in industry and defence is now expected to obtain the following main results:

- maintenance of the digital and electronic maps exchange between various customers in Russian Federation;
- increase of the quality of the production - spatial data, digital and electronic maps, its compliance to the requirements of international standards;
- reduction of laboriousness and time of manufacturing;
- compatibility of various information systems.

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AUTOMATIC METHOD OF ECOLOGY SYNDROME OF REGION DISTINGUISHING FOR ECOLOGICAL MAPPING (TERRITORIAL ASPECT)

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1. Abstract

The problem of environment and mainly its ecological aspect one tries to solve by different means: political, legal, moral and social ones. Our investigations have shown that methods of global modelling and prediction within the bounds of complex geographical and cartographical approaches are to play an important role in this task.

An integral system of methods of automatic classification and regioning is one of the approaches in this field. The principle of ecological syndrome of a territory in regioning developed by use is the more complete answer to this problem. The ecology syndrome of a region obtained in the process of crossing of different sets is the basis of this principle. The procedure of ecology syndrome enlarging and ecology regions maps making is being given.

The work is conducted with "floating" set of indicators which allows to stress a specificity of objects. The procedure permits to elaborate system of diagnostic indicators. Its goal-to obtain interconnected set of indicators for each operational-territorial unit. This set is called the regional syndrome of indicators. The ecologo-economical

syndrome though can be determined by a definite ecologo-economical set of diagnostic indicators. With its help the integral map of socio-ecologo-economical orientation of Tatar Republic (Russia) has been constructed.

Socio-economical landscape is an external expression of "territoriality" notion. The latter, in its turn, is nothing but potential possibilities of the territory, a certain complex "territorial resource"(CTR). Formalization of CTR may represent a basic foundation of the model of regional organization of the territory(of the given region).

An algorithm of the model is advanced, and on its basis possible variants of territorial organization of Tatar Republic are given.

2. Introduction.

Following a common practice, territory in geographical science is considered from the point of spatial order and positional principle. Really, the surrounding world is created and developed in two ways and by purposeful changes. Because of this, the notion of a territory includes different aspects, mainly, internal relative to life conditions: acquire shades coordinated with all course of evolution processes of socio-geographical space. The interconnected totality of components of environment of nature-social character is projected as a special "territorial" organization and forms a general structure of socio-geographical space. On its base a formalized characteristic of this space may be constructed, model expression of a really existing geographical objects. However, as this take place row of conceptions occur, exposing the essence of "territory", "territoriality", "territorial resource" notions, describing the state of peculiarities of socio-geographical space structure (Trofimov, Chistobayev, 1993, a, b).

3. Endogenous potential of a territory as a complex "territorial resource".

The basis of all considerable changes in the region, however, are peculiarities of socio-economical development, which influence both in direct and indirect ways (f.i. though changes of ecological situation. From this position) a top priority task is the analysis of socio-economical factors in order to substantiate possible scenarios of development of society(and environment as a whole).Special features of socio-economical development according to K.Kondratiev (1993) are: relative stability of a definite hierarchical structures, necessities of information before decision taking, market syndrome of industrial development and commercial operations, aspiration for upgrowth.

These peculiarities sit in the limits of a balanced development, when a certain coordinated interaction between components of environment come, which is treated by a number of investigators (f.i., Sus, 1984) as a "harmonic development of socio-economical region", where harmonization of the process of development consists in reaching such level of sensitivity of economy, that social expenditures on the restoration of equilibrium are optimum or reproaching to them. The balance principle does not deny, however, leaps in development process, and returns to "recurring points".

Mankind history is marked by landmarks of chaos (Dollfus, 1990).In its development, chaos fills all the space within the limits of the state(a so called "constrained chaos"). Situations of constrained chaos are connected even if partly with functioning of world economy. They do not develop in intervals of a system, but may appear to be one of its products. Situations of constrained chaos may be long, especially if affected regions do not play a main role in functioning of world economy.

These processes are the most clearly seen in conditions of transitional period. In reality they should be considered on the background of "great Kondratiev's waves". The basis for these waves is provided by the main conformities of the theory of "great cycles of economical conjuncture"(Kopasov, 1992).Before the great cycle begins a considerable changes in industrial technic and exchange, in conditions of money circulation, in strengthening of the role of new states and regions take place. The raising waves are more rich in social shocks then periods of lowering waves: great cycles are in the same process of economical development as a middle cycles with their phases of raise, crisis and depression do.

So the presented idea of development one may correlate with the "law of ecologo-economical development" (Gazizullin, Zaidfudim, 1993), which represents a logic stage of development of the theory of a maximum usefulness. For ensuring of vital functions of man and society the necessity in development of ecological and economical processes raises.

When it comes to the complex estimation of the region, ecologo-economical component plays a leading role. The principle side of a question is to find the most acceptable combination of consumes functions of a territory, and it will be justified not only in economical dimention, but would not entail negative consequences, that can sacrifice a prognosed economical effect (Panchenko,1993).

Mashbits (1991) considers that the territorial paradigm is of decisive importance for development of a complex geography. Its essence is not only in consideration of a territory in geography as a field of interaction of different motive forces and components of nature and society. Territoriality also show itself in existing of definite and conforming spatial forms of manifestation of natural and antropogeneous processes, their territorial conditionality and expression.

In such a way forming of socio-economical landscape goes. We may consider that socio-economical landscape-is an external expression of "territoriality" notion. In its turn, "territoriality" is nothing but potential possibilities of a territory, a kind of complex "territorial resource".

A number of investigators (Ratner, Skutin, 1990) by potential of a territory mean a system of interconnected and interactioning factors, ensuring effective and progressive development of a territory both is modern conditions and in perspective. Accepting this definition, we may consider the notion of "territorial resource" be an integral expression of a complex potential of a territory.

In his work concerning estimation of territorial resources. Panchenko (1993) shows that it is an integral formation which is characterized by horizontal(connecting autonomous and relatively sovereign subsystems of structural organization: territory-population, territory-economy, territory-nature) and vertical (describing taxonomical regulation of taxonomical unities) connections.

Hence, formalization of complex territorial resource (in the way we tried to explain it), may be the basic foundation of the model of regional organization of environment of a given region.

The result of such investigation should be the model, which may serve as a base for taking substantiated regulating decisions in changing economical, social and political conditions. Specifically, its usage has the ability to reveal territories and economical branches the most favourable for capital investment for nearest as well as for more distant perspective, and to form the prognosis scenario of development of economy and settling of population of a given region on this base, if needed. With the proper provision of realization means(computers, current information, software and personal) the model may be an efficient and effective tool for regulation and forecasting of socio-economical processes in a region.

On the data of components of territorial resource of Tatar Republic the procedure of modelling and simulating was elaborated.

The model takes into account a current state of natural-resource, demografic, agro-resource, industrial and infrastructural potential of the territory and is assumed to define prognosis scenarios of dynamic of regional organization of society depending on changes in external and internal conditions. As investigated operational-territorial unities(OTU) 43 administrative regions and 11 towns of republic submission of Tatar Republic were accepted.

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ORGANIZATION STRUCTURE AND STRATEGY OF GEOLOGICAL MAPPING IN RUSSIA

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Abstract

The purpose of regional geological mapping is to obtain complex geological information which is the fundamental basis for system geological study of the territory of the country and for the prognostication of mineral deposits. Complex geological mapping of the land and continental shelf of Russia is carried out at four scale levels:1:1,500,000 and smaller, 1:1,000,000 - 1:500,000, 1:200,000-1:100,000 and 1:50,000 and larger. The geological mapping on 1:200,000 scale and smaller is of federal importance. Works on 1:50,000 scale gained regional status. The geological mapping in Russia is progressing towards an increase in depth of investigation, upgrading of quality of the maps at the expense of more complete employment of current materials of remote surveying, widening of a number of objects and events reflected in the maps. A strategial trend in the development of geological mapping is wide introduction of GIS technologies at all stages of gaining and processing of geological information.

1. Introduction

Geological mapping is carried out for gaining comprehensive geological information lying at the basis of the system geological studying the country, predicting mineral deposits and satisfying demands for different fields of native economy, when solving various problems in land reclamation, civil engineering, defence industry, rational nature management, ecology.

2. System of geological mapping

By geological mapping is meant a complex of works and studies aimed at compiling cartographic products mainly maps and atlases of geological contents.

In Russia there is a reliable system of geological mapping which provides compilation of unified interrelated scale series of cartographic works.
The first level consists of review character maps of geological contents on 1:1,500,000 scale and smaller; the second, the third and the fourth levels are respectively maps on 1:1,000,000 -1:500,000, 1:200,000 - 1:100,000, 1:50,000 scales and larger.
A prominent place in this series of maps is occupied by State geological maps on 1:1,000,000 and 1:200,000 scales compiled with standardized map symbols, with a unified legend and published as an official document.

2.1. Review character mapping

Review character mapping of the Russia's territory is aimed at gaining generalized geological information on geological structure and minerageny of the territory of the country as a whole and of individual geological structural regions, performing extensive interregional and global geological constructions and correlations, tallying with the present-day knowledge and the advancement of Earth's sciences.
Among the most impressive recent achivements in review character mapping particular mention should be made of a set of maps of Russia and contiguous states (within the limits of the former USSR) on 1:5,000,000 scale (Geological map,1992; Map of mineral resources, 1991; Map of fuel and power resources, 1991) as well as compilation and publication of the first Geological Atlas of Russia, consisting of forty maps of various geological contents on 1:10,000,000 scale with explanatory notes. The maps are integrated into four sections:"Geological knowledge","Geological Structure and physical state of the Earth's interiors", "Mineral resources", "Ecological state of geological environment". The newest information on geology of Russia and native and foreign advancements in the Earth's sciences and in theory and practice of thematic cartography have been used in working out the Atlas structure and principles of mapping. The Atlas is a fundamental scientific substantiation of the database being compiled for state infotmation systems on natural resources.
A new trend in review character mapping is compilation of electronic maps in CD-ROM technologies. The first of them is the CD-ROM "Mineral resources in Russia and contiguous states" based on the map of mineral resources of Russia on 1:2,500,000 scale. The CD-ROM contains information on 6000 objects of 124 kinds of minerals correlated with mineragenic and structural-tectonic zonation within Russia.
Another advancement of mapping in Russia is compilation of new kind of thematic maps, such as the Geochemical Atlas of Russia on 1:5,000,000 scale, the Map of the presence of oil and gas in Russia on the same scale, a set of maps of separate time shears of the East European Platform on 1:2,500,000 scale for epochs of the most important structural reconstructions, including maps of pre-Mesozoic, pre-Eifelian and pre-Vendian deposits.

2.2 Small-scale mapping

Small-scale geological mapping of the land and continental shelf of the Russian Federation is aimed at compiling the State geological map on 1:1,000,000 scale

(Gosgeolkarta-1000) as well as sets of maps of the geological contents for individual the most important economic regions.
The State geological map of Russia on 1:1,000,000 scale consists of 98 sheets with specific sheet division enlarged by a factor of 1.5 to 2 relative to the international one in intermediate latitudes and to a factor of 4 in high latitudes. The sheet area is from 200,000 to 500,000 square km. The base set comprises maps of pre-Quaternary and Quaternary deposits and mineral resources. The compilation of the State geological map of the second generation is currently nearing completion. Under the concept of regional geological mapping from 1997 we start compiling the State geological map-1000 of the third generation, using the present-day computer technologies for collecting and storing, processing and visualizing geological information. (Problems of compilation of the third generation of the State geological map-1000 are discussed in more detail in the paper of V.Putintsev et all "National geological mapping..." in the given Proceedings)

2.3. Medium-scale mapping

The main product of medium-scale geological mapping is the State geological map of Russia on 1:200,000 scale. It is the basic source of information for substantiating and solving federal and regional problems of development of the minerals and raw materials base, ecology, education, and other aspects of rational economic activities and use of mineral resources on land and adjacent water areas.
Total amount of nomenclature sheets of the State geological map-200 for Russia without shelf territories is about 5000, more than 3000 of them have been already published. The bulk of the sheets was compiled from the fifties to the seventies. Since then new vast information has been obtained, mainly as result of geological surveys on 1:50,000 scale and other kinds of geological prospecting. The published sheets of the State geological map-200 do not comply with modern demands of economy. Therefore the federal program on regional geological mapping of Russia calls for the step-by-step transition to compiling the second generation of the State geological map-200. This work is being carried out on more than 600 sheets throughout the country.
The set of maps of the new generation consists of three obligatory maps: the geological map, the map of mineral resources and patterns of their distribution and the Quaternary deposits map. Compilation of hydrogeological and ecologo-geological maps is projected for individual regions.
The basic attribute of the technology for compiling the maps of the second generation of the State geological map-200 is that they will be mainly compiled on the basis of analysis and synthesis of currently available vast geological, geophysical, geochemical, remote sensing and other kinds of information using computer methods on the base of GIS technologies. The compilation of State map is accompanied by creation of fundamental databases of original and derivative geological information as elements of multifunctional Federal State bank of digital geological information.
Compiling the maps of the second generation is a priority task of Geological Survey of Russia.

2.4. Large-scale mapping

Large scale geological mapping is oriented to solving problems in reproduction of mineral and raw material resources of the country, for determining ecologo-geological measures of regional importance. For almost fifty years about 25% of the Russia territory have been mapped on the large scale. This work is currently carried out by geological surveys of mining companies. The federal programme of large-scale surveying is reduced to a minimum.

3. Organization structure of mapping in Russia

All works on geological mapping of the Russia's territory are performed by unitary geological (base) enterprises and research institutions, whose activity is governed and coordinated by the Department of Regional Geology, Hydrogeology, Monitoring and Protection of Geological Environment at the Russian Federation Ministry of Natural Resources. The organization structure of geological mapping is constructed following the distributive-territorial principle and involves nine exterritorial enterprises, thirty geological survey enterprises, four geophysical, ten hydrogeological, two marine, and two cartographic enterprises, performing the bulk of works on geological survey and mapping. Scientific and methodical help and compilation of small-scale and review character maps are fulfilled at fourteen Al-Russian and four Regional research institutes.

4. Key issues of the progression of geological mapping in Russia

The concept of works on geological mapping for the years immediately ahead accepted by the Ministry of Natural Resources involves the following:
a) Compilation of the State Geological Map-1000 and the State Geological Map-200 in an orderly sequence in accordance with the economic significance of regions. In this instance of great importance is rising reliability and comprehension of maps, concerning characteristics of petrological and structural complexes, mineral resources, and deep structure of the regions at the expence of more complete and complex employment of information on outstripping remote sensing, geochemical and geophysical surveys, data on deep and superdeep drilling;
b) Stimulation of works on systematic mapping of 5,000,000 square km of the Russia's continental shelf with the compilation of the State Geolofgical Map -100 for water areas, island archipelagos and the transition zone "land-sea";
c) Reorientation of regional geological mapping from large-scale geological surveys to medium-scale with the compilation of sets of State Geological Map on 1:200,000 scale;
d) Extensive introduction of computer technologies at all stages of gaining, processing, visualizing and storing geological information production, passing to computer technologies for compilation, preparation and publication of maps of geological contents;

e) Future development of the general theory of geological cartography as a component part of thematic cartography. This particularly concerns problems of improving methods and procedures for theoretical cartographic modelling as a chief way to gaining new knowledge from information accumulated previously;
f) Development and preparation of new kinds of cartographic production (including electronic ones - CD-ROM, GIS Atlases, etc.) reflecting functional and spatial-genetic relations among mapped objects (e.g. the map of the Earth's interios value, geological-economic maps, etc.);
f) Development of a geological cartographic language as a special semantic and multi-functional infornation retrieval system for compilation and rational and complex use of integrated cartographic works already compiled.

Realization of the measures outlined will enable the Ministry of Natural Resources to provide national economy with modern geological-cartographic basis and to impart necessary dynamism to its development under current conditions of national economy.

PROBLEMS OF MAPPING OF TIME AND SPACE RELATIONS AMONG OBJECTS AND PROCESSES

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1. Introduction

Both in the general, and thematic cartography, major emphasis is placed on mapping of space relations between objects. As a rule, geographic and other thematic maps record the relations between objects at a certain moment of time. Time relations between natural and artificial objects show up only in superposition of the corresponding cartographic images. The notions of changes in the natural environment form in the course of analysis of diverse thematic maps - sections which are compiled for successive time intervals. An important feature of time and space relations is their structural character attended by a system of objects of mapping - the semantic stratification of the map. It is possible to classify the thematic maps also in conformity with character of reflecting of spatio-chronological relations between mapping objects.

2. Classification of maps

2.1. Heterochronous maps

Compilation of a single cartographic model, showing succession of events is essentially possible if the mapping objects retain content characteristics, conforming to the time and conditions of their formation. At the same time, maps contain information on spatio-chronological relations (SCR) in the proper sense of the word only, if the system of coexisting parts of the space, having different absolute or relative age, is modelled. Maps of the above class should be called *heterochronous*. Parts of space, modelled by heterochronous maps, differ not only in their age, but also in genetic characteristics. Specific significance, degree of these differences and their content are depended on the scale and purpose of the map.
Most interesting in terms of revealing SCR in their relationship with genetic characteristics are thematic maps which are modelling systems of objects of definite genetic class: geological, geobotanical, hydrological, archaeological, toponymic, etc. Maps of this group can be called *monogenetic-heterochronous*.

The second group of heterochronous maps are maps, illustrating SCR of coexisting objects of different genetic classes, i.e. objects, belonging to different geospheres (maps of *heterogenic-heterochronous* type). This group of maps, primarily, comprises general geographic and topographic maps. The analysis of SCR in these maps commonly does not attract attention, possibly, due to their obvious character (somtimes seeming). Exceptions can be maps of anthropogenic or natural catastrophic impact on the geographical environment. However, in this case, one should also rather speak about "replacement" of one object by another, but not about their spatio-chronological relations.

2.2. Monochronous maps

Monochronous (parametric) maps, illustrating spatial distribution of characteristics of objects, should be distinguished from heterochronous. The number and genetic belonging of the latter can be different. These maps, similar to heterochronous ones, can form systems of the so-called *map of different time,* which characterize the dynamics of phenomena: generation and evolution of objects, their displacement in space during a certain time interval. Certain maps of such system record the state of the same object at different moments in time, without emphasizing SCR of objects in case of their heterochronous character.

2.3 Combined maps

Combined maps of different time (*maps of dinamics* [1]) are illustrating states (objects), which are not coexisting, but are successive in time, and can remind of heterochronous maps only by their outward appearance. As applied to combined maps of different time, use of the "spatio-chronological relations" notion is not justified.

In real cartography maps are often complex, and the classification in question can be applied only to their certain semantic layers. Heterochronous maps can have a rather complicated structure with individualization of SCR of certain semantic layers, and event complexes. Therefore, these maps become the model of composite structure of space and time.

3. Boundary elements

Analysing spatio-chronological relations, emphasis should be placed on the study boundaries between coexisting neighbouring objects, which are of different age. These *age* boundaries should be distinguished from *facial* boundaries, recording gradients of characteristics within objects of the same age. Age boundaries can be mark both contours time transitions-change in characteristics of the object with time, and discontinuous discrete transitions in time. A chronologically discrete boundary marks a certain age interval, an interval between the formation time of neighbouring objects. Boundaries proper are taken to be isochronous. In mobil natural environments (hydrosphere, atmosphere), they can change their position in the course of time. Their illustration in maps has a model character.

An important feature of the spatial unidimensional cartographic boundary, characterizing SCR, is belonging, in a general case, to the bidimensional boundary surface of neighbouring three-dimensional objects. An additional measurement, which is the second one for the boundary surface, and the third one for the object, can be, in many instances, neglected. At the same time, for 3D-objects, when the third measurment of the object, which is not mapped directly, is commensurable in its value with two other measurements, the study of boundary surfaces of objects of different age becomes a special task. It is this research, that is most important, for instance, for compilation of geological maps.

When the three-dimensional system of adjoining objects of different age (system of heterochronous divisibility of space) is considered and cartographically modelled, emphasis should be placed on boundary elements. Boundary surfaces of three-dimensional bodies always have a definite area and adjoin along the lines and in a point in space. The common boundary element of two bodies is a surface; of three bodies, a line; of four bodies, a point (Fig.1)

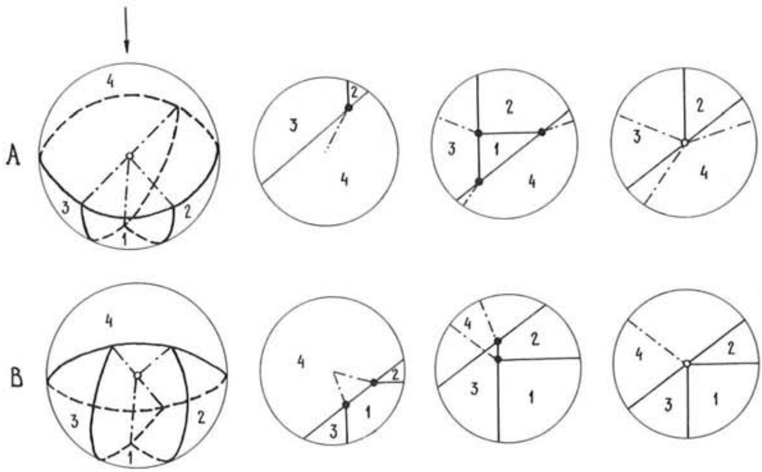

Fig.1 Version of stereometric models of heterochronous divisibility of space and their sections

Boundary elements are shown: surfaces, lines and junction points of parts of space, boundaries and points of their triple junction. Arrow shows direction, normal to the surface of sections. 1,2,3,4 - chronological succession of objects. Sections correspond to three levels: above, below, and in the junction point of parts of space.

Thus, on the mapping surface (in the map), which is cutting the 3D model, boundary elements of bodies adjoining by their surfaces, will be recorded as lines (for two bodies) and points (for three bodies). It can be shown [3,4], that mathematically (in case of minor motion) and semantically (in the sense of characteristic of age relationships) the stereometric model of four bodies of different age is stable, and not more. The appearance of the fifth (and subsequent) younger body in this situation, whose surface passes through the point of quadruple junction of younger bodies, will result in generation of two (or more) parts of space, which have no surface in common and are adjoining only along a line or in a point.

Spatial divisibility in this case is unstable under minor motions and is imaginable only theoretically, since the area of junction surface of two parts of space is equal to zero. Only two earliest bodies can have a gradual transition in time near the junction point of four bodies. In the section of this model of the Earth's surface, three bodies and three boundaries are stably adjoining in the so-called "triple junction point"(TJP). The boundary of the youngest of three adjoining bodies is always chronologically discrete, has a smooth outline and "cuts" the boundary of two other bodies at TJP or is conjugated with tangentially (rule of three bodies [3]).

Special emphasis should be placed on the physical sense of boundary surfaces of objects in heterochronous systems. These surfaces are mathematical surfaces of junction of two physical surfaces, which belong to the corresponding neighbouring bodies and differ genetically. Genetic differences of considered surfaces are determined by differences in formation conditions for the later object and alteration, for the younger one. Therefore, an essential genetic information on the mapped objects and processes is included not only into characteristics of internal structure and composition of objects, but also into characteristics of their junction surfaces. Correspondingly, the cartographic boundary is the line of junction of own contours of two neighbouring objects, differing by age and petrological parameters.

4. Examples of analysis of spatio-chronological relations

4.1. Geological map

Geological map are modelling the three-dimencional heterochronous system of a greate number of adjoining geological bodies at its intersection with the Earth's surface. All the diverse SCR in this complicated system are reduced to an elementary, basic stereometric model of divisibility of geological space between bodies of different age, divisibility into successively forming and adjoining parts (Fig.1A). Similar to the standard model, boundary elements of two neighbouring parts are surfacies; of three parts, a line; of four parts, a point. If the process is discrete in time (see above), the adjoining surface of a relatively later part of space should intersect (or adjoin) the junction surface of two younger parts. In the geological map, the junction surface of two bodies is shown by the line of geological boundary; and the junction line of three bodies, by the junction point of these bodies and their boundaries. To specific symbol construction near this triple junction point models the spatio-chronological relations under conditions of inevitable discreteness (break in time) of emplacement of the later and two relatively early geological bodies (Fig.1B).

Model specifics shows up quite comletely in geological cartography. Illustration of a natural, genetically determined combination of spatial, petrological, and chronological parameters of geological bodies ensures the professional perception of map as the metatext with an unlimited information capacity. A specific place in the model is taken by boundary elements. Near boundary surfaces, genetic information is contained, which was obtained in the course of direct studies on natural objects.

TJP are essential morphologically and are indicators of discrete age relationships, characterizing stages of geological processing and continuent events. As a rule, TJP are not subject to direct study, though they can be observed in mining and natural exposures. Most often, they are distinguished in maps by means of interpolation. At the same time, TJP is the most important element of semantic structure, from which the structural-genetic and historical geological reading of the map starts [3].

The analysis of SCR in geological cartography is conducted by means of comprehension of the *semantics of junction boundaries* of object of different age. In the process of such comprehension, transition from observation maps to analytical maps take place. This can be exemplified by successions of maps: petrographic -> geological, geomorphological -> morphotectonic, geographic -> culturological (urbanistic, toponymical, archaeological, etc.), geographical and landscape -> geochemical -> ecological. The characteristic feature of such analytical maps is the presence of age parameter in the symbolizing system of signs. The most expressive cartographic means for showing age is colour; letter and digital indicies are also applied.

Semantics of age boundaries in the geological map is determined by a set of morphological features of occurrence of geological bodies. In accordance with morphogenetic specifies, types of boundaries with individual SCR characteristic are distinguished [3[. Surfaces of geological bodies typified in terms of their formation dynamics. Initial (undisturbed) surfaces form at the beginning, end and during the emplacement period of the body. Secondary (disturbed) surfaces of younger bodies form both before emplacement of younger bodies (much earlier or are directly preceding them), and synchronously with emplacement of the latter. Surfaces of younger bodies differ in the character of their alteration: free undisturbed, erosional, fault surfaces, replacement surface. Occurrence is a complex morphogenetic characteristic of the geological body. Types of bodies with different occurrence mode (over 10) are noted for individual combinations of the above characteristics of adjoining surfaces: own, as a younger body; and surface of the younger neighbouring body. Their individual combinations reflect the characteristic, genetically determined diversity of SCR of geological bodies. The above characteristics of surfaces of geological bodies, naturally, also concern their outlines, combined within cartographic boundaries. Therefore, it would be reasonable to raise the issue of using these substantial characteristics of boundaries for developing the ideology and technology of compiling computer geological maps. In these terms, sections of geological boundaries (and contours) between TJP can be typified, as well as TJP proper, which enables to produce the "text recording" of the geological map, which differs essentially from those used in the known GIS technologies.

4.2 Map of anthropogenic impact

Among maps showing anthropogenic impact are general geographic maps, which, together with elements of topography, also show objects of human activity. If the latter are shown in scale, the indicated maps as heterochronous (heterogenous type) should have boundaries, discrete in time, and cartographic constructions which are indicatours of spatio-chronological relationships. Such is the illustration of relationships between boundaries of different anthropogenic objects (roads and wood-cuttings, quarries, dams, ploughed fields) and boundaries of topographic objects (coastline, boundaries of vegetation) in maps of a relatively large scale. The cartographic image of TJP, relationship of boundaries in TJP (cutting or tangential) are quite similar to those discussed for the case of a geological map. A part of surfaces of objects are on the Earth'surface, adjoining the atmosphere: other junction surfaces (of hydrosphere, litho- or biosphere, underground part of structures) are hidden. Junction lines of boundary surfaces of these parts of a generally heterochronous space are adjoining in the point, which is on the Earth's surface and coincides with TJP. The third measurement of the space model acquires significance in large-scale maps-plans, particularly if the cutting surface of the anthropogenic object diverges from the vertical (Fig.2A).

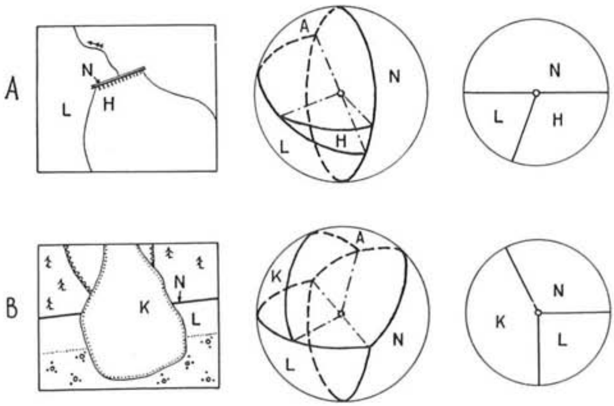

Fig.2 Anthropogenic object (dam) (A); catastrophic natural phenomenon (landslide) (B). Cartographic model, stereometric model and its section cut by the Earth's surface at the junction point of parts of space of different age. Mapped objects are marked by letters (L,N,H,K)

4.3. Map of catastrophic natural phenomena

It is not difficult to show, that in case of mapping the natural catastrophic object (landslides and avalanches, floods, areas of forest fires, etc.) with quick generation of a new object, which is later as compared to the natural landscape and anthropogenic objects, TJP boundaries of the newly generated object with boundaries of objects of the preceding geographic situation appear. Such is, for instance, the landslide, accompanied by formation of a groove on the slope, overlapping of anthropogenic and natural objects and their boundaries with a subsequent change of drainage system (Fig 2B). If account is taken of 3D nature of the cover landslide body, one can envisage junction lines and surfaces of this body and earlier objects, cropping out onto the Earth's surface in TJP and along the boundary of this newly formed body. Appearance of multiple TJP in this case is the indicator of specific heterochroniety of the model generated by the natural calamity.

4.4. Toponymic map

Essential historical cultural information is contained in the names of natural and artifical material objects. Distribution of toponymic objects in the space of map, their gropuing in terms of time and semantics allow mapping the inner historical (ideological) specifies of human activity. An interesting example is the "*Toponymic map of the city*", which displays toponymic "layers", corresponding to different historical epochs, showing formation of the historical part of the city, evolution of public conscience (through ideological constituent of toponymics) etc. SCR of parts of toponymic space (streets, bridges, squares, districts, etc.) in combination with space distribution of toponymic objects and topochrones ("topochrone" is an artefact in precise place and time coordinates [2]) - architectural and historical monuments, hystorical state institutions, turn the toponymic map into the model of city history. The corresponding work for Saint-Petersburg is conducted with participation of E.Zablotsky at the Hermitage (Project Leader is Vice Director of the Hermitage Dr.V.Yu.Matveev).
Another example could be the "*Topographic toponymic map*" - topographic map compiled in a special toponymic legend. Spatial distribution of different toponymic objects in such a map shows elements of ethnography, mentality of aboriginal, dynamics and historical environment of research and development of the territory. For such maps, it is possible to conduct zonation. Different cartographic images will appear in this case, including TJP, whose analysis using the revew possibilities of mapping would be useful for concrete historical processes at the regional and planetary levels.

5. Conclusions

1) Law of heterochronous divisibility of physical space, reflecting spatio-chronological relations (SCR), envisages distribution of space among its four successively forming

and adjacent parts, and nothing more. In the section of heterochronous model of space and the corresponding cartographic image, a semantically definite and stable junction of not more than three successively forming bodies is recorded at triple junction point (TJP) of their boundaries;
2) Identity of structure, modelling SCR near the triple junction point of chronological cartographic boundaries for maps of different contents allows regarding TJP as a specific cartographic image - indicator of age discreteness, a break in formation of adjoining objects;
3) Mapping of SCR of 3D and adjoining parts of hydrosphere and atmosphere should take account of the specificity, connected with mobility of boundary elements in time and space. For realization of the proposed approaches in carthographic modelling, the conditional and statistical distinguishing and registration of volumes, their boundaries, among them discrete-chronological ones, is necessary;
4) The necessity of the most complete presentation of SCR contradicts the ideology of GIS technologies, which are based on spatially correlated datebases. In these bases, time acts only as one of characteristics of the object. In this case, boundaries are regarded only as boundaries of map parts with different characteristics. In order to use cartographic boundaries for getting genetic and chronological information, it is necessary to introduce a definite system of substantional features for boundaries and TJP as indicator cartographic images of discreteness of spatial - chronological relationships;
5) Despite the plane, bidimensional character of the cartographic model, the analysis of SCR at boundaries of objects allows characterizing the third spatial measurment - an essential constituent of multidimensional polyparametric systems, such as objects of geospheres. Understanding of the essence of boundaries also consists in fundamentals for generalization of thematic maps [4].
6) The indicated approach to boundaries should have a universal character and promote development of different trends of thematic cartography.

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GENERALIZATION PRINCIPLES IN GEOLOGICAL CARTOGRAPHY

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Abstract

Generalization is the basic matter of data and material processing in map compilation. It is interpreted as constraction of a system of cartographic objects on a basis of principles of semantic utility and proportionality. A number of qualifications are used in the generalization (excluding, including, etc). Basic methods of data and material processing in the generalization are grouping, zonation, classification. Maps of geological content are generalized taking into account regional peculiarities of the mapped territory and geological nature of the mapping objects. Main operations of the generalization - simplification, elimination, integration. Reconstruction is a specific operation while compiling the composite maps. In the processes of the cartographic generalization spatial distortions and distortion of content take place that should be taken into account using the maps.

1. Introduction

Generalization makes up the main content of the compilation process of all maps, starting with processing of initial data and compilation of original (primary) maps up to compilation of derivative maps based on cartographic materials.The sense of generalization is presentation of the mapped part of reality in its typical features and characteristic features to fit the purpose of studying this reality. Formally, generalization can be considered as distinguishing and mapping of inhomogeneities of the studied reality with regard for their hierarchical system.

2. Principles of generalization

Generalization in geological cartography is based on common approaches and use of certain methods and rules. Common approaches consist in registration of regional geological context and geological essence of mapped objects.

Features of geological structure of the territory, a part of which is the study area, act as regional geological context. Registration of this context ensures conformity of the generalized image to the overall structure of the region and, as a consequence, a correct perception of the map and possibility of using it for practical purposes. Accounting of regional context comprises: distinguishing within the mapped area, prior to beginning of generalization, of regional model structure-forming elements and typologically similar parts, separated by them, comparison of materials on these areas, a more precise determination of the position and nature of structure-forming elements.
The geological essence of mapped objects consists in specific features of occurrence of geological bodies, reflecting their formation conditions and/or geological or practical significance of objects. Occurrence conditions are recorded in the system of morphogenetic features, including data on composition and structure, morphological features of contours and character of spatio-chronological relations of geological bodies. Geological and practical significance is primarly determined by specific features of formation conditions and composition of objects.
Therefore, among the basic principles of generalization in geological cartography are:

1) system character - compliance of generalization methods and rules to the system multidimensional (composition, spatial position, age, scientific and practical significance) structure of geological reality;

2) substantionality - reflection of conceptual unity of geological nature and spatio-chronologicalelations of geological bodies;

3) correlativity - distinguishing of combinations of related objects based on genotypes;

4) commensurability - semantic expediency of correlating details scale) of the map and details of illustrating objects;

5) continuity - contents similarity of models on different scale at the local (factual) and general (conceptual) levels.

3. Objects of generalization

Objects of generalization in geological cartography are data files and cartographic models, describing the system-structured multidimensional geological reality: combination of geological bodies of different composition, structure, age, significance and origin. Objects of generalization are both the map proper (modelling system), and the legend (symbolising system). Geological objects in the modelling system for the purposes of generalization should be classified on the basis of belonging of their contours to a single or different boundary surfaces, under single bodies and combination of bodies.
In accordance with semantics of geological boundaries the following can be distinguished within single objects: non-segregated and segregated (isolated exposures of parts, belonging to a single objects, onto the Earth's surface), morphogenetically ordered and non-ordered. The morphology of outlines of single objects can be determined both by their own morphogenetic specifics, and morphology of the Earth's surface relief.

Distinguished in combinations of objects during generalization are: coeval and of different age, monogenic and heterogenic, adjoining (including, overlapping) and non-adjoining (non-overlapping) bodies. All the above-mentioned diverse models of geological bodies have different attributes - space, time, petrological, their combinations, which are, in their turn, objects of generalization. Generalization of the map has a feedback with generalization of the legend.

Features (attributes) of generalization objects determine the combination of methods and rules. Account is also taken of the main evaluation criteria of map quality - precision, informativeness and reliability of the cartographic model [4].

4. Types and methods of generalization

Two interrelated varieties can be distinguished in generalization: logical (contents, attributive) and cartographic. Methods of logical generalization are groupping, zonation and classification [2]. Logical generalization covers both the map proper, and the legend.

Logical generalization is most extensively used for distinguishing new geological units (formations, intrusive complexes etc.), combination of minute units into a new, larger unit, distinguishing of mineragenic units (ore regions, fields etc.), environmental settings, evaluation of potentials of certain parts of the region, stability of geological environment etc. The logical generalization often represents the final stage of zonation and grouping. Its correctness is dependent on the quality (typical nature, stability in the study area etc.) of the sets of features used.

Cartographic generalixation commonly consists in changing the map content when passing from a larger to a smaller scale. In this variety of generalization, certain operational techniquies are applied along with logical generalization methods. Independent among the latter are schematization (simplification, smoothing) and elimination (exclusion), as well as reconstruction and integration (combination), associated with these methods. Generalization methods and rules are oriented at a system of qualifications, rules of selecting information.

4.1. Grouping

Grouping is a logical and/or cartographic operation of combining several objects (or their characteristics) and their substitution by a generalized object (characteristic). Grouping is primarily processing of qualitative data. It is always to a certain extent accompanied by establishing a link between features and objects.

Grouping can represent subdivision of the file of complex observations into homogenous groups under conditions of indefiniteness and distinguishing of homogenous groups and boundaries between them, when the number of such groups is known or belonging of certain observations to an apriori created system of groups (for instance in the form of a legend to map series).

Grouping is accomplished qualitatively or using automatic classification algorithms. Grouping during quantitative data processing represents typification of objects and determination of their generalized (commonly averaged) quantitative characterstic. For this purpose, statistical methods of evaluating mean values and other parameters of the homogenous multidimensional sample are used.

Grouping is conducted with regard for hierarchical structure of geological objects.

Grouping also comprises subdivision of the studied set of objects using different coefficients, assigned by the researcher processing from certain euristuc, theoretical or experimental considerations.

One of the most important tasks of grouping is comparison and subdivision. It emerges during solution of the problems of subdivision and correlation of geological objects, distinguished on the basis of similar geological features, when it is necessary to evaluate their similarity or difference using other features (geophysical, geochemical etc.). In many cases, the task of establishing similarity/difference of objects is solved using statistical methods (cluster analysis, automatic classification etc.).

4.2. Zonation

Zonation as a method of logical and cartographic generalization is associated with grouping and represents subdivision of geological data into parts with similar sets of features. In case of computer processing, zonation can be conducted in data files and then expressed in a cartographic form. In the most developed procedures zonation is based on models of objects (for instance, in mineral prediction prognostic-prospecting models are used). Similar to grouping, zonation is completed by classification.

Zonation is conducted as a separate or joint application of two approaches:

1. Successive subdivision of cartographic image (data set) into homogenous fields (subsets) on the basis of similar features [2] or into compact parts with pre-assigned or minimum permissible value of difference (commonly, distance) in the space of features and mapping of the distinguished inhomogeneities.
2. Subdivision of the image (file) into parts on the basis of abrupt changes in the mapped field, irrespective of the petrological filling of the map fields distinguished. It can represent successive distinguishing and mapping of hierarchically subordinated inhomogeneities.

The generalization of zonation after grouping of inhomogeneities comprises two successive or simultaneous operations:

1. Mapping of distinguished groups of inhomogeneities and/or their combinations on the basis of analytical or cartometric characteristics. The most important mapping technique is the use of cartographic images and/or their combinations as complex features.
2. Mapping of abrupt lines or gradual boundary zones (lines) of map fields with different combinations of inhomogeneities and/or their groups.

4.3. Classification

Classification is the method of logical generalization, during which groups of objects or data are assigned a new property, characterizing the classificational belonging of the combination of objects and often non-deducible from properties of single objects. Classification can also represent correlation of grouped data with scientific classification of objects. In a particular case, the classification turns into symbolization - designation of a group of objects using the symbol of their classificational belonging.

5. Operation of generalization

5.1. Schematization

Schematization (simplification, smoothing) represents levelling of data or image with substitution of minor inhomogeneities for generalized data or image of the same content. It is planned to smoothly change the characteristics. This method reduces the influence of erroneous or random extreme observations and the level of information noise. Common smoothing techniques are averaging in a round or square gliding window and approximation of the initial field by low-degree polynoms with distinguishing of the smooth constituent. In the course of field smoothing, described by potential functions, recalculations to the upper semispace are also used.
During smoothing in the initial field, minor details disappear, but the general patterns of its changes are revealed. Smoothing should be applied quite carefully for fields, characterized by an irregular arrangement of extreme values and fields with distinct structure, since it can distort or weaken structural lines. The most complicated issue of smoothing is consideration of extreme values. Its solution requires consideration of the contents characteristics of the field. During smoothing, values at boundaries are lost within the band, whose width is dependent on the size of the averaging area.

5.2. Elimination

Elimination (excluding generalization) consists in removal of the image of certain bodies or parts thereof. Elimination is performed for single objects. For non-adjoining bodies-inclusions, elimination is conducted in a pure form; for adjoining bodies, with triple junction points of boundaries [5], elimination is accompanied by reconstruction. Elimination of objects of a particular age group can be full or partial and should take account of the requirement of preservation of complete geological chronicles during generalization. Partial elimination also takes account of the geological context, primarily space and structural parameters of a partly eliminated group of objects. Elimination of a part of bodies can be accompanied by combination and/or displacement of the remaining bodies.

5.3. Reconstruction

The necessity of reconstruction own contours of a relatively "younger" body arises in case of elimination of the "latest" among the adjoining bodies or combination of the latter with the reconstructed body. Reconstruction takes account of occurrence, morphology and structural characteristic of bodies. Reconstruction of contours in combination with integration of bodies is accompanied by disappearance of triple junction points of boundaries. Reconstruction in case of eliminating the latest of adjoining bodies can result in appearance of new triple junction points and even a new body (for instance, fault), which were not recorded in initial materials. Generally, the number and validity of triple junction points of geological boundaries, which are indicators of age relationships, reflect the quality of generalization and the cartographic model proper in terms of informativeness and reliability [4,5].

5.4. Integration

Integration (combination) of single, genetically homogeneous objects is associated both with schematization, simplification of the legend, and partial elimination of bodies. In the first case, combination of stratified formations with elimination of the boundary of conformable bedding, unconformity or adjacent occurrence, separating them, is most common. In the second case, combination is accompanied by reconstruction.

Commonly, most frequent operations during generalization of single bodies are schematization and integration with accompanying elimination. During generalization of a system of bodies, schematization is commonly applied, as well as elimination with subsequent integration, schematization and reconstruction. Generalization of the system of adjoining bodies proceeds as schematization and elimination, including that with subsequent integration.

6. Rules of generalization

Rules of generalization are cartographic rules, whose observation ensures precision, optimal informativeness and reliability of the resulting map [4]. Among rules of precision in case of generalization are the following ones: of geometric qualification, cartographic (geographic) framework and structural framework. Rules of informativeness include: the rule of marker areas or local characteristic, and the rule of integral characteristic, based on application of including and generalizing qualifications. Among rules ensuring reliability of maps, are rules of system hierarchization of bodies, completeness of geological chronicles, multilevel individualization (rule of own contour), semantic definiteness and stability (rule of geological essence, rule of three bodies).

7. System of generalization qualifications

System of qualifications is formalizing. It is closely associated with methods and rules of generalization. The system comprises excluding, including and generalizing qualifications.

1.The excluding qualification of dimensions is exclusion of objects, whose size is not expressed on the map scale. It does not take account of the geological essence of objects (which results in distortion of contents) and should be supplemented by the use of including qualifications.

2.Excluding qualification of meanings of mapped objects is the exclusion of objects, whose characteristics are not essential for the map contents. This qualification should also be supplemented by including qualifications with retaining of geologically or practically significant minor details, revealed , for instance, using maps of the local constituent of the mapped field.

3. Excluding qualification of contents is used in composition of the derivative maps and represents exclusion of objects or parts thereof. Both relatively small bodies with retaining of larger bodies of the same age and composition are excluded, and all bodies of certain age and composition. The most common examples are simplification of the geological map during compilation of the map of mineral deposits; distinguishing of thematic layers, necessary for solving a specific task, from composite maps. Excluding generalization for a part of body is most common in case of generalization of faults, reduction of outlines of sedimentary Quaternary deposits in the resulting map, with Quaternary volcanites being retained.

4. Including qualifification of geological essence is preservation of objects, which are of great significance for understanding the geological structure and evolution history of the region (for instance, minor intrusive alkaline-ultrabasic rock bodies, which are indicators of certain geodynamic conditions, preservation in the legend and map, irrespective of the thickness of units, characterizing specific conditions or turning-points in evolution of the region.

5. Including qualification of practical significance is inclusion of minor objects or preservation of the corresponding map fields due to their practical significance (for instance, preservation of single occurrences of new mineral species in the map, whereas for the common ones, only deposits can be shown).

6. Generalizing qualification of integral characteristics - the content of generalization is determined by the content of the integral characteristic. Such is, for instance, generalization, proceeding from geological-economic characteristics, of the complexity of geological structure, generalization of maps of geoenvironmental conditions based on risk characteristics of geological hazards, stability of the geological environment, degree of favourability for man etc.

7. Generalizing qualification of paleoenviroments is generalization of cartographic image in the course of paleogeographic, paleotectonic, paleogeodynamic and other reconstructions.

8. Distortions during generalization

In the process of cartographic generalization, spatial and contents distortions are generated. Spatial errors consist in distortion of the geometric precision of maps. Special research, conducted by A.M.Berlant [1] showed, that within an extensive range, mean errors in the position of map parts in case of 1.5-4 timts reduction for geological maps are 0.3-0.7 mm; for geomorphological maps, 0.8-1.4 mm, and for landscape ones, 0.4-1.5 mm; the maximum errors reach 1.5, 2.0 and 2.8 mm, respectively. The value of absolute errors is almost independent of scale reduction degree and technical procedures of generalization. Relative errors have a much greater value, and in certain cases reach 50%; and relative dimensions of areas can differ more than 3 times from the standard map. Distortions, introduced by generalization, are not

governed by laws of random errors,since preservation of certain objects is not compensated by elimination of the other ones.
Contents changes represent changes in the composition of objects presented - the change in the ratio between mineral deposits and shows is well-known in maps of different scale. Additional distortions are introduced due to the fact, that in maps of mineral deposits all objects are shown outside the areas of ore regions and selectively - within ore regions proper . As a result, the possibility of accomplishing cartometric operations (for instance, investigation of density of shows in different parts of the region) is reduced.
A common error in generalization is presentation of four or more bodies in the junction point of boundaries. These configurations appear during automatic reduction of initial materials, when approximated junction points of bodies are practically merging. In this case, one should apply the technique of displacing boundaries and their junction points by the value, which does not exceed the qualification of geometric precision, or conduct generalization, rejecting the details of the image.

9. Conclusion

Generalization, up to now, remains one of the most subjective mapping procedures. Most of GIS and Automated Cartographic Systems (ACS) lack a sufficiently intelligent generalization tool [3]. Changes in the map scale are associated with their redrawing and reforming, or construction of special data bases in the computer medium for each scale. Modern developments are mostly imitating manual procedures. It is due to this circumstance, that the development and introduction of a system of qualifications, rules and algorithms into generalization programs will enable to formalize the generalization process and automate the evaluation of input and generalized data. Approaches, system of qualifications, methods and rules of generalization in geological cartography can significantly extend the possibilities of generalization of thematic maps with other contents, particularly those, reflecting space-time relations of mapped objects.

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NATIONAL GEOLOGICAL MAPPING IN RUSSIA ON 1:1,000,000 SCALE (STATE, PROSPECTS)

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Abstract

State geological maps at 1:1,000,000 scale are compiled on nomenclature sheets on a basis ofcommon regulations and standarts. Intercorrelation of the map's sheets and their regular renovation as new factual material is accumulated provide high informative contents of maps and their widespread employment in different fields of economy. The new series of State geological map consist 98 sheets for continental part of Russia. The set includes map of pre-Quaternary and Qaternary formations and mineral resources as obligatory ones. Maps of deep shears, underground waters, prediction for oil and gas are included as supplementary ones depending on geological structure of regions and prospects of their development. Every set of maps is accompanied by explanatory notes. The main task of future development of works is the renovation of maps using geophysical, geochemical, remote sensing and other materials. The renovated sets of maps will be published both in traditional paper version and in digital form.

1. Introduction

Composite small-scale geological mapping is one of priority trends in comprehensive regional geological studies on subsurface in Russia. This work is based on State Geological Maps at 1:1,000,000 scale. They are compiled within the nomenclature Sheets on the basis of common rules and requirements. Mutual correlation of map Sheets and their systematic renewal with accumulation of new data ensure a higly informative character of State maps and their extensive use in different fields of economy, including gelogical exploration, as well for solving scientific geological problems of theoretical and applied types (interregional correlation of geological formations, compilation of specialized and sketch geological maps etc.).

2. Status of the State Geological Map

State Geological Map of the Russian Federation at 1:1,000,000 scale is a regular link in the system of regular comprehensive geological study of the territory of the country, analysis and creative geological cartographic generalization of surveying materials, primarily on 1:200,000 scale, results of geophysical, geochemical and aero-space investigations. Work on compilation of the State Geological Map is essentially research work and is based on the latest developments on stratigraphy, petrology, lithology, tectonics, metallogeny, on the analysis and creative application of different tectonic and mineragenic concepts (subsurface geodynamics, lithosphere plate theory, theory of geoblock divisibility, nonlinear metallogeny etc.), as well as on modern technologies of method and comprehensive interpretation of geological-geophysical and geochemical information.

Geological mapping of water area floor differs markedly from similar works on land due to the fact, that it is based on geophysical evidence which should be subject to geological interpretation. Therefore, the State Geological Map of Russian Federation at 1:1,000,000 scale for water areas is mainly based on results of completed regional geological-geophysical studies on evaluation of oil-and-gas presence potentials, which in some regions are essentially supplemented by materials of parametric, reference and prospecting drilling, placer prospecting and exploration, shelf surveying at 1:1,000,000 and 1:200,000 scale, bottom sampling, specialized thematic work and other research of different type.
Compilation of State Geological Map of Russian Federation at 1:1,000,000 scale is regulated by a series of instructive methodological documents, the main among them being "Reqirements on Compilation and Preparation for Publication of Materials of the State Geological Maps at 1:1,000,000 scale (new series)" (1982), with supplements, presented in "Recommendations on Increasing Reliability of the State Geological Map"(1990), and the series of "Type symbols to maps with geological contents"(1975-1989). Thus allows attaining the common scientific technical policy and a high level of standartization of the main materials of the State Geological Map and, thus, its great significance as the most convenient form of creating a constantly replenished State Bank of Geological Data, which is the basis for development of strategic issues os solving tasks of rational nature management (primarily, subsurface exploration).
Compilation of the State Geological Map of Russian Federation at 1:1,000,000 scale solves the task of creating the bank of fundametal geological information, which is necessary for development of geological science, general knowledge on geological structure and mineragenic potential of land and water areas of adjacent seas, including continental shelf, dynamics of geological processes and phenomena, elaboration and realization of strategic issues of studying and a rational subsurface exploitation.

3. Stages of work

Compilation of the first sheet-by-sheet State Geological Map at 1:1,000,000 scale for the territory of the former USSR started in 1938. The initiator and developer of a detailed working schedule was the outstanding Russian geologist A.P.Gerasimov. Under his leadership "The Instruction on Compilation of Authors Originals of the State Geological Map of the USSR" was prepared. In the process of work, the Instruction was essentially specified (1944,1954) as regards requirements to information on mineral resources. Data on hydrogeology became necessary.
Compilation of the first series of the State Geological Map at 1:1,000,000 scale was completed in 1966. It ensured a qualitatively new level of major geological cartographic generalizations both for the entire territory of the country, and for most of geological regions. In the process of this work several deposits of different minerals were discovered, geological grounds for distinguishing new mineragenic provinces were provided. The first series of sheets of the State Geological Map became the most important basis for the Geological Map of USSR at 1:2,500,000 scale, first published in 1956 without "white spots". It was also extensively used to compile the first specialized maps on the same scale for the entire territory of the country - tectonic (1960), hydrogeological (1960), metallogenic (1967). The result of generalization of new information was the five-volume monograph "Geological Structure of the USSR" with the Atlas of maps at 1:7,500,000 scale (1968).
A significant amount of new materials, accumulated by the early 60's from results of geological surveying at 1:200,000 scale determined the creation of the new series of the State Geological Map at 1:1,000,000 scale. This series for the territory of the Russian Federation comprises 98 nomenclature sheets in sheet division enlarged 1.5-2 times at medium and to 4 times at high latitudes as compared to the international one. Such sheet divisionn is adopted to enhance the sketch character of certain map Sheets and to implement a more economic process of their compilation and publication. The

above number comprises 10 sheets, characterizing large islands and archipelagos of the Arctic and Kuril island arc with adjacent water areas.
Work on compilation of new series started simultaneously with completion of the first series (in 1963). The following obligatory maps are comprised into the set of the new series: maps of pre-Quqternary and Quaternary formations and mineral resources. In accordance with specific features of geological structure of regions, their development potentials, as well as with regard for the current and possible requirements of economy, additionally comprised into the sets are maps showing subsurface sections (in platform areas), groundwater, prediction for oil and gas. Each set of maps is accompanied by Explanatory Notes. Such comprehensive mapping is traditional for the Russian geological cartography.

4. State of the work

At present, compilation of the State Geological Map at 1:1,000,000 scale (new series) is in its final stage (fig.1). There are published sets on 56 Sheets for the territory of Russia. Besides, prior to disintegration of the USSR, 23 more Sheets of the new series were compiled for the territory of the former Union Repubics. Twenty-one Sheet is being compiled, and the work will be completed in 1997-1998. It is planned to comile other sheets before 2000. Centralized publication of materials of the State Geological Map is accompanied at VSEGEI and its Cartographic Plant.
Materials of the new series of the State Geological Map at 1:1,000,000 scale played the decisive role in comilation of new sketch maps both for the Russian Federation as a whole (geological, 1992; mineral resources, 1987,1991; tectonic etc.), and for large geological structural regions: Far East (including water areas of marginal seas), East European and Siberian platforms, Altai-Sayan area, etc. Materials of the State Geological Map of the new series not only served as the basis for major generalizing works, but also stimulated a new interpretation of certain important issues of regional geology and matallogeny.

5. Potential development of the work

Future development of the work on State Geological Map at 1:1,000,000 scale is determined in addition to common causes of moral outdatedness of maps and physical exhaustion of their published copies for certain regions, by several factors,ensuing from new economic conditions of development of Russia and, thus, essentially changed and increased requirements to the contents of these maps:
- change of the balance and infrastructure of the mineral-raw material base of Russia (due to disintegration of the Soviet Union, there is a marked deficiency of certain minerals, and there occured "a deterioration of their distribution geography", the mineral-raw material situation in old ore regions became more acute);
- a drastic need of geological information for solving nature protection problems;
- the necessity of developing the information base for solving new tasks, which are non-traditional for the Russian geology (licensing, privatization, marketing of geological information etc.);
- increase of the number of consumers of materials of the State Geological Map: geological exploration and mining enterprises, state and territorial bodies on subsurface fund management, land management and other nature management organizations, enviromental protection services, system of higher and secondary education etc.

The above circumstances and the real possibility of using modern computer technologies for analysing geological cartographic data in geological cartography allow a princpally new solution of the tasks of renewal of the State Geological Map at 1:1,000,000 scale.
The third generation of the Map should be realized as the geological-cartographic information system of GIS type, with constant updating of maps, extending the

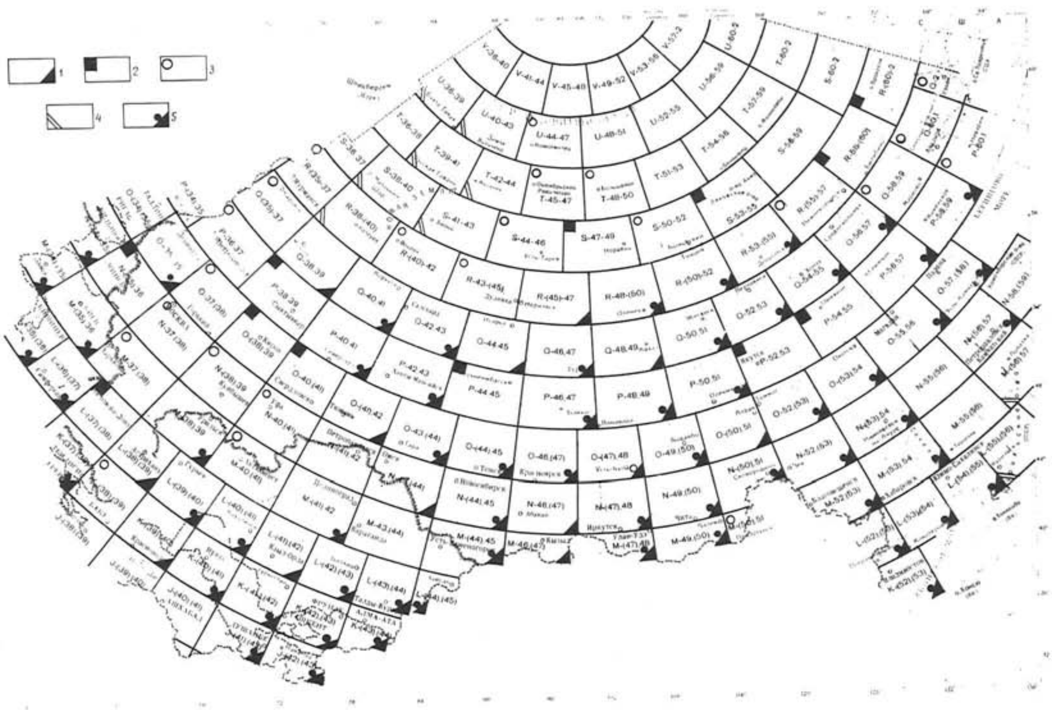

Fig.1 Scheme of geological study of Russian Federation and contiguous States
(within borders of the former USSSR) on 1:1,000,000 scale

1,Sets of maps are published; 2,Sets of maps are in publication; 3,Sets of maps are being compiled; 4,Sets of maps are being planned for compilation in 1997-2000; 5,Explanatory Notes are published information capacity of sets of maps as a whole. This system, when completed, should comprise the basic set of maps (in analog and digital forms), as well as specialized maps - geophysical, geochemical, etc., sections, flow charts, diverse text, tabulated, statistical information. This procedure fully corresponds to the main evolutionary trends of geological cartography in the world [ ].

The new State Geological Base at 1:1,000,000 scale should provide different branches of the country's economy with qualitative and diverse information. Therefore, when compiling the third generation of the State Geological Map it is planned to:

1. Use the latest evidence on stratigraphy, petrology, lithology, tectonics with regard for different geodynamic concepts both in general geology, and metallogeny;
2. Increasing depth of research on the basis of a comprehensive interpretation of geophysical evidence. Geophysical maps proper and interpretation maps are not comprised into the set. However, comprehensive geological interpretation of geophysical materials, including those based on geotransections deep and superdeep wells using computer software is the main means of increasing the research depth and getting additional data on the surface.

Taking intoaccount the multiversion character of interpretation models, the work on geophysical data processing should be conducted on the basis of specific geological tasks. Results of comprehensive interpretation should be reflected in maps of the set proper, and as additional schemes, sections, flow charts outside the map frame.

3. A more complete use of geochemical data, including re-interpretation of earlier obtained results using modern techniques of geochemical information processing ("Geoscan", "Multidimensional fields", "Geofield" etc.).
4. Increase of the quality of maps, comprised into the set due to comprehensive use of modern remote sensing materials and results of their computer processing. Use of these materials should be based on GIs technology, which ensures stage-by-stage distinguishing of thematic layers of information, reflected in the geological map, integrated analysis of remote and geological-geophysical information at all stages of map compilation.
5. Increase of the informativeness of maps, covering shelf areas, due to application of the "transparency" principle, i.e. getting a 3D notion of the sedimentary cover structure under ubiquitously occuring Late Cenozoic deposits, with simultaneous mapping of its main stratigraphic costituents.
6. The maximum complete presentation of data, necessary to enchance the work on predictive evaluation of territories, in the maps. These data should ensure revealing of areas, which show potentials for new types of deposits, including a wide range of sedimentary, hydrothermal and sedimentary volcanogenic hydrothermal deposits and other types.
7. Specialized geological-ecological mapping within the scope of the work on the State Geological Map. Ideology of such mapping should be based on evaluation of the impact of natural and technogenic geological factors on the enviroment, as the basis for taking economic and nature management resolutions. Obviously, certain emphasis should be placed on the economic-geological evaluation of the territory with compilation of economic geological maps, which should ensure revealing of regions, favourable for economically effected and enviromentally safe subsurface exploitation, comprised into the set as obligatory ones and, finally, allowing the evaluation of subsurface cost [1].

6. Conclusion

Compilation of new generation of the State Geological Map in GIS version puts forward extremely complicated tasks, which require solution of a set of theoretcal, methodological, organizational and technical problems. One of the most important tasks is improvement of theoretical base of geological cartography, particularly further development of generalization issues (see the paper by A.Burde, E.Zablotsky, S.Strelnikov in the present Proceedings), improvement of geological cartographic language as the semiotic basis of constructing legends which would most fully reflect

space-time associations of geological formations, facilitating the analysis of maps proper and geological and mineragenic correlations.
The necessary condition is the increase of information capacity of the legend in terms of petrological composition of geological bodies. Improvement of legends should be accompanied by improvement of classifications of mapping objects in terms of the logics of subdivision and grouping of objects and parts thereof, elimination of reiterated information in distinguished groups etc.
The final objective of the work on the State Geological Map of Russian Federation at 1:1,000,000 scale should be creation of the geological-cartographic information system of federal significanse, operating as a constituent of the general federal geological information system and aimed at constant satisfaction of needs of the country's economy in modern geological information.

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CARTOGRAPHIC ANIMATION AND LEGENDS FOR TEMPORAL MAPS: EXPLORATION AND OR INTERACTION

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Abstract

Temporal cartographic animations are increasingly common. For users to understand a temporal animation, they must not only apply an appropriate spatial knowledge schema that allows them to interpret relative geographic location, they must also apply an appropriate temporal schema that allows them to interpret meaning inherent in the sequence and pacing of the animation. Similar to static maps, then, the animated maps should be accompanied by a legend that prompts an appropriate schema. However, with animation, the legends function, not only as an interpretation devices but also as a navigation tools. This paper describes potential legends for temporal animation and argues that choices among them should be made with regard to the nature of the temporal data. A test is proposed to assess the viability of the different legends.

Introduction

In today's world of spatial data handling, visualization requires an interactive and dynamic environment. The cartographic animation plays a prominent role here, and can be used not just to tell a story or explain a process, it can also reveal patterns or relations which would not be clear by looking at static maps. The cartographic animation is often categorised into temporal and non-temporal forms. The last is used to explain spatial relations by presenting individual map images in a logical sequence. The temporal animation is used to display world time in a temporal sequence, especially to display and explore the increasing varieties of spatio-temporal data sets becoming available. Temporal animation has some interesting advantages over traditional static temporal maps or map series. In particular, it offers scientists the opportunity to deal with real world processes as a whole.

This paper presents a conceptual approach to possible legends for temporal cartographic animations. The approach focuses on matching legend styles to the context for map use. Specifically, we argue that there are different aspects of spatio-temporal data that use of visualization might be focused upon and corresponding differences in kinds of spatio-temporal queries that visualization interfaces in general, and map legends in particular, must support. Legends for temporal maps serve a variety of roles (as they do for non-temporal maps). Among these roles is to suggest an appropriate knowledge schema for interpreting information presented. For animated temporal maps, legends can also become a vehicle for dynamic control of the animation. As such, they suggest schemata for framing spatio-temporal queries (and may also discourage use of alternative schemata).

The approach to legends for spatio-temporal maps that we develop leads to a variety of questions that call for empirical research. The paper concludes, therefore, with a proposal for a usability experiment designed to assess the general approach to temporal legends developed.

Spatial data and temporal animations

Cartographic animation is about change, change of spatial data's components. Animations can depict change in space (position), in place (attribute), or in time. Their real power, of course, is to show the interrelations among these three components (see figure 1).

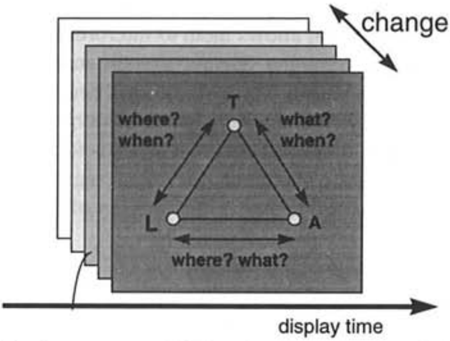

Figure 1. Interrelation between spatial data's components and the animation frames.

Temporal animations show change of spatial patterns in time. In these animation, a direct relation between display time and world time exists, and a transition between individual frames implies change in the spatial data's locational and/or attribute component. Display time can be described as "representational-time", as refers to the moment a viewer of an animation actually sees the images. World time is "real-world"-time (time units can be seconds, weeks, years, etc.), referring to an event that take place. Examples of temporal animations are those of the Dutch coastline from Roman times until today, boundary changes in Europe since the second World War, or the changes of yesterday's weather. Temporal animation can also deal with time aggregates, such as the display of weekly or monthly cycles.

Animations cab have a narrative character. They often tell a story (Monmonier, 1990). The flow of the story can be influenced by application of the dynamic variables (MacEachren, 1995. Most prominent of these variables are duration and order, which have a strong impact on the animation's narrative character. They define the time an individual frame is visible, as well as the order of the frames. In case of a temporal cartographic animation order presents the viewer the link to world time.

For the user of a cartographic animation it is important to have tools available which allow for interaction while viewing the animation (Monmonier & Gluck, 1994). Seeing the animation play will in most cases leave the user with many questions of what he/she has seen. Just a re-play is not sufficient to answers questions like 'What was the weather in the north-west at noon?', or 'On which side of the city did the tornado strike'. Most general software to view animations already offer facilities such as 'pause', to look at a particular frame, and '(fast-) forward' and '(fast-) backward', to go to a particular frame. Dynamic temporal legends, as will be explained in more detail below, can add significantly to a users ability to interact with the animation.

Temporally dynamic maps, as described above, can be classified on the basis of the structure of the temporal data being viewed. One such characteristic of data is whether the information is linear or cyclic in structure. This is both a philosophical and pragmatic distinction. Information of a linear temporal structure changes steadily or chaotically, as observed. Information of a cyclic nature, on the other hand, is related to perceived temporal patterns. Weather forecast maps, like those seen on television, provide examples of both types of data. On a synoptic (continental spatial and week-long temporal) scale, features such as air masses, warm and cold fronts, and upper-air winds change and progress in linear time: such parameters as speed and intensity of these large-scale features would show no regular periodicity (more technically, no peaks in their frequency spectra). However, other important features such as temperature patterns, fog areas, and surface winds have very periodic (most often diurnal) patterns. What are the most effective ways of portraying the temporal variable of these different types of phenomena? Might we find conclusive evidence that one type of legend is more appropriate for cyclical than linear phenomena?

Another characteristic of spatio-temporal data that might have an impact on the optimisation of the legend is the phenomenon's temporal regularity. This is analogous to the cartographic problem of finding ways to represent irregularly distributed spatial data (e.g. point observations) of continuous phenomena. In animation, it may be important to make the viewer aware of the fact that the information presented occurred or was collected at irregular time intervals. In the examination of certain types of spatio-temporal phenomena, a researcher might vary the temporal detail through the animation. For example, pollution measurements of a water body might be taken twice monthly during the summer months, but only once monthly during the winter. In medical applications, temporal frequency might go up during a certain critical event, like an outbreak of measles in a community. Thus, an indication of the real world location in time must be complemented by an indication of the animation's (potentially variable) real-world temporal frequency. It is perhaps this type of situation in which a sonic legends (or a sonic supplement to a visual legend) have the greatest advantage (Krygier, 1994).

In data exploration tasks, it may be useful for the viewer to observe an animation of spatio-temporal information in non-temporal as well as temporal order, an analysis method that DiBiase, et al. (1992) term re-expression. Order is considered by MacEachren (1995) to be one of six fundamental dynamic variables for animated maps; placing a time series in a non-temporal order can reveal trends that are otherwise hidden. For example, by placing monthly frames of an animation in order of model prediction variance (rather than in chronological order), DiBiase, et al. (1992) showed that the most significant variation in model prediction variance occurred in the spring months (during the planting season). This important aspect of the model's output would have been missed if the order had not been transformed. We hypothesize that, for this type of exploratory analysis, some temporal legends will afford greater clarity than others. This hypothesis is based on an assumption that different styles of temporal legends will differ in their ability to help analysts adapt a knowledge schema developed for understanding change (in location or attributes) across time to one that deals with change (in location or time) across an attribute sequence.

Legend types

Animated maps need a legend, just as any other map. Part of this legend has to explain the meaning of the map symbols used in each individual frame. However, the part of the legend that explains the animation's temporal component can have a dual function: it tells the time and lets you travel time (figure 2). The first function links display time to world time. The second function allows the user, within the limits of the time-scale, to manipulate various aspects of time, including: moving to a particular point in time, specifying a period in time across which information is aggregated, or selecting the temporal resolution at which information will be examined.

The combination of legend as an interpretation device and an interface control tool allows the user to answer questions related to the existence of an entity (if?), the temporal location (when?), time intervals (how long?), temporal texture (how often), rate of change (how fast?), and its sequence (what order?) (MacEachren, 1995). These kinds of queries range from binary choices (if something exists at a particular time or not) through queries of information at the ratio level (the speed of an object through space) - see figure 3).

The choice of a legend form depends on the nature of the spatio-temporal phenomena displayed by the animation, the nature of the temporal queries that users are expected to make, and the knowledge schema concerning spatio-temporal entities that we are trying to prompt (e.g., time as a line versus a cycle, space-time as a volume versus space as a volume with time as an attribute of that volume).

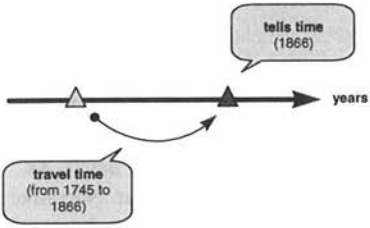

Figure 2. The two main functions of the legend of a temporal animation illustrated in a linear time-model.

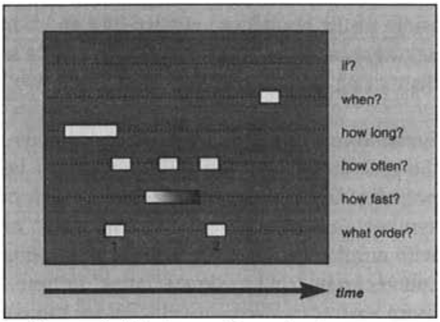

Figure 3. The type of queries to answer when the animation's legend properly combines the 'tell time' and 'travel time' functions.

For temporal animation, two major legend types can be distinguished. In a direct transfer from static maps, the legend can appear in a visually separate display area (window). The dynamic nature of animation, however, also allows for legends that are visually or sonically embedded directly into the map display (see figure 4).

With legends in windows, three sub-categories can be identified: an analogue clock in which location in time is represented by the orientation of a dial or hands, a slide bar in which location in time is represented by a marker on a line that depicts the time span of the animation, or through numbers that represent time in discrete units.

Indication of time by numbers is precise but the user has no idea of the total time scale or position within a cycle and interaction is difficult. In addition, numerical legends will probably distract viewers from the main display more than any other legend type. However, numbers might be suitable in combination with either a bar or a clock.

A round clock or clock-like legend is very suitable to explaining cyclic time, such as the day and the seasons. Legends modelled on clocks, as with real clocks, will generally depict one cycle of time that may be repeated many times across the time span of an animation. Thus location within the temporal cycle is clearly depicted, but location in the full time span may not be.

The slide bar is suitable to explaining linear time, such as the progress of an oil spill as it spreads and shifts location over time. The full temporal scale is visible and it can be easily interacted with. Repeated cycles are less easily shown. For both the clock and slide bar, the notion of past, present and future can be depicted. Past is signified by filling/colouring the area which has past, present is represented by a sign-vehicle indicating the boundary between past and present, and future is represented by the unfilled area. When the present is a time aggregate rather than an instance in time, the width of the boundary between past and future can depict the time period across which aggregation takes place. All three visually separate legend types are likely to be distracting since the user has to look at two 'views'.

Embedding the legend visually or sonically within the map has the potential to avoid the problem of dividing a user's attention between two competing views. Visually, the notion of time can be represented through periodic changes to the background or map symbols (e.g., the screen dims slightly at "night" and brightens during the "day"). As with numbers, sound might work in combination with the clock or slide bar. Narrative sound can be used to signal "dates" in time. To represent the passing of time, however, more abstract sonic sign-vehicles are more useful (e.g., a repeated tone the frequency of which indicates how rapidly time is advancing in that portion of the animation). Sound can "tell" the time, but control of time through sonic input is quite difficult to realise (although spoken controls are increasingly possible as voice recognition software becomes more widely available).

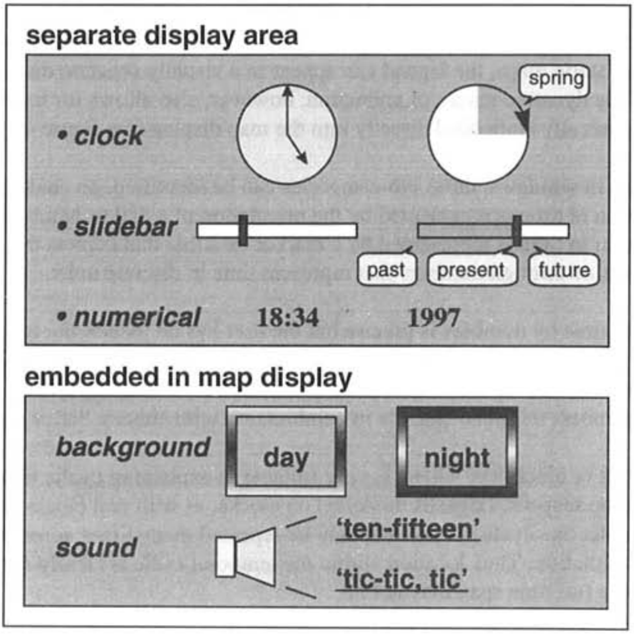

Figure 4. Classification of potential temporal map legends.

This context-driven conceptual approach to dynamic map legend design remains untested. The next step in our research is to assess its viability by employing a task-based human-subjects approach in which performance in dynamic map interpretation using alternative legend designs will be compared. The theoretical underpinning of the logistics of such an experiment are not trivial. Here, we offer some ideas for an empirical assessment of these and related topics.

In a review of cartographic design experiments, Petchenik (1983) calls for, among other considerations, "naturalistic" design research in which the subjects tested are shown real-world examples of the maps under assessment, rather than "test" maps which isolate the variable to be studied in some artificial or forced way.

This is particularly important in our research, where the goal is to inform the design of maps for exploratory visualization purposes, where context is so essential. Our choice of phenomena (as well as different legend designs) to be presented to subjects, therefore, is a key consideration. Dynamic map applications shown in the experiment will be chosen to be particularly illustrative of the contextual applications of structure, regularity, and order, as explained above. For example, test animations may show meteorological model output (regular temporally, with both linear and cyclic phenomena), historical land-use data (irregular temporally), and the Mexican climate model output described above (in non-chronological order).

Another important consideration in map design research is the identification of the experience of the subjects with the maps tested. Distinguishing between "experts" and "novices" might reveal important differences in design according to the maps' potential uses. Because we will have difficulty (for this experiment) finding a significant number of experts in cartographic animation, we may choose as one of our test maps a weather forecast map (very much like those on television) a map type for which otherwise novice subjects have some expertise because of their familiarity with this type of presentation. For other less familiar applications, most subjects will be considered novice users of cartographic animations.

It is proper to assess the efficacy of the temporal legend not only according to the potential application, but also according to the task at hand. In an experiment by DeLucia and Hiller (1982), which focused on the role of legends in understanding static maps, questions were asked which led subjects to not only acquire data from the map but also visualize the environment on the map. Their experiment showed that a "natural legend", which showed (in their specific case) hypsometric terrain shading on schematic mountain, rather than in the "standard" legend boxes, enhanced subjects' ability to visualize the landscape, but did not aid in more specific data acquisition. MacEachren (1995) suggests that this experiment demonstrates that maps in general -- and legends in particular -- prompt users to see, organise, interpret, and interrogate the information presented through the use of schemata, cognitive methods of distinguishing between graphical stimuli. Specifying terrain using a symbolic pictorial representation prompted appropriate schemata for map interpretation in DeLucia and Hiller's subjects. With carefully chosen questions, similar analysis might be possible with symbolic pictorial representations of time (like clocks or timelines).

Although our goal is to evaluate representative legend styles from the typology outlined above, it is possible that for certain animated map applications, a legend is not only redundant and unnecessary but perhaps distracting and confusing, a pitfall described by Campbell and Egbert (1990). Thus, map use with and without temporal legends should be compared as part of our investigation.

Conclusion

An experiment to investigate optimal temporal legend design is presently being planned and constructed. It is designed to fit into the conceptual framework of temporal animations described herein. We will assess different legend forms in different use context in an effort to develop guidelines for appropriate matches between legend style and intended use (and users).

The above description of the proposed experiment serves to demonstrate that the investigation of this type of map design question must be carefully and deliberately considered. This experiment proposal thus serves not only as a specific outline of our upcoming test, but also as a guide for conducting empirical research on similar questions.

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GEOPHYSICAL ATLAS OF CHINA, PRODUCTION AND USE

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Abstract

This paper gives a short report on a new kind of atlas, the Geophysical Atlas of China. The Atlas have been published in 1996 both at home and abroad for the first time. The Atlas includes 47 maps of country-wide and region. And it represents the actual data in the geophysical survey and the explanation with illustrations and tables.

The computer and the traditional method have been used during compilation. And the important thing is that the Atlas published using PC MAPCAD.

1. Introduction

The rapid development of the sciences and the technique advances the geosciences to a new stage. And the national economic construction need more and more information about the earth sciences. By adopting the new technique, the new method and the new theory, the much more achievements have been gained. That is the necessity and the possibility for compiling the Geophysical Atlas of China. The geophysical method is one of important methods in the geological survey, including the geomagnetic, gravity, electromagnetic, earthquake, geothermal, etc. Nearly fifty thousand geophysicists worked during the past half century in China. The chief compiler of the atlas is the famous geophysicist Yuan Xuecheng who leaded a compiling committee and a group of compilers to work for the atlas. The Atlas is in octavo volume with Chinese and English. It was published and distributed in 1996 by Geological Publishing House both at home and abroad for the first time. The publication No. of International Lithosphere Program is 201. The Atlas shows systematically the geophysical features of the lithosphere in

China.

2. Contents

This Atlas includes two parts, the first part is the geophysical maps for the whole country, the second is the regional maps.

2.1 The country-wide maps

There are 37 maps for the whole country and they are divided into six groups in this part.

2.1.1 Geomagnetic maps

This group includes 5 maps. The Aeromagnetic Anomaly Map represents the magnetic inhomogeneity of upper crust; the Filtered Aeromagnetic Anomaly Map shows the magnetic inhomogeneity of lower crust; the MAGSAT Anomaly Map; the Top Depth of the Magnetic Tectonic Layer; and the Bottom Depth of the Magnetic Tectonic Layer.

2.1.2 Gravity maps

This group includes 8 maps. The Bouguer Gravity Anomaly; the Free Air Gravity Anomaly; the Isostatic Gravity Anomaly; and five satellite gravity anomaly maps for 2-49, 50-100, 101-180, 2-180, 2-360 Satellite Gravity Anomaly (China and its adjacent area).

2.1.3 Electromagnetic maps

Five maps indicate the electromagnetic features of lithosphere in China. The Resistivity at a Depth of 30km and the Resistivity at a Depth of 90km show the distribution of receptivity in the upper mantle and in asthenosphere. The Depth of the Crustal Low-Receptivity and the Depth of the Low-Receptivity Layer in Upper Mantle show the distributing features of the lower receptivity in the lithosphere.

2.1.4 Velocity maps

There are 13 maps in this group. Nine horizons are taken to describe the velocity distribution of the lithosphere, they are the upper crust, the middle crust, the lower crust, the top of upper mantle, the velocity at depth 45^{-0} km, 45^{+0}km, 110km, 220km, 400km, 600km (China and its adjacent area). And the other four maps are the Moho Depth, the Depth of the Low-velocity Layer in the Upper Mantle, the Epicentres of Earthquakes, the Seismic Velocity(Pn) of the Upper Mantle.

2.1.5 Geothermal Maps

It includes five maps. They are Temperature at a Depth of 2km, the Vertical Geothermal Gradient at a Depth of 2km, the Terrestrial Heat Flow, the Temperature at the Moho, the Thickness of the Thermal Lithosphere.

2.1.6 Geophysical-Tectonic Framework

Using all the data above the map represents a probale thickness of lithosphere and the new ides of the crustal evolution in China.

2.2 The regional maps

There are 10 maps for the regional. They are the Geophysical Integrated Map of the Northeast China Area, the Geophysical Integrated Map of the North China Area, the Geophysical Integrated map of the Southeast Littoral Area, the Geophysical Integrated Map of the Qilian Mts. Area, the Geophysical Integrated Map of the Middle-lower Reaches of the Yangtze River Area, the Geophysical Integrated Map of the Qinling-Daba Mts. Area, the Geophysical Integrated Map of the Nanling Mts. Area, the Geophysical Integrated Map of the Southwest three River Area, the Geophsical Integrated Map of the Xinjiang Area, the Geophysical Integrated Map of the Qinghai-Xizang(Tibet) Area.

All the regional maps represent the aeromagnetic anomaly, the Bouguer gravity anomaly and the heat flow.

3. The characteristic

3.1 The base map of geography

According to the format of the atlas, the content of each map, data and the area, the unified country-wide and the regional base maps of geography have been compiled at the different scales for the atlas. The country—wide maps adopt the conical equal-area projection with two standard parallels. The regional maps adopt the equal-angle projection with two stsndard parallels. All the base maps of geography represent the main elements of cities, rivers and thier names. The names of major mountaints are also been showed. In the English copy of the atlas all the names of geography on the map are unified by the traslating principles.

3.2 The datd

Theis Atlas supplies a plentiful acture material with higher accuracies, i.e.:

The Aeromagnetic Anomaly Map represents the data in the past 30 years of aeromagnetic survey which at various sales cover about 80 percent of continental China and its adjacent aera. The flight altitude, the measuring accurcy, the data editing and processing, etc. detailes in the explanation of this map; the MAGSAT Anomaly Map uses the MAGSAT satellite data which was launched on October 30th 1979. 379 dawn passes and 427 dusk passes and 96221 observed values have been used; the Bouguer Gravity Map uses the data from the systematic regional gravity surveys mainly by the Ministry of Geology and Mineral Resources during 1979-1988. The measurements of the gravity were made at more then 300 000 stations; the Resistivity at the Depth of 30km, 90km, 150km maps bases on the results of the field survey for the magnetotelluric sounding during the past 10 years by the Ministry of Geology and Mineral Resources and other departments. The total data is about 900 sounding stations; the Seismic Velocity of the Upper,Middle, Lower Crust and the Top of the Upper-Mantle uses about 40 000km seismic sounding profiles by artificiality; the Map of Seismic Velocity at Depth of 45^{-0}km, 45^{+0}km,110km 220km, 600km uses P-wave traveltime data 50485; the Epicentre of Earthquakes represent $M \geq 5$ Epicentre of earthquakes; and the Temperature at a Depth of 2km compiles using the data of the hole geotemperature surveying, etc.

3. 3 The data processing

One of the main problems is the data processing. The data obtained from the different methods of the geomagnetic, MAGSAT satellite, gravity, electromagnetic, earthquake, geothermal and the measurements were performed with various accuracies over many years. So the data must be processed for eliminating on meaning the errors, and making them homogeneous. All this have been expained in the Atlas.

3. 4 The explanation

Every map of the Atlas has a short explanation with illustrations and tables. The main goal is to provide more information that have not represented in maps, such as the data source, the data selecting, the data precision, the data analys, the data processing, the compilation methos, the geological interpretation and the new idea, etc.

It is important that the different interpretations for the same problems by different authors, even the opposite opinions have been remaind in the explanation.

3. 5 The colour

Most of maps in the Atlas represent by isogram. For beeing clear at a glance we designe a colour chart which based on the four basic colours. The different

shades represent the different anomaly values:
the yellow shows the zero anomaly;
the warm colour shows the positive anomaly;
the cool colour shows the negative anomaly;
The more the positive anomaly higher the more the warm colour stronger;
the more the negative anomaly lower the more the cool colour deeper.

Some maps didn't follow the rules above.

4. Production technology

4.1 Compilatiom

The compilation of the Atlas is a complex thing. Because the most of maps need data editing and processing. Here cite an example in point.

Bouguer Gravity Anomaly

--Reduction of the gravity data;
All of the data should be reduced to the Potsdan gravity system, the Beijing coordinates system(1954), the Yellow Sea elevation system(1956), the Helmert (1901-1909) normal gravity formula, the density of a stone slab use in elevation correction(2.67g/cm), and the radius use in the terrain correction(166.7).

--Selection of the point:

For compiling this map the more then 2000 points at a ratio of selecting one point from a 45'×30' domain have been selected from the data more then 300 000. So the mean gravity value, the different between the value at each point and the mean value within a domain have been calculated. Then selecting the points which is nearest the central point of domain from the first five points.

--Compiling the map:

This map compiles with both computer and artificiality in the contour lines.

The method of other maps will be omitted here.

4.2 Publishing

All the maps of this Atlas published using the system of PC MAPCAD which researched and developed by China University of Geology. Although the digital charting in China is later then other countries in the world and the PC MAPCAD is not so perfect how, there is no denying the fact that the publishing technology of PC MAPCAD is crowned with success at least.

The technological process showed by block diagram.

5. The uses

according to the data of geomagnetic, gravity, seismic, geoelectric, geothermal;, this Atlas shows the structure of lithosphere at different levels in China. Some new concepts for the carton, the lithosphere thickness, the tectonic domains have been put forward. The plentiful actual data will be of wide uses for the geosciences study, the geological survey, the discovering mineral resources. For example: the geomagnetic maps provies the data of the magnetic anomaly, the top and bottem depth of the magnetic tectonic layer. It is very useful for studying geophysical-tectonic framework, metallogenic prognosis earthquake prediction, especially for searching the oil, natural gas, metallic and nonmetallic ore deposits and evalution of ore potentil, etc. The gravity maps shows the information of gravity anomaly, the crustal thickness, the density of crustal. They will be widely used for determining the place, depth, shape and the scale of the ore diposits. The map of seismic exporation can be used to discover the coal basins, the oil and gas fields and the geothermal resources, etc. So the Atlas will be great value for the national economic construction.

6. Conclusion

This is a new kind of atlas. The compilation and the publication of the Atlas is a great devotion to China economic construction as well as to the ICA. But it is not meaning that the work end. I think that we will be faced with an arduous task of the database, atlas information system and the electronic atlas.

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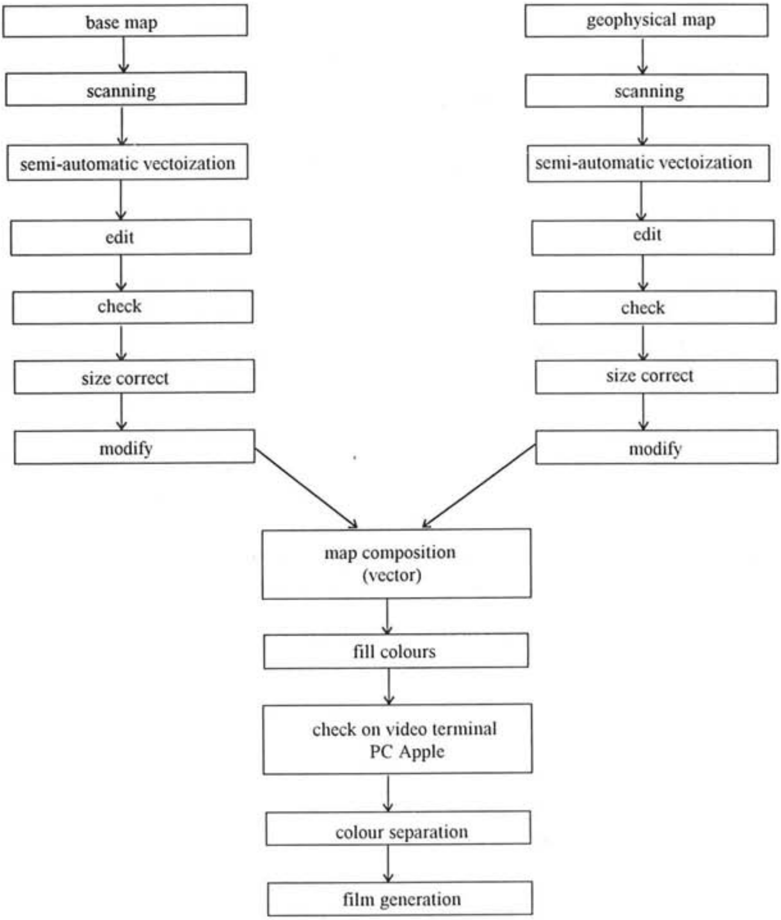
Thchnological process



MAPSITE - FINLAND'S BASEMAPS IN WWW-SERVICE

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Abstract

World Wide Web (WWW) is one of most popular services in Internet. Internet is growing very fastly and Finland is one of the leaders in Internet connections (Second in Internet connections per capita).

Mapsite is WWW-mapservice and it's based on raster maps. Mapsite is developed in National Land Survey of Finland's Geographic Data Centre. Mapsite includes NLS's raster maps from 1:20 000 to 1:8 mill. User needs only HTML 2.0 compatible WWW-browser and Internet-connection. Mapsite has very simple graphical user interface that includes tools for panning, zooming and searching places by coordinates. Mapsite's GUI is also customisable by users. Mapsite is also connected for several services. Namedatabase is based on NLS's 1:400 000 maps (approx. 28 000 names).

Mapsite has two different services. Citizen's Mapsite is free service. It includes some maps and limited services. Customer can buy more detailed maps and services with Ecash. Professional's Mapsite is liable to charge. It includes the most detailed maps from Finland and all services. User of Professional's Mapsite pay before using. They can buy 100-1000 hits to the most detailed maps. Some big customers are also intrested in unlimited access to Mapsite.

Mapsite is developed in spring 1996. Experimental stage was in summer 1996 and first version of Mapsite will be launched in October 1996. This paper describes developing of Mapsite and the current status.

Introduction

Growth of Internet has been expotentially last 20 years. In the 90´s World Wide Web (WWW) has grew to the most popular service of Internet. WWW was developed at CERN in early 90's. WWW is based on HyperText Tranfer Protocol (HTTP) and HyperText Markup Language (HTML). HTTP is an application-level protocol for distributed, collaborative, hypermedia information systems [1]. HTML is a markup language for hypertext which is used in WWW clients.

Maps can easily distribute via WWW. Most services providing maps are simple HTML-pages without interaction. Different databases (including GIS-databases) can integrate to WWW-server with CGI (Common Gateway Interface). CGI is a standard for interfacing external applications with information servers [2].

National Land Survey of Finland (NLS) started development project in January 1996 to develop WWW-mapservice, Mapsite (*Karttapaikka*, in Finnish; *Kartplats*, in Swedish). After short research we choose to use CGI-interface to NLS's Topographic Raster Database (TOPRAS). TOPRAS is covering whole Finland with scale 1:20 000 (pixel size is 2 meter) [3]. Small scale maps are also included in Mapsite.

Using Mapsite

Mapsite is very easy to use. Registrated user opens Mapsite's URL (Uniform Resource Locator), http://www.kartta.nls.fi/kartta/. This URL is actually CGI-program which make HTML-page (Figure 2) to user and sends it to user via WWW-server and Internet (Figure 1).

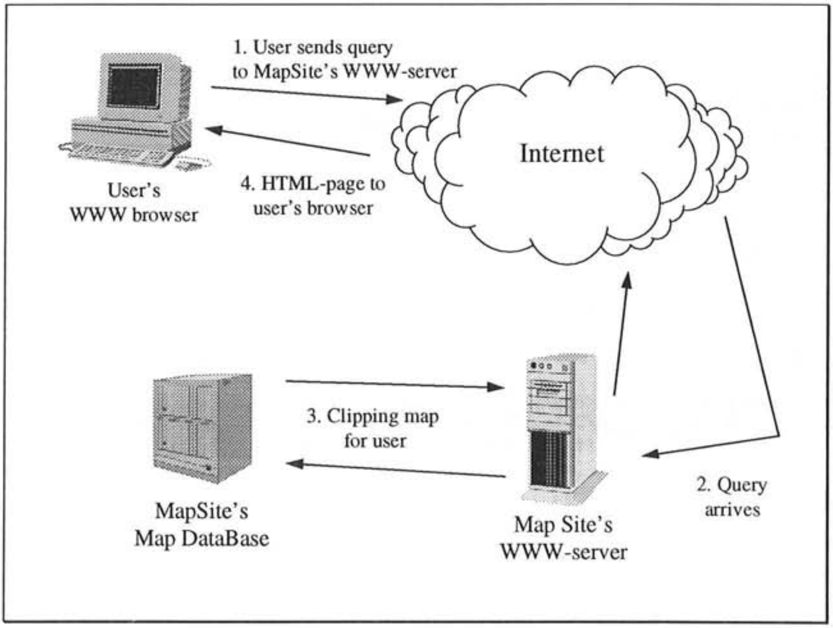

Figure 1: Mapsite on Internet

<u>Graphical User Interface</u>

Graphical User Interface (GUI) has two main objects: Map Window and Control Panel (Figure 2). Map Window is a map in GIF- (Graphical Interchange Format) or PNG-format (Portable Network Graphics). Control Panel includes tools for panning, selecting maps and searching maps by coordinates.

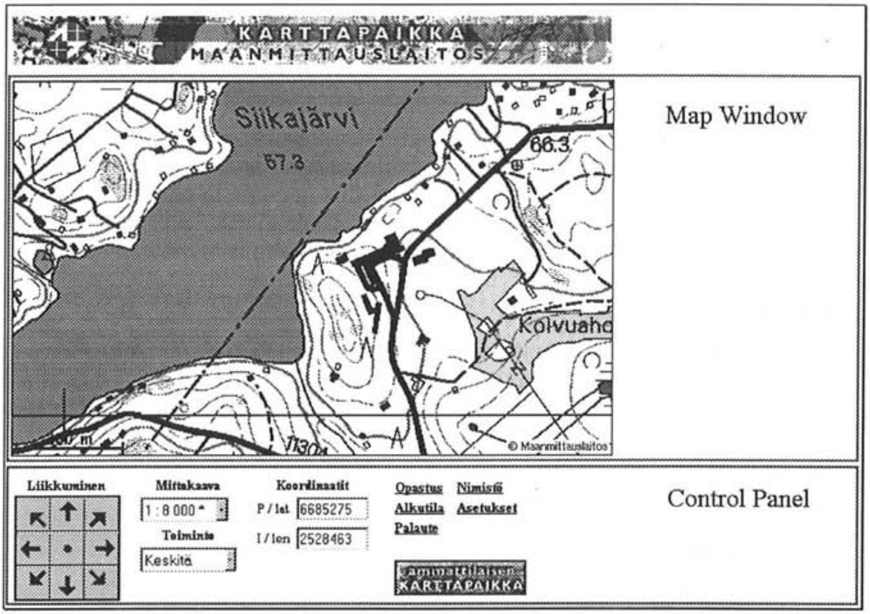

Figure 2: Mapsite's GUI

Name Database

Mapsite's Name Database is copy of NLS's map database 1:500 000's place names. Database containing 28 000 place names and it will be update yearly.

User's interface to Name Database is also very simple (Figure 3):

Figure 3: Searching place name "Turku"

If query finds more than one place name, user can choose the right one from all the names founded (Figure 4).

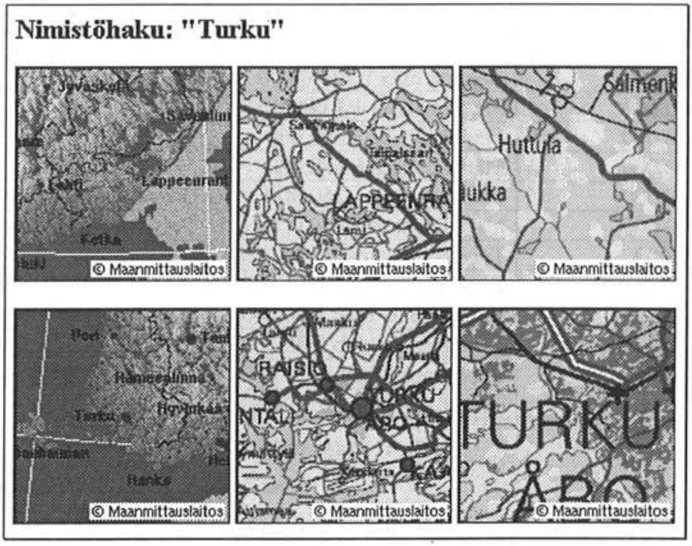

Figure 4: Result of searching place name "Turku"

Maps

All the maps used in Mapsite are raster images. Raster maps are easier to use, cartographic presentation is better and raster maps are already covering whole Finland.

National Land Survey of Finland collects Topographic Database (TDB). All topographic maps in scales 1:5 000 - 1:50 000 are based on TDB. Also smaller scale topographic maps (1:100 000 - 1:1 mill.) include some features derived from TDB. Topographic Database is a vector database and we started to collect that 1992 and collecting should be finished by the year 2000 [4].

A part of Mapsite's maps are scanned from original printed maps, but mostly maps are produced from vector databases. Updating is made directly from TDB and NLS's small scale databases. Updating is made yearly.

Scale of the maps is right when map is presented on display with pixel size 0,25 mm. 14" display with 1024 x 768 pixels have pixel size 0,25 mm. Also 17" with 1280 x 1024 pixels and 20" 1600 x 1200 pixels has right pixel size.

Scale	Origin of map	Note
1:1 mrd.-1:8 mill.	Maps from Internet	8 different scales
1:2½ milj.	General map 1:1 000 000	
1:800 000	General map 1:1 000 000	
1:800 000	Map database 1:1 000 000	
1:400 000	Map database 1:500 000	
1:200 000	Map database 1:500 000	
1:200 000	Map database 1:250 000	Only for PMS's users *
1:100 000	Map database 1:250 000	Only for PMS's users *
1:50 000	Topographic map 1:20 000	
1:20 000	Topographic map 1:20 000	
1:8 000	Topographic map 1:20 000	Only for PMS's users *
1:4 000	Topographic map 1:20 000	Only for PMS's users *
1:2 000	Topographic map 1:20 000	Only for PMS's users *
1:1 000	Topographic map 1:20 000	Only for PMS's users *

Table 1: Maps of Mapsite

* PMS: Professional's Mapsite (see below)

Citizen's Mapsite vs. Professional's Mapsite

Mapsite has two different user groups: users of citizen's Mapsite (CMS) and users of professional's Mapsite (PMS). Main difference is that citizen's Mapsite is free of use and professional's users pay an annual fee.

Citizen's Mapsite

Users of citizen's Mapsite must register to use Mapsite. They must have e-mail address and their Internet connection must be in Finland (.fi -domain). They can use all maps which are not dedicated for PMS's users (Table 1). In the near future we will add Address Database (containing 2½ millions buildings) for users of the Mapsite. Address Database will be also free of charge.

Professional's Mapsite

Professional's Mapsite's users have all the maps and services of citizen's Mapsite. They have also coordinate information available.

PMS's users buy certain amount of queries to chargeable maps. PMS's prices are very modest (Table 2).

Queries to chargeable maps	FIM	SEK (10.3.97)	USD (10.3.97)
100 queries	180 FIM	277 SEK	36 US$
250 queries	350 FIM	538 SEK	50 US$
500 queries	700 FIM	1077 SEK	140 US$
1000 queries	1300 FIM	2000 SEK	260 US$

Table 2: Professional's Mapsite's prices

Pricing of PMS's queries was and is very difficult problem. Mapservices in Internet must and can be much more cheaper than traditional ways to use maps. Price differences between small and large scale maps must be modest. Also "empty" maps (for example all pixels white) must have price, but how much ? If user make heavy queries to databases, he must pay more. But how can user know before making query that it's big query ?

Conclusion

Mapsite will never be ready. Over 19 000 registrated users in 6 months has made almost 690 000 queries (9.3.1997). This has shown to NLS that Internet will be very big media to distribute and to sell maps.

People want easy-to-use tools for maps, not very sophisticated GIS tools. They will search places by names, not by coordinates. They are not intrested about different map projections or coordinate systems. Much more important is that maps are updated and easy to read.

Acknowledgements

Mapsite is mainly made by Ville Saari. Teija Tarvainen has answered users questions and she makes most Mapsite's manuals and guides. Iiro Harra has made graphics for Mapsite.

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THE COLLECTION OF RARE 16TH-17TH CENTURY DUTCH MAPS AND ATLASES IN THE RUSSIAN NATIONAL LIBRARY

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In 1996, St.Petersburg celebrated the 300th anniversary of Tzar Peter I's historical voyage to Holland which became the beginning of the long and fruitful relationship between that country and Russia. This cultural link was also reflected in the significant collections of Dutch artefacts formed in Russia, to which there belonged maps. The works by Dutch "Golden Century" map artists occupied their well-deserved place in the libraries used by governmental officials and scholars. Thus, e.g. the prominent religious activist and governmental official, Peter 1st's assistant, Feofan Prokopovitch, had a private library featuring the multi-volume editions of the atlases by Jan Janssonius and G.Blaeu. Later, these publications were included into the map collection preserved in the Russian National Library (RNB) as one of its basic components.

Presently, the 16th-17th-century Dutch map collection in the RNB contains over 400 volumes of atlases and several hundred maps being the largest in Russia. It consists of the works by a brilliant team of map designers, engravers, and publishers who had caused a major influence over the development of Russian mapping. At the same time, despite its doubtless value, the aforementioned collection has never been opened for the wider circles of the scholar community. This report has an objective to fill in this gap, at least to some extent.

In principle, the collection includes two parts, one main consisting of the maps and atlases kept in the Map Department, and the other with the maps pasted in the books preserved in the Rarity Department and the Foreign Publications

Departments of the Library. The whole provides for a sufficient degree of completeness and consistency disclosing the most prominent period in the history of Dutch mapping.

The review could well be started from the city prospectives drawn by an artist from Utrecht, Erhard Reuwich. His xylographies had been included into the book by Bernhard von Breidenbach, "Peregrinatio in terram sanctam" (Mainz, 1486) and became the prototypes of later city maps.

The oldest dated printed map in the Map Department collection is the first world map by the Dutch artist J.Ruysh, "Universalior cogniti orbis tabula..." (Rom, 1508). It was one of the first printed maps presenting the shore outlines of America, discovered just a few years before. Of interest are the xylographed world map by Gemma Frisius, a forefather of the scholarly approach to mapping, and included into his book: "Cosmographia Petri Apiani, per Gemmam Frisium..." (Antverpiae, 1545).

The vast collection of atlases includes works by different authors belonging to diverse schools of Netherland cartography.

The most prominent representatives of the Antwerp school of cartography were Abraham Ortelius (1527-1598) and Gerard de Jode (1508/9-1591). They both, in more or less the same time, developed the idea if a cartographic edition novel for that time, a world atlas. A.Ortelius was the first to print one. In 1570, he published the first world atlas, "Theatrum orbis terrarum" which was later reprinted for over 20 times in several languages. The RNL collection has the following editions:

"Teatrum orbis terrarum":

1570. Lat. text

1572. Germ. text

1573. Germ. text. Convoluted with: Beschreibung u. Kontrafaktur... der stät der Welt. (G.Braun, S.Novellanus, F.Hogenberg) B.I. Köln, 1574

1579. Lat. text. With Parergon a. Nomenclator Ptolemaicus

1580. Germ. text

1584. Lat. text

1590. Additamentum IV. Lat. text. Convoluted with: Additamentum quintum. Lat. text

1609. Lat. text.

1612. Lat. text.

1624. Theatrum orbis terrarum Parergon

"Epitome"

1579. "Epitome du Théatre du monde..." Fr. text. 1590, 1598, 1601 convoluted with: Compendio dal theatro del mondo... 1601, 1602.

1585. "Epitome Theatri Orteliani..." Lat. text. 1589, 1601, 1595.

1593. "Theatro d'Abrahamo Ortelio..." Ital. text. 1598, 1655, 1667.

1604. Ausszug auss des Abrahami Ortelii. Germ. text.

A.Ortelius' competitor, G. de Jode, did manage to publish his atlas before 1578. It went almost unnoticed, and the publisher's son Cornelius de Jode (1568-1600) printed a second revised edition in 1593. There exist copies of this atlas containing maps of Europe dated of 1613. It is this edition that is represented in the RNL collection, "Speculum orbis terrae" (Antverpiae, [1593-1613]). Due to the fact that no later reprints ever took place, all preserved copies are rare. Besides, the book collection has a treatise on mathematics, also by C. de Jode, "De Quadrante geometrico Libellus" (Norinberg, 1594) dealing with the basics of trigonometric surveys.

However, the true priority in Netherland cartography development during the 16th century belonged to Gerard Mercator (1512-1594). He started his work in Netherlands, but became most active following his exile to Duysburg. The RNL has the following editions by G.Mercator:

- finished during his lifetime: "Claudii Ptolemaei Alexandrini Geographiae libri..." (Colon, 1584); "Galliae tabule geographicae..." (Duysburg, 1585); a book "Cronologia..." (Colon, 1569; Basileae, 1577).

- "Atlas sive cosmographicae meditationes de fabrica mundi et fabricati figura" (Duysburg, 1595) published soon after G.Mercator's death.

As is well known, in 1604, the brass plates of Mercator's atlas got passed over to a prominent publisher belonging to the Amsterdam catrography school, Jodocus Hondius I (1563-1612) who continued printing later done also by his sons Jodocus Hondius II (1593-1629) and Hendric Hondius II (1597-1651). Our library possesses the following variants of their work:

"Gerardi Mercatoris Atlas sive cosmographicae..."

1606. Lat. text.	[1611-1612-1613]. Lat. text.	1630. Lat.text.	1633. Lat. text. Vol.I.
1607. Lat. text.	1619. Fr. text.	1633. Fr. text.	1633. Germ. text.

"Atlas minor..."

Lat. text: 1607, 1610, 1620/21, 1628, 1634

Germ. text: 1609, 1631, 1651.

"Claudii Ptolemaei Alexandrini Geographicae libri..." (Amsterdam, Fracoturti, 1605).

There further are a few copies of the 1602 maps signed by J.Hondius I; the rare books department boasts his "Nova et accurata Italia Hodernae descriptio..." (1627). The works by Willem Hondius (1597-1660) are represented by a wall map of the Smolensk siege "Smolenscium Urbs..." (1636).

Besides, the book collection has studies on perspective and fortification written by yet another member of that prolific family, Hendric Hondius I (1573-1650). At that, his "Description et breve declaration des Regles generales de la fortification..." (The Hague, 1625) contains maps.

The RNL also has the first printed Naval atlas, "Spiegel der seefart..." (Amsterdam, 1589), by Lucas Waghenaer (died in 1598), and his atlas "Thresorie ou cabinet..." (Amsterdam, 1606).

It is impossible to remain silent about the works by an outstanding map engraver, F.Hogenberg (1535-1590) who started his career engraving maps for A.Ortelius, and later, like a lot others, had to emigrate from the Netherlands and move to Colon. He was the first artist to represent the Netherlands map as a lion, "Leo Belgicus" printed in "De Leone belgico..." (1585) by M.Aitzinger and also represented in the RNL book collection. Besides, the Map Department has a few editions (since 1574 through 1618) of the famous city atlas "Civitates orbis terrarum" published by F.Hogenberg and G.Braun in Colon.

A sizeable number of copies represent also various editions of 1638 through 1681 by Jan Janssonius (1588-1664), the major atlas publisher who in 1638 inherited the plates of the atlas by Mercator-Hondius. There are further the four-volume British edition of J.Janssonius' atlas published in London in 1680-1683, and the seven-volume atlas of world cities "Illustriorum... urbim tabulae..." (Amstelodami, 1657) based by J.Janssonius on the plates on the atlas by F.Hogenberg-G.Braun.

The highest level of the map business development in Amsterdam was reached by the company of W.Blaeu (1573-1638). The RNB treasures a few reprints of the atlas "Appendix Theatri A.Ortelli..." done in 1631-1655 in Latin, French, and Dutch, including its complete six-volume version, and finally the famous twelve-volume "Atlas major" (1667). Besides, the library has a few volumes of the Blaeu city atlas.

A significant number of copies represent maps and atlases by F.de Wit, C.J.Visscher, sea atlases by P.Goos, J.van Loon, G.van Keulen, C.J.Voogt, small atlases by H.Quad, etc. In books, there are maps designed by P.Plancius, W.Barentsz, and others. The Foreign Department of the Library counts a vast number of books on diverse subjects published by the companies of Hondius, Blaeu, etc.

As is well known, many an author, engraver, and publisher produced also pieces of art. These activities by, the multiple members of the Hondius, de Jode, and other families are represented in the collection of the Print Department.

It shoud be mentioned that the NLR obtains the number of items similar to the collection of the Library of Congress (USA).

A certain deficiency of the RNL collection may be seen in its having virtually no wall maps by Dutch authors.

By now, the maps and atlases preserved in the Cartography Department have been identified and described in the catalogs. As for the maps present in books, no systematic work on their identification or describing has regretfully been conducted yet.

The information on the collection offered above allows for its assessment from the viewpoint of the most common criteria used in regard to the cultural value of the documentary heritage. They are the following:

- Completeness and consistency. The discussed collection adequately reflects the level of the 16th-17th-century Dutch mapping.

- Influence, time, and place. There is no need to quote the generally accepted significance of Dutch mapping for the science progress during the post-Columbic period.

- Authors. The collection contains works by the scholars who made a noticeable contribution into the mapping theory and practic.

- Format and style. The listed editions are outstanding samples of the artistic map design following definite styles, and therefore are of a tremendous artistic value.

On the basis of all this, one can suppose with certainty that the collection of the 16th-17th-century Dutch maps in the RNB is of a world-wide importance as a cultural value far exceeding the framework of a national culture.

COGNITION STUDIES WITH CONTINUOUS AREA CARTOGRAMS: GENDER DIFFERENCES

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1. Introduction

Research and science are subject to processes which are continuously changing. Geographers and many other scientists intend to present their ascertained findings in an appealing way, often as a map. Here we face apparently insurmountable difficulties. For example how does one depict the average Swiss income, when almost the entire population (and therefore also the incomes) is situated down in the valleys, but two-thirds of the map area is taken up by the sparsely populated Alps? Isn't it therefore legitimate to look for a more appropriate, maybe even better representation of human geographical data? Area cartograms are just one attempt to by-pass the mentioned inadequacy of conventional maps. Area cartograms show true quantity (units representing large/small values appear large/small), therefore they don't reveal a geometrical-alike but a topological-correct depiction of area (Brassel et al. 1991). But how does the average map reader react once he sees himself confronted with such a map?

This paper is based upon an inquiry about readability and interpretation of continuous area cartograms (Aschwanden 1995), and tries to show that pattern identification is possible. It further reveals gender differences regarding estimation of area size.

2. Definitions and Construction - Procedures

Bertin (1974) calls continuous area cartograms 'cartographic anamorphoses' and describes them as constructions which distort the geographical net in order to represent a non-geographical component.

Bertin and Muller (1985) however point out that an important problem with cartograms lies within the different transferring principles. So it is possible that cartogram versions of several map authors showing the same topic could look entirely different.

The computer replaced the time consuming and uncontrolled manual constructions by controlled computer supported transformation algorithms.

Merrill, Selvin and Mohr (1991) interpret continuous area cartograms as projection of which the generation of equal density areas is set as final function. Hake and Grünreich (1994) write similarly but they allow a further meaning. A map-anamorphose is a distorted (distortion follows defined rules), quantity-faithful representation of the earth; the scale either shows large fluctuations or depends on a non-geometrical basis. They further define 'large fluctuations of scale' as 'geometrical distortions' which are especially oriented on the changing graphic density of a map and hence, the resulting extent of legibility. For Hake and Grünreich a 'non-geometrical basis' is a 'time- or topic-related distortion' which gives up the precise connection to the standard-geometry and introduces different scale parameters instead.

Tobler (1973a, 1973b) starts from an equal-area representation in his two procedures and models the polygon- respectively raster-areas on a rectangular grid. A target-area-size (attributes like population) is appointed to each unit. An iterative process subsequentley changes the magnitude of the units in proportion to the attribute values. Here each neighbour unit exerts a 'power effect' in form of a translation vector on every border point. This process is repeated several times until the difference between the original depiction and the target-area-size has become negligible or a pre-set iteration-number is reached. Finally, the co-ordinates of the units are retransformed on the distorted grid.

Whereas Tobler's algorithm averages only the resultant 'power vectors' of the direct neighbour units and shifts the border points for the amount of this vector, the algorithm of Dougenik et. al. (1985) refers to the effects of areas by which the powers decrease with increasing distance to the unit center. The formulas calculate with territorial units as if they were circles (well visible at high values for single areas). At the beginning of the iteration process the sum of the shift is somewhat smaller than computed in order to preserve the topological structure. This procedure is not reversible.

All of the cartograms used in this investigation had been drawn with a computer program based upon the algorithm of Dougenik et. al. and developed by A. Herzog.

3. Cognitive Approach

The terms 'cognitive' or 'cognition' originate from psychology where cognitive procedures like to perceive, to detect, to recognise, to visualise, to evaluate, to memorise, to learn and often to speak, form objects of research. The so called 'advanced procedures' which a human being uses to gather, to retain, and to apply information are being investigated.

As opposed to psychology, experimental studies within cartography examine a visual product: the map. The method of cognitive research, although known for a long time, was hardly applied in cartography until today. Olson (1979) emphasises that the main interest for cartographers in dealing with cognition studies lies within an attempt to understand maps better, and to increase communication by improved maps. This paper follows Olson's request that additional findings of how people use maps (in this case area cartograms) should be gathered. The primary focus of examination is not only how a map reader interprets a cartogram, but also **how** it is read and applied.

How does one investigate the general communication ability of maps, their strengths as well as their weaknesses? What should the purpose of a map be? Kennedy (1994, p 19) states it very short, "A maps primary purpose is to display the spatial distribution of the data." Many cartographers agree that the most obvious function of thematic maps is the transmission of information and trends of geographical spreads by means of patterns. From the map reader's point of view, identification of the mapped pattern is essential.

Different authors (Antes and Chang 1990) have alluded to gender differences regarding the reading of maps, thus, this paper also attempts to investigate the influence of the variable 'gender' upon continuous area cartograms.

Since well documented cognitive studies with choropleth maps already exist (Muller 1979 and 1980), some parts of their experiment set-ups were followed.

4. Experimental Design

To investigate several hypotheses about the interpretation of continuous area cartograms, a cognition experiment with 120 subjects was performed. Two questionnaires formed the work bases for all the test respondents. Questionnaire A contained all of the cartograms. Booklet B consisted of exact instructions how the tasks had to be performed and extra space so the answers could be written down.

A tape led through the trials so equal conditions could be guaranteed and the tester hardly influenced the subjects. A given time-handicap seemed appropriate since Megaw and Richardson (1979) observed that test respondents become overcautious when given an unrestricted time span.

The tasks had to be solved onward. Going back to correct possible mistakes was not permitted. During the test talking was disallowed and all questions had to be answered despite possible insecurities. The test respondents were fully aware that the validity of the test is severely falsified by copying the neighbour's results.

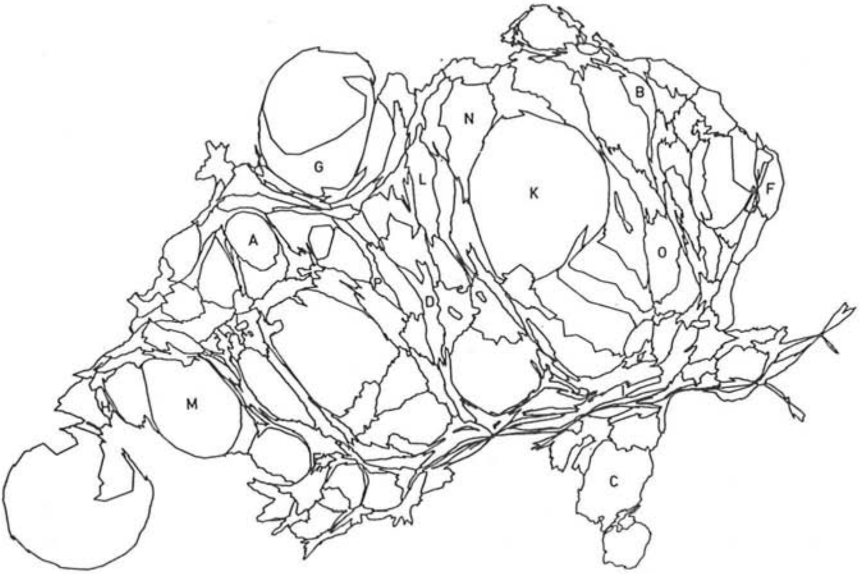
Twelve main questions (some of them were divided even further) formed the entire test, but only one of them will be discussed in this paper.

5. Pattern Identification

Is it altogether possible to identify a pattern? On an area cartogram consisting of 184 Swiss counties which had been distorted after the variable 'inhabitants 1990', 15 test-areas were chosen (see figure 1). A short explanation how an area cartogram functions followed the request to assign the five categories 'hardly any', 'a few', 'medium', 'many' and 'very many' inhabitants to all of the areas. The time-handicap amounted to five minutes (see table 1). It was noted that varying magnitudes and surface-shapes had been taken into consideration. The possibility that large areas surrounded by small areas could be looked at differently than if these units were situated next to areas with identical size was taken into account.

19 out of originally 100 test respondents had not solved the task completely and therefore could not be considered for the analysis. From the remaining 81 questionnaires, 29 (35.8%) belonged to the category 'women' and 50 (61.73%) to the category 'men'. Two questionnaires (2.47%) could not be assigned to either of the two groups.

Figure 1: Counties of Switzerland distorted after the variable 'inhabitants 1990'



5.1 Evaluation

First, the responses were coded with 1 to 9 according to the labels 'hardly any' to 'very many' (see table 1), then the median, mean, variance and range for each single test-area were determined. Table 2 shows means and variances of the categories 'women' and 'men'. At the means we will be reused later on (see chapter 5.1.3 Evaluation of the variable 'gender'). The variance as scatter-measurement shall inform the reader about which zone and how the data are approximately dispersed.

Table 1: Codification of responses

Set a mark under the expression, which characterises each single area most precisely.

Area		**hardly any**		**a few**		**me-dium**		**many**		**very many**	
M	has							X			inhabitants
D	has	X									inhabitants
Codification											
		1	2	3	4	5	6	7	8	9	

Table 2: Population, median, mean, variance, range

Area	Population	Median	Mean	Variance	+/- one category	+/- two categories	Women Mean	Women Variance	Men Mean	Men Variance
K	449371	9	8.88	0.53	96.30%	98.77%	8.66	1.4	9	0
M	192295	7	6.88	1.1	77.78%	98.77%	6.72	1.1	6.96	1.12
G	134435	7	6.49	1.39	71.61%	96.30%	6.17	1.52	6.7	1.21
C	104559	6	5.84	1.27	62.96%	95.06%	5.48	0.94	6.06	1.38
N	98769	5	5.59	1.18	69.13%	98.76%	5.14	0.88	5.84	1.21
O	62980	5	4.83	1.35	74.08%	98.77%	4.38	1.62	5.1	1.05
L	57805	4	4.23	1.09	65.43%	98.77%	3.83	1.11	4.46	0.97
A	56068	5	4.69	1.72	70.37%	96.29%	4.14	1.57	5	1.6
D	39242	3	3.61	1.27	65.83%	94.95%	3.25	1.47	3.56	1.17
I	33883	3	3.01	1.27	75.30%	100%	2.66	1.4	3.22	1.09
F	33467	3	3.38	1.82	69.14%	97.53%	2.9	2.16	3.66	1.46
B	33064	3	3.36	1.42	75.30%	96.29%	3	1.59	3.56	1.25
P	15778	3	2.72	1.22	72.84%	100%	2.17	0.9	3.02	1.14
H	7958	1	1.44	1.43	86.42%	96.30%	1.1	0.16	1.66	2.1
E	4156	1	1.43	1.33	85.19%	93.83%	1.34	1.4	1.5	1.33

5.1.1 Interpretation

One may ask if the classification of the test-areas related to the expressions of quantity 'hardly any' up to 'very many' is random or does it cluster indeed around a joint denominator? For a better understanding histograms are drawn for each of the 15 test-areas divided after the variable 'gender' and discussed separately (see figure 2).

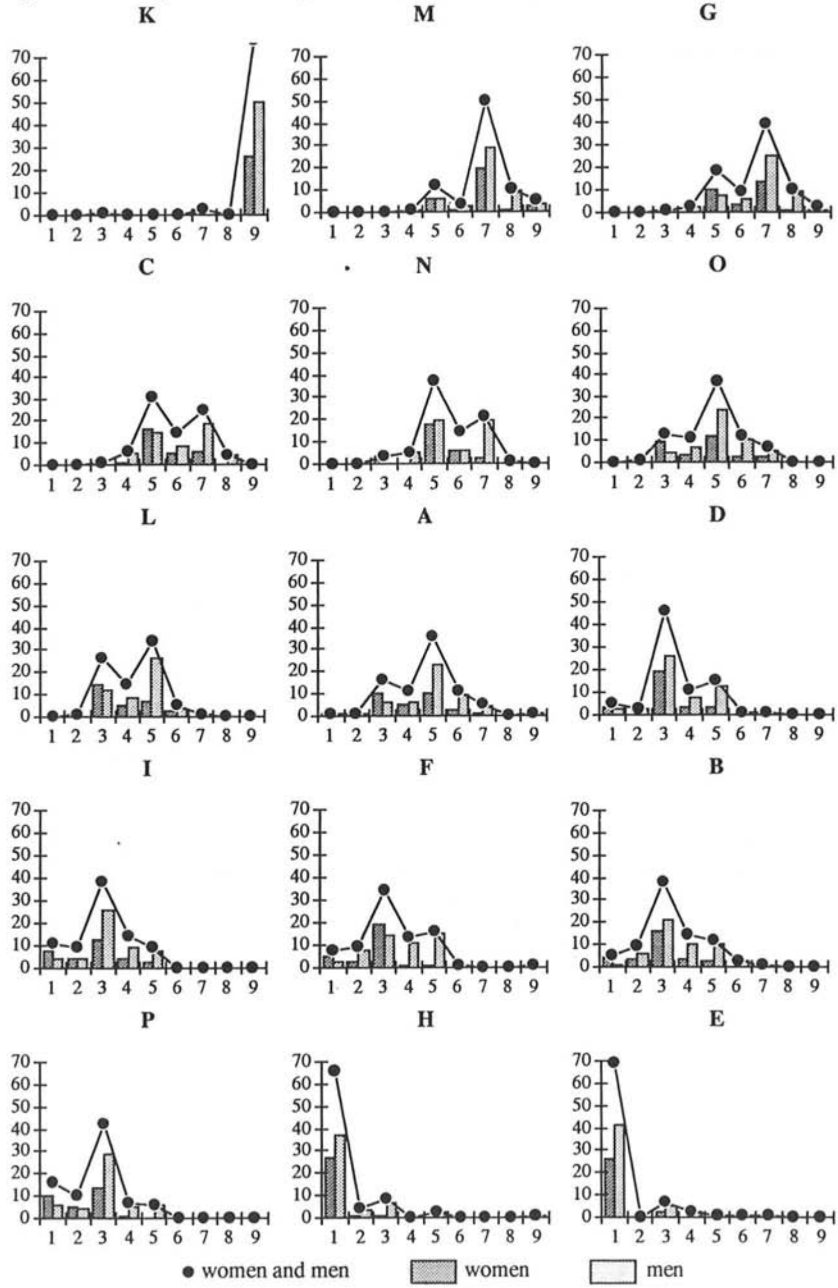
Looking at the overall results (indicated by dots), most areas can be definitely assigned to one attribute ranging from 'hardly any' to 'very many'. For the largest and the two smallest areas, the result turns out to be quite obvious; we state the hypothesised values lie most likely close to 'very many' for area K and close to 'hardly any' for the areas H and E. Also the outcomes of the areas M and G were assigned rather definitely to 'many', the result of area O to 'medium' and the ones of the areas D, I, B and P to 'a few'.

Tight is the outcome for the areas C and N, both vary between 'medium' and 'many' and L between 'a few' and 'medium'. As 'tight' we define an area if its peak doesn't count at least twice as many nominations as the second assignment. One explanation can be found within the charts of the areas C and L, each chart showing two different culminations for either the category 'women' or 'men'. Two peaks within the category 'men' can be observed for the areas N and F and for the category 'women' in area A.

5.1.2 Distribution of Replies

In order to analyse the variable 'gender' even further we subtracted the answers of each single woman and man from the median, counted the positive and negative deviations and put them down in a chart. Positive deviations (x-axis) signify an underestimation of the area-magnitudes, negative deviations (y-axis) an overestimation of the test-areas with respect to the median. The closer a dot to the origin of the graph, the tighter the generalisation is.

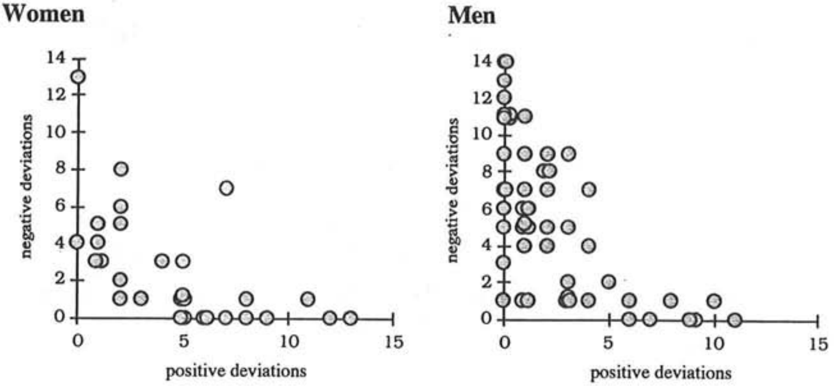
Figure 2: Histograms showing results of each tested area



While men (n=50) rather over-estimated the area-magnitude in the ratio of 33 to 14, women (n=29) underestimated in the ratio of 9 to 18 (see figure 3).

For men the range goes from one up to altogether 14 deviations, for women from three up to 13. In the zone 'x and y smaller/equal 7' deviations we count 30 of 50 subjects for men (60% of the answers), 21 of 29 subjects for women (72.41%).

Figure 3: Variable 'gender'



5.1.3 Evaluation of the variable 'gender'

This paragraph explores the direct influence of the variable 'gender' on pattern identification. Are the means of the individual categories of a variable significantly different from each other for the 15 test-areas? Alternative and zero-hypothese is formulated as the following:

$$H_0: \mu_1 = \mu_2$$
$$H_1: \mu_1 = \mu_2$$

With the paired sign test we examined which mean (see table 2) is larger within the tested areas. In this test, areas with identical means will be dropped. We also explicitly mention that the category 'women' contains only 29 subjects.

In all of the 15 tested areas the mean of the category 'men' was larger than the mean of the category 'women'. Therefore we calculated a P-value of 'smaller 0.0001'. Consequently the zero-hypothesis must be rejected, and the alternative-hypothesis after which means of women and men differ accepted.

An additionally performed Wilcoxon-test shows a similar picture:

gender	<0	Sum Rk <0	>0	Sum Rk >0	P-Value
women (n=29)/men (n=50)	15	120	0	0	0.0007

Both tests indicate that the means of the categories 'women' and 'men' differ significantly.

6. Conclusion

To class each of the 15 test-areas the subjects could choose among nine attributes ranging from 'hardly any' up to 'very many' inhabitants. They did not receive any particular explanation after which criterions the generalisation had to be effected and yet the classification did not occur randomly but accumulated around certain values. It seems therefore possible that subjects identify patterns on area cartograms.

Taking also the findings in chapter 5.1.1 and 5.1.2 into consideration we conclude that in continuous area cartograms women see single areas and districts smaller than they actually are whereas men tend to over-estimate them.

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NEUROCARTOGRAPHY - NEW TREND FOR RESEARCH IN THEORETICAL CARTOGRAPHY

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1. Introduction

Recent advances in computer cartography along with the progress in the information theory of vision permit revealing the conceptual linkage between mapping and visual perception. So far specialists in cartography, image interpretation and photogrammetry addressed vision, as a rule, in its neurophysiological or psychophisical aspects, especially when it was necessary to consider the characteristics of visual system during map compilation, image producing or visual perception of images in the process of their practical use. The aim of this report is to prove that the information procedures of visual perception of the material world have much in common with the compilation of geographical maps on the basis of aerial and space imagery.

2. Aerospace mapping

Fig.1 illustrates general scheme of map compilation using the images. The left square is the object of mapping or investigation, i.e. the Earth's surface, processes and phenomena under study. Information needed for mapping could be obtained through aerial and space surveys which should meet the requirements reasoning from the scale and content of the designed map. At this stage the initial information is represented in

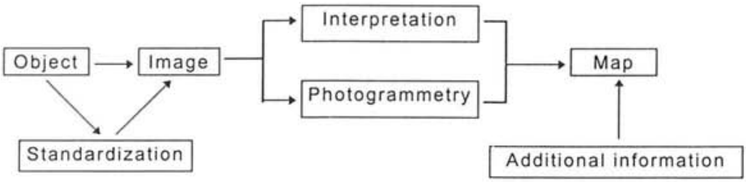

Fig.1. shows the principal information procedures of aerospace mapping (map compilation using images). Concrete model (image) is transformed into conceptual model (map).

the form of image which is a model of the object under mapping. When needed several images of different types could be taken providing for the comprehensive description of the object of study. A considerable bulk of initial information is acquired through the standardization of images by referroing to the real "on-ground" situation. For example, the survey of test sites provides the basis for controlled classification.

Next stage is the image processing aimed at the "extraction" of information necessary for mapping. There are two main types of processing, namely the acquisition of thematic information, or image intrpretation, and that of geometric data, or photogrammetric processing. This subdivision is true for both traditional processing of analogue images, or photos, and computer processing of discrete, or digitized, images. The results of thematic interpretation and photogrammetric processing of images are integrated into a map which is a conceptual model of the object under study compiled in accordance with the legend. However, the experience suggests that the information obtained from images is inadequate to produce high-quality maps. It is necessary to use additional sources of data, namely cartographic, statistical, field, etc.

Any map is compiled through generalization which includes two inverse processes - that of selection and graphic representation of the essential features and that of rejecting less important ones. When images are used for mapping the generalization takes place at the very first stage of surveying, and then continues through image processing, map compilation and design. So we are dealing with continuous cartographic-aerospace generalization which provides for the transition from the image, being a concrete model, to the map, or abstract model.

3. Visual perception

Many outstanding scientists have tried to cognize the phenomenon of vision, i.e. to understand processes which occur in the visual system while we are watching the surrounding objects. But this fundamental problem of natural science is still far from being resolved. There are as yet more questions than answers.

Figures 2 and 3 taken from the recent publications on psychology give an insight into the system of vision. Both figures show the best-investigated parts of this system, from eye to primary striate cortex. In the beginning of the vision path the crystalline lens produces a luminous central-projection picture on the retina. Neurons of the retina code the distribution of brightness over the picture by neural impulses which are sent via optic nerve to the cerebrum where the mental image is formed. Photoreceptors are grouped into receptive fields of different size, each having two zones, i.e. the centre and the periphery. Each zone could respond to light by either excitement with the increased frequence of impulses, or inhibition when the frequency of impulses goes down. The most characteristic feature of the optic system neurons is their clearly selective response. The majority of neurons respond to abrupt changes in brightness, to borderlines or contours, and not to general lighting, color or tint. In psychology it is commonly supposed that identification of objects, i.e. answering the question what is the object under observation, is carried out by a system of neurons involving numerous

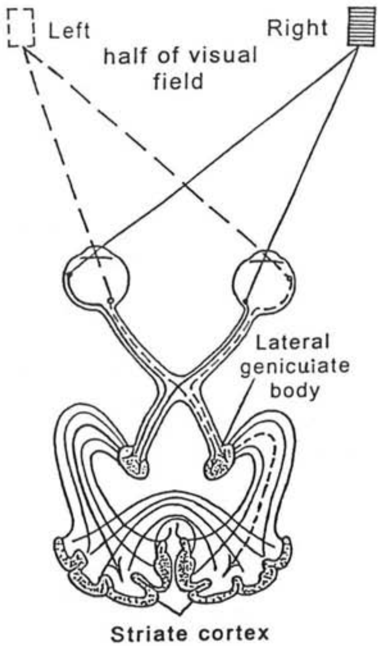

Fig.2. shows the main elements of vision system. It represents the part of the system from eye to striate cortex. The functioning of vision system is determined by the properties of neural cells. Part of them being photoreceptors could transform light effect into electric signals. Other cells are neurons, which are capable to receive information in the form of impulses, integrate it and pass it to other neurons.

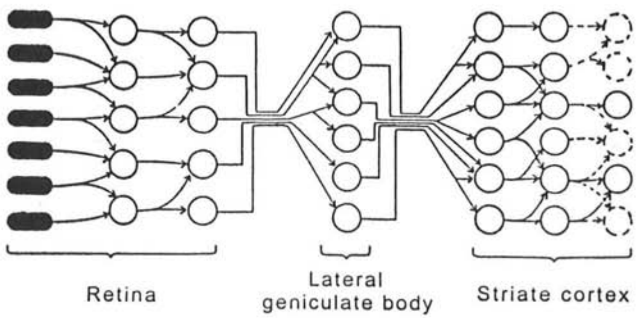

Fig.3. Vision path begins from the eye's retina. Photoreceptors excited by light pass signals to the cerebral neuron structures which include millions of cells forming the mental image. Blocks of higher cortex zones are shown by dash lines as there is little understanding of them in psychology.

cells of different cortex zones. An answer to the question where is the object is formed by another system of neurons which is relatively autonomous.

In the process of vision a person examines the object by viewing it (Fig.4). Visual system is an active one operating in the real time and showing the high degree of adaptability. The information scheme of how the mental image of material world is formed could be represented as on Fig.5.

Fig.4. This is the pattern of a human view "scanning" the well-known picture of the famous Russian artist I.I.Shishkin. The essential and less important detailes of the picture are clearly seen. They produce quite different amount of information to be send to cerebrum. This is the information basis for generalization which is commonly carried out by vision system.

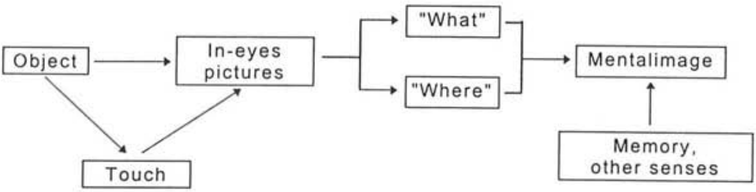

Fig.5. Simplified scheme of visual perception of the material world. The input information includes in-eyes images. The output is the realistic mental image, or visual model, free of inessential details.

4. Comparison of two schemes

The above schemes of aerospace mapping and visual perception are rather simplified. They show the key procedures only, such as acquiring data about the material world, proceeding of the information and its final representation. The similarity and even commonness of the information procedures could be clearly seen. In the process of visual perception of the surroundings and the form of objects the *standardization* is based mainly on the sense of touch which is use during the whole process of studying the vision. In order to form a mental image of the material world the in-eye images prove to be inadequate. As in the process of applying aerospace images some *additional information* is required, coming from other senses and taken from the memory. The system of vision accomplishes the effective biological synergism of information.

While analysing the final information procedure of mapping and vision the correspondence could be found between a *map* and a *mental image*. According the psychologists, true mental image of the material world is its interpreted symbolic description (representation) free of inessential details. This is quite close to the definition of a map from the manuals in cartography.

Another concept of the visual perception psychology states that the material world cannot be seen until its organization is understood. Moreover, the visual perception by itself is defined as an activity aimed at surveying the object and producing the *copy* of it. This coincides with the aim of mapping, though it goes without saying that different terms are used.

Thus, vision and aerospace mapping have the common strategic aim, i.e. to identify *what* and *where* is situated in the material world through the use of binary images and to represent it clearly. Furthermore, these processes are based on common information approaches leading to the achievement of this aim. It is important to note that identification of spatial location and form of the objects is considered by psychologists as a *priority aim* of vision while cartographers rank it first among the priority tasks of mapping.

5. Conclusion. Problem of neurocartography

There are several spheres in the present-day interactions of vision psychology and aerospace mapping.

a. Traditional sphere of interaction includes the problem of using the abilities of human vision while working with maps and images. It is necessary to develop studies in perseption of such psychological realities as cartographic and interpretation images, mental maps.

b. Another sphere includes the elaboration of *cartographic concept*, or hypothesis, within the theory of vision. This is a new idea in theoretical cartography. Publications in psychology give a lot of experimental results and theories which require cartographical interpretation. One example is a phenomenon of successive projecting of retina's field on spatial neuron structures in brain. Studying and cartographic description of this cortex projections provide for the mathematic cartography participation in solution of the fundamental problem of natural science.

It can be predicted with certainty that the application of basic cartographical concepts summarizing the long-time experience in graphical representation and cognition of the world, such as of the cognitive and communicative role of maps, of generalization, symbols, etc., in studying the process of vision, analysing vision as a *biological mapping system* should contribute to the successful solution of the problem.

c. The "symmertic"sphere of interaction includes the assimilation of knowledge accumulated by the sciences of vision in cartography. This is the case of a *bionic aspect of cartography*. The fact that the Nature has evolutionally chosen the color, though transformed, image for representing the material world proves the strategic importance of photocartographic images for the future development of cartography. Therefore of extreme importance are the techniques of computer covering of digital relief models with half-tone images of the surface. On the other hand, the profound transformation of initial retina images (in-eyes images) within the vision system indicates the risk of the overestimation of original aerospace images as final means of spatial representation.

The analysis of specific features of the mental images taken along with photographic, computer and digital ones would enrich the scientific notion of image and widen the sphere of geoimages. Advanced tasks of computer image processing and automated interpretation require the application of euristic algorithms, which are used by humans in the process of vision. One example is the elaboration of the resulting classification algorithms based on a method which was named "neuron networks". Therefore the advances in vision psychology are of great interest for this branch of aerospace mapping too.

Many notions and concepts of vision psychology correlate with cartographical ones. The comparative analysis of close scienific notions would be of mutual usefullness.

We have pointed out just some tasks which if developed will mark the beginning of a new branch of cartography - *neurocartography*. The above examples suggest that the comparative analysis of aerospace mapping and vision as the systems providing humans with important spatial information is of great scientific interest. In recent decades the developments in theoretical cartography are usually related to advances in physics, mathematics and technical sciences, thus leaving psychology and biological sciences beyond the scope of cartographic research. However, the progress of cartography should be based on the interaction with these sciences, especially those of vision. It can be said with certainty that the use of achivements of these sciences would provide for advanced development of theoretical and methodological concepts of cartography. The fundamental studies in modern cartography should take into account both methodology of neighbouring disciplines, such as remote sensing or geoinformatics, and the concepts of the information theory of vision.

CARTOGRAPHIC REPRESENTATION OF THE VELOCITY FIELD FOR A MOUNTAIN GLACIER

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1. Introduction

Improved cartographic representation of the dynamics of glaciation is among the tasks of mountain cartography. Materials of the repeated aerospace surveys open up new avenues for these investigations.

It is well known that the dynamic state of a glacier is reflected by changes of plane and altitudinal position of the points on its surface. At the stage of glacier activization its surface rises due to growing thickness of ice, the velocity of ice movement increases and the glacier flows down the valley. At the stage of glacier degradation its surface becomes lower, the velocity decreases and the glacier tongue retreats. According to the glaciologic theory of plastic movement changes in plane position of a glacier are always greater than in altitudes. Moreover, the plane coordinates of a point taken from aerospace images are more precise than its altitude, the index of stereo surveying, this is the ratio between the base and the altitude, usually being less than one. Therefore, the horizontal component of the surface points movement, and thus the ice movement velocity, are the most reliable indicators of the glacier dynamics which could be determined from the aerospace images. The pseudostereoeffect produced through watching the stereopairs of multitemporal images of the moving glacier could be of considerable value in this case.

2. Acquistition of information

The Laboratory of Aerospace Methods of the Moscow University is involved in the elaboration of technology aimed at the application of aerospace images for the estimation of ice movement velocity in mountain glaciers on the basis of pseudoparallax measurements. The technique of pseudoparallaxes suggested by Richard Finsterwalder for the phototeodolite images has been modified to be appropriate for helicopter, aeroplane and satellite imagery. The measurements of photographic (analogue) images could be made on stereocomparators, the digitized images could be processed on personal computers provided with the system of stereo measurements. The aerial images allow to determine daily velocities of ice movement while the space imagery is used to determine the annual ones. The points for velocity measurements could be selected on the glacier surface as frequently as one likes.

It is not our intention to deal in length with the technology of repeated, or binary, aerospace surveys which produce multitemporal images needed for stereopair measurements. It should be pointed out, however, that there are certain requirements concerning the season and the lighting conditions of surveys. Without looking into details of the photogrammetric processing of multitemporal stereopairs, let us state that the available techniques allow to use these images for estimation of both ice movement velocity and its direction, as well as the coordinates of a mobile point on glacier surface. Thus, it is possible now to acquire information needed for the cartographic representation of glacier position as well as its velocity field.

3. Cartographic representation of glacier velocity field

The glaciological mapping suggests several techniques for velocity representation, namely isotaches, movement vectors or blockdiagrams. Each of them has its pros and cons. Isotaches are convenient to show the velocity field of glaciers with the plastic-type movement. But they are less suitable when there is the block sliding along the glacier bed. For the representation of glacier flows with slowly changing velocities movement vectors would be appropriate. If the range of velocity changes is great this technique lose its illustrative value. General picture of ice movement could be well represented with blockdiagrams. They are constructed using various programs, such as the commonly known SURFER one. In this case the Z-coordinate of the model is the length of velocity vector. The movement is represented as pseudotopography with "hills" and "depressions" being proportional to its velocities. We propose the construction of stereoblockdiagrams which are especially illustrative (Fig.1). They could be produced by displaying two analogous blockdiagrams simultaneously. If we make a slight change in the angular orientation of one blockdiagram the observation of the resulting pair will produce the stereoeffect. However, despite their high illustrative value the stereoblockdiagrams are of limited utility for cartographic measurements.

4. The proposed method of stregenels

The available methods could be supplemented by the computer-based technique of representing the surface velocities of glacier ice movement - the "stregenels" (from the Russian word "strezhen" meaning "the channel line with rapid flow"). A stregenel looks like a band of varying width. Its curves correspond to the direction of movement and the width correlates with the velocity. It could bear additional cartographic symbols representing the specific features of ice movement, such as the flow breaks on icefalls, hypothetical parts, etc. Computer construction of the stregenels system requires rather dense network of velocity measurements. For the majority of mountain glaciers these could be obtained from the binary aerospace images using the pseudoparallax technique.

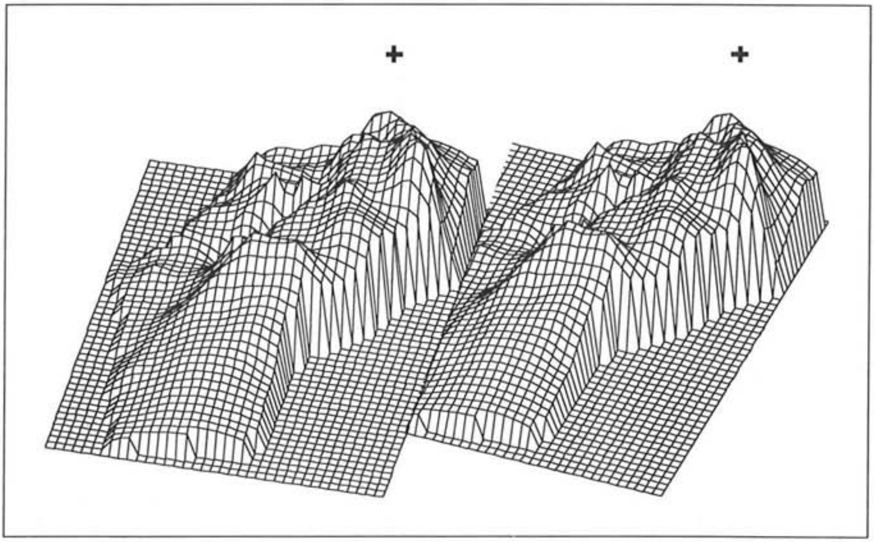

***Fig.1**. Stereoblockdiagram of the ice movement velocity field for the Medvezhy glacier. The pseudotopography represents the values of velocity in different parts of the glacier. Crosses in the upper part of the picture provide for the stereoeffect in the absence of stereoscope.*

5. Algorithm of stregenels construction

The stregenels are constructed automatically by the appropriate program. The algorithm is based on the following stages of construction: calculation of the movement vector length and components for a given point on the glacier surface using the available field of vectors; calculation of coordinates for borderline points a_i, b_i, the set of which forms both lines of the stregenel; displaying the picture of stregenels.

The process of construction is based on the field of vectors produced by stereo measurements of aerial or space images. For each stregenel the coordinates of the initial point are specified in the coordinate system of the image or the photogrammetric model, as well as its transverse scale and the spacing between points. The stregenels are formed by two borderlines A and B and the central line C (Fig.2). They are constructed as follows: the distances from the current point c_i on the axis to the four nearest velocity measurement points are calculated on condition that c_i lies within the quadrangle formed by these points. If this requirement could not be met (the glacier edge), the construction of this very stregenel is finished. The radius of the area is determined as half distance from the axis of the neighboring stregenel. If there is only one stregenel the radius is half width of the glacier. Finally the weighted averages of vector components for the point c_i are calculated the weights being in inverse proportion to the distances from the points within the circle.

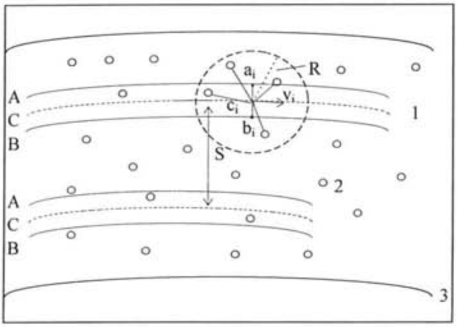

Fig.2. *Scheme of the automated construction of stregenels. 1 – stregenels, 2 – velocity measurement points, 3 – glacier edge.*

At the next stage the coordinates of the borderline points a_i and b_i lying on the line normal to the vector direction are calculated. The distance a_i - b_i equals to the length of vector in the specified scale, c_i is the midpoint between them. Then the position of the next midpoint c_{i+1} lying on the extension of the vector line is calculated according to the specified spacing and the cycle of calculations is repeated.

The displaying of all points a,b and connecting them with continuous lines which form the stregenels is performed by the graphic block of the program.

6. Use of stregenels

An example of stregenels application is the representation of velocity field for the Medvezhy glacier in the Pamir Mountains (Fig.3).

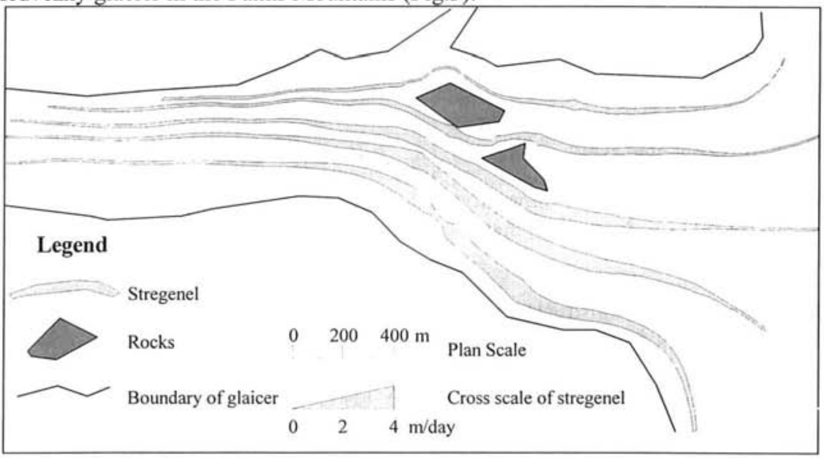

Fig.3. *Use of stregenels to represent the surface velocities and directions of ice movement for the Medvezhy glacier during the period from August 8 to August 16, 1990. For the stregenel placed at the bottom of the plan the average velocity was 1.75 m/day. The calculated time of ice movement over stregenel length is 1880 day.*

This glacier is of pulsating type, its sudden movements caused a lot of dangerous situations.Therefore it is monitored through repeated aerial surveys. Materials of these surveys were used to construct digital models of glacier movement, including the stregenel one.

The stregenels allows to carry out the cartometric measurements. This can be illustrated by calculations of the average velocity of ice movement and the estimation of time needed for the ice from the area of glacier accumulation to reach a given point on its tongue.If the velocity is expressed as a function of the distance l travelled by the point, i.e. V=F(l), then the average value of this function between the points 1 and 2 could be calculated by integrating within these limits. Numerical value of the integral equals to the area of the part of stregenel between the points 1 and 2 divided by the length of the central line. The formula is

$$V = \frac{S}{L} \cdot M_V, \tag{1}$$

where V is the average velocity of ice movement within the area,
S is the area of the part of stregenel,
L is the length of its central line
M_V is the cross scale of stregenel

The time of ice movement – T between the points 1 and 2 is calculated as T=L/V or, with the account of (1),

$$T = \frac{L^2}{S} \cdot \frac{M_L}{M_V}, \tag{2}$$

where M_L is the plan scale.

It should be noted that the dimension of S depends on that of velocity vectors. If the velocity is expressed in m/day, then the dimension of S is m^2/day and T is expressed in days.

Stregenels could be constructed both upstream and downstream the glacier flow. The program provides for both alternatives. Therefore, by setting up the initial points in the area of glacier accumulation it is possible to precalculate the place and time taken by ice to reach the certain points within the lower lying parts. And vice versa by specifying the points on the glacier surface it is possible to determine the places within the area of accumulation from which ice comes to these points. Analysis of the average velocities of ice movement within different parts of the glacier and correlation of these data for different periods of surveys provide the basis for forecasting. In so doing the account must be taken of velocity changes both across the surface of glacier and in time. Thus the forecast is to be based on the glaciological data about seasonal and annual variations in the ice movement velocity. The cartometric properties of stregenels provide for the automated acquisition of ice movement parameters from maps or images.