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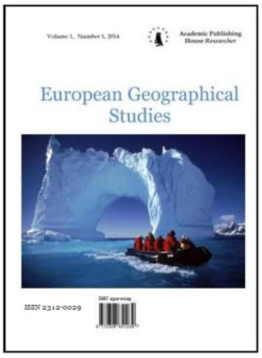

Articles and Statements

Some Aspects of Economic – Geographical View on the Sustainable Development of Mineral Resources

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Abstract

Sustainable development involves meeting the needs of human societies while maintaining viable biological and physical Earth systems. To attract responsible exploration and mining, governments of mining nations will need to provide: regional – scale geo – scientific datasets as required to attract and guide future generations of exploration; resource access through multiple and sequential land use regimes, and frameworks for dealing with indigenous peoples' issues; and arrangements for consideration of mining proposals and regulation of mines that ensure responsible management of environmental and social issues. The minerals industry will need to continue to pursue advances in technologies for exploration, mining, processing, waste management and rehabilitation, and in public reporting of environmental and social performance (Lambert, 2001).

Keywords: Sustainable development, mineral resources, aspects.

1. Introduction

Modern urbanization, industrialization, transportation and communication systems are the achievements of worldwide sustainable mineral resource development and their proper utilization in various sectors. Sustainable mineral resources have played, and are still playing, a vital role in shaping the modern civilized industrial world. This means that the sustainable socio-economic infrastructure of any country is an indication of its richness in natural resources, its technological knowhow, its ability to explore and exploit mineral resources, and, finally, its wisdom in utilizing those resources properly in the development activities of the nation. In development activities, countries of the developing world are generally far behind compared with countries in the developed world. This is mainly due to a lack of adequate natural resources, properly educated human resources and good socio – economic conditions (Akhtar, 2005).

Wide – spread environmental contamination associated with historic mining in Europe has triggered social responses to improve related environmental legislation, the environmental assessment and management methods for the mining industry. Mining has some unique features such as natural background contamination associated with mineral deposits, industrial activities

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and contamination in the three – dimensional subsurface space, problem of long – term remediation after mine closure, problem of secondary contaminated areas around mine sites, land use conflicts and abandoned mines. These problems require special tools to address the complexity of the environmental problems of mining – related contamination. Geological knowledge on mineral resources exploration is essential and should be used for the environmental contamination assessment of mines. Also, sufficient methodological experience, knowledge and documented results are available, but harmonization of these methods is still required for the efficient spatial environmental assessment of mine contamination (see Jordan, 2009).

Assessments of undiscovered mineral resources provide a basis to help society recognize, discuss, manage, and minimize environmental impacts associated with mineral exploration and mining while maintaining or expanding mineral supplies. Quantitative assessments are essential for effective evaluation of the consequences of alternative resource-related decisions. Potential applications of the global assessment include mineral supply issues, evaluations of tradeoffs associated with mineral development, and environmental planning. The global mineral resources assessment will provide a consistent, comprehensive level of information and analysis of undiscovered global nonfuel mineral resources. The assessment results will provide all nations with a regional and global context for planning sustainable development, evaluating their known and undiscovered nonfuel mineral resources, designing new mineral exploration, anticipating and preventing environmental problems, and making land - use decisions (Hammarstrom et al, 2006).

2. Materials and Methods

The whole information volume in this article was obtained through specific methods for the selective research, respecting all its stages from the methodological point of view: identification of the researched issue, research framework delimitation, information collection, data processing, analysis and interpretation drawing up the conclusions. Research also played an important role in the article, which consisted, in the identification of other studies and articles from the international literature on the same subject (Rajović, 2013; Rajović and Bulatović, 2013). The research results are based on a series of mainly qualitative analyses, on the one hand, and on a series of logical rationales, on the other hand (Rajović and Bulatović, 2013; Basilashvili, 2016).

Analysis results and their generalizations

One of the greatest challenges facing many national governments is integrating economic activities with environmental integrity and social concerns. Therefore, on the basis that a sustainable approach to minerals development is essential to effective and continued wealth creation and poverty reduction, the industry has been challenged, particularly since 2003, to address this problem. The application of sustainable development to the industrial minerals sector is effected primarily through the application of education, technology and a proactive legal and regulatory framework to uncover new reserves, promote recycling, substitute one mineral for another, embrace cleaner technology, minimize waste generation, effectively rehabilitate disturbed lands, ensure acceptable environmental practices and minimize negative impacts on human populations (Rainford and Richards, 2008). Additionally, it involves the application of visionary management to invest the proceeds of mineral exploitation in health, education, technology, physical amenities, good governance, equity, effective environmental management and other areas of economy in a planned and sustained attempt to improve the well – being of current and future generations. Agenda 21 outlines several principles to be considered for a country to progress along a sustainable path. Those of particular significance to the minerals industry include the precautionary and the polluter pays principles, sustainable patterns of production and consumption, and the principles relating to social equity and governance (Rainford and Richards, 2008).

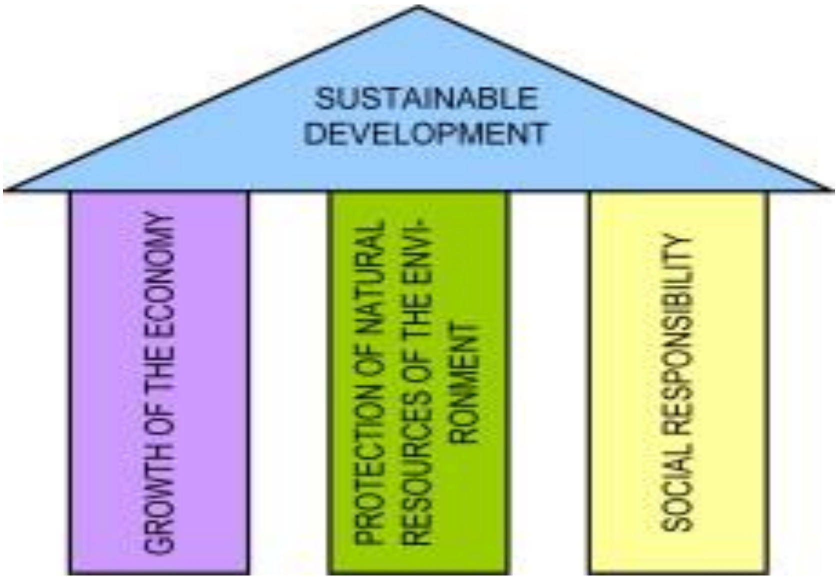

Fig. 1. Elements that create the term of "sustainable development" (Dubiński, 2013).

Thus, sustainable development is, according to Dubiński (2013) in any case, an ongoing process, and not a temporary undertaking. It has clearly defined goals and means of achieving them, in all of the above mentioned key areas by Dubrńki (2013) citing research Dubrńki et al (2007) highlights yes areas are of equal importance. Hence, the emphasis on one area usually leads to a crisis across the entire area of mining activity. Economic growth means achieving long - term sustainability both in regards to planned production volumes, and in meeting the needs of customers, as well as achieving economic efficiency obtained from the sale of the excavated mineral. Protection of natural resources and of the environment means concern for the bed and the protection of its resources by its rational acquisition, which is characterized by savings in its depletion. This also means taking measures that minimize the negative impact of the different processes related to the extraction of mineral resources on the various forms of the geological environment and natural environment on the surface. Social responsibility, taking into consideration the nature of the mining environment, this means above all ensuring safe working conditions, but also concern the social aspects of mining, including the families of miners, the mining environment (Dubiński, 2013).

The European mining industry has a long tradition providing many regions with growth and employment. However, now in the European Union, consumption of many minerals and especially metals considerably exceeds the EU mining industry's internal supply capability. In the last years, it was pointed out in many EU documents that securing reliable and undistorted access to raw materials is becoming an increasingly important factor in the EU's competitiveness and hence crucial to the success of the Lisbon Partnership for growth and jobs. Therefore, the European mining industry is faced with a major challenge which is creating appropriate ecological, economic and social conditions, referring to the idea of "growth through opportunity" (Kulczycka, 2013).

Highly industrialized countries such as those of Western Europe, which import all of their metallic mineral resources and most of their energy supplies, still produce a large proportion of their required nonmetallic mineral resources (that is, raw materials for construction and many of the industrial minerals). In Germany, for example, nonmetallic mineral resources total about 80 percent of mineral commodities consumed. The lifetime curve of nonmetallic resource production in a country shows a positive time offset relative to the curve for production of metallic resources and attains a maximum when almost all of the metal mines in that country have been abandoned (Figure 2) (Wellmer and Becker – Platen, 2000).

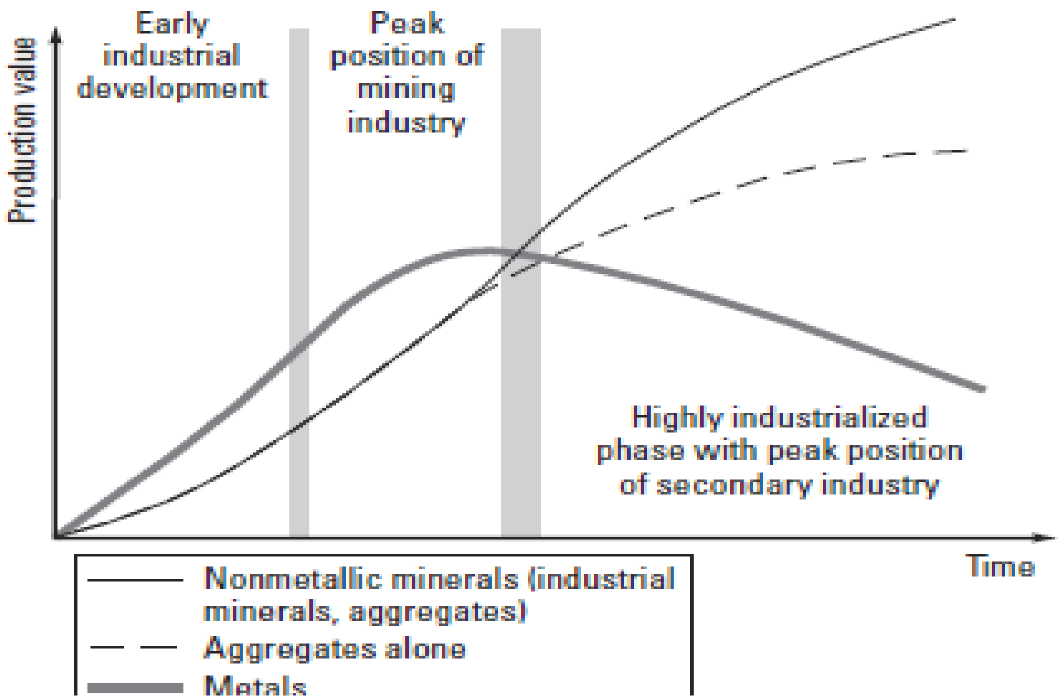

Fig. 2. Comparison of the production trends of metallic ores, industrial minerals, and aggregates in industrialized countries according to Wellmer and Becker - Platen (2000) and Wellmer and Lorenz (1999) modified from Bristow (1987).

This lifecycle applies to all mined materials including coal, industrial minerals, metals, and precious metals. It provides a framework for both understanding and managing the environmental, social and economic impacts of mining at every stage of the mining project (Table 2). Primary deposits linked to magmatic and hydrothermal REE-mineral forming processes and secondary deposits related mainly to sedimentary remobilization and weathering processes of mainly REE-bearing igneous rocks (Figure 3). Europe - wide REE mineralized belts can be recognized. Geophysical measurements applying airborne and ground magnetic, electromagnetic and gravimetric methods have been conducted across Europe on national and regional scales. They may provide valuable data and offer efficient REE exploration tools at a range of scales, but this is based more on the interpretation of the responses and signatures received from the wall and host rocks of the mineralization rather than the REE mineralization it. As yet there is limited information to show how interpretation of geophysical data may be better used to pinpoint REE mineralization (see Arvaniditis and Goodenough, 2014).

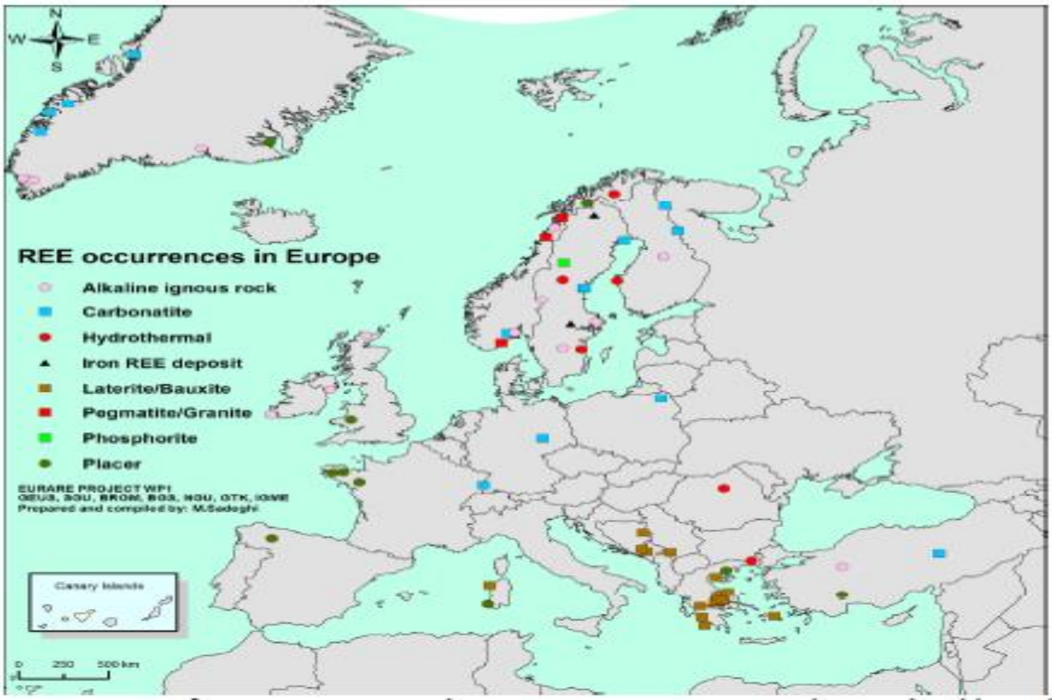

Fig. 3. Overview of major REE mineralization types in Europe and Greenland based on EURARE data and information (Sadeghi et al,2014). There is obvious exploration potential and high prospective interest for primary deposits in Greenland, the Nordic countries and the British islands, and secondary deposits in mainly NW France, Greece and west Balkans (Arvaniditis and Goodenough, 2014).

According to Tiess (2011) citing research EC (2011) highlights yes due to environmental, societal or economic reasons there are still many unexplored and unexploited resources within Europe. Europe's non – energy extractive industry is hindered by a heavy regulatory framework and competition with other land uses. In the new Communication "Tackling the challenges in commodity markets and on raw materials" published in February 2011, the Commission considers the improvement of framework conditions: defining national minerals policies/strategies; setting up land use planning policies for minerals; authorizing minerals exploration and extraction providing certainty and streamlining the administrative process. Presently, only three countries of the EU-27 – Finland, Germany and France - provide a national minerals strategy (see Table 1).

Table 1. Comparison of the raw materials strategies of Finland, Germany and France

National Mineral Strategy			
	Finland	Germany	France
Publication	Minister of Employment and Economy (2010)	Minister of Economy and Technology (2010)	Minister of State, Minister for Ecology, Energy, Sustainable Development and Sea
Minerals	Metallic, industrial and construction minerals	Metallic, industrial and construction minerals	Metallic minerals (additionally sub strategies for the other minerals)

Objectives	Three strategic objectives: Promoting domestic growth and prosperity, solutions for global mineral chain challenges and mitigating environmental Impact.	Nine objectives: e.g. Support of economy in the development of synergies through sustainable management and increased material efficiency Development of bilateral commodity partnerships with selected countries	Access to strategic metallic minerals in good conditions is needed to ensure French industry conditions of development and to enable the development of products more virtuous and more competitive
Actions	Strengthening R&D capacities and expertise. * *Analysis* of the *minerals deposits potential* /discovery potential *Demand/production forecasting *Analysis of minerals industry *Improve regulatory framework	Actions are contained in the context of the objectives	Action plan focuses following issues: Improving knowledge of strategic metals Extension of geological knowledge by exploration campaigns Development of new exploration tools Recycling policy.

Source: Tiess (2011) according to Tiess (2011)

Badera (2014) citing research EC (2011) highlights yes many international and national studies have stated that there are a considerable number of mineral deposits available in Europe. In 2008 the European Commission initially accepted the new integrated strategy called the Raw Material Initiative; actual Communication from the Commission on this topic has been published in 2011. According to Badera (2014) the following key challenges of the EU mineral policy have been recognized and indicated as main pillars: (1) ensuring a fair and sustainable supply of raw materials from international markets, (2) fostering a sustainable supply of raw materials from European sources and (3) boosting greater resource efficiency and promoting recycling. In the 2nd pillar the issue of public acceptance should be considered without a doubt. One of requirements of the European mining industry is the improvement of the EU minerals knowledge database. Socio-environmental issues harmonize with the tasks of Work Package no. 3 (Knowledge management) within the Minerals4EU project (www.minerals4eu.eu) conducted within the EU 7th Framework Programme and they should become a part of the Minerals4EU knowledge data platform. Another similar 7th FP project is ProMine (www.promine.gtk.fi), including amongst others Sustainability Assessment and Exploitation. Summing up, modern approaches to social issues associated with mineral activities include strategies of bilateral communication, mediation/ negotiation, cooperation between stakeholders to a larger extent than in the past. However, it is the continuous need for extensive, in – depth social debates on mineral development projects in the European Union, as well as in Non – European countries, in both the energy and non – energy branches.

Table 2. Mining lifecycle stages and impacts at each stage

	Activities	Environmental Impacts	Social Impacts	Economic Impacts
Mineral Resource Development	Drilling, Feasibility, Mine Planning, Mine Design, Permitting	Land Disturbance, Vegetation Disturbance, Noise, Dust, Water Consumption, Energy Consumption,	Worker H&S, Community H&S	Jobs
Mine Development & Operation	Infrastructure Development, Overburden Removal or Underground Mine Construction, Ore Extraction	Land Disturbance, Noise, Dust, Asthetics, Water Consumption, Energy Consumption, Water Discharge, Air Emissions, Biodiveristy Protection, Resource Efficiency	Worker H&S, Community H&S, Capacity Building, Skills Development, Enhanced Community Services,	Jobs, Royalties, Taxes, Capital Investment
Ore Handling	Transport ROM to Plant (truck, pipeline, conveyor, other), Storage	Land Disturbance, Vegetation Disturbance, Noise, Dust, Water Consumption, Energy Consumption,	Worker H&S, Community H&S	Jobs
Processing	Crushing, Screening, Grinding, Separation, Concentration, Particle Size Fractionation, Physical or Chemical Removal of Contaminants, Drying	Waste Generation, Recovery and Reuse; Water Consumption, Water Contamination, Discharge and Reuse; Energy Consumption and Recovery; Air Emissions, Resource Efficiency; Noise	Worker H&S, Community H&S, Capacity Building, Skills Development, Enhanced Community Services (water, power, roads, schools, hospitals)	Jobs, Royalties, Taxes, Capital Investment
Transportation	Product to customer by rail, truck, ship.	Air emissions, Noise, Dust	Worker H&S, Community H&S	Jobs
Waste Disposal	Process and mine waste to, impounds, backfill or deep well injection	Land Surface Disturbance , Water Contamination, Aesthetics	Worker H&S, Community H&S	Jobs
Closure	Backfilling, Removal of Equipment, Removal of Buildings & Pipelines, Monitoring, revegetation	Waste Disposal, Biodiversity Protection, Water Discharge, Aesthetics	Worker H&S, Community H&S, Future Land Use	Jobs, Revenues from post mining land use (timber, agriculture etc)

Source: Kogel (***).

According to Kogel (***) citing research Cutifani (***) highlights yes how do we harness the value that mining generates and use it to not only solve real social, environmental and economic problems today but to create a better future for the next generation? The answer is not simple but there are 4 areas where the industry needs to shift or sharpen focus: (1) people affected by mining must be treated fairly and with respect; (2) mining companies must create a culture of transparency by being more inclusive in engaging with stakeholders including NGOs; (3) the industry must step up efforts to support social and economic development especially in underdeveloped countries where wealth tends to be concentrated in natural capital (minerals, oil, gas) while wealth in advanced economies tends to be concentrated in physical and human capital thus creating disparity between the two and (4) as grades decline and demand for minerals grows, the industry must change the way it operates through innovation, new technologies and new processes.

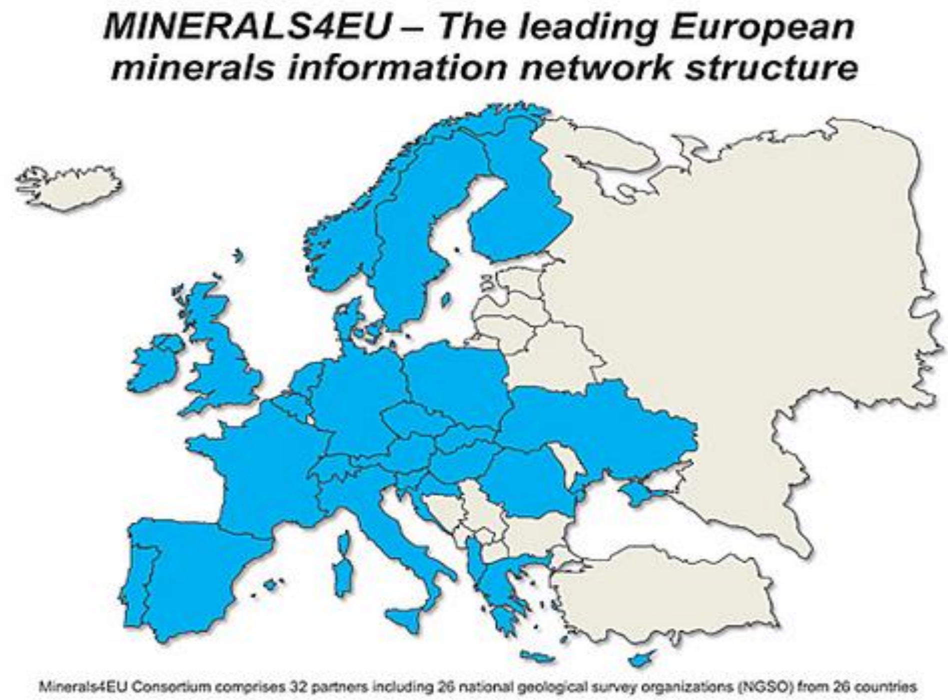

Fig. 4. Minerals4EU project – Provides tools and expertise to enhance resource efficiency and minerals supply security and supports sustainable minerals development for Europe (www.minerals4eu.eu).

The Minerals4EU project is designed to meet the recommendations of the Raw Materials Initiative and will develop an EU Mineral intelligence network structure delivering a web portal, a European Minerals Yearbook and foresight studies. The network will provide data, information and knowledge on mineral resources around Europe, based on an accepted business model, making a fundamental contribution to the European Innovation Partnership on Raw Materials (EIP RM), as key for the successful implementation of the major EU2020 policies (www.minerals4eu.eu).

Table 3. Operational Strategy – Optimal exploitation of the mineral resource

BUSINESS GOAL UNITS	OPERATIONAL STRATEGY	FOCUS AREA	TARGETS OR OUTPUTS
		Exploration	Optimize the mineral resource by executing the exploration strategy / programmed.
			Develop and follow the formal exploration strategy.
	The optimal exploitation of the mineral resource: The optimal exploitation of the mineral resource by effective	Geomodelling	Continuously update geological and grade models that add most

	exploration, the collection and processing of geological information, mine design and scheduling, risk management, grade control, mining methods and the utilization of the best available technology to continuously satisfy the plant demand in terms of ore quality and volume.		value to mine planning exercises.
		Geotechnical support	Develop system to assess the risk of slope failure versus the financial benefit that will add the most value.
			Dewater pit in accordance with LT mine plan.
			Decrease stripping ratio.
		Pit Design	Evaluate methods for optimum pit design techniques by allowing for ore grade and the maximum utilization of the mineral resource.
		Resource Exploitation	Pit Development Strategy/Resource Exploitation Strategy. Determine sensitivities for the following:
			1. Ore quality strategy,
			2. Stripping strategy,
			3. Selective mining strategy,
			4. Waste rock dumping strategy,
			5. Pit dewatering strategy,
			6. Surface structures,
		Mining Operations	7. Adjoining properties,
			8. Mining equipment strategy.
			Develop mining methods and equipment strategy for the maximum

			utilization of the ore reserve.
		Grade Control	Develop an efficient grade control system ensuring that the short term plan is followed within approved norms and the ore product grade values are produced within acceptable limits.

Source: Bender (2005).

Mineral Resource Management exists out of various functions/elements that need to be addressed for complete and thorough understanding of the whole process. Mineral Resource Management is used to optimize the integration of all system components in such a way that the whole is greater than the sum of the individual components in reaching a common goal. Customer Relationship Management and Project Management Principles enhance this process to obtain an integrated resource planning and management approach in the extraction of the mineral reserves over different time horizons to benefit all customers over the value chain (see Bender, 2005; Zhakupov et al, 2014).

Conclusion

Sustainability in general is understood in the sense of security of the planet or a country and that in relation to mineral resources is linked with security of raw material availability. On the other hand, sustainable development of mineral resources denotes ways and means in which mining should be carried out and is linked to corporate social responsibility (CSR) and certain other activities with a view to developing the areas and the peoples around mines. In a sense, the former is more security-centric while the latter is more welfare-centric (Chatterjee, 2015).

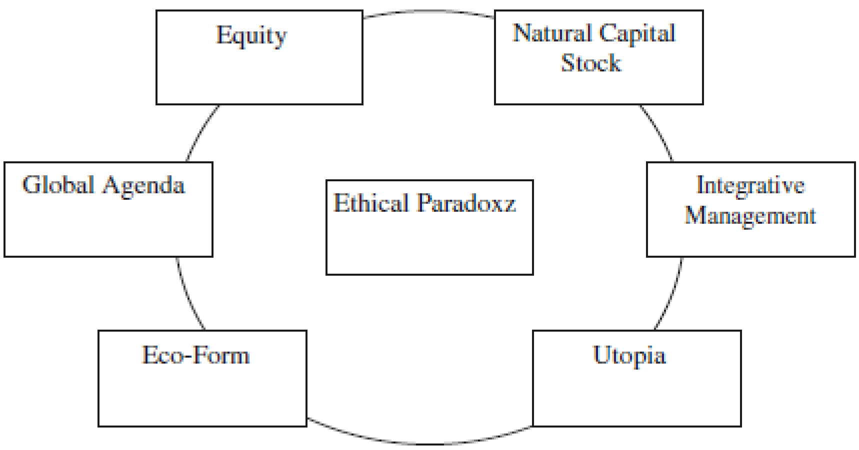

Fig. 5. A Conceptual framework for sustainable development (Jabareen, 2008)

The conceptual analysis according to Jabareen (2008) identifies seven concepts which together synthesize and assemble the theoretical framework of 'sustainable development'. Each concept represents distinctive meanings and aspects of the theoretical foundations of sustainability. In addition, they have interwoven relations as Figure 5 shows. The concept of ethical paradox rests at the heart of this framework. The paradox between 'sustainability' and 'development' is articulated in terms of ethics. In other words, the epistemological foundation of the theoretical framework of sustainable development is based on the unresolved and fluid paradox of sustainability, which as such can simultaneously inhabit different and contradictory environmental ideologies and practices. Consequently, SD tolerates diverse interpretations and practices that range between 'light ecology', which allows intensive interventions, and 'deep ecology', which allows minor interventions in nature. Jabareen (2008) nicely concludes the concept of natural capital represents the material aspect of the theoretical world of sustainability. Natural capital represents the environmental and natural resource assets of development and preservation. The theoretical framework of sustainability advocates keeping the natural capital constant for the benefit of future generations (see Stymne and Jackson, 2000; Roseland, 2000; Mozaffar, 2001; Gudkova, 2016).

Finally, according to Titon (1996) citing research Kesler (1994) and Simon (1995): At the end of the twentieth century, we are faced with two closely related threats. First, there is the increasing rate at which we are consuming mineral resources, the basic materials on which civilization depends. Although we have not yet experienced global mineral shortages, they are on the horizon. Second, there is the growing pollution caused by the extraction and consumption of mineral resources, which threatens to make earth's surface uninhabitable. We may well ponder which of these will first limit the continued improvement of our standard of living ... (Kesler, 1994). People have since antiquity worried about running out of natural resources – flint, game animals, what-have – you. Yet, amazingly, all the historical evidence shows that raw materials – all of them - have become less scarce rather than more ... Natural resource scarcity – as measured by the economically meaningful indicator of cost or price – has been decreasing rather than increasing in the long run for all raw materials, with only temporary and local exceptions ... The trend toward greater availability includes the most counter-intuitive case of all – oil ... Concerning energy in general, there is no reason to believe that the supply of energy is finite, or that the price of energy will not continue its long-run decrease forever(Simon,1995).

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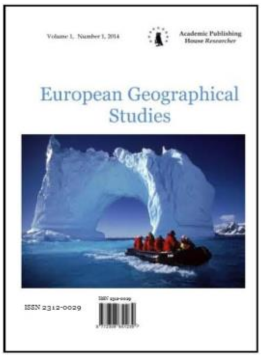

Identificaton and Assessment of Geoheritage Objects in the Karst Landscape (Niksic Polje, Montenegro)

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Abstract

The presented paper aims at proposing and evaluating potential geoheritage objects in Niksic polje, a karst field located in western part of Montenegro. According to scientific literature, cartographic sources and requirements which are set out in the Nature Protection Law, four objects of geoheritage were sugested: estavelle Gornjepoljski vir, karst spring Vidov brook, hill Trebjesa and slope Slivlje. Once identifed, objects were evaluated in order to show their significance. Assessment method integrated scientific, aesthetcal, ecological and morphometric values, combined with analysis of dangerous natural processes which can influence physical state of landscape. Based on the evaluation and inventory of potential objects, the first geodiversity map for research area was accomplished. The interpretation of results allows us to compare sites and use them to support tourist and management decisions.

Keywords: Montenegro, Niksic polje, geoheritage, asessment, karst.

1. Introduction

Value of a certain area reflects in its richness and diversity of the natural elements. Karst landscapes are recognized by their unique underground and surface forms of the relief, specific forms of biocenosis and complex structure of hydrological network (Zhyrnov, 2015). All those natural elements represent geodiversity, from which representative objects of geoheritage are selected (Pantić et al., 1998). According to Nature Protection Law (Official Gazette of *Montenegro*, 62/13) geoheritage represents all geological, geomorphological, soil and the special archaeological values created during the formation of the lithosphere, its morphological shaping and interdependence of nature and human culture. Most of these objects are located in nature, with the exception of different mineralogical and paleontological collections that are in the museum premises (Moscicka, 2011). Geological structure of Montenegro caused a remarkable geomorphological diversity. The large limestone terrain led to different karst processes that have contributed to the creation of numerous phenomena and forms of surface and underground relief (Djurovic et al., 2006).

The data collected by significant institutions shows that some parts of Niksic polje are for many years among one the most vulnerable areas in Montenegro. A special impact on this situation

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has inadequate application of the adopted laws and underdeveloped environmental awareness of citizens. Some of the geoheritage objects are partially protected through various levels and forms of legislation. However, it is necessary to make a new (official) list of objects that will be nominated for the protection as geological heritage, representative objects of geological diversity.

The presented paper aims at suggesting and evaluating geoheritage objects in Niksic polje, Montenegro. Methodology includes identification of potential objects, their quantification and analysis of results. The interpretation of results allows a comparison between sites and is of particular use in supporting site management decisions (Pereira, Pereira, 2010).

1. Materials and Methodology

2.1 Research area

Niksic polje is the largest karst field in Montenegro, with area of 66.5 km². Its complex hydrological conditions and the development of various forms of relief makes it one the most interesting karst fields (Radojičić, 2015). Because of its uniqueness, since 2000, an initiative was launched for the protection and monitoring of natural resources by the Institute for Nature Protection. As a result, two natural objects, Trebjesa hill and estavelle Gornjepoljski vir, were protected.

Because of the absence of official list of geoheritage objects in Montenegro, in this paper, preliminary list of potential objects classified according to international standards of The European Association for the Conservation of the Geological Heritage (ProGeo) is proposed. The first stage was to investigate the geological and geomorphological conditions based on available scientific articles and cartographic sources in order to identify potential objects. Once identified, objects were outlined on the geological map. In addition to the general requirements which are set out in the Nature Protection Law (Official Gazette of Montenegro, 62/13), of great importance was that objects met the appropriate criteria such as representativeness, rarity, the aesthetical value, the possibility of cost-effective conservation, possibility to use for educational and tourist purposes, etc. (Reynard, 2005; Pereira et al., 2007; Pralong, 2005).

According to ProGeo, geoheritage sites are classified into nine main groups: historical-geological and stratigraphically sites heritage, structural sites, petrological sites, geomorphological sites, neo-tectonic activities sites, speleological sites, hydrological-hydrogeological sites, pedological sites and archeological geoheritage sites (Wimbledon, 1996; 1999). Of nine given groups, two are presented in the research area: geomorphological and hydrogeological. Suggested objects in these groups are: Trebjesa hill (geomorphological group), estavelle Gornjepoljski vir, intermittent spring Vidov brook and slope Slivlje (hydrogeological).

2.2 The assessment methodology

The possibility of measuring and evaluating geoheritage is unambiguously related to the effectiveness of the incorporation of geodiversity in land management (Serrano, Purificacion, 2007). Due to that, various assessing methods have been developed. With aim to reduce subjectivity, most of these methods propose criteria (Reynard, 2007) such as scientific, aesthetical and ecological value (Zhyrnov, 2015). Because of the nature of karst terrain in Montenegro, author pays significant attention to analysis of potential threats which can influence physical appearance of area and/or tourist traffic (Zhyrnov, 2015). According to Zhyrnov (2015) morphometric characteristics represent an important aspect of assessment because they define visibility, attraction, variety and passability of the terrain. Applied methodology merges mentioned estimation values with morphometric characteristics and possible dangerous natural processes (Zhyrnov, 2015).

2.2.1 Scientific value

It is generally accepted that scientific value represents the essential value of geoheritage object (Pereira, Pereira, 2010). In the domain of scientific value, criteria like integrity, representativeness, rareness and diversity are stressed (Table 1) (Zhyrnov, 2015). The last and the one important is paleogeographical value that allows us to evaluate the importance of the site for the knowledge of Earth and climate hisroty (Reynard et al., 2007).

2.2.2 Aesthetical value

Aesthetical value has a significance in touriste valorization. According to literature on landscape perception, contrasted landscapes, landscapes with pronounced vertical indentation and color contrasts are considered to be more attractive (Reynard et al., 2007). Its assessment can be very subjective and it consists from such categories as: uniqueness of landforms, architectonic composition, visibility, exoticism, attendant effects, compatibility with other elements of landscape, pictorializm, photogenicy, emotinal perception and ethnic and social significance (Zhyrnov, 2015, modified).

Table 1. Numerical assessment of scientific value

Scientific value	Short characteristic	Points
Integrity (State of conservation)	Highly damaged	0
	Damage but preserving essential geomorphological features	1
	Slightly damaged but still maintaining the essential geomorphological features	2
	No visible damage	3
Representativeness (Exemplarity)	Low representativeness and whitout pedagogical interest	0
	With some representativeness but with low pedagogical interest	1
	Good example of processes but hard to explane to non experts	2
	Good example of processes and good pedagogical resource	3
Rareness (Rarity of the object with respect to a reference space)	More than 5 occurrences	0
	Between 3 and 5 occurrences	1
	2 occurrences	2
	The only occurrence	3
Diversity (Number of different partial features and processes whitin the karst object)	1	0
	2	1
	3	2
	More than 3	3
Paleogeographical value	Absence	0
	Low value	1
	Weighty value	2
	Important value	3

Source: Zhyrnov,2015

2.2.3 Ecological value

Ecological value represents the level of protection according to environmental legislation (Pereira et al., 2007) and any antrophogenic variations presented at the site. The parameters of the ecological value are:

1. Level of antrophogenic variation of the relief (changes in the original appearance, the presence of metal or wooden structures, tourism infrastructure, etc.).
2. Presence of anthropogenic garbage such as food waste, grocery containers, used equipment, etc.
3. Changes of the air, existence of unpleasant smells or evaporations (Zhyrnov, 2015, modified)

Aesthetical and ecological values are measured with a tree-point scale. Each criteria is evaluated with points from 0 to 3, where 3 presents significant intensity (aesthetical value)/absence of change (ecological value) (Zhyrnov, 2015, modified).

2.2.4 Safety of object

One of the key criteria in the evaluation of any object of geological heritage is the safety of visitors. The karst landscapes are characterized by a variety of natural processes that can lead to accidents. Such natural processes include earthquakes, landslides, occurrence of landslides or avalanches. They can lead to changes in ecosystems, physical state of landscape as well as the stability of tourist infrastructure. Therefore, it is very important to take account of the potential risks in the field when evaluating geoheritage objects (Table 2).

In addition to these values, the classification of geological heritage facilities in karst terrain requires good knowledge of morphometric characteristics, such as elevation, slope, aspect and diverse of the relief (Table 3). These features greatly affect the possibility of valorization. Height affects the view that stretches from a certain area, which is connected with the mental and emotional effects of visitors. The slope of the terrain and exposure determinate the ability of building recreational and tourist facilities. Diverse relief affects the possibility of building transport infrastructure, the wealth of the various forms of relief and overall aesthetic experience.

Table 2. Estimation scale of possible dangerous natural processes

Index of natural processes danger	Kinds of dangerous processes	Points
Catastrophical processes	Earthquakes	0
	Landslides	
	Avalanches	
	Mudflows	
	Screes	
Dangerous processes	Failures of the carbonate breeds roof	1
	Dissolution of carbonate rocks	
	Aggressive action of karst groundwater	
Negative processes	Overcooling	2
	Overheating	
Absence		3

Source: Zhyrnov, 2015

Table 3. Estimation scale according to morphometric criteria

Absolute altitude (m)	Gradient of slopes (°)	Depth of relief ruggedness (m)	Points
0-500	0-6	<300	0
500-1000	6-12	300-600	1
1000-1500	12-45	600-800	2
>1500	>45	<800	3

Source: Zhyrnov, 2015, modified

2. Results and discussion

Each of suggested objects was assessed with the methodology presented above (Table 4) and represented on a map.

The scientific value is most pronounced in the estavelle Gornjepoljski vir, one of the biggest estavelle in the Dinarides, because of its preservation and paleogeographical value. In addition to this, the site is currently used for educational and tourist purposes. Aesthetical value is most evident at Trebjesa hill which is directly connected to its expressed morphometric characteristics. They affect visibility, exoticism and photogenicy of object, and thus the grater emotional perception of visitors. The greatest ecological value has the slope Slivlje, as the only object that is currently not available to tourists nor modified by any anthropogenic activites.

Table 4. Assessment of geoheritage objects in Niksic polje

Criteria		Gornjepoljski vir	Trebjesa hill	Vidov brook	Slope Slivlje
Scientific value	Integrity	2	2	1	3
	Represent.	3	2	2	2
	Rarity	2	2	2	2
	Diversity	2	0	1	0
	Paleogeogr. value	3	1	3	3
	Total	12	7	9	10
Aesthetical value	Uniqueness	3	2	3	2
	Composition	3	2	0	0
	Visibility	3	3	1	0
	Exoticism	1	3	0	3
	Attendant effects	1	3	1	2
	Compatibility	3	2	0	0
	Pictorializm	2	3	1	3
	Emotional perception	3	3	0	3
	Ethnic and social sign.	0	2	0	0
	Total	19	23	6	13
Ecological value	Level of antrophogenic variation of the relief	3	2	0	3
	Presence of anthropogenic garbage	3	1	0	3
	Changes of the air	2	0	2	3
	Total	8	3	2	9
Dangerous natural processes		0	0	0	0
Morphom. Value	Absolute altitude	1	1	1	1
	Gradient of slopes	1	2	0	3

	Depth of ruggedness	0	2	0	3
	Total	2	5	1	7
All criteria	Σ	**41**	**38**	**19**	**39**

Based on the analysis of the total value of estavelle Gornjepoljski vir (Fig. 1a), it can be concluded that scientific and aesthetical values are prevailing. Aesthetic value is reflected in the landscape contrast of the water surface with karbonant layers in the hinterland, which is, due to existing protection, minimally modified by anthropogenic activities. The fact that this is the bigest estavelle in Montenegro gives it greater scientific importance. In accordance with these values facility has a predisposition to be used for educational and tourism purposes.

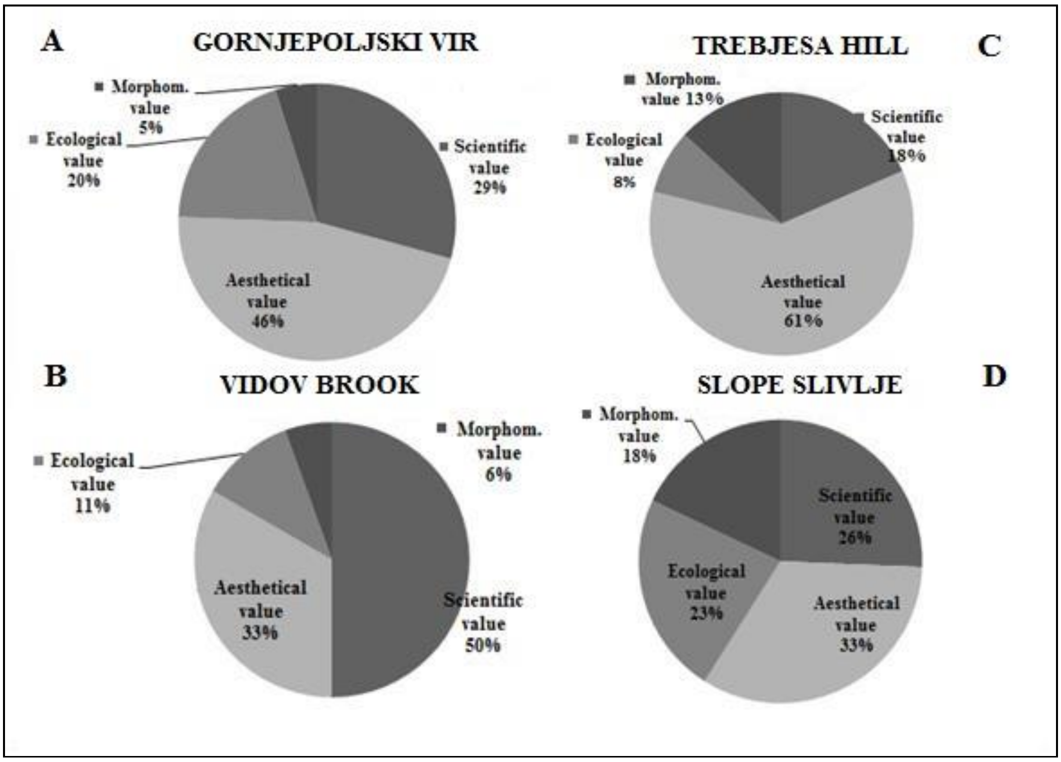

Fig. 1. Results of assessment for all four investigated localitations

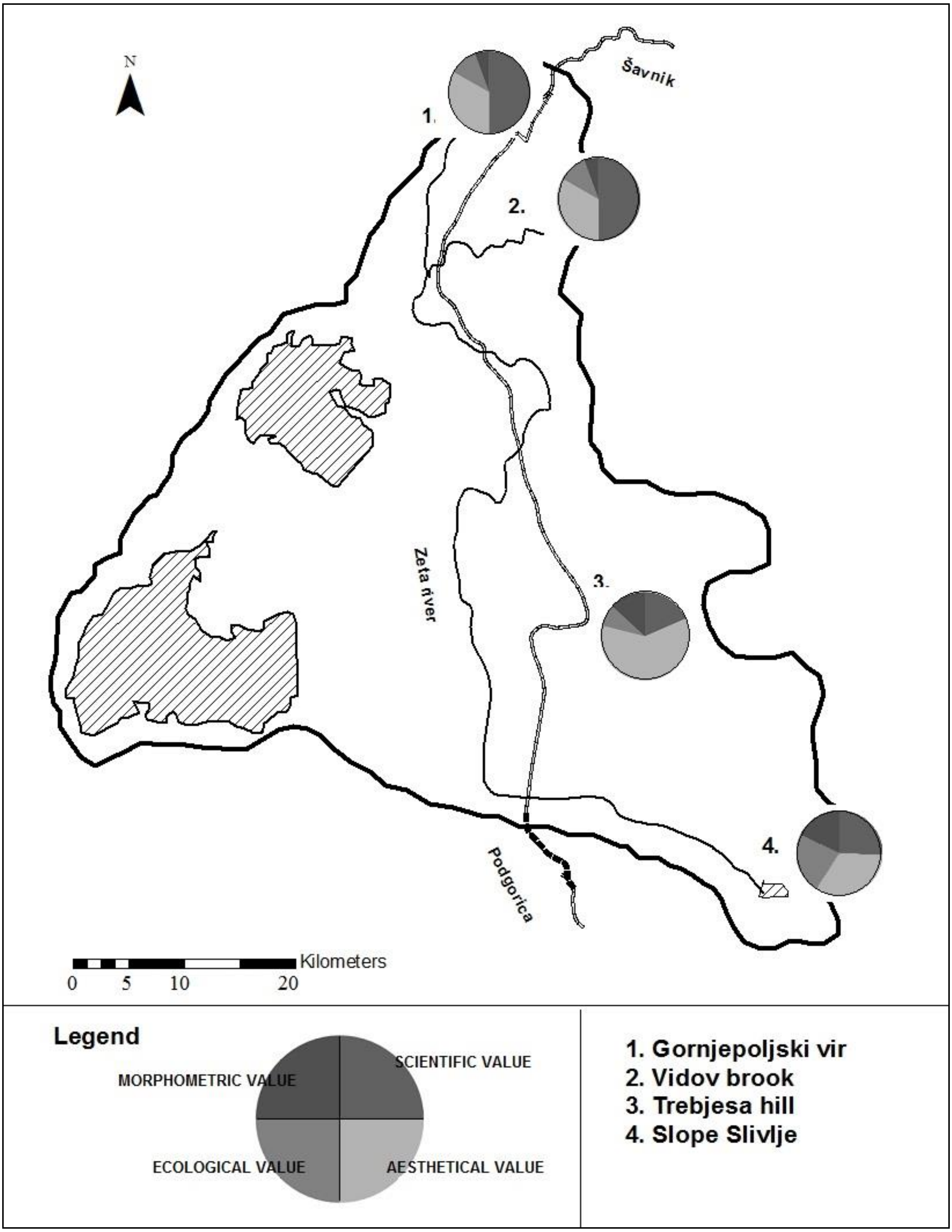

Fig. 2. Geoheritage map of Niksic polje

Examining the proposed object Vidov brook (Fig. 1b), it can be concluded that minor aesthetical and ecological value stems from the fact that the object was modified by anthropogenic activities and has not preserved its original appearance. Nevertheless, intermittent spring has greater scientific importance because it is a rare occurrence in karst terrain. Due to the non-existent protection it is necessary to first declare the object a monument of nature, and then valorize it for educational purposes.

Pronounced morphometric characteristics of Trebjesa hill (Fig. 1c) appear as a result of higher slopes and greater segmentation of relief. Thus they contributed to the higher aesthetic value of the site. The scientific value stems from the preservation of the object and the variety of processes that have contributed to its formation. It adds to the specific flora and fauna of the area. All this resulted in a major tourist and educational importance, which is already recognized.

Notable ecological value of the slope stems from its less accessibility for regular visitors. This has precisely effected on the smaller scientific and aesthetic value. Although not suitable for tourism development, we should not neglect its educational and scientific importance in the study of hydrology and hydrogeology in karst terrain. The object has not been fully studied, which leaves place for further research for domestic and foreign experts (Fig. 1d).

Based on the inventory and assessment of suggested geoheritage objects, by using GIS techniques, the first geoheritage map of this area was made (Fig. 2). On it, the scientific, aesthetical, ecological and morphometric values are represented. The distinction of each circle into four parts represents the contribution of each value.

Proposed map can have its contribution in territorial planning, managing geotouristic products, process of geoconservatio, etc. (Comanescu et al., 2013).

4. Conclusion

During the last decade, the promotion of geoheritage raised rapidly due to creation of geoparks and development of geotourism. Despite that, knowledge of geodiversity in Montenegro needs further progress and promotion. One of the future objectives is creation of the official inventory of geheritage objects. Systematic research of the Case study area by authors has resulted in an inventory of four objects: estavelle Gornjepoljski vir, karst spring Vidov brook, hill Trebjesa and slope Slivlje. Suggested inventory represents only the basis for further research which can contribute to the promotion of eco- and geo-tourism in the area.

Development of universal evaluation method is very difficult owing to the diversity in geomorphological environment (Pereira, Pereira, 2010). In this paper, objects were evaluated according to the scientific, aesthetical, ecological and morphometric criteria, and potential threat of natural processes which can harm physical state of landscape. As a result of evaluation, geoheritage map was presented with account of above mentioned criteria.

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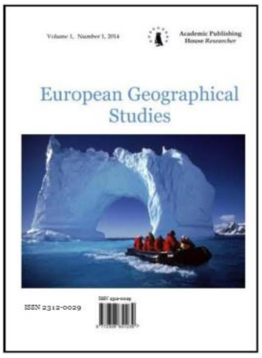

Statistical Structure of the Number of Hot Days on the Georgian Territory

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Abstract

Based on the materials of observation of 40 meteorological stations of Georgia for the period between 1936–2013, research has been made of statistical structure of the number of hot days, when the maximum temperature is higher than 35°C. The change of the annual number of hot days with the altitude, the repeatability of different grades, the distribution of the number of hot days with temperatures varying gradations for the summer months, the duration of high temperatures are studied.

It is established that with the increase of altitude of the site the annual number of hot days naturally decreases and at an altitude of about 2300 m there are no hot days. In the plain territory of Georgia, the number of hot days is more than 70, in the low-mountain zone is decreased to 60, and in the middle mountain zone it is less than 60.

The annual number of very hot days, when the maximum temperature exceeds 35°C, reaches 7 in the Kolkheti lowland, 5 on the plains of East Georgia, and 1-2 days per year in the coastal and lowland zones.

On the Black Sea coast, high temperatures (more than 25 °C) last for 4-5 hours, in the inner regions of the Kolkheti lowland their average duration is 9 hours, in the eastern arid part of Georgia, duration of temperature of more than 25 °C increases to 10-11 hours, and in the lowland zone The Caucasus is reduced to 3-4 hours.

Keywords: hot days, statistical structure, recurrence, coefficient of determination.

1. Введение

Всемирная Метеорологическая Организация (ВМО) и экспертная группа мониторинга и индексов Межгосударственной комиссии экспертов по изменению климата (МГЭИК) для выявления экстремальных явлений климата рекомендовала 27 климатических индексов (Peterson, 2005). Исследования климатических индексов в условиях Грузии были начаты недавно и к настоящему времени исследованы фоновые характеристики некоторых основных индексов температуры и осадков (Элизбарашвили и др., 2015; Элизбарашвили и др., 2016; Elizbarashvili et al., 2012; Elizbarashvili et al., 2014).

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Одним из главных климатических индексов для условий Грузии являются жаркие дни. Согласно определению жаркими считаются дни, когда максимальная температура воздуха превышает 25°(SU25).

В равнинных районах Грузии в условиях жарких дней температура воздуха часто превышает 40° С (Климат и климатические ресурсы Грузии, 1971; Опасные гидрометеорологические явления на Кавказе, 1971). Жаркие дни отрицательно воздействуют на организм человека и могут создать стрессовые тепловые нагрузки на ее организм, которые не могут быть сняты даже полным комплексом гигиенических и градостроительных мероприятий (Гвасалия, 1968). При высокой температуре и, характерной для западной Грузии, высокой влажности воздуха у человека возникает чувство духоты, оказывающее отрицательное влияние на здоровье, труд и отдых человека. В результате, жара становится невыносимой (Гвасалия, 1986).

Целью настоящей статьи было исследование статистической структуры числа жарких дней в сложных физико-географических условиях Грузии, в частности, исследование распределения годового числа жарких дней, повторяемости их различных градаций, статистического распределения числа жарких дней с температурой различной градации и продолжительности высоких температур.

Объект исследования

Грузия занимает крайне северную часть субтропического климатического пояса и здесь встречаются все типы климатов характерные для данного пояса, от климата вечных снегов и ледников высокогорий до степного континентального климата Восточной Грузии и влажного субтропического климата Черноморского побережья.

В северной части территории в направлении с северо-запада на юго-восток простирается Главный Кавказский хребет. В южной части Грузии почти параллельно Главному Кавказскому хребту простирается Южно-Грузинское нагорье, являющееся частью Малого Кавказа. Главный Кавказский хребет соединяется с Южно-Грузинским нагорьем Лихским хребтом, который является водоразделом бассейнов Черного и Каспийского морей и делит Грузию на две климатические области: Западную, с влажным субтропическим климатом и Восточную, с умеренно сухим континентальным климатом. Между Большим Кавказом и Южно-Грузинским нагорьем пролегает тектоническая депрессия, которая представлена низменностями, долинами рек, равнинами и плоскогорьями – Колхидская низменность, Имеретинская возвышенность (Западная Грузия), равнины Шида и Квемо Картли, Алазанская долина, Иорское плоскогорье (Восточная Грузия).

2. Материалы и методы исследования

В исследовании использованы материалы наблюдений 40 метеорологических станций Грузии за период 1936–2013 годы. Жаркими считались дни, когда максимальная температура воздуха превышала 25°(SU25), очень жаркими считались дни, когда температура превышала 35°. Для восстановления пропущенных данных в рядах была использована следующая процедура. Составлялись корреляционные матрицы для всех станций и на основе их статистического анализа, а также с учетом физико-географических условий местоположения станций выявлялись группы высококорелируемых станций, коэффициенты корреляции между которыми для были значимы на уровне 95 % и более. Далее внутри каждой группы пропущенные данные определялись применением метода соответствующих разностей. Максимальная интенсивность жарких дней выражалась абсолютным максимумом температуры, а средняя интенсивность жарких дней выражалась средним максимумом температуры, чем больше эти величины, тем интенсивнее жаркий день.

При анализе полученных данных использованы статистические методы исследования.

3. Обсуждение результатов

Структура годового числа жарких дней

В нашей статье (Элизбарашвили и др., 2015) была разработана геоинформационная карта годового числа жарких дней для территории Грузии за базовый период ВМО (1961–1990 гг.), согласно которой максимум числа жарких дней отмечается на юге Квемо Картли и в центральной части Колхидской низменности и составляет более 130 дней. На Алазанской долине число жарких дней превышает 100. На Черноморском побережье оно менее 100 дней, на Южно-Грузинском нагорье колеблется в пределах 0–50, а в центральной части Большого Кавказа составляет 0–30 дней.

На рис. 1 представлена зависимость изменения годового числа жарких дней от высоты местности по данным более 30 метеорологических станций. Из рис. 1 следует, что с высотой местности число жарких дней закономерно уменьшается и на высоте около 2300 *м* жаркие дни отсутствуют.

Изменение числа жарких дней с высотой местности хорошо описывается линейной функцией вида:

$$y=-0.05x+111.9, (1)$$

где y – число жарких дней, x – высота местности над уровнем моря в метрах.

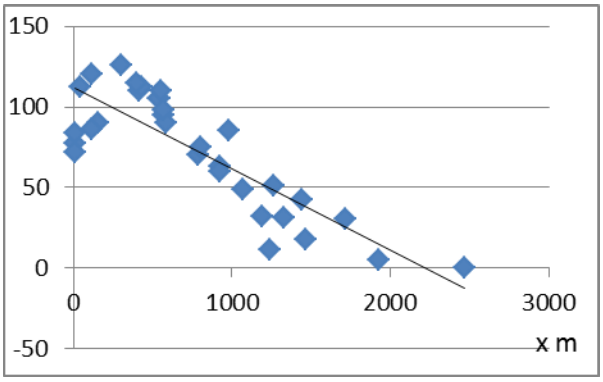

Рис. 1. Изменение с высотой (x) годового числа жарких дней (y)

В данном случае коэффициент детерминации составляет 0.71, следовательно вклад фактора высоты в изменении числа жарких дней составляет 71 %.

Из рис. 1 следует, что в равнинной части территории Грузии число жарких дней составляет более 70, в низкогорной зоне до высоты 1000 *м* уменьшается до 60, а в среднегорной зоне оно менее 60. В высокогорной зоне, примерно с высоты 2300 *м* жаркие дни не наблюдаются. Судя из уравнения регрессии вертикальный градиент числа жарких дней составляет 5 суток на 100 *м*.

На рис. 2 представлены повторяемости различных градаций годового числа жарких дней в различных физико-географических условиях Грузии за период 1936–2013 годы: Тбилиси, характеризующий равнинные районы Восточной Грузии, Батуми, расположенном на Черноморском побережье и Абастумани, характеризующую горные районы.

Из рис. 2 следует, что распределение числа жарких дней по градациям существенно зависит от физико-географических условий местности. В Тбилиси, также, как и на остальной равнинной части территории Восточной Грузии наиболее вероятны повторяемости 101–120, а также 121–140 жарких дней за год. Повторяемость этих градаций составляет 48 %. На Черноморском побережье (Батуми) наибольшая повторяемость соответствует градации 61–80 дней и составляет 40 %. В горной зоне (Абастумани) преобладающими являются градации 41–60 и 61–80 дней, повторяемость которых составляет 40 %.

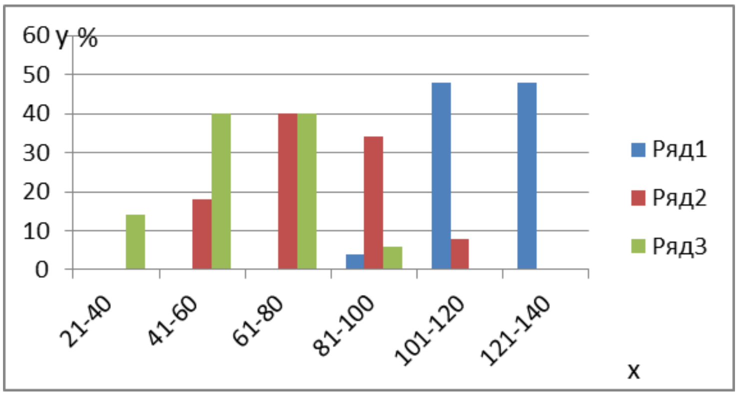

Рис. 2. Повторяемости(y) различных градаций годового числа жарких дней(x):
1 – Тбилиси, 2 – Батуми, 3 – Абастумани

Годовое число очень жарких дней, когда максимальная температура превышает 35°, достигает на Колхидской низменности 7, на равнинах Восточной Грузии -5, а в прибрежной и низкогорной зонах составляет 1–2 дня за год. Более подробно о структуре годового числа очень жарких дней можно судить по данным таблицы 1, в которой представлены вероятности наступления очень жарких дней в различных физико-географических условиях Грузии.

Из таблицы 1 следует, что очень жаркие дни с температурой более 35° в равнинной части территории Западной Грузии (Черноморское побережье и Колхидская низменность) длятся с апреля по сентябрь. Их вероятность наибольшая на Колхидской низменности и составляет в августе 8–9 %, а в июле – 7–8 %. В июне и сентябре вероятность наступления очень жарких дней составляет соответственно 3–4 и 2–3%.

На Черноморском побережье вероятность очень жарких дней в июле-августе составляет в среднем 1 %, а в остальные месяцы она меньше 1 %.

Таблица 1. Вероятности наступления очень жарких дней %

Район	Месяцы					
	IY	Y	YI	YII	YIII	IX
Черноморское побережье	менее 1	менее 1	менее 1	1	1	менее 1
Колхидская низменность	менее 1	менее 1	3-4	6-7	8-9	2-3
Равнины Восточной Грузии Тбилиси	-	-	1-3 менее 1	1-4 11	2-5 12	менее 1 1
Низкогорная зона	-	-	менее 1	1-3	1-4	менее 1

На равнинах Восточной Грузии и в низкогорной зоне Кавказа и Южно-Грузинского нагорья в апреле и мае очень жаркие дни отсутствуют. Здесь в июле и августе вероятность наступления очень жарких дней составляет соответственно 2–5 и 1–4 %. Исключение составляет Тбилиси, где соответствующие показатели вероятности существенно больше, составляя соответственно 12 и 11 %, что можно объяснить эффектом урбанизации.

В низкогорной зоне, до высоты 800–1000 *м*, вероятность очень жарких дней составляет в августе 1–4 %, а в июле – 1–3 %, в остальные же месяцы она меньше 1 %. В среднегорной зоне, выше 1000 *м*, очень жаркие дни отсутствуют.

Структура числа жарких дней с температурой различной градации за летний период

Жаркие дни особенно опасны для здоровья летом, когда температура превышает 35–40° и более. При таких температурах человек теряет свыше 100 *г* пота в час, температура тела человека повышается и наступает гипертермия (перегрев организма). В результате большого перегрева температура тела может подняться до 40°, при этом наблюдается анемизирование внутренних органов. Большой перегрев тела может сопровождаться тепловым ударом.

На рис. 3 представлены гистограммы числа жарких дней с температурой различной градации за летние месяцы и их апроксимирующие функции для пунктов, расположенных в различных физико-географических условиях Грузии: Черноморское побережье (Батуми), Колхидская низменность (Кутаиси), равнины Восточной Грузии (Тбилиси, Шираки), предгорная зона Восточной Грузии (Телави), низкогорная зона Западного Кавказа (Они), низкогорная зона Восточного Кавказа (Душети), среднегорная зона Западного Кавказа (Местиа).

В уравнениях регрессии, представленных на рис. 3 **x** является порядковым номером градации. Например градации температуры 25–30° соответствует x =1, градации 31–35° соответствует x =2, а градации 36–40° соответствует x =3.

Согласно рис. 3 эмпирическое распределение числа дней с различной градацией температуры воздуха в большинстве районах хорошо апроксимируется линейной функцией, исключением являются равнины Восточной Грузии (Тбилиси, Шираки), где эмпирическое распределение соответствует полиному второй степени. Причиной этого является увеличение числа жарких дней с градацией 31–35° .

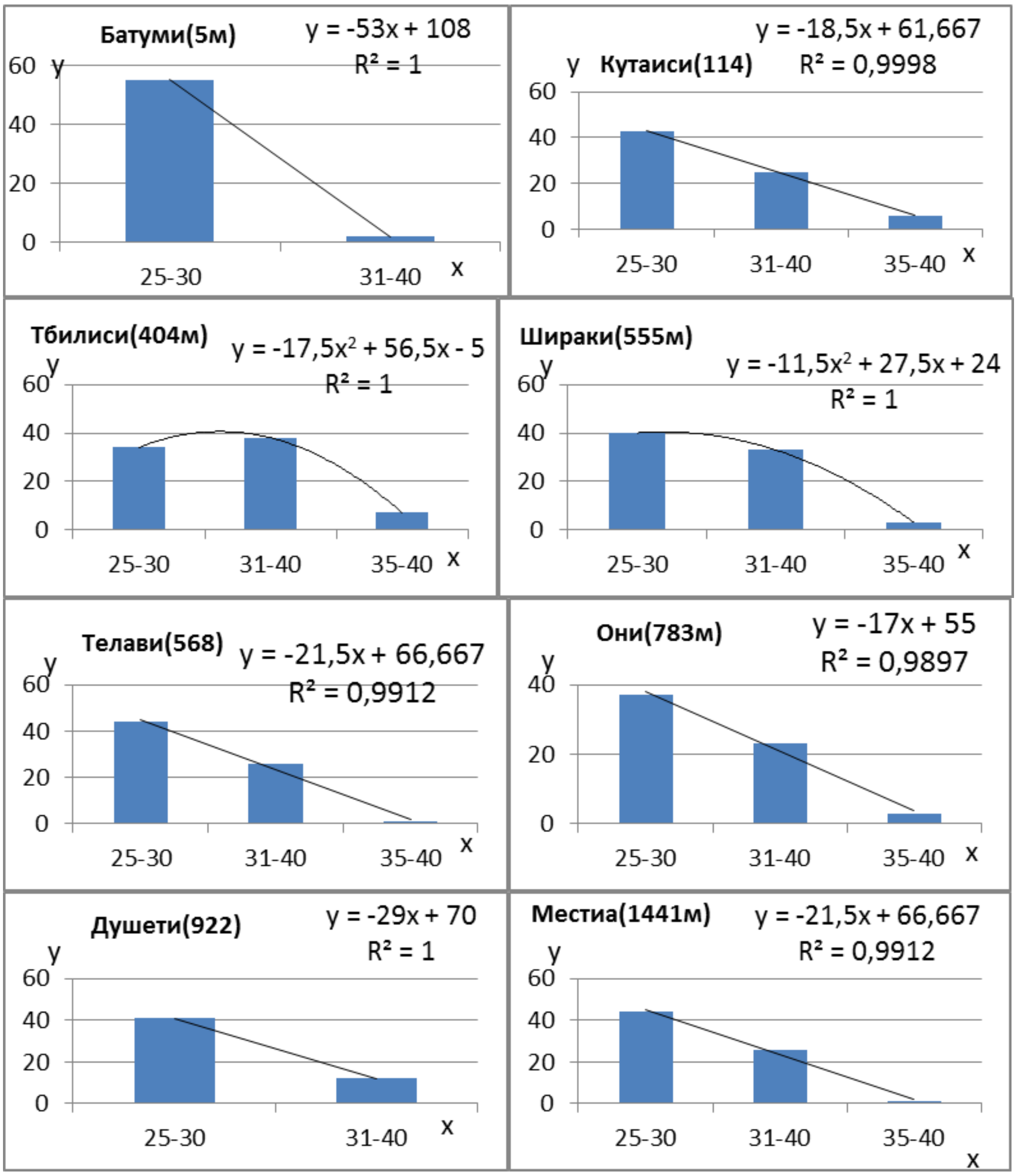

Рис. 3. Гистограммы числа жарких дней с температурой различной градации за летние месяцы и их апроксимирующие функции: **x** - градация температуры, **y** - соответствующее число жарких дней, R^2 - коэффициент детерминации.

Из рис. 3 следует, что летом на Черноморском побережье отмечаются две градации числа жарких дней с температурой 25–30° и 31–35°. В первую градацию попадает 55 дней, а во вторую попадает два дня. Очень жаркие дни, когда температура воздуха превышает 35°, на побережье не отмечаются или наблюдаются очень редко. На Колхидской низменности, в связи с удалением от Черного моря, в условиях жарких дней температура воздуха может превышать 35°, и таким образом появляется третья градация с температурой в пределах 36–40°, в которую попадает 6 случаев жарких дней. В равнинных районах Восточной Грузии также отмечаются 3 градации жарких дней. Из-за усиления аридности климата в Шираки несколько увеличивается число жарких дней с температурой 25–30° и уменьшается число дней с температурой 36–40°. В Тбилиси , в отличии от остальных станций, мода распределения соответствует градации 31-35°. В предгорной зоне Восточной Грузии увеличивается повторяемость числа жарких дней с температурой 25–30°. В низкогорной зоне Западного Кавказа также преобладают дни температурой 25–30°. В верхней части низкогорной зоны Восточного Кавказа и в среднегорной зоне Западного Кавказа отмечаются лишь первые две градации числа жарких дней.

Суточный ход и непрерывная продолжительность высоких температур (более 25°)

На рис. 4 представлен суточный ход высоких температур, более 25°, в июле-августе для различных физико-географических условий Грузии.

Из рис. 4 следует, что на Черноморском побережье (Кобулети) высокие температуры (более 25°) длятся в среднем в течение всего 4–5 часов, в основном с 12 по 16 часов. Во внутренних районах Колхидской низменности ослябляется влияние Черного моря и увеличивается длительность высоких температур. Так, в Кутаиси их продолжительность составляет в среднем 9 часов, они наступают в 10 ч и заканчиваются в 18 ч. В восточной аридной части Грузии (Гардабани) еще более увеличивается продолжительность температур более 25°, и составляет в среднем 10–11 час, с 10 по 20 час. В низкогорной зоне Кавказа (Душети) продолжительность высоких температур уменьшается до 3–4 час (с 13 по 16 час).

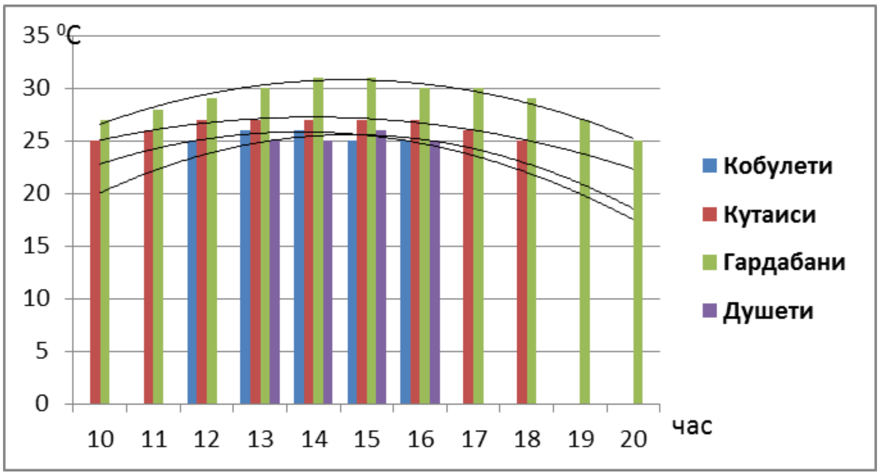

Рис. 4. Суточный ход высоких температур в июле-августе

Представленный на рис. 4 суточный ход температуры удовлетворительно описывается полиномом второй степени:

$$y=ax^2+bx+c, (2)$$

где y – температура воздуха, x- время в течении сутки (час), a, b, c – коэффициенты, которые представлены в таблице 2.

Таблица 2. Коэффициенты для уравнения (2)

Район	a	b	c	R^2
Черноморское побережье	-0.214	2.042	20.97	0.619
Колхидская низменность	-0.136	1.363	23.83	0.954
Восточная Грузия	-0.194	2.199	24.57	0.969
Низкогорная зона Кавказа	-0.25	2.85	17.45	0.4

В таблице 2 R^2 –коэффициент детерминации.

По уравнению (2) и представленным в таблице 2 коэффициентам можно рассчитать суточный ход высоких температур в различных физико-географических условий Грузии. Судя по коэффициентам детерминации наилучшие результаты получаются для равнинных районов Восточной Грузии и Колхидской низменности.

Интенсивность жарких дней

Максимальная интенсивность жарких дней выражалась абсолютным максимумом температуры, а средняя интенсивность жарких дней выражалась средним максимумом температуры, чем больше эти величины, тем интенсивнее жаркий день.

На рис. 5 представлены графики годового хода максимальной и средней интенсивности жарких дней с мая по октябрь для различных условий Грузии.

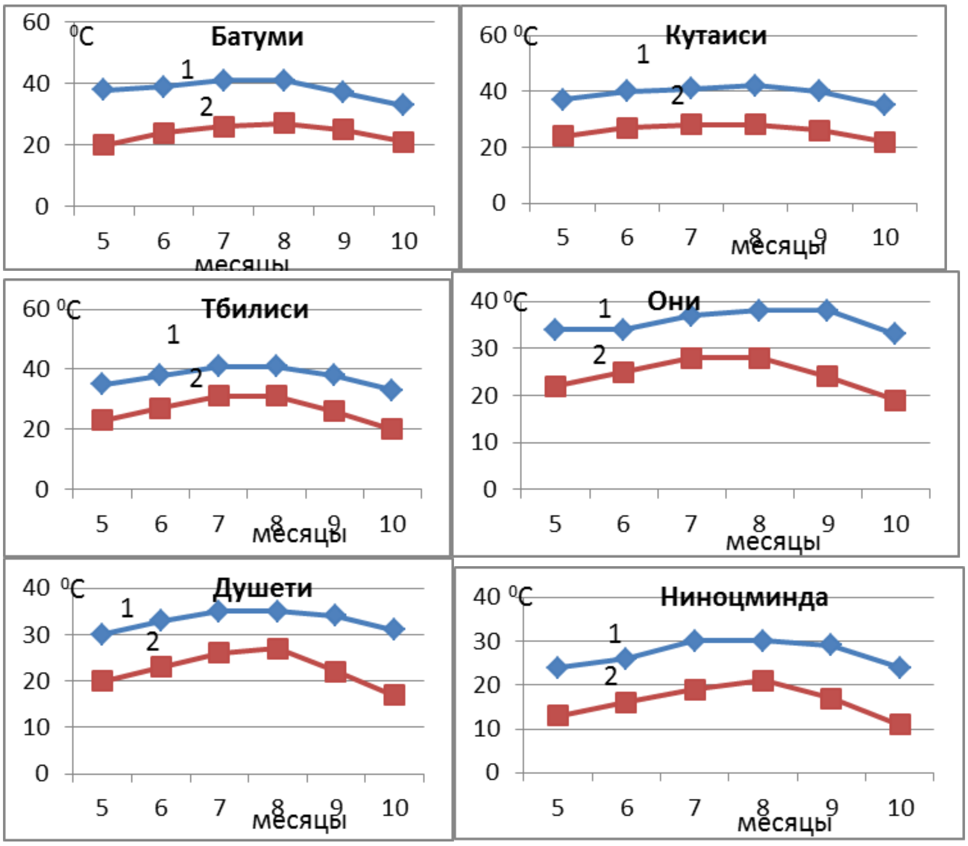

Рис. 5. Годовой ход максимальной (1) и средней (2) интенсивности жарких дней

Из рис. 5 следует, что средняя интенсивность жарких дней на черноморском побережье Грузии (Батуми) в июле-августе не превышает 28–27°, на Колхидской низменности (Кутаиси) составляет 28°, в равнинной части Восточной Грузии (Тбилиси) возрастает до 31–32°, в низкогорной зоне Большого Кавказа (Они, Душети) уменьшается до 27–28°, а в нижнем поясе высокогорной зоны (Ниноцминда) она меньше 21°.

Максимальная интенсивность жарких дней на черноморском побережье и на равнинах восточной Грузии составляет 41°, на Колходской низменности -42°, в среднегорной зоне составляет 35–38°, а в нижнем поясе высокогорной зоны она меньше 30°.

4. Заключение

1. С высотой местности годовое число жарких дней закономерно уменьшается и на высоте около 2300 *м* жаркие дни отсутствуют. В равнинной части территории Грузии число жарких дней составляет более 70, в низкогорной зоне уменьшается до 60, а в среднегорной зоне оно менее 60. Изменение числа жарких дней с высотой хорошо описывается линейной функцией. Вертикальный градиент числа жарких дней составляет 5 суток на 100 *м*.

2. На равнинной части территории Восточной Грузии наиболее вероятны повторяемости 101–120, а также 121–140 годового числа жарких дней. На Черноморском побережье наибольшая повторяемость соответствует градации 51–80 дней. В горной зоне преобладающими являются градации 41–60 и 61–80 дней.

3. Годовое число очень жарких дней, когда максимальная температура превышает 35°, достигает на Колхидской низменности 7, на равнинах Восточной Грузии -5, а в прибрежной и низкогорной зонах составляет 1–2 дня за год.

4. Эмпирическое распределение числа дней с различной градацией температуры воздуха в летние месяцы в большинстве районах хорошо апроксимируется линейной функцией, исключением являются равнины Восточной Грузии (Тбилиси, Шираки), где эмпирическое распределение соответствует полиному второй степени. Причиной этого является увеличение числа жарких дней с градацией 31–35° .

5. На Черноморском побережье высокие температуры (более 25°) длятся в течение 4–5 часов, во внутренних районах Колхидской низменности их продолжительность составляет в среднем 9 часов, в восточной аридной части Грузии продолжительность температур более 25° возрастает до 10–11 час, а в низкогорной зоне Кавказа уменьшается до 3–4 час.

6. Средняя интенсивность жарких дней на черноморском побережье Грузии в июле-августе не превышает 28–27°, на Колхидской низменности составляет 28°, в равнинной части Восточной Грузии возрастает до 31–32°, в низкогорной зоне Большого Кавказа уменьшается до 27–28°, а в нижнем поясе высокогорной зоны она меньше 21°

7. Максимальная интенсивность жарких дней на черноморском побережье и на равнинах восточной Грузии составляет 41°, на Колходской низменности -42°, в среднегорной зоне составляет 35–380, а в нижнем поясе высокогорной зоны она меньше 30°.

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Статистическая структура числа жарких дней на территории Грузии

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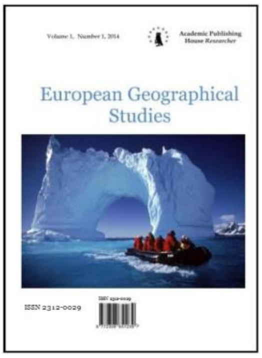
Аннотация. По материалам наблюдений 40 метеорологических станций Грузии за период 1936–2013 годы исследована статистическая структура числа жарких дней, когда максимальная температура воздуха превышает 25°. Исследованы изменение годового числа жарких дней с высотой местности, повторяемости их различных градаций, распределение числа жарких дней с температурой различной градации за летние месяцы, продолжительность и интенсивность высоких температур.

Установлено, что высотой местности годовое число жарких дней закономерно уменьшается и на высоте около 2300 *м* жаркие дни отсутствуют. В равнинной части территории Грузии число жарких дней составляет более 70, в низкогорной зоне уменьшается до 60, а в среднегорной зоне оно менее 60.

Годовое число очень жарких дней, когда максимальная температура превышает 35°, достигает на Колхидской низменности 7, на равнинах Восточной Грузии -5, а в прибрежной и низкогорной зонах составляет 1–2 дня за год.

На Черноморском побережье высокие температуры (более 25°) длятся в течение 4–5 часов, во внутренних районах Колхидской низменности их продолжительность составляет в среднем 9 часов, в восточной аридной части Грузии продолжительность температур более 25° возрастает до 10–11 час, а в низкогорной зоне Кавказа уменьшается до 3–4 час.

Ключевые слова: жаркий день, статистическая структура, повторяемость, коэффициент детерминации.



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The Dynamics of Air Temperature and Precipitation in the Chui Basin

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Abstract

The study of the regional manifestations of climate change in mountain areas is of special significance, because it can refine the planetary picture. The dynamics of climate change has been studied through the use of long-term meteorological data (60 years). Chui basin considered as an object. Established a steady warming trend, with a slight cold snap of the last decade, as well as the absence of significant changes in precipitation. This fact shows a clear trend of increased aridity of the territory, since the air temperature observed increase is not accompanied by a corresponding increase in precipitation.

Keywords: climate change, Chui basin, aridity of the territory.

1. Введение

Актуальность исследований современных изменений климата, к сожалению, не вызывает никаких сомнений. Мировое сообщество всерьез обеспокоено ростом числа стихийных бедствий, огромными ущербами от наводнений засух и пожаров, которые являются следствием происходящих изменений в окружающей среде (Заявление ВМО…; Изменение климата; Изменение климата…; Ротанова и др., 2012; Сыромятина и др., 2010). В заявление ВМО о состоянии глобального климата в 2015 году отмечается, что "одним из самых действенных средств для адаптации к последствиям изменения климата является укрепление систем заблаговременных предупреждений о бедствиях и климатического обслуживания" (Заявление ВМО…: 3). В связи с этим изучение региональных проявлений изменений климата в горных территориях приобретает особый смысл, так как способно детализировать общую картину.

Объект и методы. В таких регионах как Республика Алтай межгорные котловины – это наиболее заселенные и освоенные в хозяйственном отношении территории. Чуйская котловина, или Чуйская степь – одна из них, находится в Юго-Восточной Алтайской провинции. Днище котловины расположено на высоте 1750-1850 метров над уровнем моря и со всех сторон ограничено горными хребтами: Курайским на севере, Северо-Чуйским и Южно-Чуйским на западе, хребтом Сайлюгем на юге и хребтом Чихачёва на востоке.

Рельеф очень специфичен – здесь практически отсутствуют наклоненные участки равнин. Из-за малого количества осадков особо представлена плоскостная эрозия.

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Имеющиеся конусы выноса и делювиальные шлейфы очень незначительны и не способны сформировать наклонную равнину. Днище котловины в основном сложено озерными, аллювиальными и пролювиальными отложениями (Михайлов, 1961).

Резкая континентальность климата обусловлена географическим расположением в центре материка и орографической изолированностью. Климатические особенности значительно отличаются от климата долин и водоразделов. В зимние месяцы выхолаживание воздуха на днищах котловин обусловлено господством антициклональных условий, стоком воздуха со склонов и его застоем. Зимы суровые и малоснежные. В теплый период с восстановлением западного переноса воздушных масс при переваливании наветренных склонов хребтов возникает барьерный эффект, и на подветренных склонах облачность размывается, поэтому осадков выпадает мало. На подветренной стороне образуется барьерная тень. При опускании воздух адиабатически нагревается, облака размываются и возрастает число часов солнечного сияния (Сухова и др., 2012).

Динамика климатических изменений изучалась на основе использования многолетней метеорологической информации (60-летний период). Для корректного анализа временного распределения основных метеорологических показателей на территории Чуйской котловины были использованы ежедневные данные наблюдений оперативно-наблюдательных подразделений Горно-Алтайского ЦГМС – филиала ФГБУ “Западо-Сибирского УГМС” по метеостанции Кош-Агач, данные, размещенные на официальном сайте ВНИИГМИ МЦД (URL: http: www.meteo.ru.climate.sp_clim.php), для продления рядов использовались данные по количеству осадков по срокам наблюдений с сайта оперативных метеорологических данных (URL: http: rp5.r).

2. Результаты исследования и их обсуждение

В результате проведенного анализа продолжительности солнечного сияния за теплый период (май-сентябрь) (Рис. 1) установлена статистически не значимая положительная динамика – в среднем увеличение составляет 10 часов за весь анализируемый период с 1961 по 2012 гг. Однако, начиная с 1997 года, отклонения от нормы имеют меньший диапазон, но большую изрезанность графика, что объясняется изменением циркуляционных процессов, приводящих к увеличению облачности.

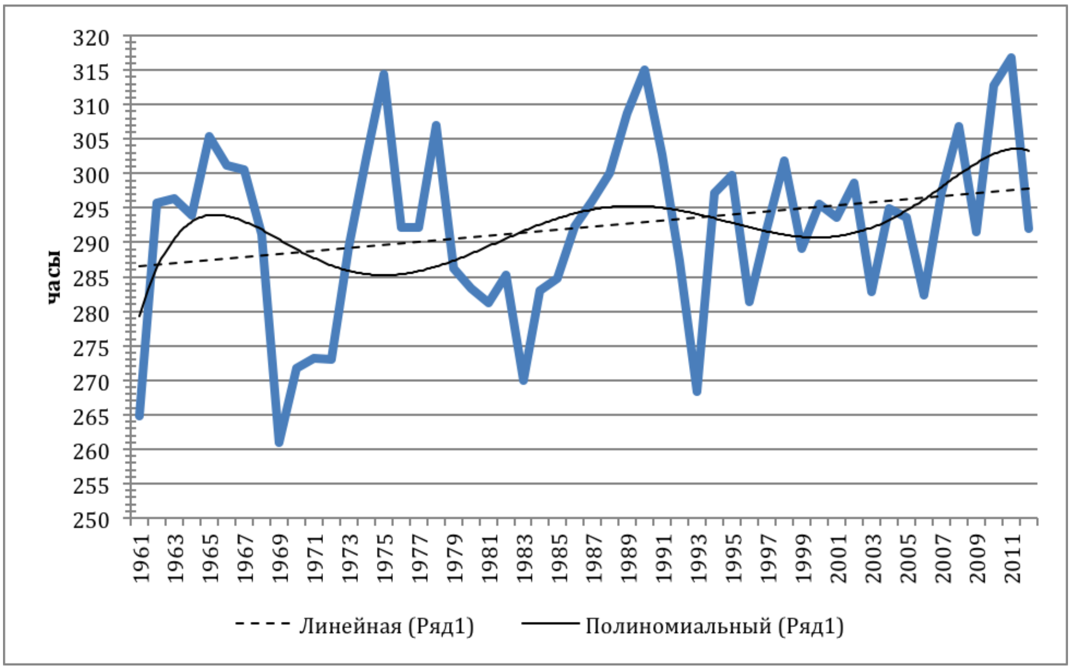

Рис. 1. Продолжительность солнечного сияния за теплый период (май-сентябрь) МС Кош-Агач

Проведенные расчеты годовой температуры воздуха в календарных рамках позволили установить значительный положительный линейный тренд. Величина повышения среднегодовой температуры воздуха за 60 лет (1955-2015 гг.), на основе линейных трендов, составила 3 °С (Рис. 2), при средней многолетней температуре этого периода -4,7 °С, что на 2 °С выше климатической нормы по справочным данным, однако на 0,9 °С ниже аналогичного показателя за последние 30 лет. Это объясняется наибольшими темпами потепления начиная с 1997 года.

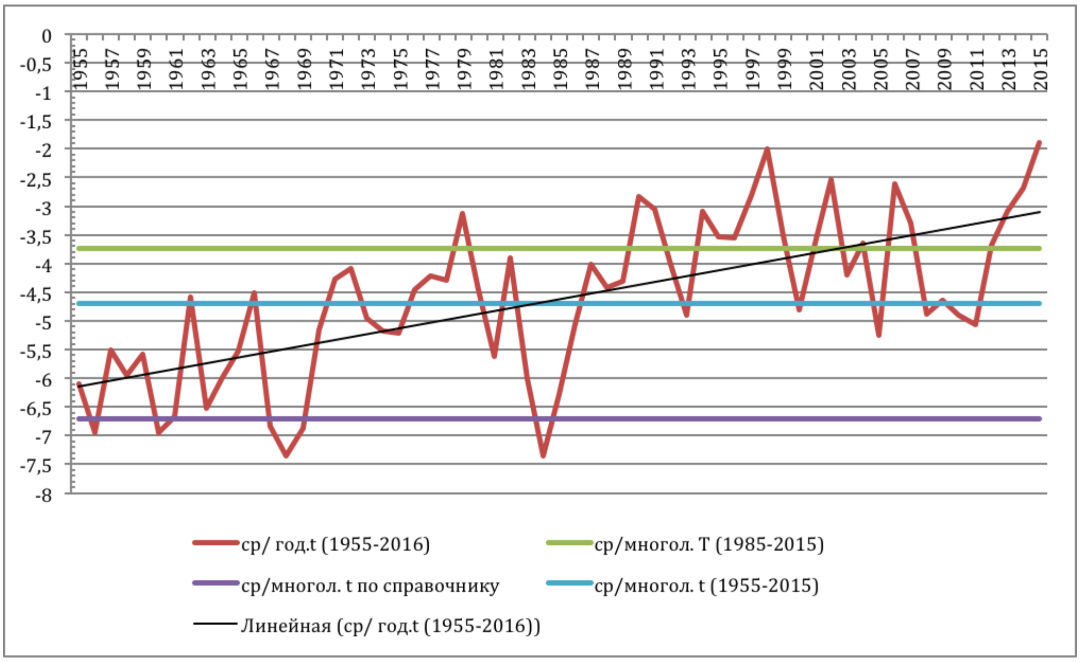

Рис. 2. Динамика среднегодовой температуры воздуха, МС Кош-Агач

Однако отклонения температуры от нормы в средних годовых показателях не отражают полную динамику термического режима в течение годового цикла.

По сезонам года местные циркуляционные условия могут изменяться довольно значительно: от преобладания антициклональной, малооблачной и сухой погоды зимой до неустойчивой циклональной погоды с чередованием волн тепла и холода, осадками весной и осенью.

В условиях горной территории погодные (и климатические) характеристики еще более дифференцируются под влиянием рельефа, что находит отражение и в особенностях термического режима. Таким образом, наиболее объективная картина отклонения температуры воздуха он нормы раскрывается при сезонном анализе (Рис. 3).

Анализ динамики среднесезонных изменений температуры воздуха, показал неоднородость изменений в течении года (Рис. 3). Так, наибольшая положительная тенденция наблюдается в зимний период и составляет 3,2 °С. И, хотя за последние 60 лет средняя температура зимы повысилась, изменение ее далеко не однородно. Так в 60-е годы в Чуйской котловине средняя температура зимы составляла -23,1 °С, в 90-е годы -18,5 °С. Однако в последние годы (2006–2015 гг.) наблюдалось значительное понижение температуры, при средней температуре зимнего периода – -20,3 °С. Мы вправе констатировать и значительные флуктуации значений, так например в 2008 году средняя температура зимы составляла -17,3 °С, в 2015 г. -15,7 °С, в 2006 и 2009 гг. около -23 °С, а в 2011 г. – 24,4 °С.

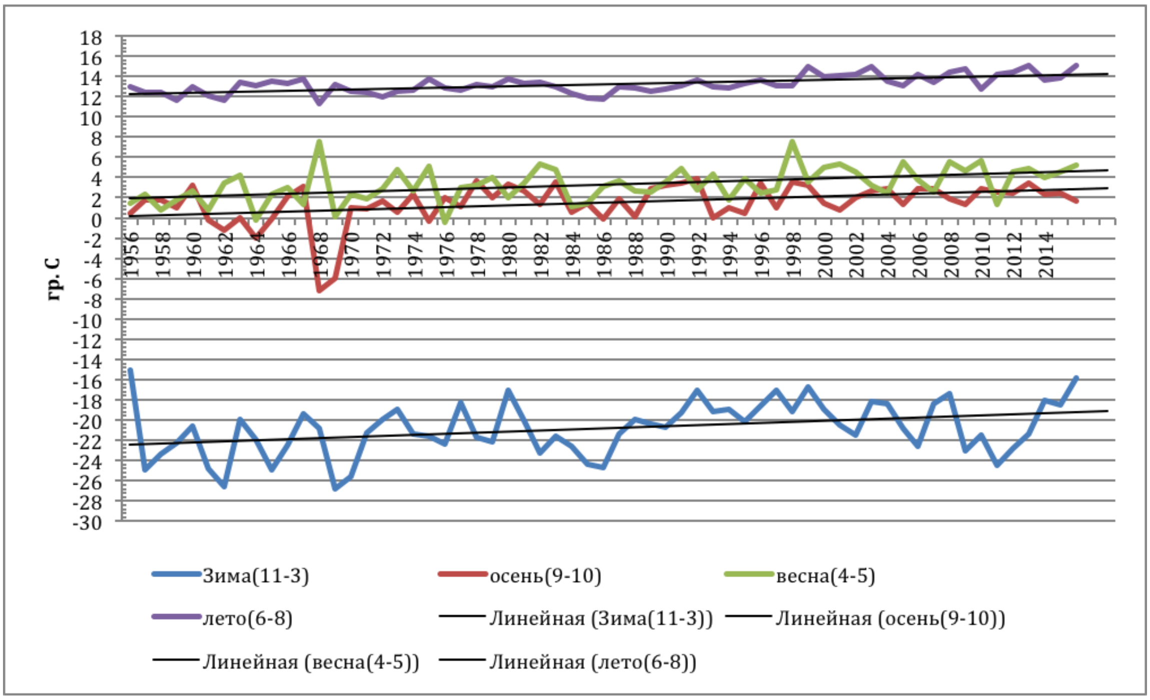

Рис. 3. Динамика среднесезонной температуры воздуха, МС Кош-Агач

Для весеннего сезона характерна очень большая изменчивость температур: на графике линии имеют глубоко изрезанный вид. Относительно теплые весны сменяются более холодными. В целом за 60-летний период весной отклонение температуры воздуха от нормы в сторону повышения температур составило 2,2 °С.

В отличие от других сезонов, межгодовое распределение среднесезонных температур лета имеет более плавный ход, что свидетельствует об относительной устойчивости летних погод. Вертикальная поясность температуры воздуха летом выражена наиболее четко. Превышение температуры относительно нормы летом составляет около 1 °С.

За последние 60 лет наиболее холодным было лето 1968 года, когда средне летняя температура составила 11,3 °С, что ниже нормы на 1,2 °С.

Динамика изменения средне осенних температур по большей части синхронно весенним, в противофазе находится 1968 г. когда средняя температура осени составила – 7,1 °С, 2001 год 0,8 °С при норме 0,7 °С. Отклонения температуры в сторону понижения не столь глубокие и продолжительные как зимой.

Анализ изменения годового количества осадков за период с 1956 по 2015 г. не выявил статистически значимых отклонений (Рис. 4).

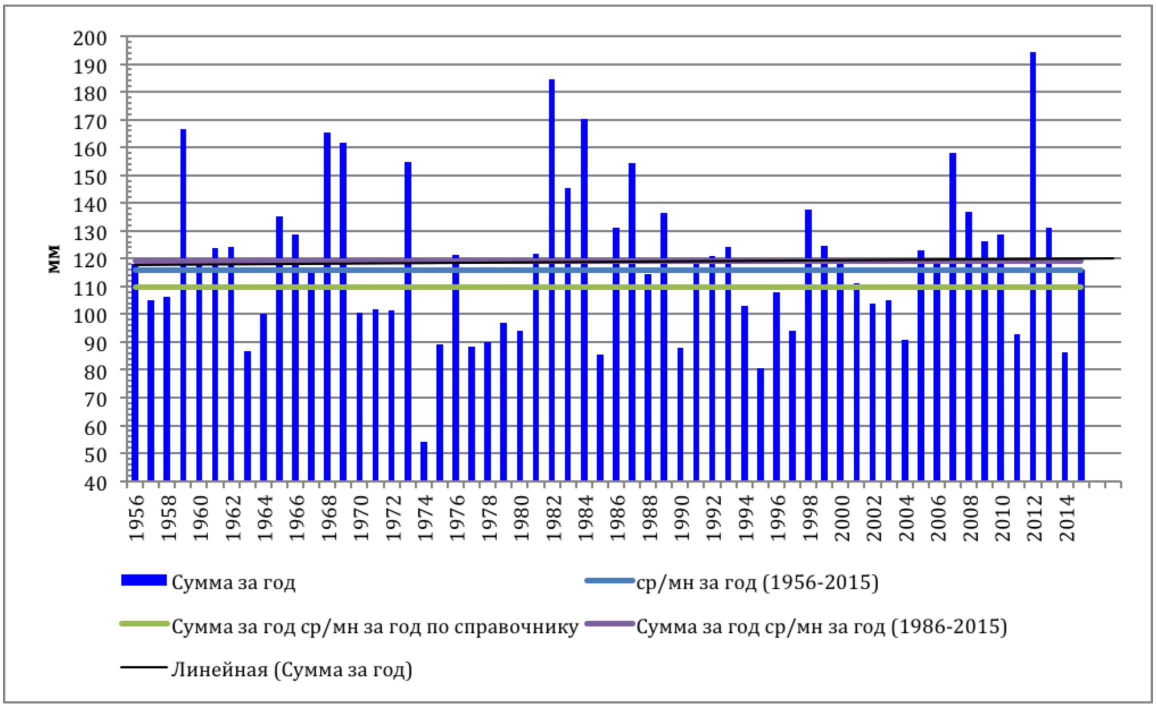

Рис. 4. Динамика годового количества атмосферных осадков, МС Кош-Агач

При рассмотрении сезонной специфики на основе линейных трендов выявились некоторые отличия (Рис. 5), так величина повышения летних сумм осадков составила 12 мм, величина понижения зимних сумм 10 мм. Однако, оба этих значения не являются статистически значимыми.

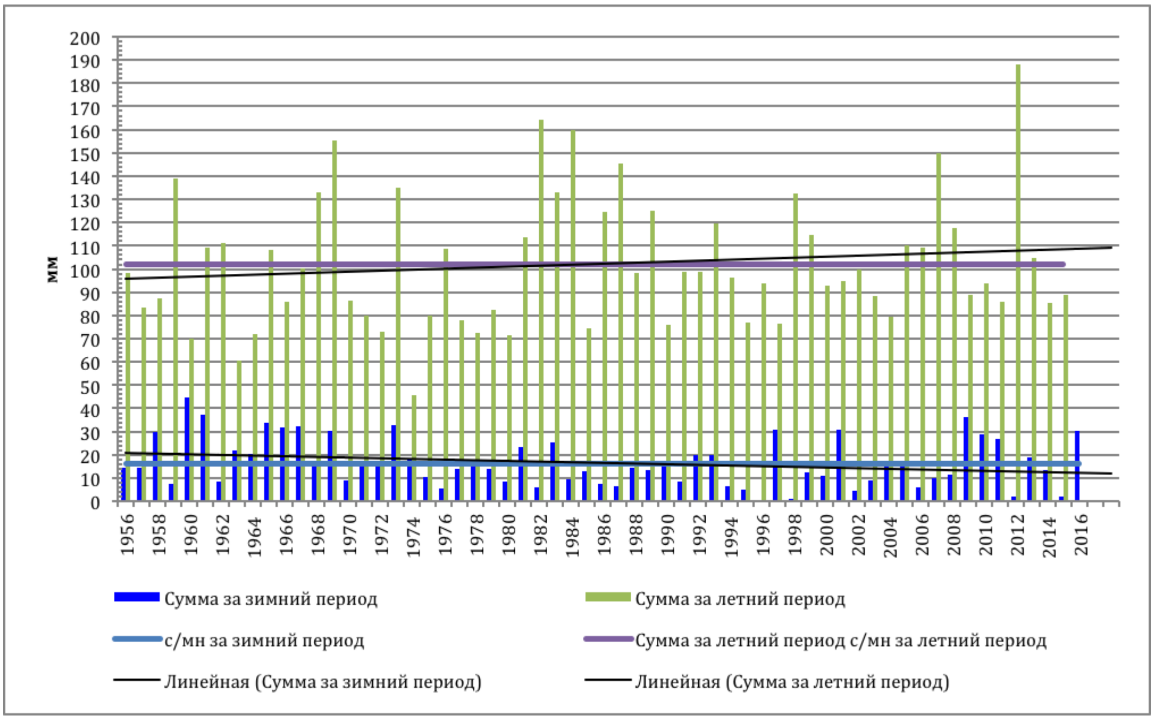

Рис. 5. Динамика атмосферных осадков теплого и холодного периодов, МС Кош-Агач

3. Заключение

Таким образом, проанализировав динамику изменения температуры воздуха и осадков на территории Чуйской котловины, мы установили устойчивую тенденцию к потеплению, при незначительном похолодании последнего десятилетия, а также отсутствие значимых изменений в режиме осадков. Данный факт свидетельствует о четкой тенденции усиления аридизации территории, поскольку наблюдаемый прирост температур воздуха не сопровождается соответствующим увеличением атмосферных осадков.

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Динамика изменения температуры воздуха и осадков в Чуйской котловине

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Аннотация. Изучение региональных проявлений изменений климата в горных территориях приобретает особый смысл, так как способно детализировать планетарную картину. Динамика климатических изменений изучалась на основе использования многолетней метеорологической информации (60-летний период). В качестве объекта рассматривалась высокогорная Чуйская котловина. Установлена устойчивая тенденция к потеплению, при незначительном похолодании последнего десятилетия, а также отсутствие значимых изменений в режиме осадков. Данный факт свидетельствует о четкой тенденции усиления аридизации территории, поскольку наблюдаемый прирост температур воздуха не сопровождается соответствующим увеличением атмосферных осадков.

Ключевые слова: изменение климата, Чуйская котловина, аридизация территории.

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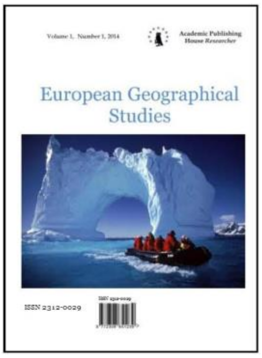

The History and Current State of Thematic Mapping in Russia

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Abstract

The paper describes a 300-year history of thematic cartography in Russia, which began in the first half of the XVII century. Special attention is given to atlas mapping that was first implemented at end of the XIX century. The most prominent examples are the Great Soviet World Atlas and Physical Atlas of the World. The National Atlas of Russia (in four volumes) is described in detail. The role of integrated regional atlases of the country is demonstrated. The modern thematic cartography in the country is focused on mapping seas, oceans, and environment, and creation of maps for higher educational institutions.

Keywords: Russia, thematic mapping, history, atlases.

1. Introduction

Thematic mapping is multifaceted and covers all areas of the environment, demography, and economics, as well as all territorial levels – the world, as a whole, continents, countries, and individual regions; it is a comprehensive representation of geographical phenomena and processes. Comprehensive mapping involves creation of systems of interrelated (interconnected) thematic maps that reflect natural and/or socio-economic territorial complexes. The concepts of territorial complexes laid a foundation for methodological principles that allow creation of systems of interconnected maps (Evteev et al., 1997a). These principles require modeling of relationships between elements, presentation of characteristics and relationships of the mapped territorial systems with the help of charts, creation of functional mapping types (base, derivatives, independent) that determine sequence of mapping stages, and reconciliation of the methods (i.e., semantic and graphic [contour, network, etc.]) (Integrated regional atlases). Comprehensive mapping is the cornerstone of system mapping, which places stricter requirements on temporal relationships of mapped data, scales, generalization approaches, etc., when establishing characteristics of various types of systems. Computer mapping should be specifically emphasized. Thus, a computer version of a comprehensive atlas, in terms of the systemic approach, is a system of interrelated thematic layers, which allows one to readily superimpose, change, update, and enhance them, which, in turn, allows developing new maps and new knowledge on structure, interrelationships, and dynamics of phenomena. The informational content of a comprehensive atlas may be broken into several functional types:

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multifaceted – these layers are the basic layers for general geographical maps and thematic layers for other maps (hydrographic and transportation networks, populated locations and administrative boundaries);

inventory – these layers, including the basic layers, are thematic layers that are included in other maps completely or partially (e.g., landscape, soils, land use, unsettled territories);

assessment and assessment-forecast – these layers are based on expert comprehensive or specific assessments (e.g., environmental conditions of natural environment – terrain, surface water, soil, vegetation, etc.);

monitoring – these are the actual thematic layers that require continuous updates (e.g., emissions, effluents, radiation, forest fires, etc.) (Evteev et al., 1997b).

These principles are embodied in comprehensive thematic maps and atlases, and more recently, in atlas information systems.

The purpose of this paper is not the analysis of the entire array of cartographic products of various periods in the Russian history but the presentation of the most significant cartographic works, especially those that are not readily available to specialists who do not possess knowledge of the Russian language, though we have considered some works on the history of the Russian cartography published in English (e.g., Postnikov, 1996; Postnikov, 1999, Postnikov, 2005). This paper also does not discuss the contribution of foreign prominent scientists (such as Alexander von Humboldt) to the Russian thematic mapping, which can be a subject of separate analysis.

2. Discussion

The first thematic maps of Russia. A consistent mapping of the country began in the middle of the XVIII century; however, certain mapping efforts had been made much earlier (the XVII century).Academy of Sciences played the major role in mapping of the country from the 1740s to the end of the XVIII century; in 1739, the Department of Geography was established specifically for this purpose. Since 1797, systematic scientific mapping work was carried out mainly by the Mapping Depot of the General Staff, transformed in 1822 into the Corps of Military Surveyors. Production of marine (nautical) maps concentrated in the Cartographic Drawing Office of the Admiralty Board, established in 1777.

From the middle of the XIX century, many agencies, institutions, organizations, and private companies were involved in mapping activities, among which was the largest private mapping company in Russia founded in1859 "A. Ilyin's Mapping Surveying"; another prominent company was "Marx Publishing House." The Russian Geographical Society was also actively involved in mapping work; it published a large number of maps and took part in creation of many cartographic products.

Though most areas of thematic mapping were developed in the XX century – the time of the most intensive advancement of thematic mapping – mapping of rivers' networks, forests, and mining industry started in the XVII century (Yanvareva, 2012). The history of these cartographic areas is presented in this paper only briefly.

Hydrographic charts. Rivers have been the main transportation routes in Russia since ancient times. In the XVII century, map sketches identified navigable routes, which were not only the transportation ways but played an important military role. Rivers connect Russia with all the seas: the Baltic, White, Black, and Caspian. On sketches, rivers were reflected in most possible detail and showed navigation features. The sketches from all over Russia were stored in the Senate, the Siberian and the Ambassadorial Prikazs (i.e., offices or boards). In the XVIII century, the first collections were compiled; the collections included atlases and general maps at small scales (the classification of scales in Russian cartography is generally as follows: 1:200 000 and larger – large-scale; 1:200 000 – 1: 000 000 – medium-scale; and 1: 000 000 and smaller – small-scale). The first general map was created in 1782.

During the rule of Peter the Great, construction of water systems connecting water basins of the main European Russian rivers (Mayinskyaya, Vyshnevolotskaya, and other systems) began. In 1832, the General Directorate of Railways issued the "Hydrographic Atlas of the Russian Empire" and a series of general maps at scales of 1: 1680000 and 1:3260 000. At the end of the XIX century, "Lists of Inland Waterways of European and Siberian Parts of Russia" that catalogued all the rivers with their length and other characteristics, were compiled.

Forest mapping. The first forest map of the Russian forests was the "Drawing of Forest Surveys" (1701; approximate scale 1: 400000). The forests were broken by species.

From this time on, under the orders of Peter the Great, and until the XIX century, drawings and, later, land-maps of timber mast suitable for construction of ships, galleys, boats, and sloops were compiled.

The forest maps covered only strips along rivers. Wood was rafted to the shipyards where the ships were built. The maps indicated the size of forest area. The Forest Department of the Admiralty Board kept thousands of such maps. The first "Forest Atlas" was compiled from these maps in 1733-1782. In the 1841-1842, the "General Map of Forests and Forest Industry" was created. It showed four levels of forested land, species, and forest-industry facilities. After the introduction in Russia of the German land administration system (the land was subdivided into sections by strips), statistical atlases, e.g., "Forest Statistical Atlas of European Russia" (1878), were compiled only at small scales.

Mining industry. By the XVII century, Russia had substantial knowledge on proven mineral resources. The construction of mining plants began (iron foundries, iron works). The first two mining-plant regions formed in Russia. The first one was around Tula and Moscow and the second one, the northern, worked with Swedish ore and was near Belogorsk, Vologda, and Velykyi Ustyug. At the end of the XVII century, the construction of facilities began in Urals. In 1700, at the initiative of Peter the Great, the Ore Prikaz (it managed construction of plants) was established (and the Berg-Collegia, in 1719).

Examples of thematic maps of the end of the XIX century – beginning of the XX century (Fig. 1 and 2).

Fig. 1. Ethnographic Map of Slavic Peoples, St. Petersburg, 1877. Scale 1:4200000

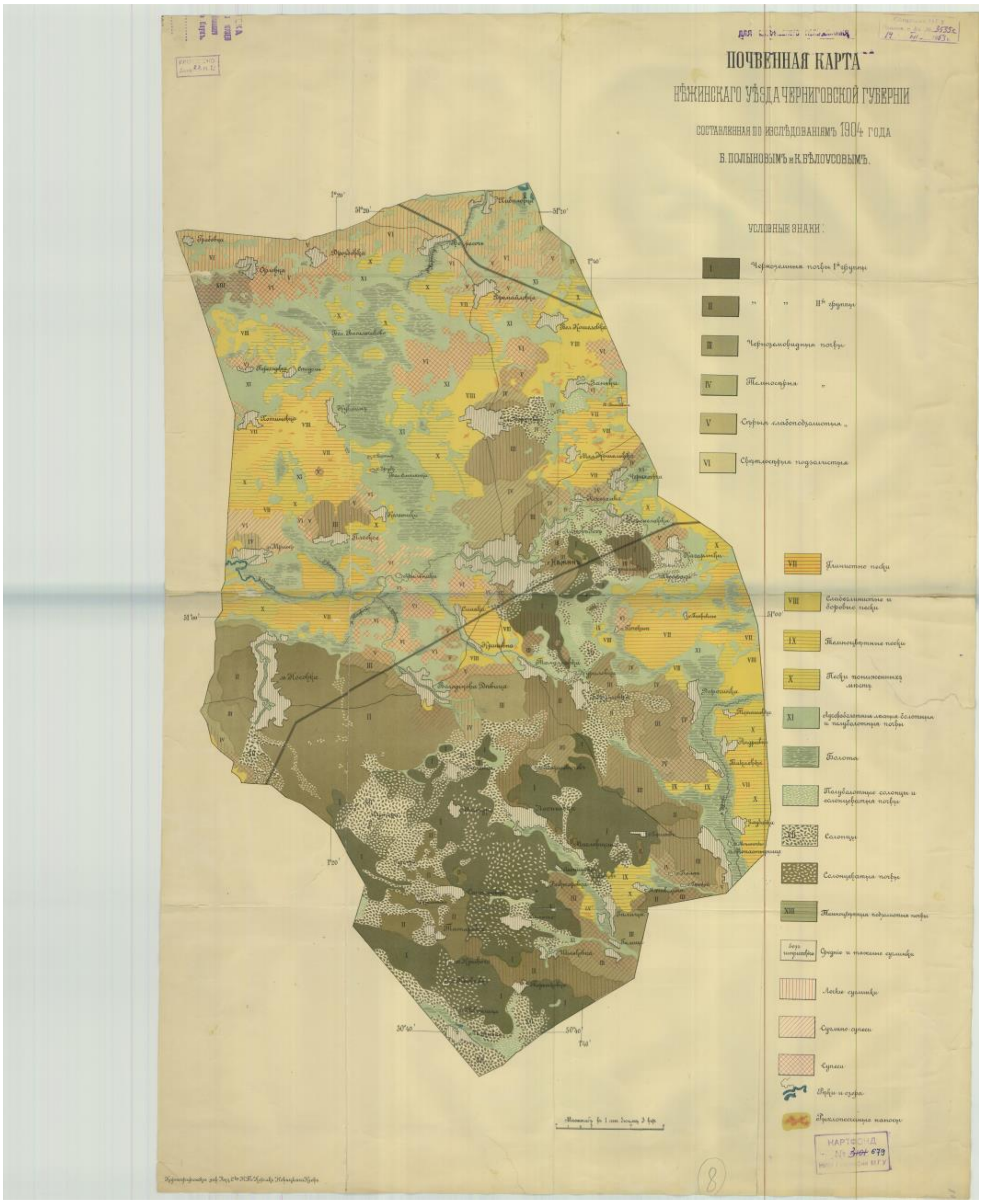

Fig. 2. Soil Map of the Nezhinsk County of the Chernigov Province compiled based on research of B. Polynov and K. Belousov conducted in 1904. Scale 1 inch = 3 verst

Examples of thematic maps of the first half of the XX century (Figs. 3 and 4)

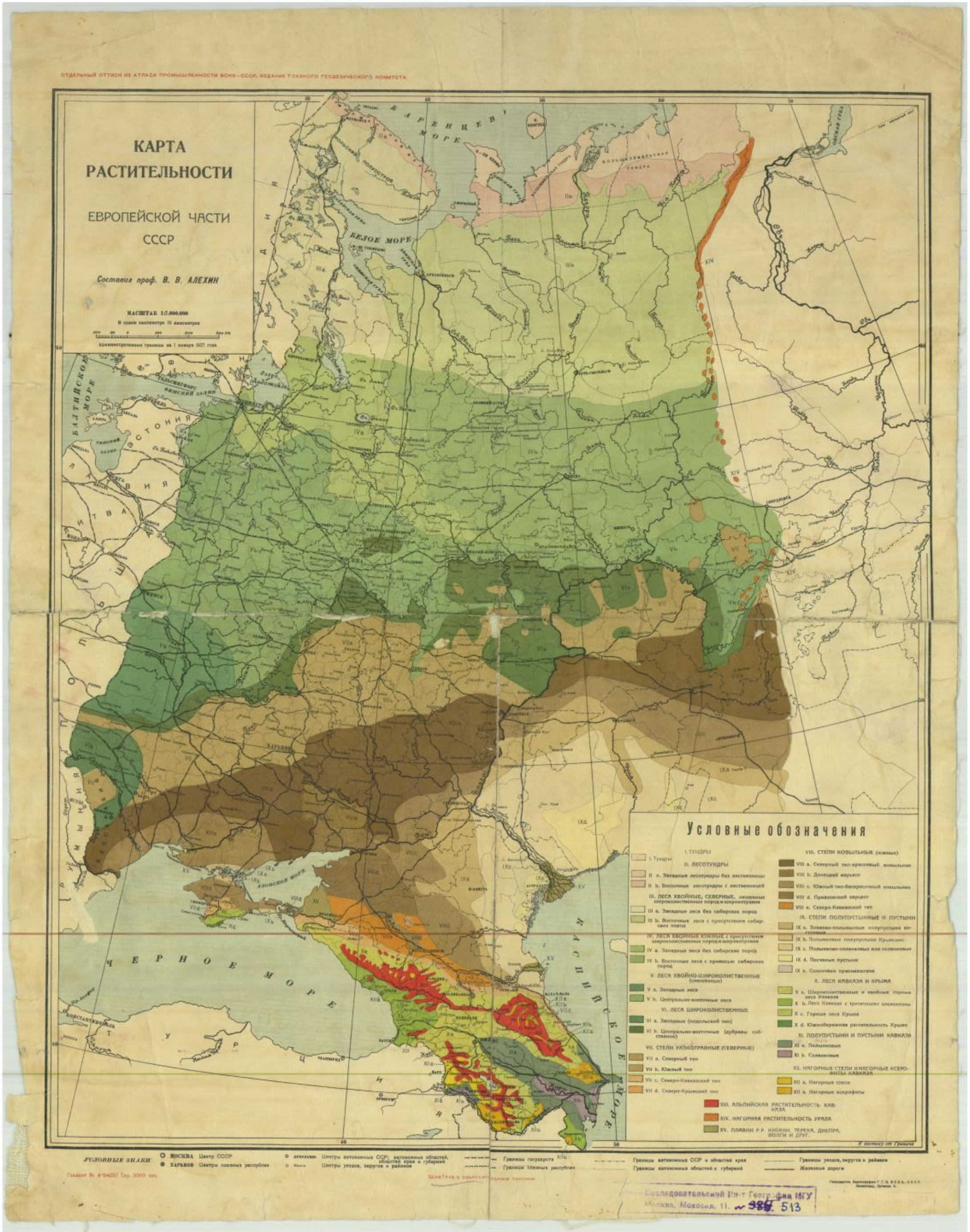

Fig. 3. Vegetation Map of the European Part of the USSR, 1927. Scale 1: 7000000

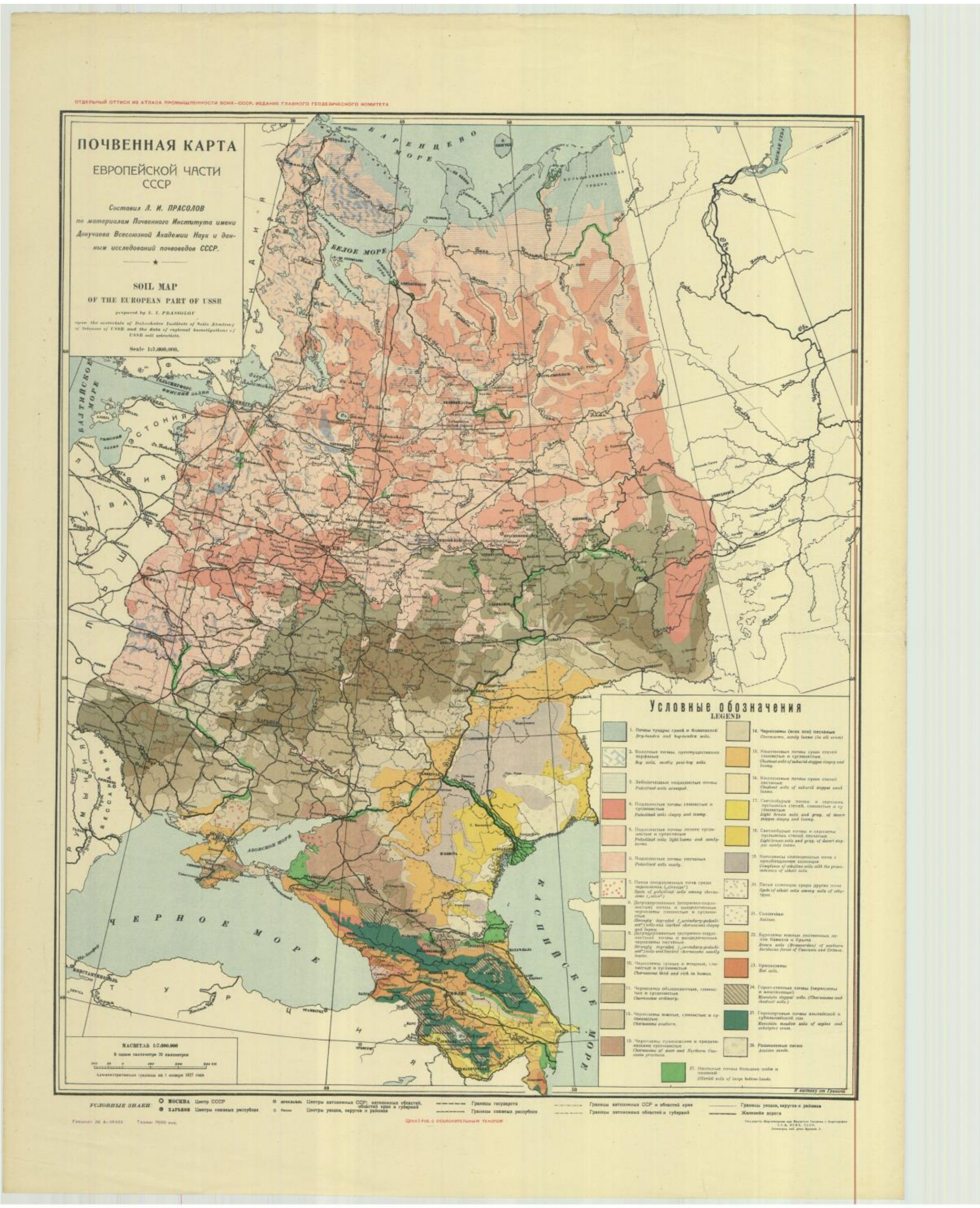

Fig. 4. Soil Map of the European Part of the USSR, 1927. Scale 1: 7000000

Atlases. At the end of the XIX century, a series of atlases was created in Russia: "Forest Statistical" (1873), "Economic Statistical", (by the Department of Agriculture; 1851), and "Statistical of the Most Important Sectors of the Manufacturing Industry of the European Part" with by-name lists of factories and plants of the Department of Trade and Manufactures (1869). They provided information in statistical format. Representation of true geographical locations of the objects was not required.

Russia was transitioning from the feudal and industrial-serfdom relationships to the industrial-capitalist system. Feudal relationships impeded economic development and division of labor. Serfdom workhouses were transforming into plants. It was necessary as quickly as possible to be able to obtain information about the current state of affairs. At approximately same time

(1861) serfdom was abolished in Russia. According to the law of 1906, peasants received the right to leave the communities to establish farmsteads. The prior existing form of peasant land tenure had led to fragmentation of farms in the central provinces of the European part of Russia and the lack of available land. P.A. Stolypin's reform was aimed at solving the problem of land shortage through resettlement of peasants in Siberia.

In 1914, a fundamental comprehensive "Atlas of Siberia" was published by the Resettlement Division of the Main Department of Land Development and Agriculture. The atlas contained maps of natural land conditions in Siberia, the existing forms of land use, and a series of sectoral maps of locations of various types of agricultural activities, resettlement conditions, and land-use types. Prior to the release of the atlas, the Resettlement Division in 1911, 1912, and 1913, created maps for the settled areas of the part of the Urals at a scale of 1:1680000. In addition to the maps on resettlement and economic sectors (farming, life stock breeding, fishing, hunting), the atlas contained three volumes of text on geography and economics. This was the first scientific reference atlas in Russia in the beginning of the XX century.

The "Great Soviet World Atlas" (GSWA) represented a special stage in the development of thematic mapping. It was created by the decision of the Central Executive Committee and the Council of People's Commissars from December 17, 1933.

For this purpose, a special institute was established, whose function was to develop a program of the atlas, identify agencies and organizations that had to provide information, and involve in work on the atlas the best scientists of the country.

The original design of the atlas included three volumes. The first volume contained maps of the world. The second volume contained maps of Russia. The third volume contained maps of foreign countries.

The first volume had the following maps:

geographical representations of the Earth (the V century BC map of Hecate, the II century BC Ptolemy map; hemispheres from the 1492 M. Behaim's Atlas; maps of expeditions and discoveries [from 1200 to 1918]); a series of physical maps of the hemispheres; bathymetric maps of the oceans (Atlantic, Pacific, and Indian) with data on the temperature at the water surface (February and August), atmospheric pressure, wind, and salinity at the surface of the water;

the Arctic (with the routes of scientific expedition from different countries);maps of the Kara and Barents Seas. A map of Atlantic;

maps of the world (the magnetic declination, gravimetric, volcanic activity, epicenters of catastrophic and devastating earthquakes);

a series of maps on deposits, climate (atmospheric pressure, wind, precipitation, temperature), and the Köppen climate classification.

a series of global maps on soils (135 types), vegetation, zoography (with the distribution of animal species);

a series of maps on population density, nationalities, tribes, and religion;

economic mapson electrification (the world and Western Europe), maps on coal and oil industries, ferrous and nonferrous metals, machinery, chemical industry in the capitalist countries, as well as maps of rubber and chemical raw materials;

maps of forest and paper industry; textile raw materials, and food products;

Makarov's point-map on farming (point weight is 50 thousand ha);

mapson fisheries;

a series of transportation maps: water and rail.

The GSWA contained maps on financial leverage of capitalist countries (export of capital and capital investment spheres, markets and raw materials markets) and political maps (1785) ‚world' division of 1784-1876 and 1877-1914, maps on competing powers before the first world war of 1914-1918, the first world war – the military operations and the theater of war; the political map of the world (in 1933), the map of the pacific ocean, and the map on economic cooperation of the pacific nations.

Such a detailed description of the subjects of the first volume of the GSWA, which was created in just three years, demonstrates how multifaceted and original the themes of the maps were. It also explains the reaction of the scientific community to the Atlas when it was shown at the World Exhibition in Paris in 1937 and where it was awarded the "Grand Prix" diploma.

The second GSWA volume contained economic and natural-environment maps of the USSR and its regions; it was published in 1940 and was presented at the International Fair in New York where it also sparked great interest in the scientific community.

The third GSWA volume has not been published because of the outbreak of the Second World War.

Almost simultaneously with the GSWA, several cartographic products were released: “Atlas of Industrial Sectors of the USSR” in five volumes (1929-1935) and “Atlas of Energy Resources of the USSR” (1933-1935).

The next scientific-information atlas created in Russia was the atlas on physico-geographical conditions of the world.

The Physico-Geographical Atlas of the World (PGAW). Twenty five years had passed since the publication of the GSWA. A large volume of information on natural environment had been accumulated over this period. Comparison of the GSWA and the PGAW legends show the increase in the volume of the accumulated information; specifically, the volume of information had increased in the areas of geology-geomorphological and soil and vegetation sciences three-, two-, and four-fold, respectively. The principles and methods of mapping of the natural environment had changed also.

The main purpose of the PGAW (Gerasimov, Leontiev, 1967) was to reflect as best as possible a complete and precise situation in the natural environment of the world using modern theories of geography and cartography. In terms of its content, the atlas was unrivaled at the time.

An example of thematic map of the second half of the XX century (Fig. 5).

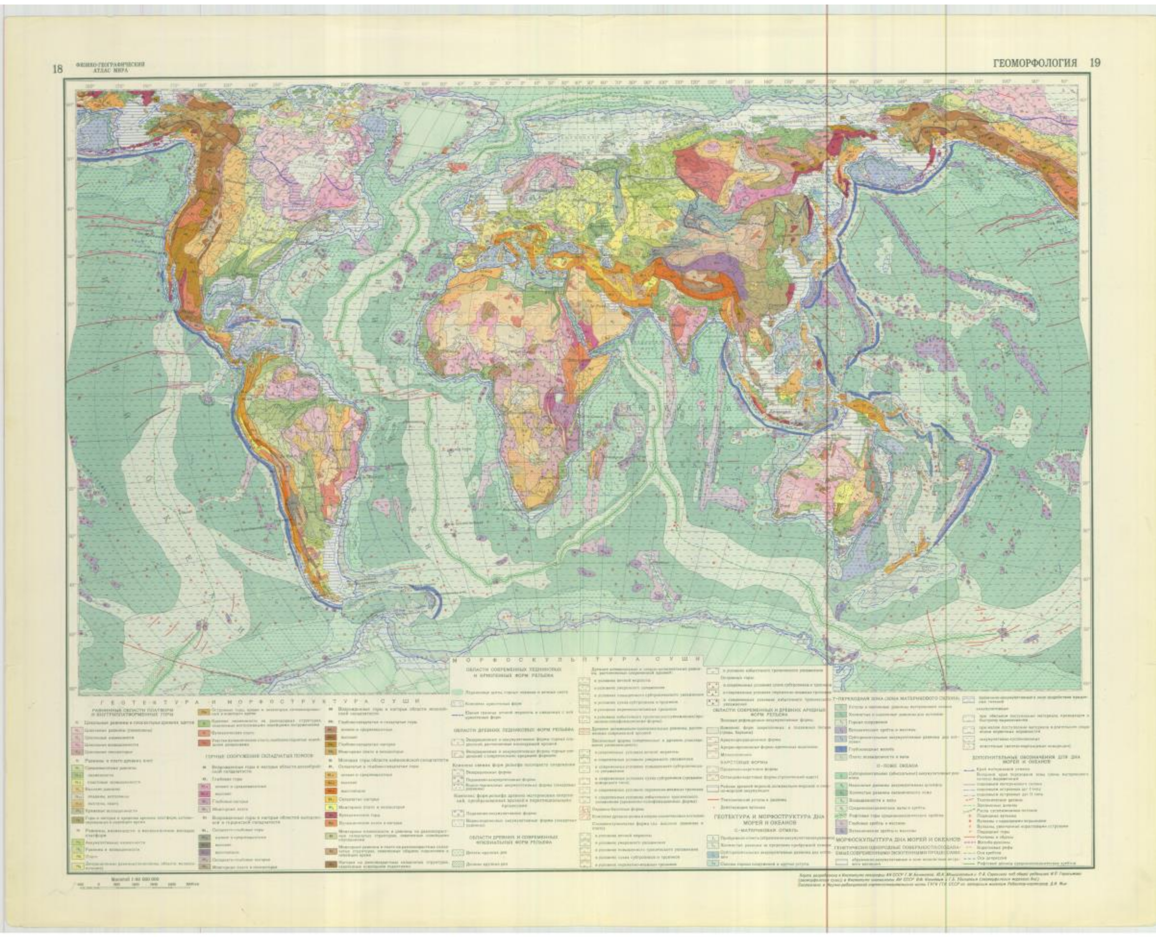

Fig. 5. Geomorphologic Map (in: Physico-Geographical Atlas of the World), Moscow, 1964. Scale 1:60000000

The atlas was created at the initiative of the Institute of Geography of the USSR, together with the Geological Committee of the USSR, the Hydrometeorological Service of the USSR, and the Ministry of Higher and Specialized Secondary Education of the USSR. Hundreds of experts in the field of geology and geography and the leading scientists of the country were involved in the creation of the atlas. The atlas included three main regional levels: world, continents, and the USSR.

The atlas had eight sections and included maps of the world; the Arctic and Antarctic; Europe, including the territory of the USSR to the Urals and part of West Siberia; Asia, Africa, North America, South America, Australia; and several maps of the USSR.

The maps of these eight sections described the relief, tectonics, geology of mineral resources, geomorphology, climate, vegetation, and fauna. Each section ended with physico-geographical zoning maps. The section on the USSR had the largest number of maps. Climate and surface- and groundwater were presented in great detail. At the end of the atlas, there was a textual part on the natural conditions of the continents and oceans.

The main scales of the PGAW were: world – 1:80 000 000 and 1:60 000 000; Europe – 1:7 500 000; Asia – 1:25 000 000 and 1:40 000 000; Africa, North and South America – 1:20 000000 and 1:30 000 000; Australia – 1:25 000 000 and 1:30 000 000; USSR– 1:15 000 000, 1:20 000 000 and 1:35 000 000 (climate).

It should be noted that the PGAW, for the first time in the history of atlas mapping, has emphasized map adjustment and reference. This greatly increased the value of information and, above all, scientific credibility of the atlas (demonstration of genetic links of the mapped objects). The atlas improved assessments (in comparison with the World Atlas of 1962) of the land areas of Asia (+1.25 %), Africa (+0.31 %), Australia (-3.39 %), North America (+0.96 %), South America (-0.76 %), and Europe (-7.68 %).

Among the major atlas products, several other atlases should be mentioned: “Climate Atlas of the USSR” (1960-1962), “Atlas of Earthquakes in the USSR” (1962), “Atlas of the World” (1964), “Physical Atlas of the World” (1964), “Atlas of the Antarctic” (1966, 1969), “Atlas of the Economy and Culture of the USSR” (1967), “Agroclimatic Atlas of the World” (1972), “Atlas of the Oceans” in five volumes (1974, 1977, 1980, 1993, 1996, and 2005), “Geologic- Geophysical Atlas of the Indian Ocean” (1975), “Atlas of the Arctic” (1985), “Geologic- Geophysical Atlas of the Atlantic Ocean” (1990), and other products. This is far from the complete list but it demonstrates the breadth of scientific research and high level of utilization of thematic mapping in fundamental research.

The end of the XX century in Russia was marked by the publication of the major fundamental atlases: “Atlas of Snow and Ice Resources of the World” (1997), “Our Earth” (1997), “The Nature and Resources of the Earth” in two volumes (1998), and “Atlas of the World” (1999). These atlases continued the traditions of the Russian school of geographical cartography and are the products of a new generation in terms of thematic presentation, the character of information used, and application of remote sensing and methods of creation and publication. The digital comprehensive atlas of the continents “Our Earth” was developed as an active geographical information system with the use of ArcInfo and ArcView and became the first interactive atlas of the Earth. The “Atlas of Snow and Ice Resources of the World” won the highest Prize of the Government in the Field of Science and Technology.

Several thematic atlases cover the entire country’s territory: “Agricultural Atlas of the USSR” (1960), “Atlas of Economy and Culture of the USSR” (1967), “Forest Atlas” (1973), “Atlas of Ranges and Resources of Medicinal Plants” (1976), and many other products.

Thus, a scientific school of comprehensive atlas mapping has formed in Russia; M.V. Lomonosov Moscow State University (MSU) and the Institutes of Geography of the Russian Academy of Sciences (IG RAS) and the Siberian Branch of the Russian Academy of Sciences (IG SB RAS) played the leading roles. Scientific experience of these and other organizations and scientific and technological potential of the enterprises of “Roskartographiya” and other institutions supports the statement that Russia at that time had accumulated sufficient scientific and technological potential to produce its own national atlas discussed at the end of this paper.

Influence of traditions on the modern state of thematic mapping. *Mapping of the seas and oceans.* Marine cartography represents a special epoch in thematic mapping. First of all, we should mention the “Naval Atlas” (1950-1953). This atlas became an outstanding cartographic product. It was created by the Naval General Staff and commissioned by the Council of Ministers of the USSR. Many organizations participated in its creation: research institutes of the USSR Academy of Sciences, universities, the General Directorate for Hydrometeorology, All-Union Geographical Society, etc. The atlas was based on a large volume of factual data. The first volume was published in 1950 and contained general navigation-geographical characteristics of the oceans and seas and showed the main world's ports. The atlas maps presented similar detailed topographic description of the seas and land (isobaths and contours), i.e., the maps rendered the global surface.

The second volume (1953) included maps of the natural conditions of the World Ocean. The maps also presented characteristics of water and land. For example, sea currents were shown on a supplemental map together with wind directions on land, which influence the currents. The relationships and interactions were reflected on a set of hydrological and climatic maps: reconciled maps on thermal balance and atmospheric circulations, climate and hydrography, etc.

The third volume of the atlas described the history of naval theory and battles from the ancient time to the present day.

The next fundamental work was a five-volume "Atlas of the Oceans": Pacific Ocean (1974); Atlantic Ocean (1977); and Arctic Ocean (1980).

The first three volumes of the atlas had the same structure and contained seven sections: history of oceanic research, oceanic floor, climate, hydrology, hydrochemistry, biogeography, and reference navigation-geographical maps.

The maps "History of Oceanic Research" described expeditions from 1872 to 1970.

The section "Oceanic Floor" had maps on oceanic floor relief, epicenters of earthquakes, volcanoes, tectonics, geomorphology and types of shores, types of precipitation, and a series of bathymetric maps of the oceanic floor. It also had information on morphometry of the oceans and seas (volume, area, maximum depth) with updated calculations based on large-scale nautical naval maps. There were also detailed data on tsunamis and the amount of thermal energy emitted by the oceanic floor – the most important energy characteristic of the Earth.

The basic map scales of the atlas were 1:10 000 000, 1:16 000 000, and 1:12 000 000. In the 1960s-1980s, two more comprehensive fundamental atlases were published ("Atlas of the Antarctic" [1969] and "Atlas of the Arctic" [1985]). The atlases had nearly 300 maps on the natural conditions associated with ice regime and history of exploration of the circumpolar regions.

Environmental mapping. Environmental mapping developed rapidly in the 1990s when data on human impact on the environment became readily available. Approximately at that time, the maximum permitted concentrations (MPC) of pollutants in the atmosphere from industrial and transport emissions – dangerous to human health level – have been established.

Also at that time, the methods for studying pollution and the most efficient sequence of research have been identified: 1) the impact on the natural environment; 2) changes in the natural environment by human activities; and 3) methods of protection of the environment as human habitat. Spatial changes of the state of the environment were presented on environmental maps. Methods of their creation have been developed in Moscow, St. Petersburg, Saratov, and other research centers.

Differentiation of environmental maps took place rather rapidly. The objects of mapping were the ecological state of the atmosphere in the cities; pollution of rivers and other water bodies; contamination of soils and mining sites; the environmental state of forests; etc.

In 1997, the first comprehensive environmental and geographical map of the USSR (scale 1: 4 000 000) was created. Its legend represented a system of tables that assessed the stateof forests, soils, and rivers.

Maps for Higher Education. The Decree of the Ministry of Higher and Secondary Special Education of November 10, 1974, marked the beginning of a new period in development of thematic mapping – maps for higher education. The Decree stated the need for establishment of the Scientific-Editorial Board (SEB).

The MSU Faculty of Geography was charged with the implementation of the work. Prof. K.A. Salishchev, Head of the Department of Cartography and Scientific Advisor of the Fundamental Research Integrated Mapping Laboratory (FRIML), was appointed the SRB Head.

The purpose of the maps for higher education was to provide scientific-informational support of instruction on general fundamental courses in all areas of geography and geology, which was offered at approximately 100 institutions of higher education in the nation, and to create a pool of highly educated experts who possess knowledge on a wide range of subjects.

Prior to the beginning of work, FRIML had defined a preliminary list of thematic and general geographical maps through polling and systematization of the responses form institutions of higher education. This list was discussed and approved by the SEB. It was decided to compile thematic maps of the world (1:15 000 000), of the USSR (1: 4 000 000), and the regions of the USSR (1:10 000 and 1:6 000 000). General geographical maps of the continents were compiled at these scales also. A special basis and projections have been developed for the general geographical maps. A group of homolographic projections with small distortion of angles was selected: the CSRI-GAC arbitrary polyconic projection (M. Urmaeyev) for the world with insert maps of the Antarctic Basin and the Antarctic, which were used for the world map on modern tectonics sand climate. The equidistant conic projection was used for the maps of the USSR. The azimuthal projection was used for the general geographical maps of the continents (scale 1:10 000 000).

A number of internationally renowned scientists were involved in this work: M.A. Glazovskaya, I.P. Zarutskaya, V.I., Fridland, G.V. Dobrovolskyi, O.A. Mazarovich, N.V. Bashenina, O.A. Leontiev, V.E. Khain, R.S. Chalov, A.G. Isachenko, A.N. Rakitnikov, and many others.

Most of the thematic and geographical maps had been created for the first time ever. Among them: "Geographical Zones and Zonal Types of Landscapes of the World"; "Landscape Map of the USSR"; "Soil and its Main Structures of the World"; " Water Balance of the USSR"; "Channel Processes (Morphology and Dynamics of Riverbeds) of the USSR"; "Climatic Zones and Zones of the World"; "Neotectonics of the World"; "The USSR Cryolithozone"; "Nature Protection of the USSR"; "Land Use of the World and the USSR"; "Natural Forage Lands"; "Functional Types of Settlements"; and a number of other maps.

The FRIML and its scientists were the maps' authors and editors. The work on the maps in 1983-1987 and 2000-2001 resulted in creation of over 50 maps, primarily of the world and the USSR, and many general geographical maps of the continents and the USSR and its regions (I.P. Zarutskaya, [Ed.]). A number of maps have been reprinted several times since their creation (Maps for higher education; New maps for higher education).

The work on the maps for higher educational institution represents a separate epoch in thematic mapping and became part of the "golden fund" of the history of thematic cartography of Russia, suggesting its high scientific and methodological level. These maps have made an unprecedented contribution to the development of thematic mapping in Russia. All the wealth of information contained in the maps of the time, existed only as hard copies or as non-vectorized electronic versions. In order to preserve the maps for higher educational institutions, it was necessary to create a system of interconnected databases that use geo information technology and modern media.

At present, the work on a series of maps for higher educational institutions has been resumed. In 2014, several maps were published: "Landscape Geochemistry"; "Peoples and Religions" and "Population of Russia". Several maps have been prepared for publication: "Biomes"; "Mudflows in the World and Russia"; "Metallurgy, Oil, and Gas Industries"; "Transport Network of the World" and "Agriculture of the World" (Tikunov et al., 2014).

Integrated regional atlases. These types of atlas products are similar to the national atlases. The first atlases of this kind in the USSR were the "Atlas of the Moscow Oblast" (1933), "Atlas of the Leningrad Oblast" and "Atlas of the Karelian Autonomous Soviet Socialist Republic" (1934). In the late 1950s, development and publication of comprehensive atlases of the republics, territories, and oblasts of the Soviet Union resumed ("Integrated Atlases of the Republics, Territories, and Oblasts of the USSR," 1961). The 1960s-1980s experience of development of regional atlases gained by the MSU Faculty of Geography has been especially valuable. In terms of their depth and detailed design, these atlases match modern national atlases. A fundamental work "Comprehensive Regional Atlases" (1976) summarized this experience. Atlases of the former Soviet republics (Belarus, Ukraine, Moldova, Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan, Georgia, Armenia, Azerbaijan, Lithuania) published in these years can now be considered the national atlases of these states.

In the middle of the XX century along with comprehensive atlases, several sectorial and problem-oriented atlases were published. They include "Atlas of Ranges and Resources of Medicinal Plants" created by the All-Union Institute of Medicinal Plants (1983), "Climatic Atlas of the USSR" (1960-1963), "Atlas of Agriculture of the USSR" (1960), and a number of other industry atlases; these map products represented fundamental works and contributed greatly to the development of thematic mapping in the USSR.

"Forest Atlas of the USSR" (1973) consisted of three sections: 1. Overview of Forests and Forest Industry (maps of the state of knowledge of forests, forest cover, ranges, main tree species, yield class, timber resources, forest groups); 2. Timber Enterprises and Forest Reserves (reserves of wood in m^3per 1 ha for coniferous and deciduous species); Forest Exploitation and Wood Processing Enterprises; 3. Forests: Location and Species Composition of the Forest Reserves.

In the XX century, comprehensive regional mapping was developing intensely. During this time, a number of regional atlases of the republics, territories, and oblasts were created. The importance of comprehensive multipurpose regional atlases for studies of the national territory and its resources has been recognized by the national geographers; the USSR Geographical Society at its III Congress on 30 January – 7 February, in Kiev, decided to call a special meeting to review the state of affairs in this area of thematic mapping. Such a meeting was held in 1961 at the MSU Faculty of Geography by the Ministry of Higher and Secondary Special Education of the RSFSR co-jointly with the USSR Geographical Society, the Head Office of Geodesy and Cartography (GUGiK), and the Ministry of Geology and Mineral Protection of the USSR. The participants shared their experience of creating atlases of Armenia, Azerbaijan, Georgia, Kyrgyzstan, Uzbekistan, Estonia, Tatarstan, Komi Autonomous Republic and Vologda, and the Voronezh, Irkutsk, Kiev, Kustanai, Moscow, Ryazan, and Yaroslavl oblasts.

The meeting started with reports by K.A. Salishchev "Integrated Atlases of Republics, Territories, and Regions" (objectives and content), I.P. Zarutskaya "Methods of Creation of Comprehensive Regional Atlases" and G.V. Artamonov "Prospects for Work on Comprehensive Atlases of the USSR" (GUGiK).

There were several presentations by faculty members of various departments from the MSU Faculty of Geography and of other organizations on climatic, geologic, hydrologic, relief, geobotany, forest, population, industry, transport construction, agriculture, economic land use, and culture. Comprehensive regional atlases of the1970s-1980s turned to be fundamental multivolume cartographic products. They laid a foundation for new directions of thematic mapping, e.g., assessment cartography ("Atlas of the Tyumen Oblast and the Altai Krai").

Among the more modern regional atlases, we should note the "Atlas of Khanty-Mansi Autonomous Okrug–Yugra" (Gubanov et al., 2009; Kotova et al., 2002). It was commissioned by the Governor of the Autonomous Okrug A.V. Filipenko and was published in two volumes that characterize the history, demography, economy, nature, and environment of the territory. The atlas was created by the MSU Faculty of Geography and the Scientific and Production Center "Monitoring" (Khanty-Mansiysk) in collaboration with a number of leading research and production facilities of the country and the territory and with the active support and participation of the local administration.

The atlas, for the first time ever, presented the territory in a comprehensive way. This territory had been studied relatively well, however, inconsistently, i.e., only for some of its parts and certain themes. The new atlas systemically described the territory with the help of maps, texts, and illustrations using the latest scientific-methodological and technological achievements. The atlas analyzed and generalized long-term research of the territory conducted in the course of oil and gas exploration. These data were not used in the previous atlases of the Tyumen oblast (1971, 1976) and of the Khanty-Mansi Autonomous Okrug (1980).

Two volumes of the atlas contained more than 500 maps, grouped into 26 thematic sections. The conventional map-sections' sequence was inversed. The atlas started with the presentation of the history, population, and economy of the territory, and only then the characteristics of its natural resource potential and current environmental conditions were given; this approach is described in (Tikunov, 2002). Time will tell if this approach is accepted in regional atlas mapping; however, it is clear that it is flexible and applicable in the situations when the object of research in an troposphere is the role of humans in deformation of the integrity of the surrounding environment.

The atlas utilized the sophisticated methodological procedures: 1) multi-level presentation of phenomena and objects on the global, federal, regional, and local levels (and, therefore, at different scales); in some cases, they were presented as anamorphoses; 2) comparative-geographical, for the purpose of presenting features within the county in comparison with other subjects of the Russian Federation. Certain maps were unique and made the users appreciate rather unique natural conditions, and more precisely, adverse living conditions in the region (the highest in the Russian Federation ratio of paludal land to the population density, presence of permafrost, transportation inaccessibility, etc.)

The concept and all its subsequent implementation were built on the idea of sustainable development of the territory. The address of the Governor to the population of the territory and, thus, to all users of the atlas, at the beginning of the atlas, was permeated with the idea of the need to inform and educate the public as an essential condition of its conscious participation in solving the problems of the region and the country in the transition to a balanced development. The atlas can facilitate management decision making process, which would require its transformation into an information system (Tikunov, Yanvareva, 2002).

As was mentioned previously, a special area – assessment cartography – has formed within comprehensive regional atlas mapping. Assessment maps rendered prospects of construction of roads, pipelines, and civil engineering facilities, irrigation of arable land, and favorable living conditions in terms of the natural environment. The natural environment could favor the construction, raise the price of it, or generally be unsuitable for construction. The themes of assessment maps include types of construction or other impacts on the environment. Obstacles to the implementation may include relief, mechanical properties of soils, depth of groundwater, soils strength characteristics, climatic parameters, etc.

Small scale of the maps in the atlases (smaller than 1: 1 000 000) restricted their use to the front end of engineering design. First assessment maps were compiled for the Tyumen and the Altai territories. The Atlas of the Altai Territory (Volume I; 1980) contained a full set of assessment maps: construction of roads, irrigation of arable land, mechanized tillage; living conditions of the population with climatic parameters of temperature and precipitation regime. The "Khanty-Mansi Autonomous Okrug–Yugra" atlas had also a number of assessment maps.

The first "Environmental Atlas of Russia" was published in 2002. It contained environmental assessment of water bodies, forests, soils, and atmospheric air in cities; this atlas won the Prize of the Government of the Russian Federation in the Field of Science and Technology. The atlas consisted of six sections: 1) Conditions of the Formation of the Environment; 2) Anthropogenic Impact on the Environment; 3) Changes in the Natural Environment; 4) the State of the Natural Environment; 5) Medical and Environmental Conditions; 6) Environment and Nature Protection. The atlas was published in electronic and paper versions. Its 128 pages had 93 maps with explanatory texts. The prevailing scale was 1:20 000 000. The environmental-geographical map (scale 1: 4 000 000) and environmental atlas were created at the MSU Faculty of Geography with participation of 11 other organizations. Currently, a new environmental atlas of Russia is in the process of preparation for publication.

The National Atlas of Russia (NAR). Russia and then the Soviet Union in the first half of the last century were close to creating a national atlas, but it did not happen for a number of reasons. In 1914, the comprehensive "Atlas of Asian Russia" was published; its content was close to the idea of a national atlas. However, this atlas did not cover the entire territory of the Russian Empire.

The idea of the creation of the national atlas of the USSR was intensely developing beginning in the late 1950s – early 1960s. However, real steps have been taken only in the late 1980s, when the MSU Faculty of Geography was commissioned by the Production Cartographic Enterprise "Kartographiya" to prepare a scientific report on the issue of the national atlas creation.

The implementation of the NAR project began in 1993, when the Federal Service on Geodesy and Cartography of Russia instructed the Central Scientific Research Institute of Geodesy, Aerial Surveying, and Cartography (CSRI-GAC) to assess the prospect of setting the theme of research work "Development of the Concept, Structure, and Program of the Creation of the National Atlas of Russia." In early 1994, CSRI-GAC prepared the specification of requirements. Due to lack of the necessary financial resources, the effort failed. In 1994, the Government of the Russian Federation adopted the Resolution "On the Federal Target Program for 1994-1995 and until 2000 'Progressive Technologies of Cartographic-Geodesic Support of the Russian Federation', in which the creation of the NARwas identified as one of the most important tasks. In reality, the project implementation began only in 1995, when the Federal Center "Priroda", with participation of researchers and cartographers of 11 scientific and educational institutions, various ministries, and entities, developed a draft concept of the NAR (The basic concepts…; The concept of the National Atlas…) and proposals on the development of the federal target program "The National Atlas of Russia."

The concept defined the main goals, objectives, and scope of the NAR, its structure, content, and organizational issues. According to this concept, the NAR represented a fundamental comprehensive cartographic work designed to provide a holistic view of nature, population, economy, environment, history, and culture of Russia, a body of scientifically processed and coordinated spatial and temporal information on the national scale that is applicable in all sectors of economy, management, science, education, and national defense.

It was decided that the NARwould consist of 10 volumes: "General Geography", "Nature and Resources", "Population and Social Life", "Economy", "Environment", "History," "Culture and National Heritage", "Russia and Space", "Regions of Russia," and the cumulated volume.

All that, being part of the NAR, intended to be an independent cartographic work, which has its own information and cognitive value. The NAR, as a whole, and its individual volumes had to include maps, aerial and satellite images, textual content, references, references to geographical names, etc.

The reference nature of the NAR demanded the use of large-scale maps (for the territory of Russia as a whole, a scale of 1:10 000000 was used), detailed information, reliance on modern scientific concepts and knowledge, and exploratory research. The scientific-reference nature of the NAR and the basic scale of its maps have defined the format (45 × 57 cm). There were supposed to be two versions of the NAR, i.e., a traditional printed and a digital. The use of the same initial information would allow linking processes of creating these two versions.

Beginning in 1997, the work on the NAR was resumed, but as a four-volume edition of the official governmental publication. Its new concept was developed. The NAR came to be regarded a fundamental comprehensive cartographic work designed to give a holistic view of nature, environment, population, economy, history, and culture of the country; each of the volumes represented a separate finished work.

Thus, after five years of work, the NAR was published in four volumes: Volume 1 "General Characteristics of the Territory", Volume 2 "Nature. Environment", Volume 3 "Population. Economy" and Volume 4 "History. Culture."

The first volume "General Characteristics of the Territory" (A.N. Krayuhin [Ed.]) was published in 2004. It was intended to serve as a scientific and cartographic reference source for a wide range of consumers. It contained, in addition to general geographical and reference maps, a significant block of physico-geographical and social-economic characteristics of the country; satellite images were also used. The traditional publication of the first volume of the atlas was supplemented with its electronic version on CD/DVD.

The second volume "Nature. Environment" (V.M. Kotlyakov [Ed.]), was published in 2007. It mapped natural conditions, resources, and the state of the natural environment of Russia. The volume, besides thematic maps, contained a large volume of text, supplemental graphs, photographs, and space images.

The third volume "Population. Economy" (V.S. Tikunov [Ed.]) was published in 2008. Its structure was more complex hierarchically. Thus, its first section "General Characteristics of the Russian Federation" described contemporary Russia's place in the world in regard to various socio-economic parameters, changes of its geo-economic position, spatial aspects of the country's organization, as well as geographical factors of settlement and economy. The second section of the volume was devoted to the characterization of the population, social environment of its habitat, and social development. Accordingly, there were three subsections: the population and resettlement, social sphere, and socio-political development. The third section of the volume "The Economy and Economic Development" include done introductory and four main sections. The structure of the section was based on a logical transition from the general characteristics of the economy (introductory subsection) to a consistent characterization of the main sectors of the economy: Production – Infrastructure - Investments. The themes of the "Production Sphere" were basically related to the "primary" (agriculture, forestry, fishing, and hunting) and "secondary" (industry and construction) sectors of the economy (which is close to the internationally accepted classification of the economy). Finally, the fourth section "Regions and Regional Development" was dedicated to the regional component. Its first part contained a series of comprehensive socio-economic maps for large geographical areas (in some cases, maps of individual entities were included), which reflected their socio-economic structure and the main features of the regional economy.

The final, fourth, volume "History. Culture" (Yu.A. Vedenin[Ed.]) was also published in 2008; it had two sections, on history and on culture. The first section described the main periods of the history of formation and development of the country, starting from characteristics of the ancient peoples and tribes inhabiting the present territory of Russia and ending with the situation at the beginning of this century. The second section provided information not only on the culturebut also on the conditions of formation of the cultural and natural heritage of Russia.

3. Conclusion

Mapping in the XXI century differs radically from the classical cartography of the XX century and earlier periods. It incorporates modeling, GIS technology, electronic mapping, and systemic approach. In all of this, we believe that at the present time, Konstantin Salishchev and Irina Zarutskaya were and still remain the ideologists of modern cartography.

The works of K. A. Salishchev (Integrated atlases…; Salishchev, 1968; Salishchev, 1990 and other) analyzed emerging new ideas and views on the cartography. Having deep understanding of geography, he always argued the need for close connection between cartography and geography. As President of the International Cartographic Association and Chairman of the Commission on National Atlases of the International Geographical Union (during 15 years, from 1956 to 1972), created on his initiative, he promoted his ideas in the country and abroad. K.A. Salishchev participated directly in the creation of fundamental cartographic works (GSWA, PGAW, Naval Atlas, and Atlas of the Oceans) that have always aroused great interest in the scientific community.

I.P. Zarutskaya (Zarutskaya, 1966) created the map adjustment and reconciliation theory and developed methods of its implementation; the theory was also based on the idea of a close connection between cartography and geography. The theory clearly revealed a genetic link between elements of the environment: geology and tectonics; hydrology and climate; soils and vegetation; topography, geology, and tectonics; sea currents, the relief of the ocean floor, and motion of atmosphere; etc.

The current state and prospects of development of Russian thematic cartography are associated not only with revolutionary changes in electronic technologies, but in many respects with the wealth of knowledge, traditions, methodologies, and techniques of mapping and map compilation, which have developed over more than a 300-year history of cartography in Russia.

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