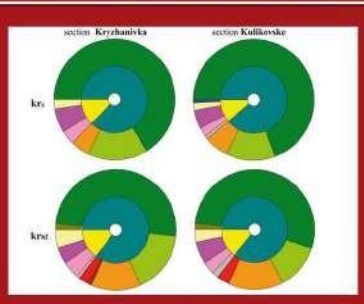
ISSN 2617– 2909 (print)
ISSN 2617– 2119 (online)

Journal of Geology, Geography and Geoecology

http://geology-dnu-dp.ua

2019 /28(4)



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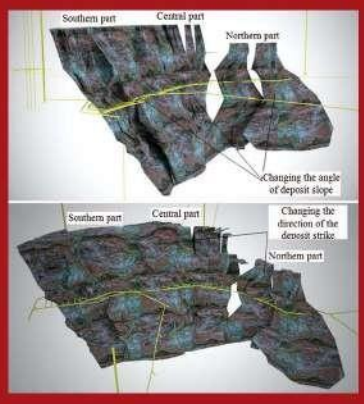

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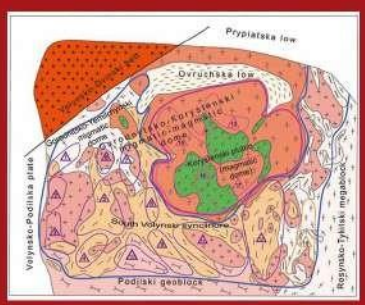

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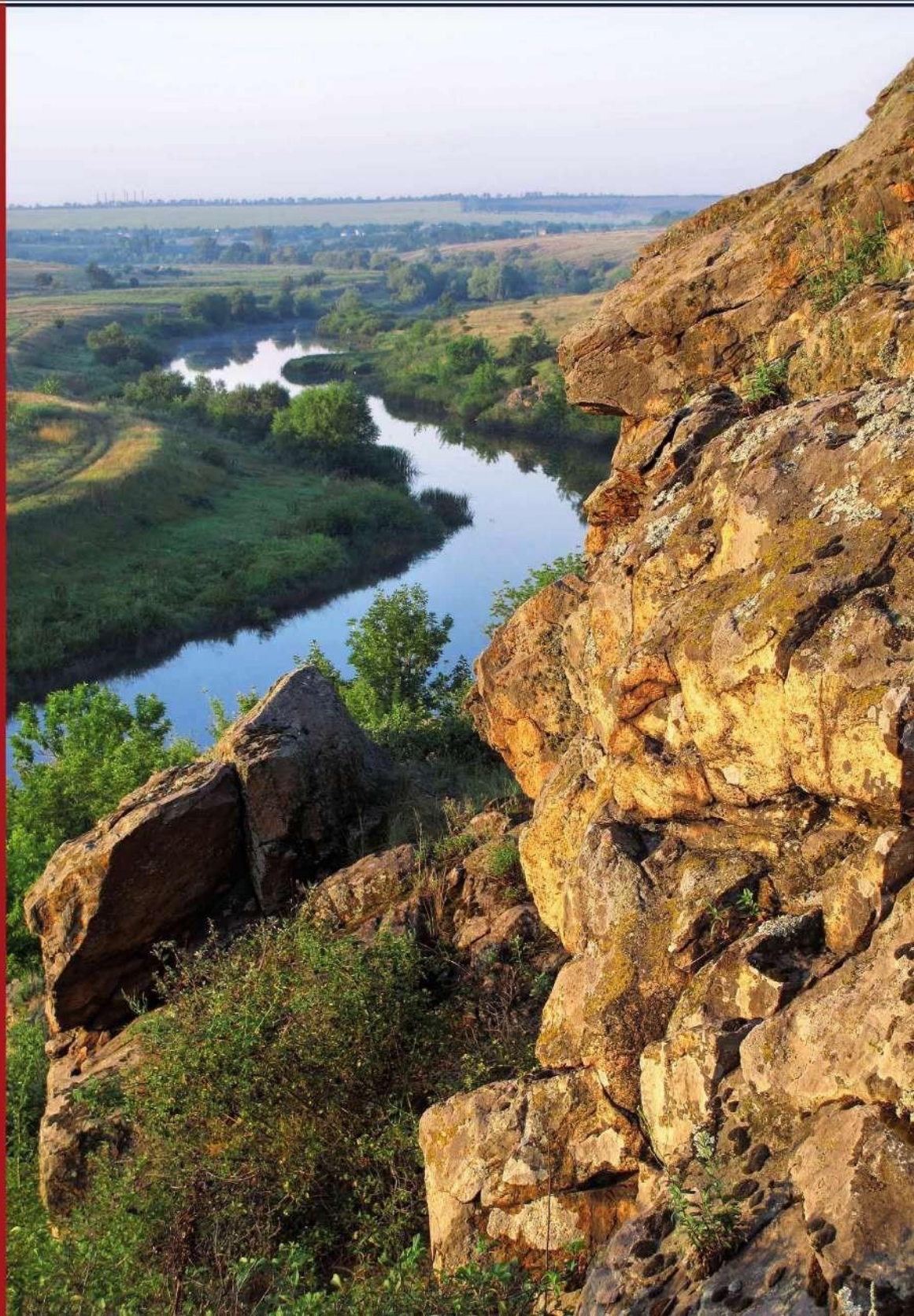

Journal of Geology, Geography and Geoecology

http://geology-dnu-dp.ua 2019 / 28(4)

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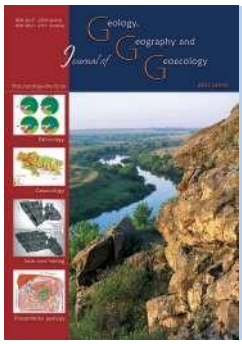
Literary editors: P.V. Bradbeer, M.O. Tikhomyrov.
Cover design: Vadym V. Manyuk.
Text Layout: Vadym V. Manyuk.

Information about publication: Journal of Geology, Geography and Geoecology. (ISSN 2617-2909 (print), ISSN2617-2119 (online). Complete information on the requirements for the publication of copyright articles in the collection can be found on the website of the journal www.geology-dnu.dp.ua or by addressing the **Editor-in-Chief** Volodymyr Manyuk at vgeoman@gmail.com.

Approved by the Decision of the Scientific Council of the Oles Honchar Dnipro National University, 72 Gagarin ave., Dnipro, 49010, Ukraine.



JOURNAL of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(4), 631–639.
doi: 10.15421/111960

Prospects for introducing inclusive rehabilitation and social tourism in Ukraine

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Received: 27.03.2019
Received in revised form: 06.09.2019
Accepted: 16.11.2019

Abstract. The article highlights the theoretical and methodological foundations of inclusive tourism development; substantiates theoretical aspects of the origin and use of the new concept of "inclusive rehabilitation and social tourism"; analyzes the modern world and Ukrainian experience in the development and implementation of inclusive tourism in the tourism sector of Ukraine. The article presents a study of the evolution and future introduction of inclusive tourism in the rehabilitation system of Ukraine, taking into account the peculiarities of the regulatory framework, political and economic problems in the country, and, as a result, the social standard of living of Ukraine. We provide a classification of groups of inclusive tourists according to the types of inclusion and the possibilities of providing rehabilitation services: social group (Chernobyl veterans, pensioners, pregnant women, large families, and others); the group people with disabilities (various groups of disabilities and nosologies), people with "war syndrome" (Afghan War veterans, military from zones of the ATO, displaced people, people with psychological trauma, children of war, war veterans, and others). The priority directions of rehabilitation care professionals were determined depending on the inclusive profile and nosology: therapeutic and recreational, cultural-cognitive, family-youth, professional-labour, non-Olympic physical culture and sports. The components for each segment of rehabilitation and social services for people with inclusion due to tourist activities are identified. A conceptually new theoretical and methodological block model of an"accessible" inclusive environment for rehabilitation of people of various inclusive groups and nosologies is presented. The connection between the main elements of this model of inclusive rehabilitation tourism is established. In order to fully understand the level of the need for the introduction of inclusive tourism in Ukrainian society, not only is a thorough scientific and methodological base needed, but also practical testing of the results.

Keywords: inclusive tourism, people with need for inclusion, small-scale groups, inclusive tourists, rehabilitants

Перспективи впровадження інклюзивного реабілітаційно-соціального туризму в Україні

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Анотація. В статті висвітлені теоретико-методологічні основи розвитку інклюзивного туризму; обґрунтовані теоретичні аспекти походження та використання нового поняття «інклюзивний реабілітаційно-соціальний туризм»; проаналізований сучасний світовий та український досвід розвитку та впровадження інклюзивного туризму в туристичну сферу України. Проведено дослідження еволюції і перспективного впровадження інклюзивного туризму в реабілітаційну систему України, враховуючи особливості нормативно-законодавчої бази, політичних та економічних проблем в країні, і, як наслідок, соціального рівня життя українців. Надана класифікація груп інклюзивних туристів за типами інклюзії та можливостями надання реабілітаційних послуг: соціальна група (чорнобильці, пенсіонери, вагітні жінки, багатодітні сім`ї й інші); група людей з інвалідністю (різні групи інвалідності та нозології); люди з «синдромом війни» (афганці, військові зони АТО, переселенці, які зазнали психологічних травм, діти війни, ветерани війни та інші). Визначені пріоритетні напрями професійної допомоги реабілітантам в залежності від інклюзивного профілю та нозології: лікувально-оздоровчий, культурно-пізнавальний, сімейно-молодіжний, професійно-трудовий, не олімпійський фізкультурно-спортивний види. Визначені складові по кожному сегменту реабілітаційно-соціальних послуг для людей з інклюзією завдяки туристичній діяльності. Надана концептуально нова теоретико-методологічна блокова модель «доступного» інклюзивного середовища для реабілітації людей різних

інклюзивних груп і нозологій. Встановлений зв`язок між основними елементами даної моделі інклюзивного реабілітаційного туризму. Для повного розуміння рівня необхідності впровадження інклюзивного туризму в український соціум необхідна не тільки ґрунтовна науково-методична база, але й практична апробація результатів.

Ключові слова: інклюзивний туризм, люди з інклюзією, маломобільні групи, інклюзивні туристи, реабілітанти

Formulation of the problem. Modern trends in the development of modern society of every civilized country provoke the creation of comfortable living conditions for all segments of the population. The social level of Ukrainian society still lags behind European and world standards, does not respond sufficiently to the acute needs of low-income groups that are included in the category of people with inclusion. The study of the process of integration into society of individuals with inclusion, and, above all, people with disabilities, the development of principles, mechanisms, key directions, substantiation of practical recommendations of this process and the solution of related problems, is an important and urgent task to Ukrainian society.

Despite the efforts observed in Ukraine, the situation about integration of people with disadvantages into society, it`s social activity and professional self-realization are still low. The situation is complicated by the presence of subjective factors: a weak level of public consciousness, self-stigmatization of people with disabilities, their weak motivational mechanisms, instability of incentives for independent living and social adaptation, as well as the lack of practical assistance in the form of a state rehabilitation programme. In our opinion, the most universal and versatile means for restoring a person's general condition is tourism, as a generally recognized means of rest, recreation, adaptation, cognition of the environment, which contributes to the comprehensive rehabilitation of a person.

The scientific idea of this publication is to show that in Ukraine there is a problem of professional assistance to people with inclusion, especially to people with disabilities, and it can be solved by means of geography and tourism, as interdisciplinary research areas in tourism research.

Analysis of previous research. Since 2006, the problems of inclusion have been considered by both foreign specialists from various fields , as well as researchers from Ukraine and the near abroad. Various foreign scientific schools offer a number of research works that highlight the problems of theoretical substantiation and practical application of methods, techniques, practices related to inclusive tourism, in which tourism acts as an accessible, barrier-free environment that helps in the adaptation of people with disabilities.

A general analysis of the academic literature on the subject of "Tourism" indicates a significant number of theoretical works, among which are the works of V. I. Azar, M. B. Birzhakova, JI.H. Zakharova, V.A. Kvartalnova, N. Kobilyatsky, JI.I. Lubysheva, V.D. Panachev, A.A. Terentyev, and others. However, the above authors do not consider purely inclusive tourism in their works.

Many authors, observe the treatment as social institutions directly related to tourism, associate tourism with sports (the touristic institutions includes sports tourism), social protection (the institution social protection includes rehabilitation tourism) and education (the educational institutions includes children's and youth tourism), considering separately rehabilitation or medical assistance.

In the related fields of science (pedagogy, physical culture, sports, medicine), the directions of educational and health tourism are actively developed, which are reflected in the works of: I.A. Droghi, A.A. Ostapets-Sveshnikova, L. Rubis, S.A. Sergeyeva. Besides, the presence of works on the sociology of management and tourism economics - A.V. Aristova, N.I. Ilina, G.M. Malyshev (Russia) and others.

During the last decade, domestic scientists, in particular, S. Bogdanov, G. Gavryushenko, A. Kolupaeva, N. Naida, N. Sofiy, I. Yarmoshchuk, and others, devoted their works to the study of the problem of attracting persons with special needs to study in educational institutions to their rehabilitation and socialization to social norms.

Since the mid-1990s, the subject of the study of recreational geography has been the study of the geospatial patterns of human behaviour in the process of recreational activity and the placement of recreational objects, which were created primarily to defense the doctoral dissertations Krachila MP, Beydika AA, Lyubitseva O .A., as well as through the publication of fundamental and regional monographic publications.

A significant achievement in tourism research is the works B.C. Preobrazhenskyi, Yu.A. Vedenina, I.V. Zorin, M.A. Ananyev, N.P. Zachinyaeva, N.S. Falkovich, E.A. Kotlyarov and other researchers of the Soviet period. During the last decade, Ukrainian researchers, in particular, S. Bogdanov, G. Gavryushenko, A. Kolupaeva, N. Naida, N. Sofiy, I. Yarmoshchuk, and others, devoted to their work to the study of the problem of attracting persons with special educational

needs to educational institutions, their rehabilitation and socialization to social norms («On Approval of the Procedure for the Psychological Rehabilitation of the Participants of the Antiterrorist Operation and the Victims of the Victorious Revolution», 2017). The issue of recreational and tourist services for inclusive tourists has been raised by such investigators as M. P. Krachilo, O. Beydik, O. O. Lyubitseva (Bozhuk, 2009, Malskaya, Khudo, 2007).

The fundamental research on the development and implementation of inclusive tourism in the rehabilitation system of Ukraine, which will be based on a clear application for methodology and mechanisms for the practical use of modern methods of rehabilitation for people with inclusion through tourism services, are at the stage of formation and scientific substantiation in Ukraine.

The purpose. Based on the subject of the article, it is necessary to focus that the purpose of this research is the theoretical substantiation of the concept of "inclusive rehabilitation and social tourism" as an integration direction in geography, which can consolidate all forms, methods and techniques of rehabilitation for people of different inclusive groups with different nosologies and inclusion. In this regard, the main objectives of scientific work on this topic are: the rationale for the introduction of this direction; coverage of forms, methods and approaches to the problem of providing professional assistance to people with inclusion, especially people with disabilities of various forms, using world experience, regulatory framework and the results of research in recent years.

Results. Tourism, as a phenomenon of social life and a derivative of social development, owes its appearance to the industrial stage of human development, which was characterized by the accelerated development of productive forces, the intensification of the division of labour and the development of urbanization processes. Accelerated innovative changes associated with scientific and technological progress contributed to the overall socio-economic development of certain countries, raising the standard of living of their people, changing the nature of work, the way and style of life. Under these conditions the social models of human activity were radically transformed. Tourism has become a form of leisure, as part of an inter-sectoral complex of the country which meet the needs of the population in recreation and rehabilitation, as well as a powerful communicative component of the globalization process (Bogdanov, 2002).

Modern tourism is a multifunctional phenomenon that covers many areas of human activity. Against the background of spectral functions of tourism, the most urgent is recreation as a form of human rehabilitation (Ustimenko, Afanasyeva, 2005).

One of the main and most significant features of tourism activities is that, unlike the branches of material production, the tourism industry does not export a product, but an impression (Natsional′na prohrama profesiynoyi reabilitatsiyi ta zaynyatosti osib z obmezhenymy fizychnymy mozhlyvostyamy na 2006-2010 roky, 2010).

In addition, the tourism sector is associated with the activities of more than 50 industries. Its development contributes to an increase in the level of employment, the level of innovation of the national economy, contributes to the preservation and development of cultural potential, the caring of ecologically safe environment, and the harmonization of relations between various countries and peoples. Tourism is one of the means of implementing the state's foreign policy on the rehabilitation of the population (Proekt «Bezbaryerna Ukrayina», 2016).

According to the UN World Tourism Organization (UNWTO), the contribution of tourism to the global gross domestic product, taking into account the indirect effect, is 10%. The total number of jobs that directly or indirectly relate to the tourism sector is 11%. In 2017, the share of international tourist arrivals increased by 4.4% and amounted to 1,184 million tourists (Bielousova, 2018, Zvit Minsotspolityky za 2017, 2018).

The legal base of Ukraine contains the legal documents, regulations and resolutions: the Constitution of Ukraine, the Laws of Ukraine «On Tourism», «On the Nature Reserve Fund of Ukraine», «On the Development of Tourism and Resorts in Ukraine», «On the Protection of Cultural Heritage», Resolution Of the Cabinet of Ministers of Ukraine dated October 7, 2015 No. 821 «Some issues of implementation in 2015-2017 of the State Regional Development Strategy for the period up to 2020», Order of the Cabinet of Ministers of Ukraine dated March 16, 2017 No. 168-r «On approval of the tourism development strategy and resorts for the period until 2026 «and others (Bielousova, 2018).

Considering the current level of development of society in the world and in Ukraine in particular, it is necessary to state the rapid growth of number of people, and if the conversation is about tourism, then gives rise to the category of inclusive tourists.

If tourism for people with inclusion is considered as a type of recreational tourism designed for people with disabilities, then inclusive tourism (fr. Inclusif -which includes, lat. Include -I conclude, I include) is the process of tourism development, which implies

the availability of tourism for all, in terms of adapting the infrastructure of tourist centers and tourist facilities to the various needs of all people, including people with disabilities, the elderly, their caregivers and family members, people with temporary disabilities, families with small children, pregnant women, children from large families, etc. (Deno, 1970). In the Ukrainian interpretation, the military, who are in the ATO area, Chernobyl victims, temporary migrants from the east of Ukraine, Afghan War veterans etc., are also referred to as inclusive tourists (Bielousova, 2018, Wang, 2009).

Compared with the already known international classifications of people withfor inclusion, Ukraine has its own characteristics, which are dictated by historical events, the features of its development in recent years, and the specifics of internal and external relations. Given this specificity, we propose a classification of groups of people with inclusion who can prospectively undergo rehabilitation in the process of tourism activities: the social group (Chernobyl victims, pensioners, pregnant women, large families and others); the group of people with disabilities (various groups of disabilities, disorders and diseases), people with «war syndrome» (Afghan War veterans, from military zones of the ATO, displaced people, having psychological trauma, children of war, war veterans, and others) (Fig.1).

It is known that the term "inclusive tourism" is currently not final, either in science or in practice. Such a phenomenon is also defined as "tourism for all", "accessible tourism" , "tourism for the disabled", "invaturism", "paratourism", "barrier-free tourism", "rehabilitation tourism", "correctional and educational tourism" and others (Bielousova, 2017).

There are several interpretations of the term «inclusive tourism». In the European Union, the tourism segment for people with disabilities is called "accessible tourism" or "tourism for all." At the same time, the essence of this type of social rehabilitation does not change.

In our opinion, the terms "inclusive tourism" and "tourism accessible to all" are synonymous, and the term "adaptive tourism" reflects the target orientation of tourism activities of persons with special needs in tourism and services. This approach allows us to consider «adaptive tourism» as the possibility of using it in the form of tourist travel in the natural environment. But the term "barrier-free tourism" reflects the degree of fitness of objects displaying the potential of tourism infrastructure and is applied, as a rule, to local tourism or sightseeing activities (Statystyka ta analiz malomobil′nykh verstv naselennya, 2018).

Finally, this term was consolidated in 2009 at the 18th session of the UNWTO General Assembly in Astana (Kazakhstan) in the "Declaration on Facilita-

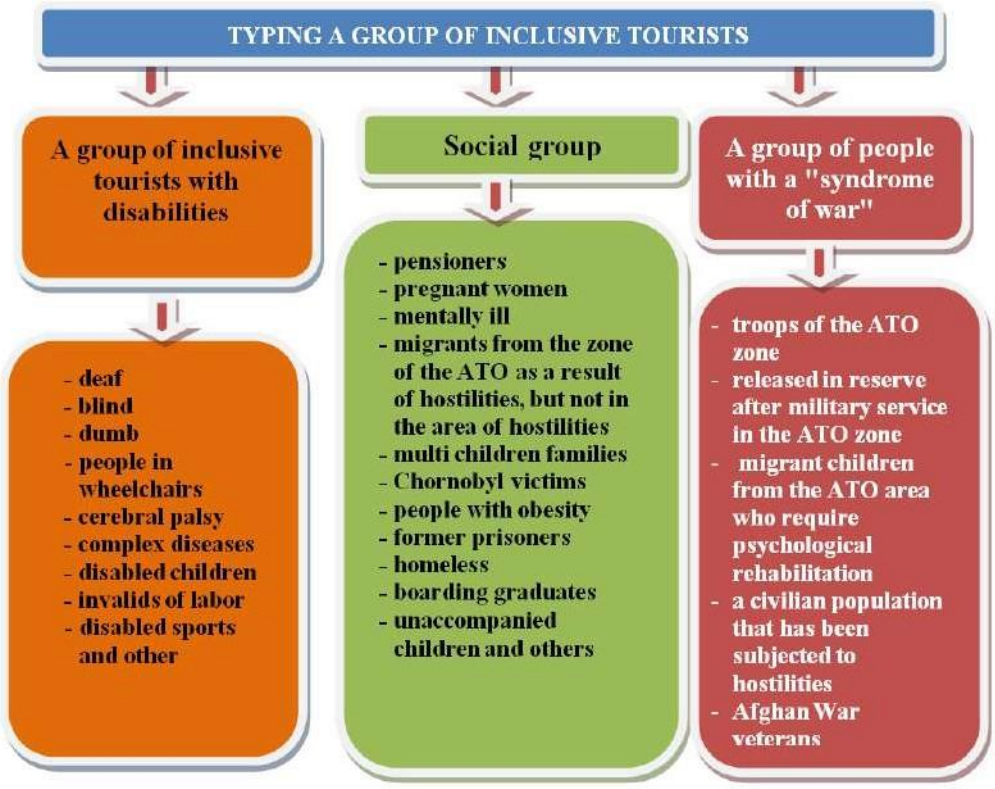

Fig.1. Scheme of classification of groups of inclusive tourists (built by the author)

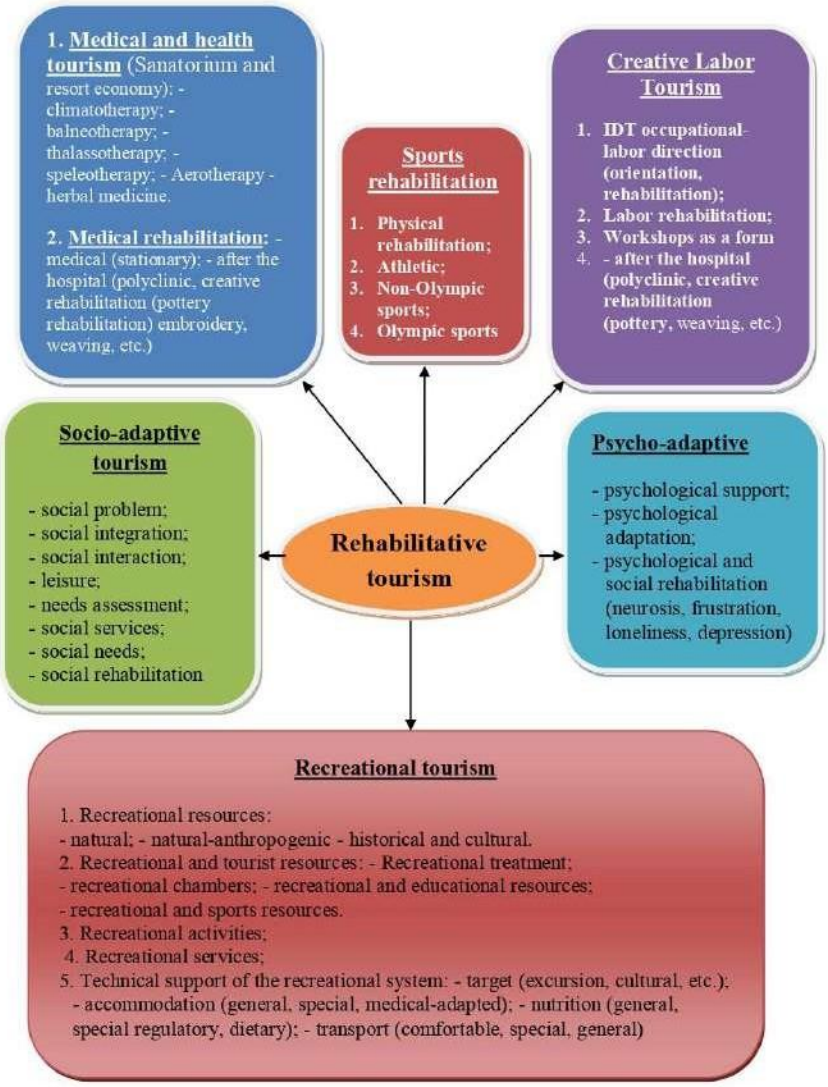

Fig. 2. The main activities of inclusive rehabilitative social tourism

tion of Tourist Travel", in which countries, members of UNWTO, proposed to create tourist facilities and institutions on the territories that would be accessible to people with disabilities, to publish clear and accessible information about existing reception services for them, as well as the problems that they may encounter during their trip (Bielousova, 2017).

Inclusive tourism can also be viewed as a form of tourism which includes the process of cooperation between various participants in the tourism industry. This allows all inclusive categories, especially people with special needs, to be involved in tourism infrastructure using an accessible environment, including mobile, visual, auditory and cognitive components of accessibility, to function independently, as equal minds, with dignity by the universal tourist products, services and environments (Zakon Ukrayiny «Pro kurorty», 2000).

The main activities of inclusive rehabilitative social tourism are medical and recreational, cultural and educational, family and youth, vocational and labour, non-Olympic physical culture and sports types (Fig. 2).

Rehabilitation of people with disabilities is presented to us as a system of medical, psychological, pedagogical, physical, professional, labour, physical culture, sports, social and everyday activities aimed at providing people with assistance in restoring and compensating for impaired or lost body functions, to achieve and maintain social and material independence, labour adaptation and integration into society, as well as providing people with disabilities with technical and other means of rehabilitation, and medical products (paragraph 11, Art. 1 as amended by Law No. 4213-VI (4213-17) of December 22, 2011 p.) (Bozhuk, 2011, Zminy do st.26 Zakonu Ukrayiny «Pro reabilitatsiyu invalidiv v Ukrayini». Ukhvala Verkhovnoyu Radoyu Ukrayiny, 2018).

An individual rehabilitation programme represents optimal types, forms, volumes, periods of re-

habilitation measures with the definition of the order and place of their implementation, aimed at restoring and compensating for the impaired or lost body functions and abilities of a particular person in order to perform the activities defined in the recommendations of the medical-social expert commission (Lukashevich, Moshak, Shandor,2015).

The development of these areas is preceded by the presence of natural and recreational resources in the form of resort and treatment zones located in the territories for recreational purposes, having natural healing resources and objects of natural, historical and cultural environment and can be used to organize recreational activities - recreation, treatment and tourism, taking into account the services of psychology and psychotherapy and could meet the need for the provision of professional health-rehabilitation services.

Considering the problems of inclusive tourism, we can state its exceptional importance for the social and physical rehabilitation of people with disabilities. The peculiarity of tourism, as a means of recreation and getting knowledge of the surrounding world, is its wide coverage of almost all types of social and physical rehabilitation. It can be presented in the form of the following model in tabular form (Table 1).

The increase in the number of inclusive groups amid deterioration of the social standard of living of the Ukrainian people makes one think about creating a mechanism for solving the problem of professional assistance, including the provision of rehabilitation services through the use of travel services. Modern factors of influence on the general condition of the versatile assistance of rehabilitators, determine the tendency towards a new perception of the problem of creating (restoring or using) recreational and tourist zones and uniting key areas of recreation and rehabilitating people of different inclusive groups into a single system of research and services - rehabilitation geography. Such an approach will help to consider tourism through the prism of a complex of rehabilitation services, the provision of which will involve spatial-geographical aspects, rehabilitation-social, psychological and adaptive form of assistance, taking into account spatial-geographical resources and capabilities of the material and technical base for the rehabilitation of Ukrainian means of tourist services.

Therefore, the issue of comprehensive assistance to rehabilitators has become quite natural, through the development of a substantially new conceptual mod-

Table 1. Model of Social and Physical Rehabilitation of People with Disabilities in Health through Inclusive Tourism

Type of Rehabilitation	Rehabilitation Impacting	Factors
Physical rehab	Recovery	Driving activity, health-improving technologies of adaptive physical culture
	Psycho-emotional influence	Aesthetic influence of natural and cultural environment, impression of tourist trips.
	Social and communicative adaptation	Changing the nature and circle of communication, activities in small groups, changing social role
	Social-household rehabilitation	Activities aimed at self-sufficiency, self-care and organization of everyday life in the conditions of a tourist trip.
	Social and environmental rehabilitation	Mastering the technology of functioning in different environments
Social rehabilitation	Social and communicative adaptation	Changing the nature and circle of communication, activities in small groups, changing social role
	Social-household rehabilitation	Activities aimed at self-sufficiency, self-care and organization of everyday life in the conditions of a tourist trip.
	Social and environmental rehabilitation	Mastering the technology of functioning in different environments
	Socio-pedagogical rehabilitation	Mastering of new knowledge, skills and abilities
	Social and cultural rehabilitation	Excursions, songs, conversations, exhibitions, photo contests, etc.
	Social-psychological rehabilitation	Social activization in the process of holding tourist events, observing the successes of other people with disabilities, the transformation of the worldview

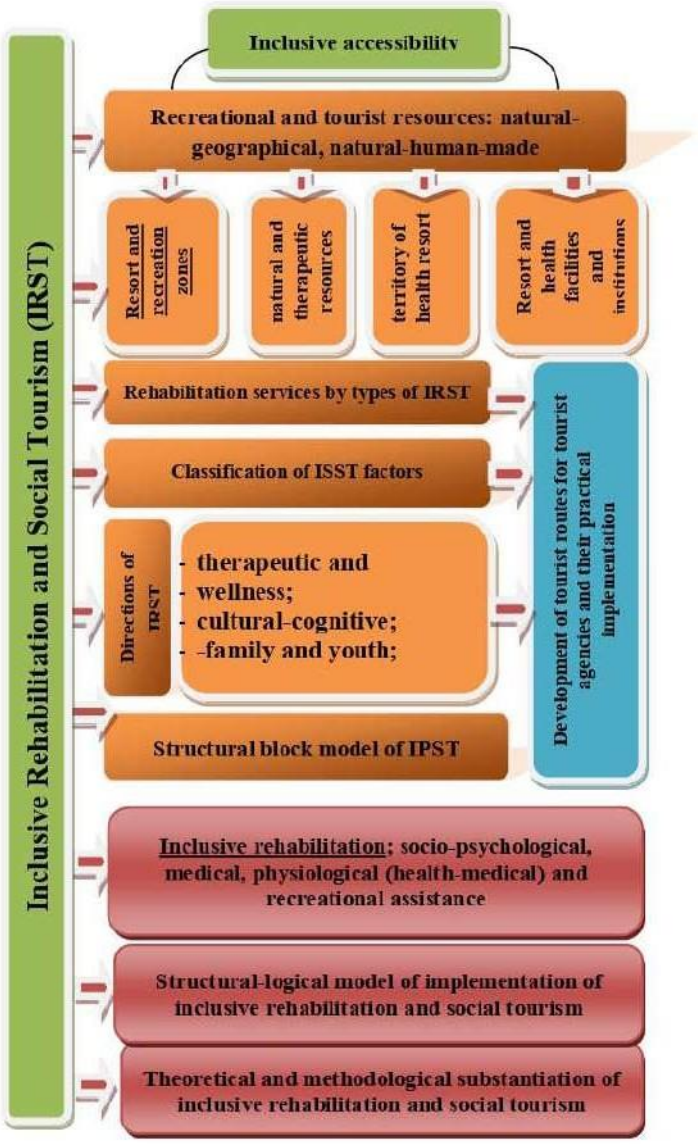

Fig.3. Block diagram of the development and implementation of inclusive rehabilitation and social tourism

el of rehabilitation for people of different inclusive groups and nosologies. Against the background of such a need, previous research, definitions and concepts of the adaptability of people with inclusion were analyzed, followed by the justification of its conceptual model (Fig. 3).

Conclusion. The idea of the development of inclusive rehabilitation and social tourism arose as a result of a number of events in recent years and changes in Ukrainian society: the increase in the number of people with disabilities due to hostilities in eastern Ukraine, expansion of the range of diseases and disabilities due to a decline in the living standards by Ukrainian expenditure indicators), lack of a balanced diet, bad habits, deterioration in the quality of drinking water and environmental instability. All this led to the destabilization of the quality of life of ordinary Ukrainian.

A number of objective and subjective factors characterizing the realities of Ukrainian life have led to the formation of a category of citizens with various inclusions and actual problems of their social inclusion and adaptation. The most effective mechanism for achieving this goal is the development of inclusive social and rehabilitation tourism, which has its own characteristics and, above all, these features relate to the formation of an "environment friendly to people with inclusive needs". Such an environment has local territorial forms and is formed on the basis of the concentration of recreational and tourist resources (balneological, natural recreational, historical and cultural), the operation of specialized rehabilitation institutions and auxiliary infrastructure facilities (social, transport).

The development of these areas is preceded by the availability of natural and recreational resources

in the form of resort and treatment zones located on health-improving lands which have natural healing resources and objects of the natural, historical and cultural environment that can be used to organize recreational activities - recreation, treatment, tourism , taking into account the services of psychologists and psychotherapists and which could meet the need for the provision of professional recreational services.

Accordingly, the formation of an inclusive environment due to diferent researches, in the first place, in the geographical sciences, recreational geography and geography of tourism, geography of services, population and settlement geography, medical geography, etc., which together form an interdisciplinary direction of research that can be described as rehabilitation geography (by target).

At the moment, inclusive rehabilitation and social assistance is one of the least occupied niches of the Ukrainian tourist market. Therefore, the process of comprehensively studying the causes and factors of the increasing number of people who belong to inclusive groups is relevant, and justifying the theoretical and methodological framework with new approaches, methods and techniques of work in the tourism sector is appropriate.

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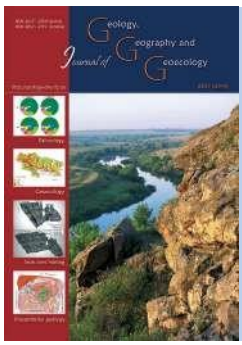

JOURNAL of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(4), 640–648.
doi: 10.15421/111961

The development of the tourist sphere of Ukraine and Zaporizhzha region based on the cluster approach

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Received: 22.05.2019
Received in revised form: 12.06.2019
Accepted: 10.07.2019

Abstract. The research is designed to analyze the development of the tourism industry in Ukraine and its regions based on a cluster approach. The following research methods have been used in order to achieve this goal: dialectical method, analysis and synthesis (when forming the algorithm of the development of tourism industry of the region on the basis of a cluster approach), graphic method (to illustrate the results of the study); system-structural and expert analysis (for determining the composition of organizations of the tourism cluster of Zaporizhzhya region). This article explores the current state of the formation and development of the tourism industry of Ukraine and Zaporizhzhia region based on a cluster approach, as well as perspectives, advantages and problem solving by clustering the tourist industry of Ukraine and its separate regions. The analysis of the development of regions of Ukraine requires the use of new modern approaches in shaping and developing the potential of the tourism industry of the country and its regions, which we believe involves the formation of cluster associations of business entities in a certain region of the country. The algorithm of the formation and development of the tourism industry of the region based on a cluster approach is proposed; the structure of a tourism cluster of the region is proposed, which, unlike the others, should include enterprises (organizations, firms) that are geographically close, the tourism infrastructure, local labour markets, and a tourism product, which is a direct geographical and historical component of the region; a targeted model for the formation of a tourism cluster in Zaporizhzhya region is proposed, which, unlike the existing models, will facilitate the development of the existing models and the creation of new types of tourism (industrial tourism, therapeutic and recreational tourism, adaptive tourism and active recreational activities). Using the above suggestions will allow the management at various levels of the governance of the tourism cluster of Ukraine, and Zaporizhzhia region in particular, to take scientifically grounded and organizational decisions on the formation and the development of the tourism industry on the basis of a cluster approach, improve the economic situation (which is characterized by the lack of coordination of actions , which adversely affects the results of activities of the entire tourism industry of the country, obstructs the holding of joint festivals, exhibitions, etc., hampers marketing and scientific investigation, progress being held back by the lack of sufficient funding, the lack of qualified personnel of the given specialty, lack of managerial knowledge and the necessary information resources) through the establishment of interaction and cooperation.

Keywords: tourism clusters; tourist clusters; tourist potential, region, competitiveness, structure of tourist cluster.

Розвиток туристичної галузі України та Запорізького регіону на основі кластерного підходу

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Анотація. Досліджено аналіз розвитку туристичної галузі України та її регіонів на основі кластерного підходу. Для вирішення поставленої мети у роботі використано такі методи дослідження: діалектичний метод, аналізу та синтезу (при формуванні алгоритму розвитку туристичної галузі регіону на основі кластерного підходу), графічний метод (для ілюстрації результатів дослідження); системно-структурний та експертний аналіз (для визначення складу організацій туристичного кластеру Запорізького регіону). У роботі досліджено сучасний стан формування та розвитку туристичної галузі України та

Запорізького регіону на основі кластерного підходу, а також перспективи, переваги та вирішення завдань шляхом кластеризації туристичної галузі України та її окремих регіонів. Аналіз розвитку регіонів України потребує використання нових сучасних підходів у формуванні та розвитку потенціалу туристичної галузі країни та її регіонів, яким, на нашу думку, є формування кластерних об'єднань суб'єктів підприємництва певного регіону країни. Запропоновано алгоритм формування та розвитку туристичної галузі регіону на основі кластерного підходу, запропонована структура туристичного кластеру регіону, в якій на відміну від інших, повинні входити підприємства (організації, фірми), які географічно близько розташовані, туристична інфраструктура, місцеві ринки праці, а саме головне туристичний продукт, який є безпосередньо географічною та історичною складовою даного регіону, запропоновано орієнтовану модель формування туристичного кластеру в Запорізькому регіоні, яка на відміну від існуючих сприятиме розвитку існуючих та формування нових видів туризму (промисловий, лікувально-оздоровчий та рекреаційний туризм, адаптивний туризм та активні види відпочинку). Використання наведених пропозицій дозволить керівництву на різних рівнях управління туристичного кластеру України та Запорізького регіону зокрема приймати науково-обґрунтовані та організаційні рішення щодо формування та розвитку туристичної галузі на основі кластерного підходу, поліпшити економічне становище (яке характеризується майже відсутністю координації дій, що негативно впливає на результати діяльності всієї туристичної галузі країни, не дає можливості проводити спільні фестивалі, виставки тощо, маркетингові та наукові дослідження, відсутність достатнього фінансування, недостатністю кваліфікованого персоналу даної спеціальності, управлінських знань та необхідних інформаційних ресурсів) завдяки налагодженню взаємодії та співпраці.

Ключові слова: туризм, кластери, туристичні кластери, туристичний потенціал, регіон, конкурентоспроможність, структура туристичного кластеру.

Introduction. Today, in a fast-moving economy, the tourism industry in Ukraine is viewed as an important economic sector, which will increase the country's economic level. But the approach to managing the tourism industry in Ukraine can be considered as insufficiently effective. Therefore, the relevance of the research is determined by the rapid development of the tourism industry in Ukraine in recent years, which manifests itself in a multidisciplinary nature and is closely interrelated with other related industries of the national economy in each specific territory, which makes it necessary to take into account the particularities of the territorial unit under the current conditions of uncertainty and instability of the internal and external environment.

The aim of the study. The purpose of the article is to study and analyze the tourism industry of Ukraine and Zaporizhzhya region in particular, and to substantiate the expediency of the development of this industry on the basis of a cluster approach.

Materials and methods. The research was carried out on the basis of regulatory documents that regulate the tourism activity of Ukraine in general and Zaporizhzhia region in particular, as well as on statistical data of the Main Department of Statistics of Zaporizhzhya Oblast, Zaporizhzhya City Council, Ministry of Economic Development and Trade of Ukraine, etc. The theoretical and methodological basis was the position of the theory of tourism, the study by leading foreign and domestic specialists on the development of the tourism industry in the country and its individual regions on the basis of a cluster approach. For accurate research, official data from the State Statistics Service of Ukraine was used. The following research methods were used in the article: dialectical method, analysis and synthesis (when forming the algorithm of development of the tourism industry of the region on the basis of a cluster approach), graphical method (to illustrate the results of the study); system-structural and expert analysis (for determining the composition of organizations of a tourism cluster of Zaporizhzhya region).

Results and discussion. The issues of functioning and the development of regional clusters of the tourism industry, increasing the competitiveness of enterprises of the tourism industry of Ukraine and its regions, in particular, have been dealt with by both domestic and foreign scholars. In particular, the work of foreign scholars deserves special importance, first of all, the work of M. Porter, the founder of the cluster approach ,should be noted (Porter, 2001). Contribution to the development of this problem has also been made by T. Andersson (Andersson & Schwaag-Serger & Sorvik & Hansson, 2004), E. Braun, van W. Winden (Leo van den Berg & Erik Braun & Willem van Winden, 2001), D Soulie (1989), M. Steiner, JA Tolenado (Tolenado, 1978), C.Cooper and M.Hall (Cooper & Hall, 2002) and many others.

In recent years, interest in the cluster approach has grown among academics - economists of Ukraine, Russia and the countries of the near abroad. This problem was developed by: M. Voynarenko (Vojnarenko, 2011), T. Tsyhan (Cihan, 2003), I. Filip Filchuk (Filippchuk), S. I. Sokolenko (Sokolenko, 2004), Yu. O. Nikolayev (Nikolaev, 2012), A. T. Okhrimenko (Okhrymenko, 2013) and others.

Theoretical aspects and practical solutions to the problems of creating and operating tourist clusters in Ukraine and its regions are reflected in the studies of V. Blagodatnogo, L. Zaburannaya, A. Kulik, T. Pinchuk, M. Rutinsky, L. Teblyashkina, T. Tkachenko, L. Shulgina and others. Hayduk A.B. (Ghajduk,

2006) in his studies highlights the key aspects of the formation and functioning of integrated tourist groups in Ukraine.

The scientific results of these works have become sufficiently distributed and have been further introduced in the process of formation and development of tourist clusters in Ukraine, namely: the authors have formed clusters of the tourism industry, which include: natural and cultural heritage, tourist infrastructure, educational, design and scientific institutions, insurance and financial organizations, etc. The authors have proved the important role of clusters in the development of regional economic tourism systems, and so on. Despite the large number of theoretical and practical studies on the significance of cluster functioning in the tourism sector, there is no general idea of the model for its implementation.

The tourist industry can be considered as one of the elements of the mechanism aimed at overcoming the crisis situation, a promising direction of socio-economic development of the country. This can be achieved by consistent and responsible actions of the government, its continuous interaction with the public and business (Shupyk, 2014).

Effective management and development of the potential of the tourism industry in Ukraine and its regions can be achieved through the search, implementation and adaptation to the current economic conditions of operation, innovative tools and methods for improving the processes of making management decisions (Herasymchuk & Bilyk, 2014; Komlichenko & Rotan, 2014).

Therefore, in order to ensure the development and successful operation of the tourism potential of the region, new methods of management of the industry are needed. Many researchers consider the most effective model to be the use of a cluster approach to the management of the tourism industry.

It is the cluster approach that can accelerate the process of structuring and modernizing the tourism industry of Ukraine and its regions and turn it into an effective segment of the national economy.

In order to form and develop the tourism industry, in our opinion, it is advisable to use an approach which uses a comprehensive assessment of the country's tourism industry and its individual regions.

Taking into account Ukrainian and foreign studies on the formation and development of the cluster approach to the tourism industry and the concept of cluster policy of the country, we propose some methodological aspects of the clusterization of the tourism industry in Ukraine and its individual regions, the general scheme of which is presented in Fig. 1.

The structure of the tourist cluster should include enterprises (organizations, firms) that are geographically close, tourist infrastructure, local labour markets, and the most important is a tourist product, which is directly the geographical and historical component of the region. The interaction of these participants in the tourist cluster is aimed at the release of target products for the cluster (Tymoshenko, 2017).

The main participants of the tourist cluster include: organizations and institutions that are directly related to the development and implementation of a tourist product (travel companes and travel agencies), sanatoriums, health-improving establishments and tourist accommodation establishments (hotels, recreation centers, campsites and etc.), skiing complexes, national natural parks; organizations supplying products (food products, resource base for medical and sanitary procedures), excursion, transport and licensing enterprises, transport infrastructure; trade enterprises, insurance and financial organizations, educational and research establishments, mass media, state regulatory bodies (Figure 2).

The tourist cluster objects proposed in the investigaton can be supplemented depending on the connections and the level of the cluster formation.

Uniting enterprises and related sectors of the tourism industry into a cluster should facilitate improvement of the economic situation (which is characterized by lack of coordination of actions , which negatively affects the results of the entire tourism industry of the country, and obstructs the holding of joint festivals, exhibitions, etc., marketing investgatons and research , the situation being characterized by lack of sufficient funding, the lack of qualified personnel of this specialty, lack of managerial knowledge and necessary information resources) through the establshment of interaction and cooperation (Danjko, 2014).

Clustering of the tourist industry of Ukraine and its individual regions will provide significant advantages and will solve the following tasks:

to increase the tourist flow to the region;

to increase the sales volume of a tourism product;

to create more opportunities to reduce prices by increasing group purchases of tourism products;

to make a transition from sales of certain types of services to joint solving complex task – a 'turnkey' system, providing the entire list of services;

to minimize costs due to joint activities in the field of marketing, advertising, management, acquisition or the development of innovative products of a tourism package;

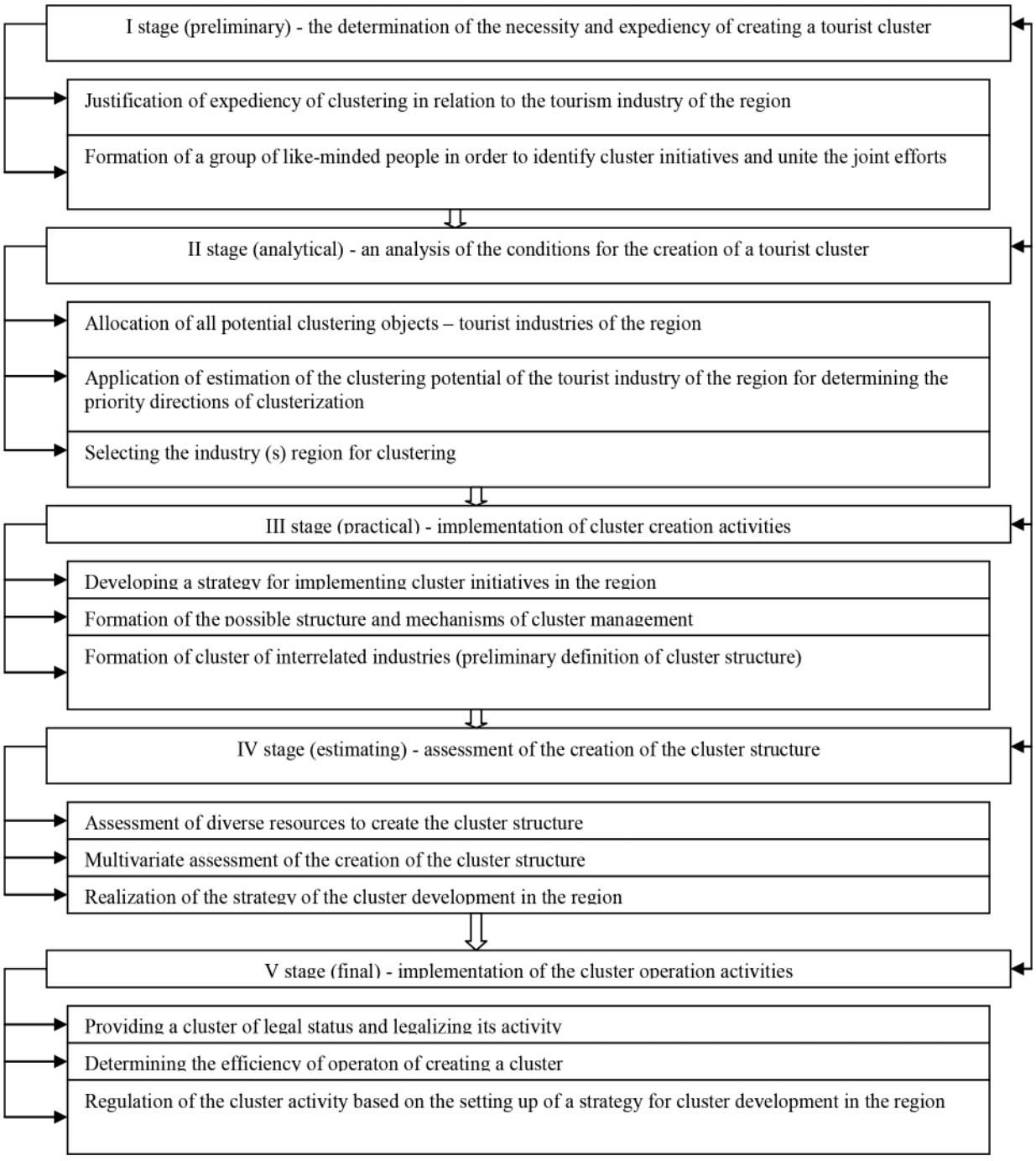

Fig. 1. An algorithm for the formation and development of the tourism industry in the region on the basis of a cluster approach

to increase the portfolio of orders, to expand the sales market, to take leadership positions, to dictate the rules of the game on the sales markets for services;

to improve the quality of services offered, and thus to attract customers not only to the range of services but, above all, to the quality of services, their novelty and the level of servicing;

to increase the investment attractiveness of each of the participants in the cluster;

to form a model of effective management of the industry enterprses, which will include the best of the existing models in organizations (due to the interpenetration of corporate cultures, the adoption of the most valuable ideas and concepts by the management personnel);

to create a new common brand that will be supported by the already existing reputation of all cluster-based organizations that will enhance the reputation of both the cluster as a whole and individual organizations in particular, which will further promote products and services (including international markets);

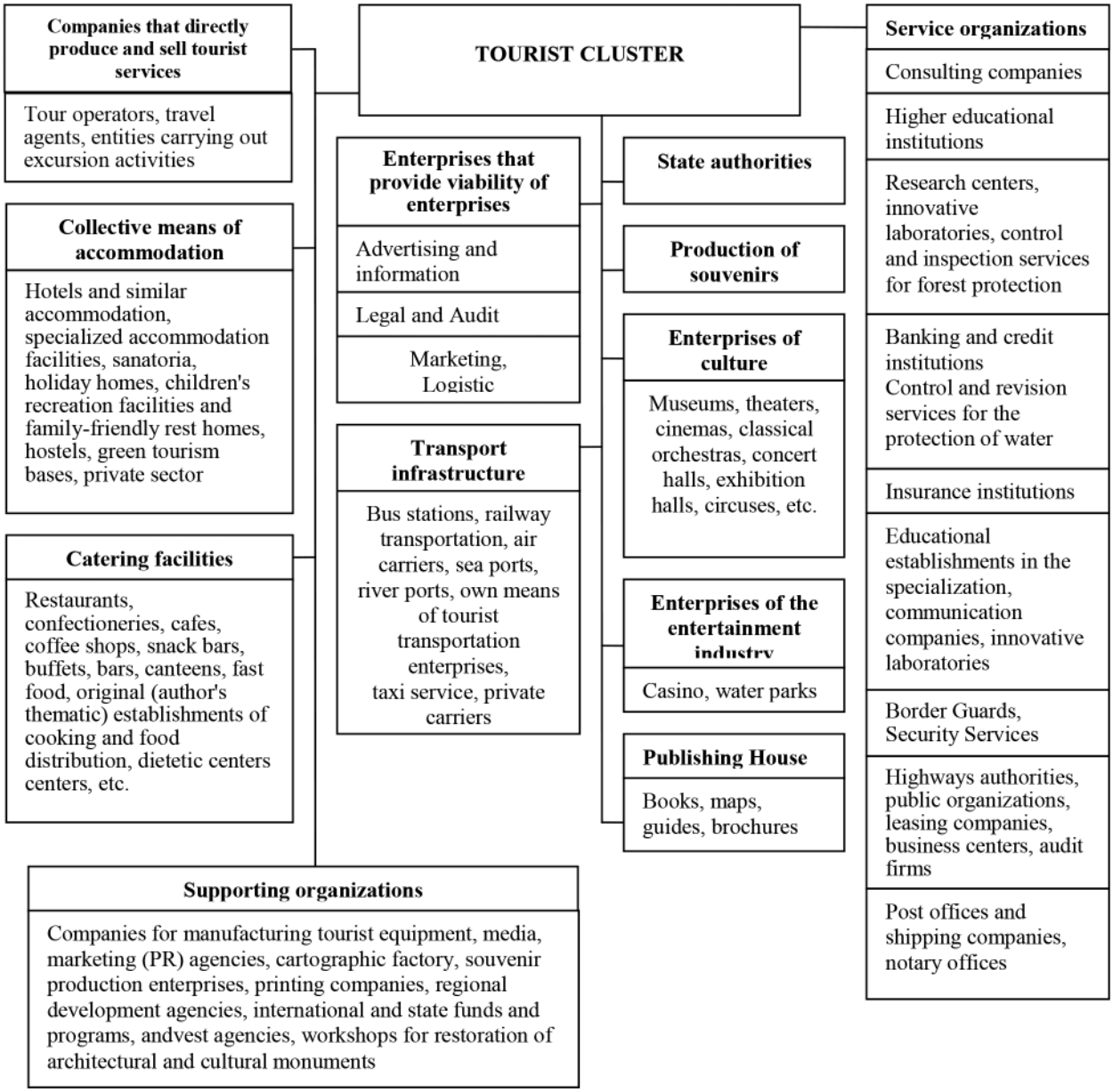

Fig. 2. The structure of the tourist cluster of the region

to reduce expenses for exhibitions, festivals, fairs, presentations, etc.;

to increase competitiveness;

to provide mutual support in concluding contracts;

to give the possibility of purchasing equipment and materials at lower prices;

to promote the development of such types of tourism as green, rural, health-improving, adaptive, etc., because they are the most promising forms of tourism of the country and its regions, which offer a high level of natural beauty and will promote the development of this industry;

to improve the quality of existing competitive tourism products and expand the range of tourist and recreational services (Javorsjkyj, 2015).

Clustering of the tourism industry in the regions of Ukraine should intensify business by concentrating business activity, promote the creation of workplaces, improve the quality of tourist services, increase incomes, and increase the competitiveness of the tourism industry by combining financial, labour, intellectual, natural and medical and recreational resources. The tourist cluster should promote greater use of innovation and information technologies, establish a relationship between cluster organizations, reorganize and attract more visitors, strengthen the image of the region and improve the quality of travel services.

According to Ocheretina D.V. , improper attention is paid to the development and use of all elements of the tourist potential, the restoration of the growth of the flow of domestic tourism through the study

and promotion of individual regions of Ukraine, the development of new promising areas that wll increase interest in domestic tourism and increase tourist flows (Ocheretin, 2015).

The promotion of the tourism product of certain regions of Ukraine, in particular Zaporizhzhya, is of great importance in the domestic and foreign markets. The image, advertising and marketing of the offered products, as well as the creation of tourist clusters play a significant role in this. To create a tourism cluster in Zaporizhzhya region, it is necessary to assess the tourism potential of the region, to identify the main directions of the current perspective of tourism activities.

The tourist potential of Zaporizhzhya region has the following components:

picturesque landscape – the Sea of Azov, the Dnipro, 4 estuaries: Bilozersky, Utlyuk, Tubalsky and Molochniy;

mineral and medicinal waters – Berdyansk mud seaside resort, Kyryllivsky balneoclimatic mud seaside resort;

historical and architectural attractions – Zaporizhzhya Sich ("Warriors of the Lower Zaporizhzhya"); National Reserve "Khortytsia" and National Historical and Archaeological Reserve "Stone Grave" (XV-XVI centuries); 8,436 historical and cultural monuments, of which 6,654 are archeological monuments, 1,725 are historical, and 37 are of monumental art; 20 – of science and technology, 25 museum establishments;

- a network of sanatoria, where it is possible to recover and heal, and so on.

The main areas of work in the sphere of tourism development in Zaporizhzhya region are:

1. Manufacturing (industrial) tourism focused on the productive use of the special industrial heritage of Zaporizhzhya, as well as the branch of industry that was historically formed as the basis of the modern economy of the city.

2. Cognitive (historical) tourism, the basis of which is the historical component of the city's development and the ethno-cultural diversity of Zaporizhzhya.

Event tourism, which involves organizing and holding annually several events at the national and international levels of an entertainment and sports direction.

4. Extreme tourism. In Zaporizhzhya region it is possible to make parachute jumps and go hang gliding. In Zaporizhzhya there is also bungee-jumping – jumping from height with a rope. (Zaporizhzhya: kudy skhodyty i shcho podyvytysya)

5. Rural (green) tourism. There are 32 agritourism objects in the region, of which 15 have already applied for certificates in the framework of EU projects. There is a historical and cultural complex "Ethnoselo" of two green estates: "Aquazoo" in the village of Petropil and "Yenotova Khata" in the village of Chervony Yar. Soon it is planned to open another one – with a real Ukrainian colouring - "The House of True Patriots". The mansion "Sea Breeze" is located in the village of Novokostyantynivka in Zaporizhzhya region. on the coast of the Sea of Azov, surrounded by saline lakes with therapeutic mud, an analogue of the mud of the famous resort on the Dead Sea in Israel.

6. Therapeutic and health (medical) tourism. In Zaporizhzhya there is a favourable climate, the presence of therapeutic mud and mineral waters, sanatoriums and prophylactic clinics on the shore of the Azov Sea and the Dnipro River.

7. In contrast to many regions of the country, Zaporizhzhya region has a significant natural potential for the development of geological tourism. In Zaporizhzhya region among the 33 objects of the geological heritage of different types (petrographic, mineralogical, geomorphological, etc.) 9 geological monuments are classified into stratigraphic and paleontological objects ("Lysa Hora" (Bald Mountain) in Vasylivka village of Zaporizhzhya region, Khortytsky granite massif (Dnipro Rapids), granite massif "Kamiani Mohyly" (Stone Graves) in Melitopol district, "Lantseva Mogila" (Lantseva Grave) in Kuybyshevsky district, Tokmak-Mohyla (Blue Mountain), "Urochysche Skedy" (Skedy Trail) (Chernihiv district), Veseliansky stratotype of the Konkovo layer, Lugovske and Tokmak location of "Pivdenni sklony" (Southern slopes), the outcrop of Tomakiv strata in Baburka village, etc. (Manyuk, 2008). The Western Azov Sea territory is one of the most attractive regions for the development of geotourism with the largest number of unique objects of geological heritage .Researchers have determined that the most promising place for the development of tourist routes are Proterozoic non-ore quartzites lying along the Berdata Berestovaya river and in the adjoining territories. (Khomenko & Isakov & Manyuk, 2018)

After analyzing the tourism potential of Zaporizhzhya region, we proposed a focused model for forming a tourist cluster in Zaporizhzhya region (Fig. 3).

The main advantages of creating a tourist cluster in Zaporizhzhya region are:

uniting efforts to attract more tourists from the regions of Ukraine and in the struggle against foreign

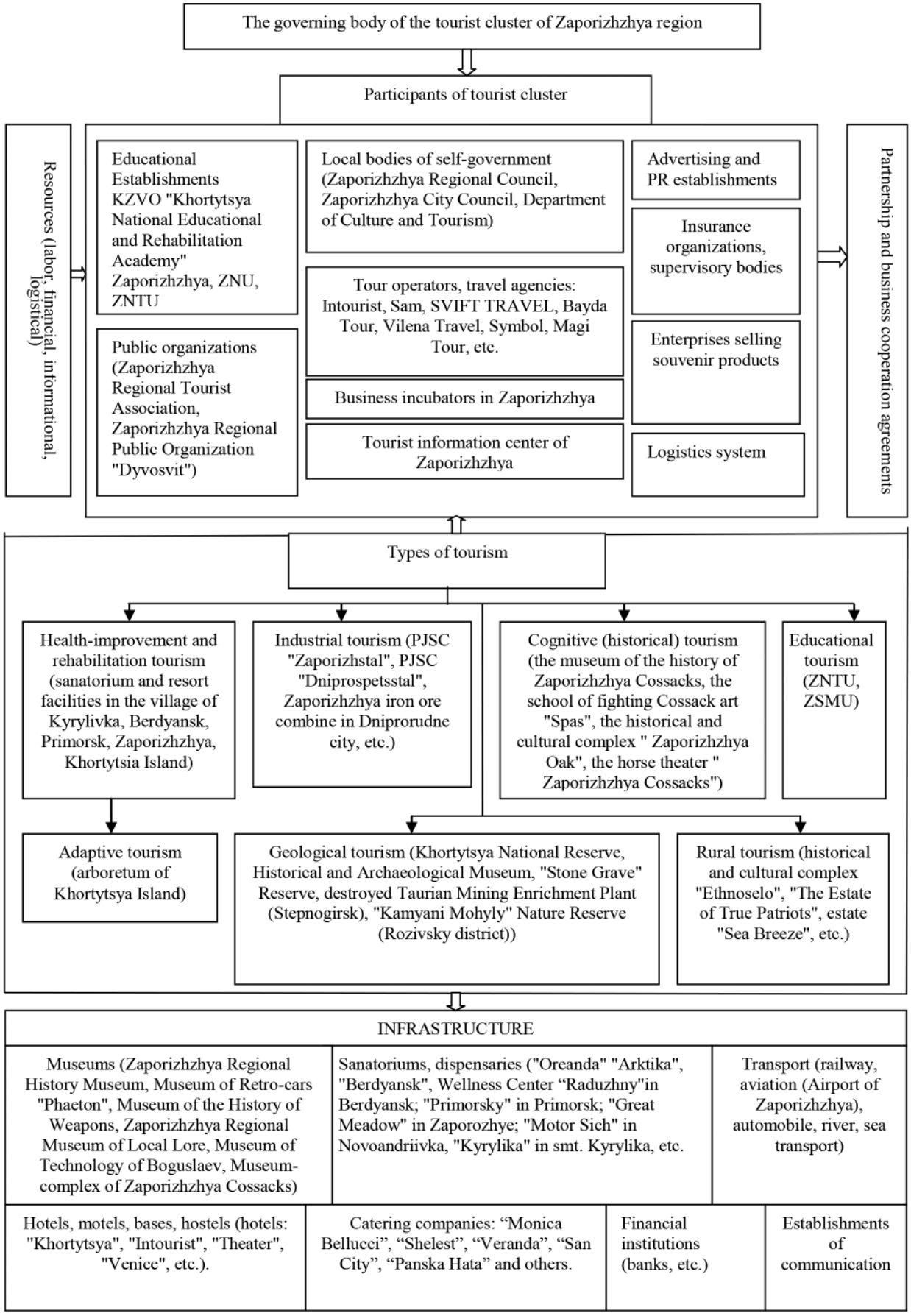

Fig. 3. Approximate model of forming a tourist cluster in Zaporizhzhya region

competitors having similar recreational resources;

increasing competitiveness and creating interesting competitive tourism products;

mutual support in concluding contracts;

reduction of advertising costs;

assistance in the development of existing types of tourism and the formation of new ones (industrial tourism, health-improving and recreational tourism, adaptive tourism and active rest).

The process of creating a tourist cluster in the regions of Ukraine is a long and very complex process, which unfortunately may not bring the expected results.

Therefore, we consider it necessary to propose one of the methods of assessing the economic efficiency of a tourist cluster, in which the main indicator is the revenue from the sale of the corresponding products (services) of the tourism industry of the regional cluster, in particular from the tourist rent (monopoly, differential, absolute, quasi-rent, consumer rent, ecological antirents) (Boyko, 2010), which is defined as follows:

$$X_{ij} = S_i \cdot (1/n - b_{ij} \cdot (p_{ij} - p))$$

where X_{ij} - revenue from the sale of services (i) revenue from the tourist cluster (j);

S_i - revenue from the sales of services (i) in general in the country (in the region, in the destination);

n - number of tourism companies providing these services;

b_{ij} - demand variable indicating the dependence of the market share of the tourist cluster on the price of its services;

p_{ij} - the price of a particular cluster service;

p - the average price of competing analogous services in other regional (international) tourist clusters.

Conclusions. The formation of tourist clusters in Ukraine and in its regions should be directed, first of all, to the development of domestic tourism. However, the development and formation of the tourist cluster faces many problems, namely the underdeveloped and outdated transport infrastructure; seasonality of functioning, which increases the cost of tourist services and reduces the competitiveness of Ukrainian clusters in the international market; the long period of formation of a cluster, that is, the time lag in obtaining benefits from it; insufficient number of skilled personnel; imperfect legal framework and so on.

Solving these problems, even at the regional level, should contribute to the creation of a modern, competitive national tourism product. At the same time, the regional cluster policy should focus on the effort of the interaction between the cluster participants, which is aimed at increasing the competitiveness and strengthening the links between them; increasing consumer demand for services offered by the cluster; attracting additional investment flows, effective use of natural and man-made recreational resources, historical and cultural heritage, and significant increase in the influence of recreation and tourism on the region's economic development.

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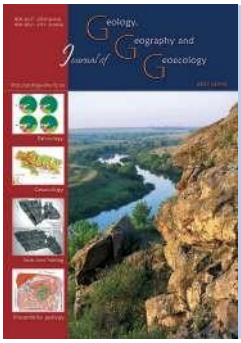

JOURNAL of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(4), 649–660.
doi: 10.15421/111962

Scientific-practical approaches to justification of location of quick service restaurants

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Received: 16.05.2019
Received in revised form: 04.06.2019
Accepted: 14.11.2019

Abstract. Research on specifics of selecting locations for QSR and assessing their potential is becoming increasingly vital in the conditions of high uncertainty and risks associated with the restaurant business. Therefore, the investigation of theoretical and applied fundamentals for justifying factors influencing the choice of QSR location is becoming more urgent. The aim of this investigation is to consider the development of recommendations on the ways of applying the above mentioned fundamentals .Decisions on deployment of the operating system of service facilities including restaurants are strategic in nature. The key factors affecting location of projected QSR can be divided into general and specific, which consider the requirements for the territorial location of the facility in the city/area and the development site. Among them are: proximity to residential areas and other objects necessary for potential employees and consumers; availability, capacity and significance of transport routes, vehicle speed; volume of transportation of potential consumers, convenient access roads; composition and territorial dispersion of a cluster of product form and territorial competitors; availability of a high-professional competitive supply network; availability and proximity to traffic generators (magnets); size, configuration, relief and other technical features; its visibility; zonal restrictions (norms for development of the territory, consistency with neighbouring objects, possibility of organizing a parking lot); appropriate format of quick-service; possibility of reconstructing leased premises. Important variables in the decision to choose a QSR location include analysis of: 1) the routes of potential customers, their initial and final destination before/after visiting a QSR with «HOUSE», «WORK», «SHOPPING (ENTERTAINMENT) « AND OTHERS» being most decisive; 2) the size of the QSR's commercial area defined as the distance customers are mentally prepared to cover for visiting a restaurant; 3) focal distance providing division of the commercial area into sectors of 5, 10, 15, 20 and 30 minutes of accessibility and showing contribution of the inhabitants of each sector to the overall structure of the QSR sales; 4) existing and potential generators of QSR customer flows, requirements for their mutual location. When choosing a QSR location it is necessary to provide a realistic assessment of the market opportunities and threats to the QSR's further development; take into account sector specificity in determining the intensity of competition and market capacity; analyze flows of customers; substantiate the focal distance and the size of the QSR's commercial area; consider generators of QSR customer flows and specifics of their mutual placement.

Keywords: location of quick-service restaurants, commercial area, visitor flow generators, psychology of consumer behaviour.

Науково-практичні підходи до обґрунтування локації закладів швидкого обслуговування

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Аннотація. В умовах високого рівня невизначеності та ризикованості ведення ресторанного бізнесу дослідження специфіки вибору місця розташування закладів харчування швидкого обслуговування (ЗХШО) та оцінка його перспективності стає все більш актуальним. Дослідження теоретичних та прикладних засад щодо обґрунтування факторів впливу на вибір локації закладів харчування швидкого обслуговування складають основу даного наукового долідження. Розроблення рекомендацій щодо способів застосування зазначених вище теоретичних та прикладних засад стає основною метою цієї роботи. Рішення щодо дислокації операційної системи сервісних об'єктів, до яких належать і заклади ресторанного господарства, є стратегічними. Ключові фактори, що визначають вибір місця розташування проектованих ЗХШО, можна поділити на загальні та специфічні, які враховують вимоги до територіальної дислокації закладу у межах міста/району та майданчика забудови.

Серед них: близькість до житлових масивів й інших об'єктів, необхідних для потенційних працівників та споживачів; наявність, потужність та значення транспортних артерій; швидкість руху автотранспорту; обсяг транспортних перевезень потенційних споживачів, зручність під'їздів; склад та територіальна розпорошеність кластеру видових та територіальних конкурентів; наявність високопрофесійної конкурентоздатної мережі постачальників; наявність та наближеність до генераторів трафіку (магнітів); розмір, конфігурація, рельєф та інші технічні; його видимість; зональні обмеження (норми на розвиток та забудову території, сумісність з об'єктами по-сусідству, можливість організації паркувального майданчика); відповідність формату закладу; можливість проведення реконструкції у орендованих приміщеннях. Важливими змінними у рішенні про вибір місця розташування ЗХШО є аналіз: 1) маршрутів руху потенційних відвідувачів – їх початковий та кінцевий пункти призначення до/після відвідування закладу, серед яких найбільш впливовими є: «ДІМ», «РОБОТА», «ПОКУПКИ (РОЗВАГИ)» ТА «ІНШЕ»; 2) розміру ареалу комерційного впливу ЗХШО – відстані, яку споживачі психологічно погоджуються долати, щоб відвідати заклад ресторанного господарства; 3) фокусної відстані, що передбачає поділ ареалу комерційного впливу ЗХШО на сектори 5, 10, 15, 20 та 30-ти хвилинної доступності та показує внесок мешканців кожного із них у загальну структуру продажів закладу; 4) наявних та потенційних генераторів потоків споживачів ЗХШО, вимог до їх взаємної дислокації. Обираючи локацію ЗХШО, необхідно реально оцінювати ринкові можливості та загрози для його подальшого розвитку; враховувати галузеву специфіку при визначенні інтенсивності конкуренції та ємності ринку; аналізувати потоки відвідувачів; обґрунтовувати фокусну відстань та розмір ареалу комерційного впливу ЗХШО; враховувати генератори потоків споживачів ЗХШО та особливості їх взаємної дислокації.

Ключові слова: локація закладів харчування швидкого обслуговування, ареал комерційного впливу, генератори потоку відвідувачів, психологія поведінки споживачів

Introduction. The restaurant business is not only one of the most significant components of the hospitality sector operating in a tough competitive environment, but also one of the highly efficient capital investment areas.

Chains of quick-service restaurants (QSR) are characterized by the highest rates of restaurant business development in the world and domestic markets, a tough struggle for optimal positioning in the market and its most promising segments, finding new customers and retaining regulars.

The most critical factor in designing a new QSR is a proper assessment of the choice of location, which has a crucial impact on formation of sales volumes, successful business operations, efficiency of investments and the rate of return.

Analysis of the latest studies and publications showed ambivalence towards the quick-service market development. Public concern about the negative impact of fast-food on the health of the population, in particular on the younger generation is well founded as for some countries this problem is becoming a matter of national concern. Most economically developed countries have raised the issue of the need for local authorities to regulate QSR development (Lukar E. Thornton, 2016).

The latest studies by researchers including Athens, 2016; Bas, 2018; Folch, 2018; Oexle, 2015; Widaningrum, 2017 demonstrate the relevance of seeking a compromise model for fast-food planning and development in the service market. This model is expected to consider, on the one hand, business interests of the QSR owners, on the other, demands of the consumers of catering services and their right to meet these demands, as well as regulatory activities of the state authorities responsible for guaranteeing food safety at the local, regional and national levels.

The behavioural factor is the benchmark for selecting a quick-service location in a certain territory. In particular, Bernsdorf (2017) proved that there is a direct correlation between QSR location density in a certain territory and frequency of visits. The findings of the studies by Garza, 2016 and Barnes, 2017 confirm a positive effect of QSR accessibility and convenience factors for formation of demand for fast-food services, in particular for communication and for spending time with kids (Eckert, 2017).

Nowadays, location of quick-service restaurants is investigated by leading Ukrainian scientists, in geographic and economic aspects. The following leading Ukrainian geographers are investigating the location of quick-service restaurants: V. I. Doroshenko, O. O. Lubitseva, T. I. Shparaga and others. The following leading Ukrainian economists are investigating the location of quick-service restaurants: A. A. Mazaraki, N. I. Vedmid', T. I. Tkachenko, V. I. Kutsenko, V. F. Dotsenko and others.

At the same time the high level of uncertainty and risk associated with this business makes the need to study the specifics of choice of location of QSR location and to assess its long-term benefits more pressing every year.

The aim of this article is to study theoretical and applied fundamentals for justifying factors influencing the choice of QSR location and to develop recommendations on the ways of their application.

Materials and methods. Theoretical and practical aspects of developing a chain of McDonald's Corporation restaurants in different countries of the world and McDonald's Ukraine Ltd, as well as the results of studies conducted in McDonald's restaurants in Kyiv and Odessa, were used as the information framework

of the study.(The research results presented in this article contain internal corporate information of the regional European and Ukrainian offices of McDonald's Corporation).

Various research methods and techniques were used, in particular statistical surveys – for establishing dynamics of certain indicators; analysis and synthesis – for structuring approaches to classification; comparisons, grouping and typing – for comparative analysis as well as the expert evaluation method. Methods of computer processing based on the MS Office application package were also used.

Results. ***Traffic routes of potential visitors to quick-service restaurants.*** Location of a restaurant is defined as the selected place of its situation within/outside the settlement with regards to traffic flows, routes of potential customers, activities of major competitors, etc. There are several types of locations for restaurants with varying effects on their success: a) in the center of a city/settlement; b) in the residential area of a city (dormitory suburbs); c) in close vicinity to a city; d) along a highway; e) near a traffic generator (magnet) – facilities attracting a large flow of visitors, for example, tourist attractions, large shopping centers, etc.; f) in an area of concentration of the bulk of customers (near the educational or business centers).

Decisions on the location of the operating system of service facilities including restaurants are strategic in nature. In Chase's writings (1998), the concepts and methods for the location of production and service facilities are carefully considered. Along with general influencing factors, the restaurant sector has its own specifics regarding the choice of location.

An important variable in choosing a QSR location is the analysis of the **routes** of potential visitors – their initial and final destination before/ after visiting a quick service restaurant, among which the most influential are: HOME, WORK, SHOPPING (ENTERTAINMENT) and OTHERS (Table 1).

As we can see, 85% of European, American and Ukrainian customers visit a quick-service restaurant as an intermediate point on their route between HOME, WORK or SHOPPING. For more details, let us consider the psychology of behaviour of Ukrainian customers of quick-service restaurants (Fig. 1). Almost half of the visits to QSR are on the way from HOME, and 37.1% on the way to HOME. It is noteworthy that about a third of Ukrainian consumers visit quick-service restaurants before SHOPPING/ ENTERTAINMENT, as opposed to 5-10% consumers in the European countries and the USA. This means that Ukrainians consider a visit to a QSR as part of the entertainment (shopping), rather than as a separate event to meet their food needs.

However, there are consumers who visit QSR purposefully on the way from HOME (12.9% in Ukraine) or from WORK (5.5%), and then return to their starting points (Table 2). The frequency of such visits is almost twice as low as in other countries, indicating differences in the nutritional culture of the population, in particular outside home/work.

Different tendencies in consumer behaviour do not allow us to assess the potential of a QSR location only by analyzing the traffic of people visiting it, as this factor does not indicate the reason for appearance of potential clients in this place, neither does it consider those for whom the visit to the restaurant is the main event.

Table 1. Traffic routes of potential visitors to quick-service restaurants depending on the initial and final points of customer disposition, %

Initial point	Final point																			
	«HOME»				«WORK»				«SHOPPING (ENTERTAIN-MENT)»				«OTHERS»				Total			
	Italy	Poland	USA	**Ukraine***	Italy	Poland	USA	**Ukraine***	Italy	Poland	USA	**Ukraine***	Italy	Poland	USA	**Ukraine***	Italy	Poland	USA	**Ukraine***
«HOME»	18.0	20.0	27.7	**12.9**	1.0	2.0	4.7	**11.7**	2.0	3.0	5.5	**15.9**	9.0	12.0	8.1	**8.4**	30.0	37.0	46.0	**48.9**
«WORK»	10.0	13.0	5.0	**7.0**	10.0	7.0	10.1	**5.5**	1.0	1.0	0.4	**2.0**	3.0	1.0	1.0	**1.3**	24.0	22.0	16.5	**15.8**
«SHOPPING (ENTERTAINMENT)»	7.0	8.0	8.7	**6.3**	(<1)	<	0.4	**0.7**	2.0	1.0	2.1	**5.4**	3.0	<	1.6	**0.9**	12.0	9.0	12.8	**13.3**
«OTHERS»	20.0	20.0	11.0	**10.9**	1.0	<	0.8	**1.2**	1.0	<	1.7	**5.0**	12.0	6.0	11.2	**4.9**	34.0	26.0	24.7	**22.0**
Total	55.0	61.0	52.4	**37.1**	12.0	9.0	16.0	**19.1**	6.0	5.0	9.7	**28.3**	27.0	19.0	21.9	**15.5**	100	94.0	100	**100**

** The research results presented in this table contain internal corporate information of the regional European and Ukrainian offices of McDonald's Corporation. Ukrainian data are based on surveys of McDonald's restaurants' visitors in Kyiv and Odessa in 2017.*

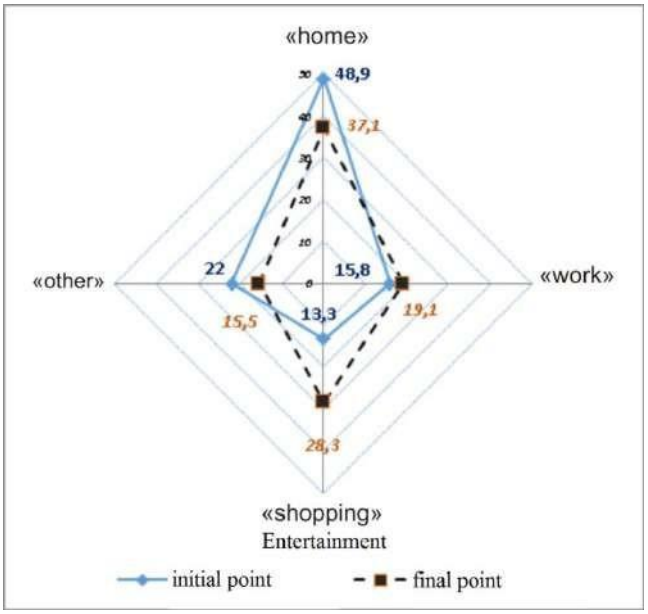

Fig. 1. Initial and final points oftraffic routes of McDonald's quick-service restaurants' potential visitors in Ukraine, %

The research results presented in this figure contain internal corporate information of the regional European and Ukrainian offices of McDonald's Corporation

The presented results demonstrate the importance of taking into account the factor of location of the projected QSR in the structure of residential development, ease/convenience and accessibility for potential clients coming from HOME. European experience shows that quick-service restaurants located next to the flows of people returning HOME function much better than those located next to morning flows of people. Therefore, the former option is viewed as a priority when placing a restaurant near the roads.

Forecasting of consumer behaviour by the factor of QSR "commercial area".

When assessing location it is important to understand not only the routes of customers, but also the distance they are ready to cover in order to visit a QSR. For this purpose we use the notion of '**commercial area'** (trading area), which is traditionally viewed as a geographic territory around the facility within which all flows of clients move before/after the visit. The distance that consumers mentally agree to cover to visit a restaurant determines the size of its commercial area (Athens, 2016).

It is logical to assume that the size of the commercial area can be defined as the area around the QSR within the radius of the most distant potential visit. However, this approach to forecasting will result in a significant error of estimate. At the same time, a considerable narrowing of commercial area can exclude a significant proportion of potential visitors from the analysis. In particular, the geographic area from which it is expected to generate up to 80% of the cash flow is used in Europe as a tradeoff between the size of the QSR's commercial area and the acceptable error of estimate in predicting the customers' behaviour.

Convenience of location is not measured by the distance, but by the time customers are ready to spend to get to the QSR. Convenience becomes even more critical if the time for visiting QSR is limited, especially for customers on the way from/to WORK. Table 3 shows the results of studying the size of the commercial area for customers from HOME and

Table 2. Visits to QSR («HOME»and«WORK» as an initial and final point of routes), %

Country	**initial - final points**		
	«*HOME*»–QSR – «*HOME*»	**«*WORK*»–QSR –«*WORK*»**	Total
Italy	18.0	10.0	28.0
Poland	20.0	7.0	27.0
USA	27.7	10.1	37.8
Ukraine	12.9	5.5	18.4

The research results presented in this table contain internal corporate information of the regional European and Ukrainian offices of McDonald's Corporation.

Table3. The size of commercial area for QSR for consumers from«HOME» and «WORK» points

Travel time before/after visiting QSR	% visits				Accumulated %			
	Germany	Italy	Spain	**Ukraine**	Germany	Italy	Spain	**Ukraine**
«HOME»								
0–5 min.	22.3	26.6	39.9	**25.6**	22.3	26.6	39.9	**25.6**
6–10 min.	27.2	43.9	32.5	**23.6**	49.5	70.5	72.4	**49.2**
11–15 min.	19.7	13.3	12.3	**14.6**	69.2	83.8	84.7	**63.8**
16–20 min.	9.4	7.9	6.0	**8.4**	78.6	91.7	90.7	**72.2**
21–30 min.	21.4	8.3	9.3	**15.3**	100	100	100	**87.5**
>30 min.				**12.5**				**100**
«WORK»								
0–5 min.	47.7	48.0	54.0	**16.9**	47.7	48.0	54.0	**16.9**
6–10 min.	19.7	30.6	24.4	**24.0**	67.4	78.6	78.4	**40.9**
11–15 min.	9.7	9.2	8.2	**15.2**	77.1	87.8	86.6	**56.1**
16–20 min.	5.6	5.6	4.3	**27.8**	82.7	93.4	90.9	**83.9**
21–30 min.	17.3	6.6	9.1	**16.1**	100	100	100	**100**

The research results presented in this table contain internal corporate information of the regional European and Ukrainian offices of McDonald's Corporation.

WORK, depending on the time spent to get to a destination before /after the visit to a QSR.

Thus, for 80% of the respondents from the European countries, the size of the commercial area of QSR for HOME and WORK destinations is within 15-20 minutes accessibility. In Ukraine, for consumers of HOME destination it is a distance that can be covered in 25-30 minutes, WORK destination – in 20 minutes. This can be explained by the less developed network of QSR and their considerable distance from each other.

The size of the commercial area for customers in the SHOPPING/ENTERTAINMENT segment is more dependent on the characteristics of the shopping center than on the QSR per se (BAS, 2018). Small (local) shopping centers do not attract a large number of visitors from remote areas, so for such locations it is necessary to consider only the population within 8-10 minutes' walk (Guimaraes, 2018; Krizan, 2018; Mulicek, 2018). The specificity of generating flows of visitors to large shopping centers, hypermarkets or malls is calculated individually.

The closer the QSR is to the customers (their home, work, shopping area), the more frequently they visit it. This phenomenon is called '**focal distance**', which involves the division of the QSR commercial area into sectors of 5, 10, 15, 20 and 30 minutes accessibility and shows the contribution of residents in each of these sectors to the total sales of the QSR (Fig. 2). The frequency and number of visits are greatest in the central area. These indicators decrease with increasing distance to the

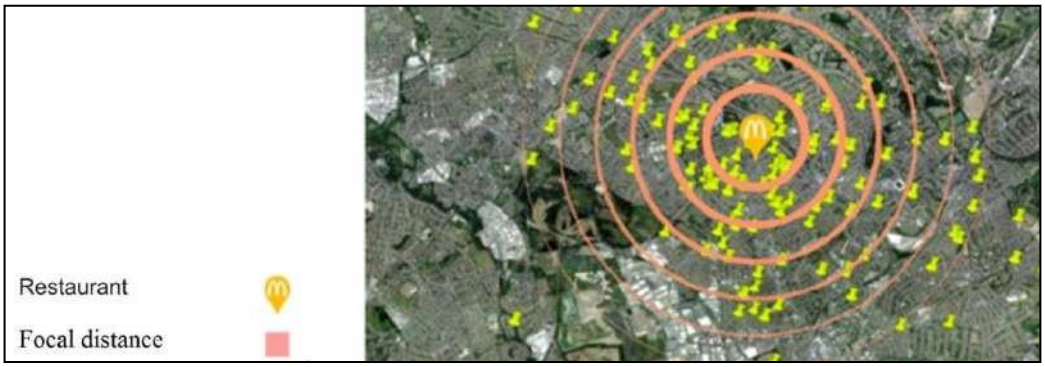

Fig. 2. Focal distance of a McDonald's restaurant in London

The research results presented in this figure contain internal corporate information of the regional European offices of McDonald's Corporation. Prepared by authors using Bernsdorf, K. A., C. J. Lau, A. H. Andreasen, U. Toft, M. Lykke & C. Glumer, 2017

QSR location, even if the number of inhabitants in each subsequent sector grows. Busy highways and other communication lines make focal distance streamlined in their sector of commercial area. So, highways and communication lines increase frequency and number of visits in peripheral zones of focal distance near their location. But, the availability of a busy highway can only be considered as a flood

Size and configuration of the commercial area are significantly affected by natural barriers (rivers, reservoirs) and artificial obstacles (roads, highways and railways) passing through its territory (Fig. 3). Obviously, a barrier means not only the lack of convenient bridges and walkways, but also a psychological component when people are not willing to cross a natural barrier.

Table 4. Influence of focal distance on QSR sales results in Ukraine and Poland

Travel time before/ after visiting QSR	Poland			Ukraine
	Number of inhabitants	Sales per 1 inhabitant, Euro/person	Share of consumers in QSR sales, %	Share of consumers in QSR sales, %
0–5 min.	48 517	16.86	46.0	25.5
6–10 min.	106 688	6.87	41.0	21.2
11–15 min.	106 943	1.0	6.0	18.8
16–20 min.	238 450	0.49	7.0	12.3
21–30 min.	-	-	-	12.5
>30 min.	-	-	-	9.7

The research results presented in this table contain internal corporate information of the regional European and Ukrainian offices of McDonald's Corporation.

generating factor when McDonald's is located on one. According to research results, only 1.0-1.5% of road-users traveling on city highways with speeds of 60-80 km per hour use McDrive services.

The concept of 'focal distance' provides a clear understanding of the relationship between the number and frequency of visits to a QSR and the time needed to get to destination before/after the visit (Table 4).

Thus, in Poland, the sector with the smallest number of inhabitants (48,517 people) generates up to 46.0% of restaurant sales at the highest average monthly bill per inhabitant within 5 minutes of access to the QSR. Therefore, when estimating the sales of a new QSR, it is necessary to consider in calculations not the total population, but the number of potential customers, taking into accounts the focal distance. In Ukraine 46.7% of QSR sales are generated by customers living within 10 minutes accessibility according to the investigation of V. I. Doroshenko and V. I. Kutsenko.

There are factors influencing the success of a QSR regardless of where it is located within the city. As shown above, customers of HOME destination on the way to/from QSR generate a significant number of visits; therefore, for accurate estimation of QSR sales it is critically important to have the results of psychological and social surveys of these customers. Each factor in combination with others has a variable effect on the QSR's performance (Table 5).

QSR commercial area potential.

Commercial area may also be limited by competitors operating within the commercial area regardless of their brands. Convenience is a key

Fig. 3. Commercial area of QSR and influence of engineered barrier (channels, highways) on its size (Rusanivka district, Kyiv city, Ukraine)

Prepared by authors using Google Maps images

Table 5. Influence of factors on QSR success at HOME and WORK destinations

Influencing factors	Level of influence on QSR success
Customers of HOME destination	
1. Time spent on the way to/from QSR:	
1.1. On transport	*Very high with* 5-, 10-, 15- and 20 minutes of accessibility. Level of influence decreases from center of the city to suburbs. The least influential factor on the highway
1.2. Walking accessibility	*Low.* As a rule, 5-10 minutes regarding time for transport to/from QSR (Bernsdorf, 2017)
2. Social-demographic portrait of potential customers:	
2.1. Family	*Very high.* Potential segments of customers
2.2. Age distribution	*High (*Garza, 2016)
2.3. Income level	The higher is the income level, the lower is the demand for QSR services *(*Garza, 2016; Eckert, 2017)
2.4. Employment	*Medium*
2.5. Education level	*Low*
2.6. Nationality/ethnicity	*Variable.* Dependence on traditions in organization of catering outside home
3. Competition:	
3.1. QSR of the same brand	*Very high.* Influences size and configuration of commercial area
3.2. QSR of international brand	*Very high.* Influences size and configuration of commercial area (Bas, 2018)
3.3. Other competitors	*High, medium.* Depends on strength and activities of the competitors
Customers of WORK destination	
1. The number of companies, offices and their employees within the QSR commercial area:	
1.1. Transport accessibility	*High/medium* Necessary to consider mobility of employees
1.2. Walking accessibility	*High/medium.* Employees have time limits for visiting QSR during lunch break so the commercial area may be reduced
2. Specifics of catering organization at work:	
2.1. Own QSR available	*Very high* QSR may attract customers by specialties and unique offers
2.2. Competitors available	*High/medium.* Depends on strength and activities of the competitors, offers of delivery menus and business lunches
2.3. While/blue collar ratio	*Low/medium.* Blue collars usually bring lunch from home

Prepared by authors using Bernsdorf, 2017; Garza, 2016; Eckert, 2017; Bas, 2018

indicator for visiting a QSR, so with the appearance of a new more convenient QSR, customers will visit it. As for the McDonald's chain, the biggest competitor for a new restaurant is the one already operating in the overlapping trading zones. Intersection of the trading zones of existing and new QSR is called the convenience line passing exactly in the middle of the area, as shown in Fig. 4. This intersection of the trading zones of existing and new QSR may be perfectly explained by the Voronoy polygon also.

Customers visiting a commercial area with the sole purpose of visiting a QSR will choose the nearest. Other reasons for visiting a commercial area form its potential for generating QSR sales (Table 6). Generators include residential areas, offices, large trading operators, subway stations, public transport stops etc.

The potential of a QSR's commercial area is significantly dependent on the situation of the magnets - generators of flow of potential customers, attracting a large number of people. There may be many magnets

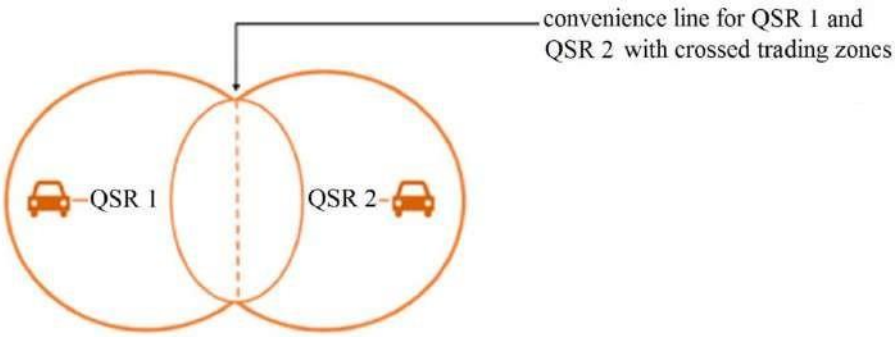

Fig. 4. Convenience line for visitors of QSR 1 and QSR 2 with crossed trading zones
Prepared by authors

in the QSR area (small shops, cinemas, tourist facilities, etc.), but it is necessary to concentrate on the largest one (Fig. 5). These magnets shown in Fig. 5 are located near busy highways because they attract potential visitors. The number of visitors depends on the level of highways capacity. So, the greater the capacity, the greater the size of the magnets.

Key factors of successful QSR location within the flow-generating magnets. The number of a QSR's customers significantly depends on the convenience

Table 6. Assessment of potential and characteristics of QSR commercial area

Potential assessment	Characteristics	Features of commercial area – **customer flow (sales) generators**
Excellent	**All sales generators** are developed	- shopping center is successfully operating or is about to be opened (in 1-2 years); - very high population density (to 50% of city residents) most of them working downtown; - many residential buildings with developed infrastructure; - high level of population motorization
Very good	**Two sales generators** developed in any combinations. For Ukraine the best combination is HOME+SHOPPING	- shopping center successfully operating at least 1 year available; - high population density (to 25% of the total), most of them working downtown; - many residential buildings with developed infrastructure; - high level of population motorization
Good	Steady market of QSR sales with certain sales generators is developed	- sales market is enough to form stable demand for QSR products
Satisfactory	Formed market is in stagnation or declining	- main flow generator is a shopping center which used to be popular 10 years ago, but which is now unfashionable
Undesirable	Market is weak, any flow generators are absent	- neighbourhood with low income level, industrial area

Prepared by authors.

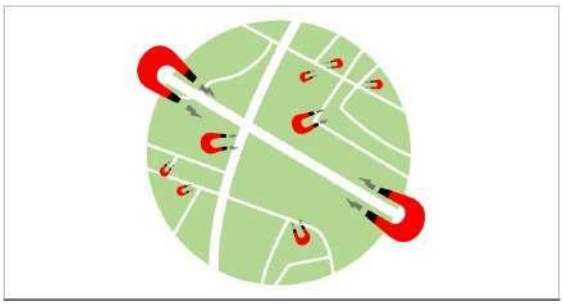

Fig. 5. Location of flow-generating magnets

Fig. 6. Location of McDonald's restaurant within flow-generating magnets

The research results presented in these figures contain internal corporate information of the regional European offices of McDonald's Corporation.

of its location within the flow-generating magnets. A powerful magnet has a much larger commercial area than a QSR, so their mutual location is decisive for visits to the latter (Fig. 6).

Table 7 presents a list of factors and their influence the success of a QSR located near a magnet.

Three characteristics are used for assessment of a QSR's location relative to a magnet: QSR convenience, visibility and accessibility from the routes leading to the magnet (Table 8).

Accessibility and visibility of a QSR in relation to magnets are particularly critical when opening a new quick-service. From this standpoint, several types of QSR locations are distinguished by the level of visibility and accessibility of **magnets** and **transport arteries** (Fig. 7). It is necessary to consider all flows of magnet visitors moving near the QSR for proper assessment of the location potential.

Feasibility of the choice of a QSR's location is strengthened by the use of integrated methodological tools for collection and expert evaluation of data, both general (social-economic specifics of the territory/region development) and specific (condition and characteristics of locations, regularities and tendencies in behaviour of potential customers, competition) as well as by considering factors influencing performance of a new QSR (Fig. 8).

Table 7. Influence of factors on success of QSR located near a magnet

Influencing factors	Level of influence on QSR success	Notes
1. Powerful magnet whose commercial area is larger than that of the QSR		
Number of magnet visitors	High	QSR visibility and accessibility are crucially important
Type of magnet:		
Shopping center (mall, SEC)	Very high	In priority when choosing QSR location
Shopping center (mall, SEC) with food-court	Very high	Considerably reduces the number of potential customers for new QSR
Recreation facility	High	Necessary to consider the seasonal factor
Tourist center	High	Seasonal factors are not influential, visibility is critical
Educational institution (school, college, university)	High	Students under 14 years dot not influence considerably. Walking accessibility is important (at most 10 minutes) (Thornton, 2016)
Others (cinemas, health facilities)	Variable	Depends on magnet power
2. Weak local magnet with less commercial area *8-10 minutes of accessibility to QSR*		
Number of magnet visitors	High	Not always known
Number of magnet employees	Variable	Depends on the size and significance of the magnet

Prepared by authors using Thornton, 2016

Conclusions. Below are the parameters recommended for the choice of location of QSR which are able to generate traffic of potential customers:

Table 8. Key factors of successful QSR location relative to magnets

Characteristics of QSR location	Recommended parameters of QSR location
1. Convenience	'Comfort zone' is the commercial area at a distance of 20-30 minutes accessibility. Magnet located within the QSR commercial area is of priority
2. Accessibility	Easy maneuvering on the way to/from QSR and access road to it including easy accessibility by car
3. Visibility	Building, poster, signs indicating the road and direction to QSR are conspicuous. Customers can easily spot the QSR

Prepared by authors

1. Potential QSR location should be between HOME, WORK or SHOPPING destinations;
2. It is more promising to choose a QSR location near flows of consumers going HOME than

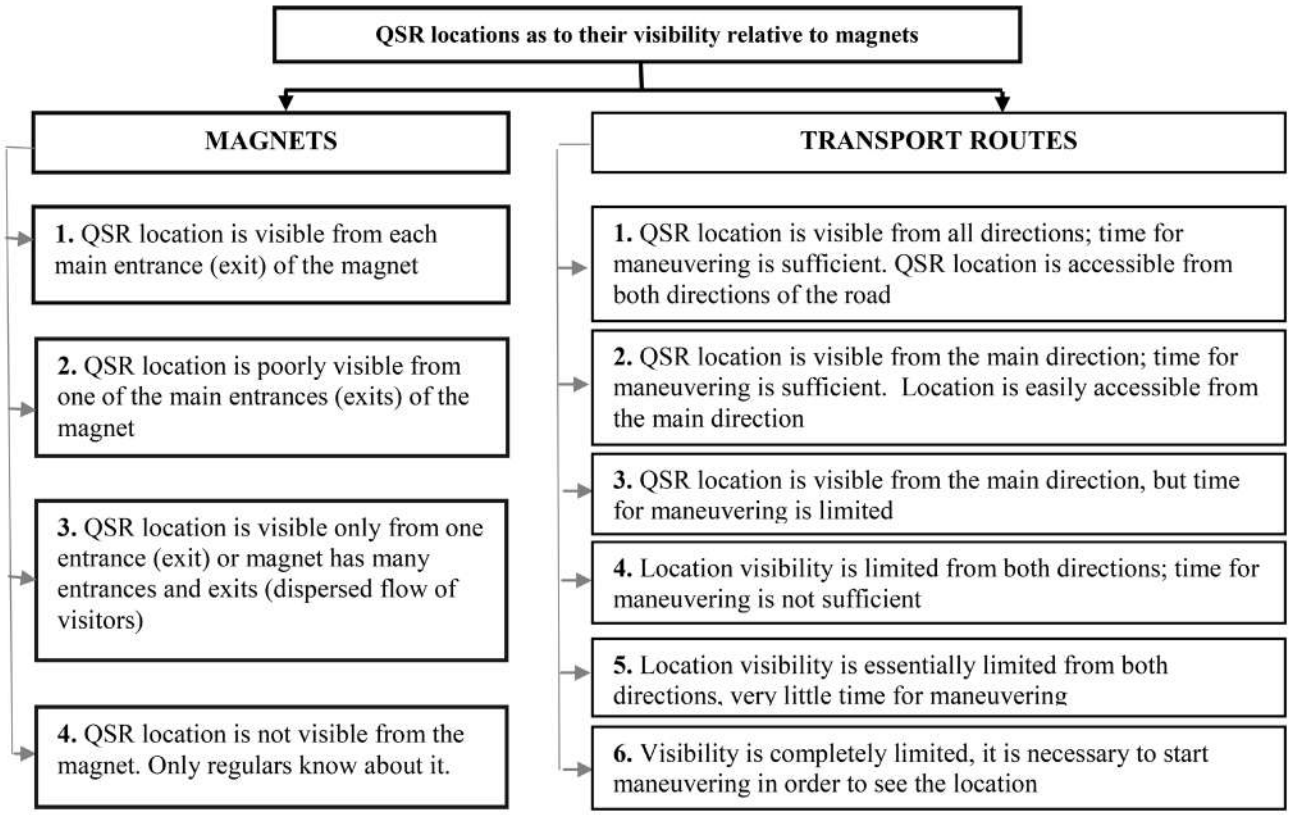

Fig. 7. Types of QSR locations by the level of their visibility and accessibility from magnets and transport arteries
Prepared by authors

Fig. 8. Factors influencing QSR location
Source: data based on works by Chase, 1998; Thomas, 2014; Zhang. 2018 further elaborated by the authors

in the vicinity of morning flows;

3. QSR location: distance for HOME destination should be covered in at most 20 minutes and distance from/to WORK – for 10 minutes;
4. Assessment of QSR commercial area potential should be 'excellent', 'very good' or 'good';
5. No artificial or natural barriers;
6. Proximity to powerful magnet (traffic generator) with commercial area greater than that of QSR; no other QSRs belonging to the magnet;
7. Convenience, accessibility and visibility of magnets in relation to QSR.

The presented factors are average and always vary between countries, cities, and different locations based on geographical, cultural and demographic characteristics. When choosing a QRS location only one of the listed factors may prove dominating. However, even a well-chosen location cannot guarantee the successful business, as high quality of services and food, and optimal price-quality ratio may become a decisive factor in shaping behavioural intentions of consumers (Namin, 2017).

When choosing a QSR location it is necessary to perform reliable assessment of market opportunities and threats to the restaurant's further development, to take into account sector specifics in determining the competition intensity and market capacity, to analyze flows of visitors; to justify the focal distance and QSR commercial area, to consider generators of QSR customers flows and features of their mutual location.

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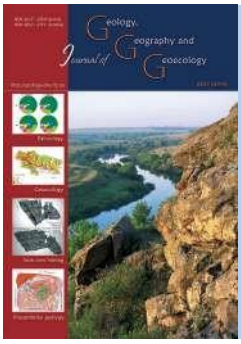

JOURNAL of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(4), 661–672.
doi: 10.15421/111963

Wooden sacral architecture as an object of cultural tourism in Ukraine

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Received: 10.09.2019
Received in revised form: 14.10.2019
Accepted: 10.11.2019

Abstract. Scientific article deals with the topic of wooden sacral architecture of Ukraine, which is the object of cultural tourism. The study of tourist resources, including cultural and historical ones, has a significant theoretical background among Ukrainian and foreign scholars. This topic is related to the study of architecture, peculiarities of construction of wooden structures, their spread in the territory of Ukraine and Ukrainian ethnic territories, which are beyond the limits of modern borders. Insights in the field of cultural heritage studies is very significant as well as the assessment of their uniqueness, geography of tourism, economic and social sciences that are related to the field of tourism. Definition of the cultural tourism, the concept of «heritage product» is related to the tourism marketing, as well as mechanisms of product management and ways of promoting cultural heritage sites for tourists attraction. This scientific article is based on the researches of experts, who study sacral architecture monuments, their classification, geography of distribution and regionalization, which are the basis for evaluating various aspects of buildings appearance. It is important to develop cultural tourism in regions, where tourist activity is in low condition. In the territory of Ukraine, there are objects of wooden church architecture that are included to the UNESCO World Heritage Sites. These structures are located on the territory of Ukraine and Poland. Objects of wooden sacral architecture are mainly located on the Carpathian foothills, Galicia and Polissia territory. The smallest number of these structures you can find in the south, where wooden architecture is predominantly located in the remote areas and belong to the Podilska and Naddnipryanska schools of temple building. There are some differences between the geography of extension of the objects of wooden temple building and index of domestic tourism for leisure and recreation purposes. Thus, objects of wooden architecture as sites of cultural tourism are concentrated in the western and in the northern regions of Ukraine, while the biggest amount of domestic tourists prevails in Kiev city, as well as in Ivano-Frankivsk, Lviv and Odesa region. The main activity on the Black Sea coast is recreation, medical and wellness tourism, or medical tourism on the resorts of the South. However, areas of the north of Odesa and Kherson regions, remain presidial. Combining tours to the north of Odesa region and rest on the banks of the Southern Bug River with active types of tourism and recreation will be promising thing. Lack of marketing activities is a significant impediment for promotion of the cultural tourism product in southern Ukraine. Also, the question of upgrading the infrastructure for tourism needs: transport system, hospitality facilities, remains unsolved. This region is perspective for the development of peripheral and rural areas and is a driver of economic growth.

Keywords: wood architecture, church, heritage product, cultural tourism, architectural and ethnographic zoning, folk temple building.

Дерев'яна сакральна архітектура як об'єкт пізнавального туризму в Україні

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Анотація. Наукова стаття розглядає питання дерев'яної сакральної архітектури України, що є об'єктом для пізнавального туризму. Дослідження туристичних ресурсів, у тому числі, культурно-історичних, має значну теоретичну базу серед українських та закордонних вчених. Дана тематика пов'язана з вивченням архітектури, особливостей будівництва дерев'яних споруд, їх поширення на території України та українських етнічних територій поза межами сучасних кордонів. Також значним є напрацювання у сфері вивчення культурної спадщини, оцінки їх унікальності, а також географії туризму, економічних та соціальних наук, які пов'язані з туристичною сферою. Так, визначення пізнавального туризму, поняття «продукту спадщини» пов'язане з маркетингом в туризмі, а також механізмами управління продуктом, інструментами просування об'єктів культурної спадщини для туристів. Наукова стаття опирається на фахівців вивчення пам'яток дерев'яної сакральної архітектури, класифікацію пам'яток, географію їх поширення та регіоналізацію, що є підставою для оцінки різних аспектів зовнішнього вигляду будівель. Важливим є розвиток пізнавального туризму для регіонів, де туристична активність є низькою. На території України розташовані об'єкти дерев'яної церковної архітектури, внесені до об'єктів світової спадщини ЮНЕСКО. Дані спо-

руди розташовані на території України та Польщі. Основна концентрація об'єктів дерев'яної сакральної архітектури переважно розміщена на території Прикарпаття, Галичини та Полісся. Найменша кількість – на півдні, де дерев'яна архітектура переважно розташована на периферійних районах розміщення основних ареалів подільської та наддніпрянської школи храмобудівництва. Географія поширення об'єктів дерев'яного храмобудівництва та показники внутрішнього туризму з метою дозвілля та відпочинку мають певні відмінності. Так, об'єкти дерев'яної архітектури як об'єкти пізнавального туризму концентруються у західних на північних регіонах України, у той час, як туристичний потік внутрішніх туристів переважає до м. Києва, проте значний також у Івано-Франківській, Львівській, Одеській області. На Чорноморському узбережжі основний сегмент – відпочинок, лікувально-оздоровчий туризм на березі Чорного моря, або лікувальний туризм – на курортах Півдня. Проте залишаються периферійними ареали півночі Одеської області та Херсонської області. Перспективним є комбінування турів до півночі Одеської області та відпочинок на березі р. Південний Буг з активними видами туризму та відпочинку. Значною перепоною є недостатня маркетингова діяльність з просування продукту пізнавального туризму на півдні України. Також залишається відкритим питання модернізації інфраструктур для потреб туризму: транспортна система, об'єкти гостинності. Даний регіон є перспективним для розвитку периферійних та сільських районів і є чинником економічного зростання.

Ключові слова: дерев'яна архітектура, церква, продукт спадщини, пізнавальний туризм, архітектурно-етнографічне районування, народне храмобудівництво.

Introduction. Wooden sacral architecture holds a special place, both in the cultural heritage of Ukraine and in the touristic field. This type of resource is related to the cultural and religious tourism and is the object of research on the architecture and geography of tourism and in general social geography.

Throughout its existence, any ethnic group has transformed the natural landscape, which has been called cultural or ethnic, also created anthropogenic objects in the form of architecture of different functional purpose. Material and spiritual culture are intertwine in a sacral architecture, made of different material. However, wooden architecture holds a special place in the development of Ukrainian culture. Most wooden churches are built by local builders and therefore it reflects the development of society in every region of Ukraine.

Study, popularization and support of the sacral architecture of Ukraine, has not only informative purpose, but also influences the social and cultural development of society, allows the formation of appropriate tourist infrastructure for tourists and sightseers service. Creation of infrastructure can have a positive economic effect, facilitating promotion of hospitality infrastructure and providing local communities with the additional work places.

Materials and methods of research. Wooden sacral architecture was researched very elaborately and there is a huge amount of works relating to this topic. Researchers include experts in the field of architecture and urban planning, history of architecture and culture, as well as specialists in the study of cultural heritage sites and geography of tourism.

Among the works on the study and classification of monuments of wooden architecture should be mentioned the work of the Research Institute of Monument Preservation (since 2017 – Ukrainian State Institute of Cultural Heritage). This institute has developed the «Classifiers of immovable objects of cultural heritage of Ukraine». This guide describes the classification of objects by typology, which clearly defines the belonging of material heritage objects to buildings with functional purpose as a cult. Sacral objects were classified by types, stylistics and planning (fig. 1).

Other important works were conducted by the Institute of History of Ukraine, Institute of Archeology of Ukraine, Institute of Art Studies, Folklore and Ethnology of Ukraine, National Academy of Sciences of Ukraine. "Methodological guidelines on preparation of materials about the Monuments of History and Culture of Ukraine" developed by these institutions, provide a theoretical basis for the classification of objects of material heritage, in order to distinguish and evaluate them. These recommendations are valuable material for specialists, involved in the study of tourism resources of Ukraine.

Thus, study of traditional wooden architecture is considered in the writings of V.P. Samoilovych, where is also indicated architectural and ethnographic zoning of the territory of modern Ukraine. V.P. Samoilovych determined, that folk architecture "was formed under the influence of number of reasons and conditions. Among them, important place took social and economic, natural and climatic conditions, which significantly influenced the creation of techniques and architectural forms."

Significant contribution to the study of wooden architecture was made by Ukrainian scientist, art critic, architect V.V. Vechersky. The scientist was involved in the designing of historic areas of Ukrainian cities, areas of protection of architectural monuments and urban planning, etc. Therefore, features of architectural and ethnographic zoning, which takes an important place among researchers of wooden sacral architecture of Ukraine, are defined.

Regional aspect of the study of hieratic wooden architecture has some differences. Thus, the iconic

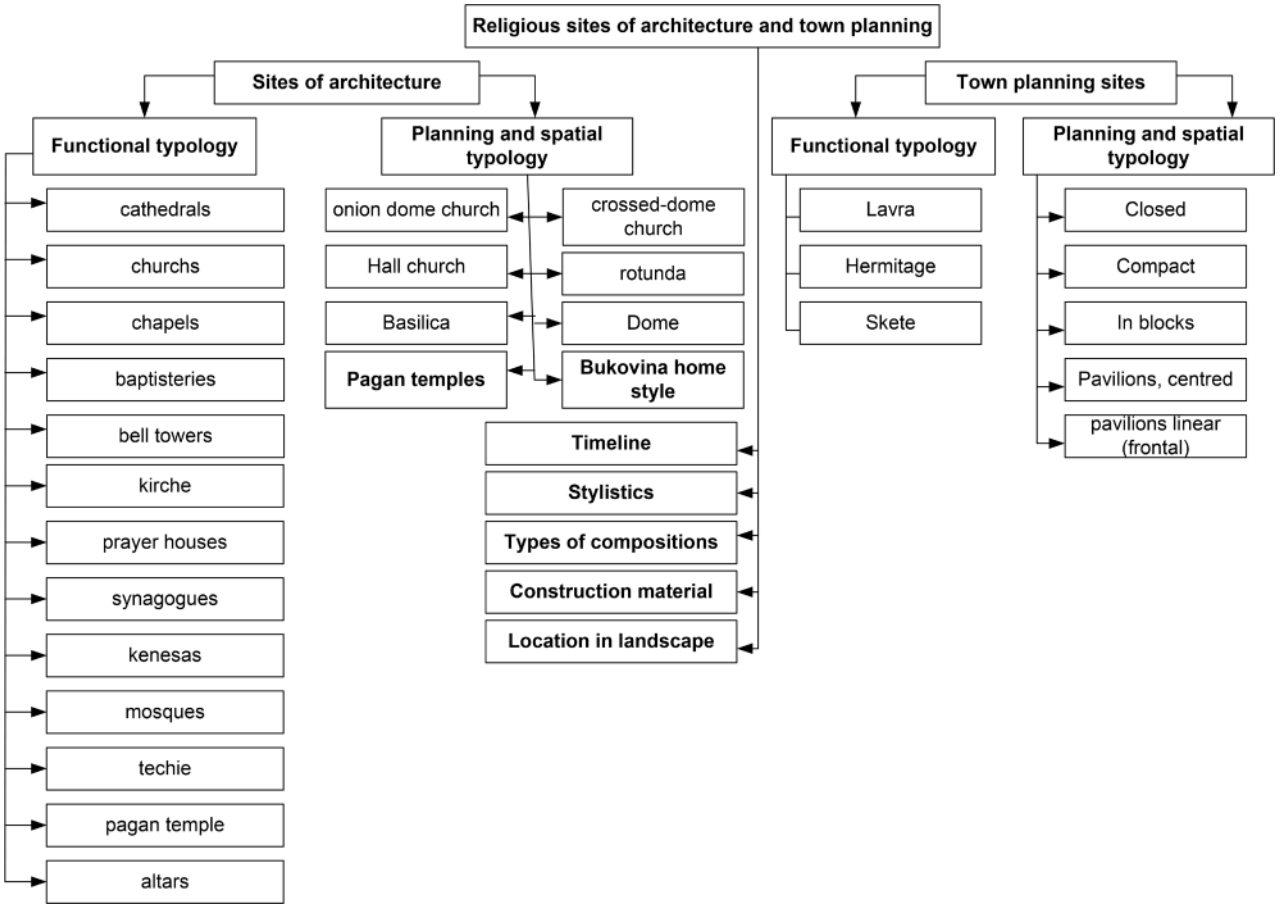


Fig. 1. Classifier of religious (sacral) sites of architecture and town planning

buildings of Western Ukraine, Polissia and Podillya have a considerable amount of materials. Instead, the study of Southern Ukraine needs further research and systematization. One of the researchers of southern Ukraine, in particular, on the study of wooden architecture is E.E. Lyman. The research concerns the church system and religious buildings. Y. Taras also deals with issues of study and systematization of wooden religious architecture. The scientist has published a dictionary of terms related to wooden sacral architecture. A number of scientific publications relate to the history of the formation of spreading area of wooden religious architecture, in particular, in the Carpathian region.

Study of cultural tourism as well as religious tourism and pilgrimage is also being studied among tourism researchers. Works of E.E. Kostashchuk, include social and geographical studies in the field of recreation and tourism. Studying of confessional aspect, which objects of sacral architecture belongs to, defining the processes of development of religious organizations of Ukraine, classification by regional significance and importance for the development of religious tourism basis gives grounds to emphasize two directions - geography of religion and religious tourism (Kostaschuk, 2016). Sacral architecture objects are located in a sacred space, that is understood as geographical combination of different denominations, in a particular territory and its impact on the population (Kostaschuk, 2016).

Some scholars consider the church building as an element of societal development of the natural environment. For example, the development of wooden church construction is inevitably linked with the development of the local inhabitants, their adaptation to the natural environment and the development of productive forces, including the exploitation of the natural resources. Therefore, the use of wood material is a form of adaptation of the natural environment to its conditions and is a consequence of the interaction of three elements: population, economy and landscapes (Romanchuk, 1998). The use of existing material for the construction of cult buildings may be a consequence of the regionalization of types of wooden churches across different types of landscapes in Ukraine.

The issue of adaptation of local inhabitants to environmental conditions, creation of a certain economic system, reproduction of cultural elements is considered in the number of works related to behavioral

geography and its branch- environmentalism (Ghold, 1990). The behavioral attitudes of the local inhabitants were shaped by natural factors and conditions.

Gold J. establishes direct relationships between human habitat, the image of that environment, and the formation of human behavior, which in turn adapts the environment to the needs of its development and use.

The development of the society and the corresponding environmental management, the active formation of anthropogenic landscapes, part of which are the cult architecture of natural materials (trees), are considered by scientists as a block of landscape-engineering system, in which one block - anthropogenic landscape and the other - an active engineering structure, wooden religious buildings).

From the genetic point of view of classification of anthropogenic landscapes, cult wooden structures are residential (Denysyk, 1998).

At the same time, KuleshovaM. distinguishes between the cultural and anthropogenic landscape. As the cultural landscape can be natural (Kuleshova, 2015). Thus, religious (cult) buildings can be an element of the anthropogenic landscape, cultural, and religious places can refer to natural (elements of relief, plants, etc.).

For understanding the nature of wooden architecture, the study of sacred landscapes is important, and also territories where churches are located, and other places of worship. Understanding the landscape as a complex of natural and anthropogenic influence, the classification of landscapes by origin was developed: cultural, political landscapes, which simultaneously has impact on the natural objects, and also reflect the development of society (Hrodzynskyi, 2005). In addition, a number of scholars classify sacral landscapes based on the nature of their origin and formation, the concept of the sacral landscape (Mishchenko, 2018).

Application of modern cartographic methods of cultural heritage sites is important for the further use, both in the creation of a cultural heritage inventory with geographical reference and the formation of object passport, as well as for the needs of state authorities related to the protection of the cultural heritage of the region, tourist field, as well as for commercial use by concerned parties, to promote certain regions for tourist purposes and attraction. Thus, scientists Ilieș A., Wendt J. A., Ilieș D. et. al. (2016), have applied cartographic methods that can serve as a basis for the study, systematization and subsequent use of maps with interactive information (Ilieș, Wendt, Ilieș. et al., 2016).

Results and their analysis. Cultural tourism takes the largest share in the provision of travel services for tourists.

Some scientists identify cultural tourism as part of the tourism industry by visiting the natural, cultural and historical heritage sites of a particular region, country.

For example, Tighe (1986) defines the concept of «cultural tourism» in his works. as a visiting of cultural heritage, arts, traditional crafts, museums, festivals sites, and study of culture in a particular region.

There is also cultural and cultural tourism, which provides the traveller with the knowledge, customs, lifestyle and other components of the culture of a particular nations, countries, regions. Religious tourism and pilgrimage are allocated to meet the spiritual needs of travelers (Kuzyk, 2011).

Cultural tourism based on resources - natural or cultural-historical - that form the basis of the tourism product and direct tourists to the places of visiting sites. Abi Sofian M.A., Azman C.M. (2010) proposed a conceptual model of a cultural heritage product that influences the growth of the tourism market, where cultural heritage sites of the region are located, and as a result create image of the region for potential consumers.

In this case, “heritage product” is regarded as components of the natural and cultural heritage, traditional environment and culture, which are appropriately included in the product, provided to the tourists (Abi Sofian, Azman, 2010).

The issue of protection and preservation of folk architecture is set out in the Plovdivska Charter. Thus, the International Charter on Folk Architecture (“Plovdivska Charter”) defines folk architecture monuments as ones that “carry coded information that introduces us not only to the concepts, technical, artistic and aesthetic methods of construction of that period of time, when they were all created, but also we get to learn about the standard of living of the people and their customs. That is why they are bright witnesses of that era, not only from architectural and artistic perspective but also in historical aspect. Their value is determined by the aesthetic features that are sometimes inferior to the ostentatious and majestic monuments of official public, sacral and civil architecture.”. The charter states that “transfer of monuments of folk architecture to the open-air museum is an exceptional measure, which is caused by extraordinary circumstances when all possibilities for its preservation are exhausted.” (Slipchenko, Mohytich, 2005).

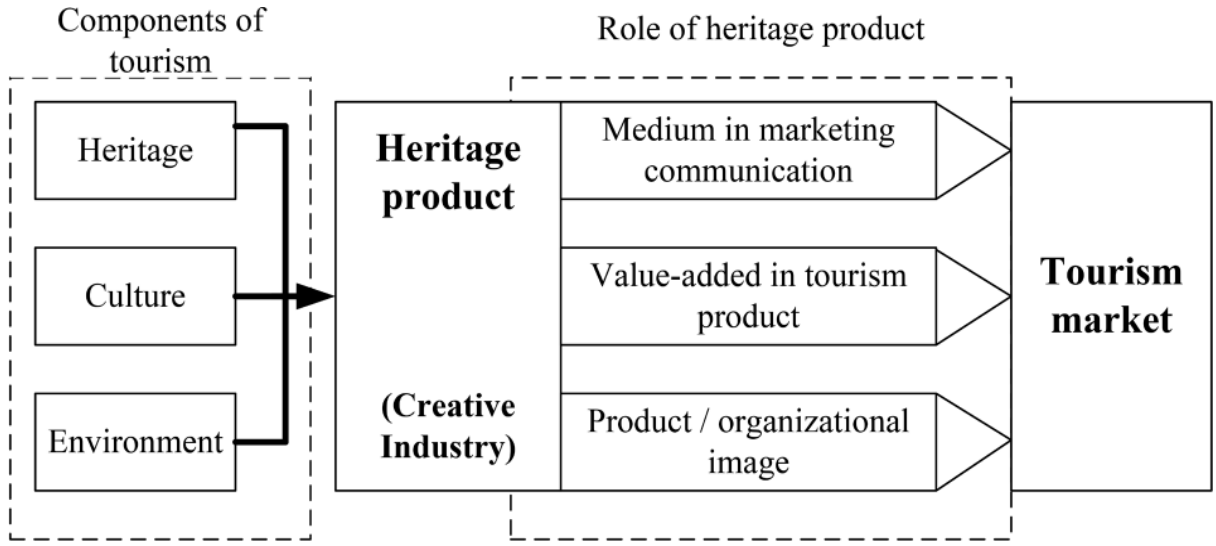


Fig. 2. The implication of heritage products toward the tourism industry

The International Charter for the Protection of Traditional Architectural Heritage (Stockholm Charter, 1998) defines the characteristics that determine the objects of traditional architectural heritage:

- commonness of the construction method inherent in a particular locality or human community;
- natural connection with the distinctive local or regional environment;
- common features of style, shape, appearance, established types of buildings;
- traditional construction techniques inherited from predecessors;
- conformability to the functional, social and natural conditions of the environment;
- effective use of traditional design solutions and techniques of erection of buildings.

Social-economic and natural-climatic conditions had a significant influence on the development and establishment of architectural forms, structural and technological techniques. The accumulation of experience in the construction of folk architecture was due to the masters, who passed on from generation to generation certain experience, skills and knowledge (Slipchenko, Mogytych, 2005).

Wooden architecture of Ukraine has a long history. Much of the wooden architecture is lost due to the short duration of wood material. Because of the lack of footing, some of the structures have disappeared for ever, which makes it impossible to restore the building in its original state. Therefore, often such buildings are sketched, photographed, or transported to open-air museums, for the purpose of reconstruction.

Architectural buildings made of wood had different functional purpose: defensive, economic, industrial, sacral, administrative, residential, etc. The most valuable and well-described are the sacral wooden buildings (churches, Roman Catholic churches, etc.), some of which are put on the UNESCO World Heritage List.

On the territory of Ukraine, the number of temples of wooden architecture is decreasing - part of them are destroyed because of natural reasons, the other one - due to human negligence. Therefore, the preservation and restoration of buildings is important.

N. Slipchenko, I. Mogytych (2005) identify cases, when wooden architecture monuments lose their authenticity, historical and artistic value:

- changes in the volume and spatial structure of the monument;
- changes of traditional materials and structures;
- disturbance of historically formed environment.

R. Mankovska lists the number of preserved wooden churches in Ukraine: more than 2.5 thousand, about 1000 structures of which, dated from the period of XV-XVIII centuries. There are approximately 500 other sites located in the surrounding ethnic territories. Only 18.3% (469) are registered and protected (Mankovska, 2010).

N. Slipchenko, I. Mogytych (2005) provide a regional distribution of identified preserved Ukrainian wooden churches (Table 2).

The first information about wooden temples related to the baptism of Kievan Rus. One of the earliest mentions of a Christian wooden church is associated with the Church of Elijah the Prophet in Podil district of Kiyv city (944 AD). Wooden temple construction had been actively developing since the XI century.

Table 1. Wooden churches of Carpathian region in Poland and Ukraine (2013)

Name of the object	Settlement	Country, region
St. Michael Archangel's Church, roman-catholic Tarnow diocese	Brunary Vyzni	Poland, Lesser Poland Province
Nativity of the Holy Mother church, Ukrainian Greek-Catholic Przemyśl-Warsaw archidiocese	Chotyniec	Poland, Subcarpathian Province
St.George Cathedral, "Drohobychyna Museum"	Drohobych	Ukraine, Lviv region
St. Paraskeva Church, roman-catholic Tarnow diocese	Kwiaton	Poland, Lesser Poland Province
Church of Cathedral of the Holy Mother, Sambir–Drohobych Eparchy of Ukranian Catholic Church	Matkiv	Ukraine, Lviv region
Nativity of the Holy Mother church, Kolomyiska Eparchy, Ukrainian Orthodox Church – Kiev Patriarchate	Nyzhnii Verbizh	Ukraine, Ivano-Frankivsk region
Protection of Our Most Holy Lady Church, roman-catholic Rzeszów diocese	Owczary	Poland, Lesser Poland Province
Church of the Holy Spirit, Sokal–Zhovkva Eparchy, Ukrainian Greek-Catholic church	Potelych	Ukraine, Lviv region
St. James Church, roman-catholic Tarnow diocese	Powroźnik	Poland, Lesser Poland Province
St. Paraskeva Church, Museum of Eastern Borderlands (Kresy) Poland in Lubaczów (museum)	Radruz	Poland, Subcarpathian Province
Church of the Holy Spirit (museum-monument of wooden architecture of the XVI-XIX centuries.)	Rohatyn	Ukraine, Ivano-Frankivsk region
St. Michael Archangel's Church Smolnik, Archdiocese of Przemiszko, Deco-Zamojsko-Lubaczów, roman-catholic Church	Smolnik	Poland, Subcarpathian Province
St. Michael Archangel's Church, Diocese of Przemysl-Novosonchiv, Polish	Tuzansk, (Turynsk)	Poland, Subcarpathian Province
Church of Michael Archangel's, Ukrainian Orthodox Church (MP), Diocese of Mukachevo	Uzok	Ukraine, Zakarpattia region
Church of Ascension of Jesus (Strukivska), Mukachevo Greek Catholic Diocese	Jasien	Ukraine, Zakarpattia region
Trinity Church, Ukrainian Greek Catholic Church, Diocese of Sokal-Zhovkva	Zhovkva	Ukraine, Lviv region

Since the XIII century, because of the invasion of the Tatar-Mongols and population decline, masonry construction was almost ceased. During this period, wooden sacral architecture was in demand in the countryside, where local craftsmen used experience and knowledge about certain architectural achievements of past generations. Hereby, certain traditions of construction and formation of public schools were established.

Active construction of wooden sacral structures took place in Galicia and Volyn in the XIV-XVI centuries, and with the seizure of lands of the Ukrainian ethnic territory by neighboring states (Poland, Hungary, Lithuania), etc., Western European architecture had a big influence on general appearance of the churches.

The main structural element of wooden church architecture was a square log (tower) made of the ground-laid timbers or bars, joined in corners by locks of various types. Depending on the number of logs, Ukrainian churches are divided into two, three, five or nine weeks. Predominantly, they are pyramidal in shape, from the periphery below to the highest bath. From the XVI century, six and eight-sided logs were used in wooden construction in Ukraine.

Exteriorly, Ukrainian wooden temples were lined with cover strips, the roof was made mainly of wooden «roof tile» - shingle. The windows were placed arbitrarily, mostly high above the ground, which created a defensive image of the building.

In accordance with local, historical and cultural conditions, availability of local building materials, specific features of life, aesthetic representations of certain social and ethnographic groups of Ukrainians, traditional folk schools of construction of sacral and residential architecture had established.

Table 2. Regional distribution of identified preserved Ukrainian wooden churches

Regions of Ukraine and ethnic territories outside Ukraine	The number of identified preserved Ukrainian churches					
	XV	XVI-XVII	XVIII	XIX-XX	Total	Under guard
Crimea	-	-	-	-	-	-
Vinnytsia region	-	1	48	69	118	10
Volyn region	-	19	128	91	238	59
Dnipropetrovsk region	-	-	1	-	1	1
Donetsk region	-	-	1	-	1	-
Zhytomyr region	-	-	38	32	70	8
Zakarpattia region	4	22	25	68	119	50
Ivano-Frankivsk region	1	9	52	338	400	57
Kyiv and the region	-	5	22	10	37	30
Kirovohrad region	-	-	1	-	1	-
Luhansk region	-	-	1	-	1	-
Lviv region	5	67	168	575	815	148
Mykolaiv region	-	-	-	3	3	-
Odesa region	-	-	1	1	2	-
Poltava region	-	-	-	12	12	1
Rivne region	-	9	137	98	244	24
Sumy region	-	-	8	9	17	5
Ternopil region	-	14	84	55	153	18
Kharkiv region	-	-	1	-	1	-
Kherson region	-	-	1	-	1	1
Khmelnytsk region	-	1	51	65	117	7
Cherkasy region	-	-	8	14	22	9
Chernivtsi region	-	4	27	121	152	11
Chernihiv region	-	1	10	19	30	10
Together in Ukraine	***10***	***152***	***813***	***1580***	***2555***	***469***
Belarus	7	42	88	95		
Poland	1	24	94	154	273	
Russian Federation	-	-	6	1	7	
Romania	-	2	10	23	35	
Slovakia	1	6	26	15	48	
Czech Republic	-	2	3	-	5	
Together in ethnic territories	***12***	***186***	***994***	***1861***	***3018***	

Y. Taras developed architectural and ethnographic zoning, which is considered as "the division of the Ukrainian ethnic territory into regions, districts by common and established architectural, planning and structural features of the solution of residential, economic and sacral structures (fig. 3.) (Taras, 2010).

Experts identify up to 14 public schools with regional features. Most public schools were appeared in the XV century, after complete disappearance of princely Russian schools. Active development and construction of wooden structures continued until the beginning of the XX century, and in Western Ukraine - until the beginning of the II World War.

Boykos school of national temple construction developed within the boundaries of the ethnographic group of the Ukrainian ethnic group - boykos. Three-storeyed churches have all-Ukrainian traditions of temple construction of wooden architecture with a certain number of logs in the tops of the church. The style of such construction was developed in the XVII and early XX centuries.

Almost all Boykos churches are located within the Turkiv and Sokal districts of Lviv region, as well as in Ivano-Frankivsk and Transcarpathian regions in Poland.

Volyn school of folk temple construction includes

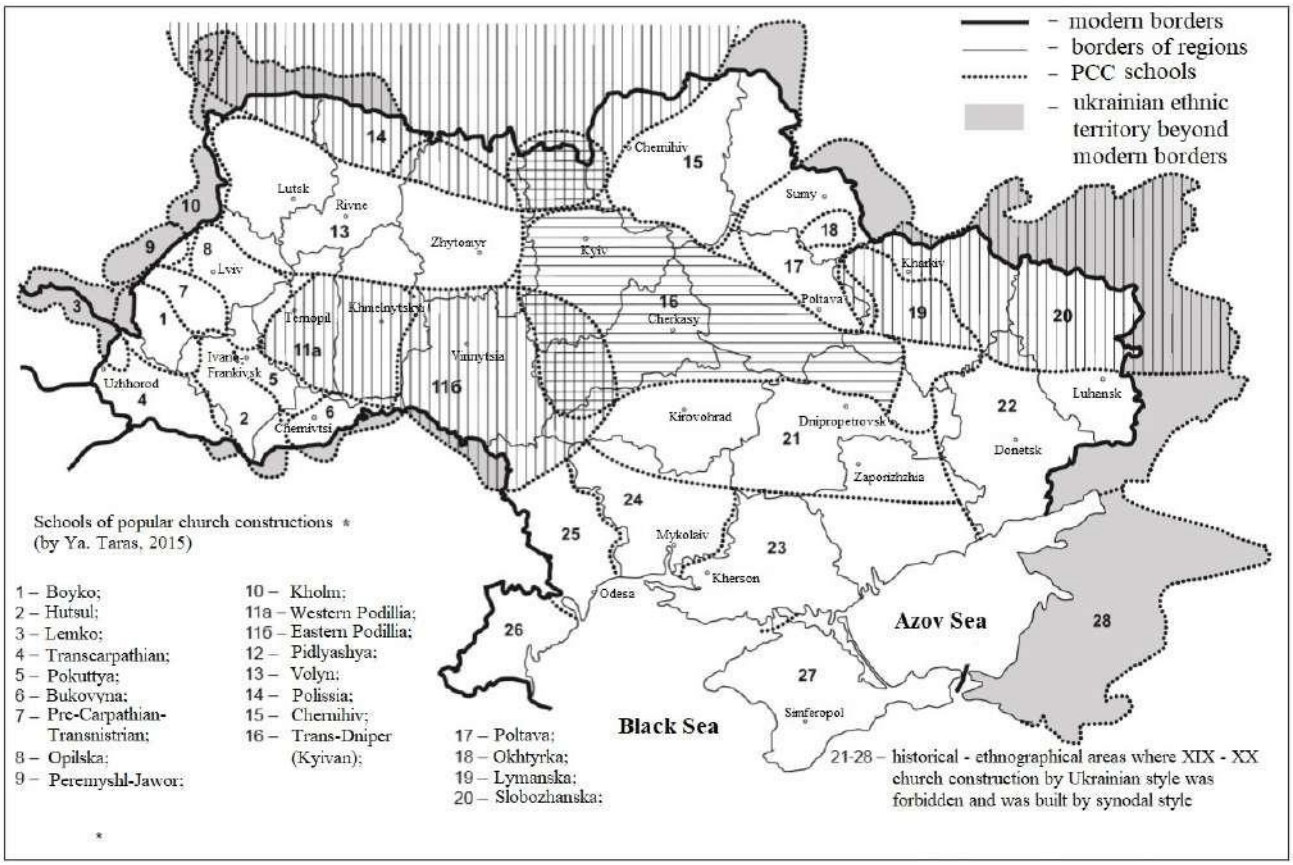


Fig. 3. Geographical position of the popular church construction schools in Ukraine

modern Volyn, Rivne, several districts of Lviv, Ternopil, Khmelnitsky, Zhytomyr regions and Brest region of Belarus. Regarding the preserved churches, Volyn school takes second place after the Galician school. Y. Taras (2006) listed 22 monuments related to the Volyn school (Taras, 2010).

Galician School has more than 800 traditional wooden churches. Within this school distinguish the archaic group, the most bright example of which is Church of the Holy Spirit, Potelych village (1502); "drohobytska" group – is characterized by the St. George's Church in Drohobych; "central» group, characterized by significant variability of buildings.

Hutsul school of folk temple construction was formed on the territory of the historic Hutsul region. The peculiarities of the temples of this school are: a cruciform plan, the presence of one store, encircles the church with a wide perron. Y. Taras (2006) divides the churches into 4 groups (cross, three-part, with Gothic and Baroque features, three-part with a low tower on the roof).

The origins of the classic Hutsul cross shaped, one-stored church are located in Kolomyia and Vorokhta. Such churches are widespread in Transcarpathian and Ivano-Frankivsk region.

Bukovynska school of folk temple construction had developed on the territory of Chernivtsi region and on the historical region of Bukovyna in Romania. The main features of the churches of this school are: the general silhouette of the church is similar to the peasant's house (house type church), a three-part plan. The construction of house-like churches related to the rule of the Ottoman Empire, which forbade building of high churches (compare with Bulgaria and Moldova, churches of that period). Sometimes, distinguish a separate Kitsman subgroup of Bukovyna churches, which have more expressive elements and is the mixture with the Hutsul school.

Transcarpathian school of folk temple construction has an important feature - presence of a bell tower, influence of Gothic and Baroque, stepped roofs. Sometimes this school is called marmorska, part of wooden churches of this school are located in Romania. In Transcarpathian, several ancient wooden churches of Ukraine have been preserved (St. Nicholas Church, Serednie Vodiane village, 1428; church in Kolodne village, 1470), characterized by the features of the defense towers of the XII-XIII centuries and wall murals. Most churches date back to the XVII century.

Lemkivska school of folk temple construction was formed in the XVI-XVII centuries. Most churches are located in the Ukrainian ethnic lands of the Prešov region in Slovakia and in the Subcarpathian

** Source: N. Slipchenko, I. Mogitich (2005)*

Fig. 4. Geography of concentration of wooden sacral objects by regions of Ukraine

Province of Poland. Churches of Lemkivska school have been partly transported to open air museums in Ukraine, former Czechoslovakia, and Poland. Lemkivska churches are two-, three-logged with a three-part organization, square two- and three-stage tents, which are topped with «dome-baths» above the central and eastern log, and a bell tower rises above the western log.

Chernihiv school of folk temple construction includes Sumy and Chernihiv regions, as well as the Ukrainian ethnic territories of Starodubshchyna (Bryansk and Belgorod regions, Russia). Churches have a tower-like appearance and a baroque influence. The prominent churches of this school are the Church of the Ascension of Jesus, Sosnytsia (1695), St. George's Church, Sedniv (XVII c.), St. Nicholas Church, Pecheniuhy (1670), St. Trinity Church, Pakul (1710), St. Trinity Church, Korop (1716), St. Nicholas, Svirzh (1745), John the Apostle Church, Popivka (1750).

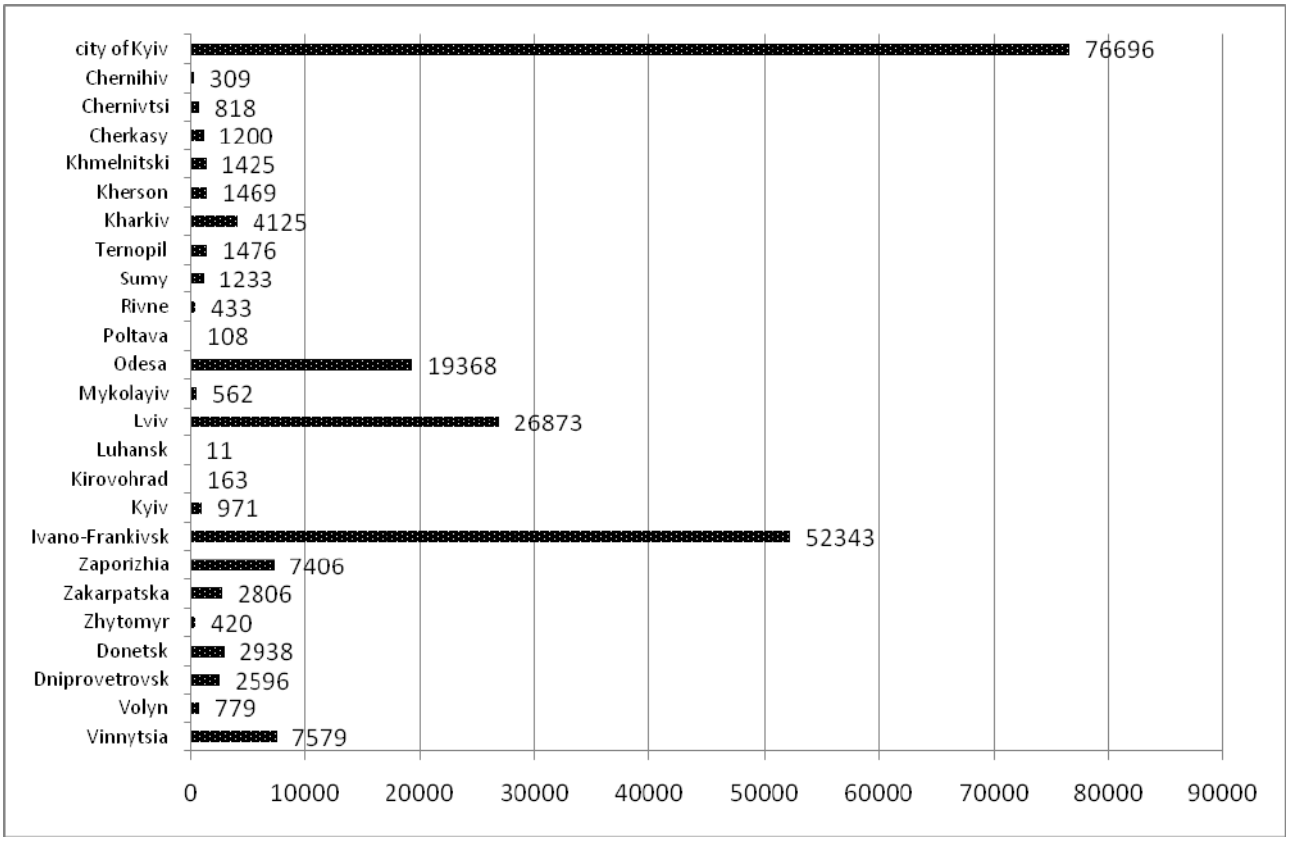
A. Vlasenko also lists churches in Ukrainian classicism (for example, St. George's Church, Sofipil city, Kyiv region, early XIX c.), Ukrainian historicism (Ivanivka Church, 1884, Rozkopantsi village, Kyiv region), and Ukrainian modernism (Pokrovska Church, 1923-1928, Bronnyky village, Rivne region).

Geography of spread of wooden Orthodox churches is shown in fig. 3. In terms of the number of objects, the highest concentration is characterized for the western regions of Ukraine - Lviv (31.9% of all sites), Ivano-Frankivsk (15.7%) regions, as well as Polissia and Volyn (Rivne - 9, 6%, Volyn - 9.3%).

At the same time, most regions, especially the southern ones, have a small number of sacral wooden architecture sites. It is necessary to consider the directions of tourist flows for recreation and leisure purpose that is close to the cultural tourism for the purpose of travel.

Indicators of domestic tourism for leisure and recreation purposes for 2017 showed, that the most attractive regions are Kyiv, Ivano-Frankivsk, Lviv, Odesa and Vinnitsa regions (Fig. 5). The largest concentration of wooden sacral architecture is concentrated in the western regions of Ukraine. At the same time, tourist flows for leisure and recreation purposes for domestic tourists in 2017 showed, that Ivano-Frankivsk and Lviv regions are attractive for visiting and have high rates of tourists.

Thus, the most attractive regions are the capital of Ukraine, the Black Sea region and the Carpathian region. Despite the relatively low numbers of wooden



Source: State Statistics Service of Ukraine, 2018

Fig. 5. Number of domestic tourists served for leisure and recreation by region of Ukraine in 2017

sacral architecture monuments, the southern regions of Ukraine can attract tourists for exploration purpose and be a part of tours. Combining excursions in order to visit wooden churches, could be a part of the out of town tour, such as Odesa, Mykolaiv and Kherson regions. For example, in the southern regions there are some unregistered and non-protected objects (Table 3).

Table 3. Wooden churches of folk temple construction of Southern Ukraine

Name of the monument	Date	Location
Nativity of the Holy Mother Church	1905-1905	Lisnychivka village, Balta district, Odesa region
St. Paraskeva Church	1903-1905	Budei village, Kodyma district, Odesa region
Pokrovska Church	1884	Ivashkiv villagw, Kodyma district, Odesa region
Church of the Exaltation of the Cross	1903-1905	Poznanka Druha village, Liubashivka district, Odesa region
Pokrovska Church	1890	Yosypivka village, Savran district, Odesa region
John the Apostle Church	Second half of the XIX century	Mazurove village, Kryve Ozero district, Mykolaiv region
St. Michael's Church	1867-1877	Kumari village, Pervomaisk district, Mykolaiv region
John the Apostle Church	1881	Stanislavchyk village, Pervomaisk district, Mykolaiv region
Vvedenska Church	1726	Beryslav city, Beryslav district, Kherson region

The development of cultural tourism, for example, in Odesa region, has directions mainly to Vilkovo, Bilhorod-Dnistrovskyi, and are linked to Odesa recreation area. While, the number of tourist trips to the north of the region where wooden sacral architectural sites are concentrated, is insignificant. In addition, according to the Program of Development of Tourism and Resorts in Odesa region for 2017-2020, one of the ways of realization is the social dimension - cultural and spiritual enrichment of citizens, creation of a positive image of Odesa region as an area with rich and diverse natural resource potential, outstanding cultural and historical sites; cultural - preservation of historical and cultural heritage.

Conclusions. Ukrainian tourism market for domestic tourism has a long process of development in recent

years, as well as search for the new sites and areas for the organization of excursions and other tourist routes. In addition, cultural types of tourism can be combined with the other tourism types. For example, recreation type of tourism can be supplemented by cultural excursions during the trip breaks or long stays in accommodation establishments, etc.

Analyzing the concept of «heritage product», we return to the understanding that the formation of this product occurs due to the several basic components: communication environment, material resources, personnel. Communication environment is needed to promote and build marketing tools for potential consumers and concerned parties in promoting, for example, a sacral architecture. Material means, that include transportation, accommodation and catering establishments, are necessary basis for creation of conditions for excursions or long tours. Personnel is the base in serving the consumers of the tourist market, and their competence influences the quality characteristics of the product.

In addition, according to the concept of «heritage product», the role of cultural heritage objects, lies in the fact that they create for tourists the image of the region, increase quality characteristics, conditions for the development of small and medium businesses that are directly or indirectly involved in tourism activity.

Examined geography of the location of wooden sacral architecture sites, shows that Ukraine has a considerable potential for the development of cultural tourism, including religious tourism and pilgrimage. The concentration of these objects in Prykarpattia and Volyn regions gives advantages in the organization of tours, since the regions have a positive image for tourists.

Southern regions of Ukraine have a small amount of such sites, but they need protection of the sacral architecture. In order to attract tourists to these sites, it is necessary not only to carry out information activity but also to organize events, related to the promotion of wooden sacral objects as unique ones, which reflect the history and culture of the region.

Despite the considerable potential in the organization of educational tours with the inclusion of these objects, such as to the north of Odesa region, the questions of transportation to these sites, hospitality establishments, availability of tourist signs and other information, including electronic databases, remain unsolved. It is also necessary to involve specialists in the development of quality tourist routes, first of all, to the regions where this aspect of tourism is still underdeveloped. In order to develop cultural and religious tourism projects, state-private partnership can be also possible. Further studies should be concerned with the research of the potential consumer segment, possibility of organizing of such tourist routes and promotion of this idea at the regional level of separate administrative units, for which economic impact from tourism development can be favorable.

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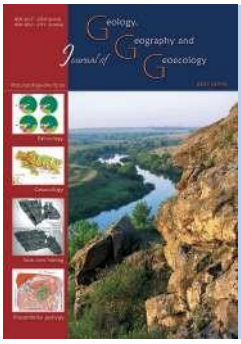

JOURNAL of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(4), 673–691.
doi: 10.15421/111964

Location pattern and genetic classification of granite pegmatites of the Ukrainian Shield

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Received: 17.02.2019
Received in revised form: 04.03.2019
Accepted: 20.09.2019

Abstract. The pegmatites of the Ukrainian Shield, their formation and occurrence are considered. It is shown that the Ukrainian Shield is a pegmatite province encompassing seven regions: Middle Prydniprovia, Western Pryazovia, Eastern Pryazovia, Ingulski, Rosynsko-Tikytski, Dnistersko-Buzki and Volyn, respectively encompassing megastructures of the same names and including pegmatite fields of different mineralogical composition and geochemical specialization. The Volynski, Ingulski, Middle Prydniprovia, Western Pryazovia regions have rare-earth and rare-metal specialization presented by pegmatites of different origin and petrological and mineral composition and occurring in different structural and tectonic conditions, having different formation age, which allows a full classification scheme of the pegmatites of Ukrainian Shield to be given. These structures can be considered as having formed as a result of abyssal magmatic plumes. The geological-structural position of these megastructures with obvious signs of influence of certain abyssal processes on their formation supports this assumption. We present the main geological structural and genetic factors of formation of pegmatite-bearing megastructures of the Ukrainian crystalline core-area, these factors forming the basis of a classification scheme of pegmatites of Pre-Cambrian shields. We have systematized the pegmatites of the Ukrainian Shield , and designed their classification scheme . We have distinguished the following groups of pegmatites by the development of pegmatite-generating zones: - three genetic groups of pegmatites: ultrametamorphogenic, magmatogenic and metamorphogenic-metasomatic; - six genetic subgroups of pegmatites: migmatic; autochthonous granite massifs; metamorphogenic and metasomatic displaced and formed pegmatites; multiphase intrusive granite massifs; multiphase intrusive alkaline massifs; multiphase granite batholiths. By the nature of pegmatite-bearing structures, the following structural groups have been singled out: granite-gneiss regional structures and domes; dome-synclinore and dome-trough plume-structures (subgroups: interdome synclinore and trough structures, in particular greenstone structures; intrusive domes and batholiths); specific tectonic zones of stress tensions.

Keywords: *Ukrainian pegmatite province, Volyn, Ingulets, Middle Prydniprovia and Western Priazovia pegmatite regions, gneiss granite dome-shaped structure, synclinore, greenstone belt, pegmatites, classification of pegmatites.*

Закономірності розміщення і генетична класифікація гранітних пегматитів Українського щита

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Анотація. Розглянуто пегматити Українського щита, закономірності їх формування та розміщення. Показано, щоУкраїнський щит (УЩ) є пегматитовою провінцією, яка об'єднує сім районів: Середньоприднiпровський, Західноприазовський, Східноприазовський, Інгульський, Росинсько-Тікицький, Дністерсько-Бузький і Волинський, які відповідно охоплюють однойменні мегаструктури і несуть пегматитові поля насичені пегматитами різного мінералогічного складу і геохімічної спеціалізації. Середньоприднiпровський, Західноприазовський, Інгульський і Волинський райони представлені пегматитами різного генезису і петролого-мінералогічного складу та розміщуються в різних структурно-тектонічних умовах, мають різний вік формування, що дає змогу на основі їх систематизації надати повноцінну класифікаційну схему пегматитів Українського щита. Мегаструктури, що складають ці пегматитові райони, можна вважати такими, що утворилися внаслідок дії глибинних магматичних плюмів. На користь такого припущення свідчить геолого-структурна позиція мегаструктур з чітко вираженими ознаками впливу на їх формування специфічних глибинних процесів. Відображені основні геолого-структурні та генетичні чинники формування пегматитоносних гранітних комплексів мегаструктур покладені в основу розробленої класифікаційної схеми пегматитів древніх докембрійських щитів. Проведено систематизацію і складено класифікаційну схему пегматитів Українського щита. За розвитком пегматитогенерувальних осередків виділено: – три генетичні групи пегматитів: ультраметаморфогенні, магматогенні і метаморфогенно-метасоматичні; – шість генетичних підгруп пегматитів: мігматитові; автохтонних гранітних масивів; метаморфогенно і метасоматично заміщені й утворені пегматити; багатофазних

інтрузивних гранітних масивів; багатофазних інтрузивних лужних масивів; багатофазних гранітних батолітів. За характером пегматитовмісних структур виділено такі структурні групи: гранітогнейсових регіональних структур і куполів; купольно-синклінорних і купольнотроговихплюмструктур (підгрупи: міжкупольнісинкліноpні і трогові, зокрема зеленокам'яні структури; інтрузивні куполи і батоліти); специфічних тектонічних зон стресових напруг.

Ключові слова: Українська пегматитова провінція, Волинський, Інгульський, Середньопридніпровський і Західноприазовський пегматитовий район, гранітогнейсові куполи,синклінорії, зеленокам'яні пояси, пегматити, систематизація пегматитів.

Introduction. Fundamental issues of geological and structural laws of formation of granite pegmatite fields and their occurrence in these fields lie at the basis of studies aimed at revealing the areas of development of pegmatite fields, their separate nodes and bodies and grounded prognostic exploration of rare metals and ceramic raw materials. Pegmatites of Pre-Cambrian complexes are the main indicators of commercially viable abundance of a range of rare metal elements, for some of them being the only indicator. In particular, according to statistics, from 73 to 92% of all reserves of Li, Rb, Cs, Be and Ta concentrated in pegmatites occur in Pre-Cambrian complexes.

There is a general classification of development process of pegmatite formation and Pre-Cambrian pegmatite field formation; this classification takes into account geological-structural and historical-geological features of earth crust development in the Archean, which allows further clarification of the sequence of geological processes influencing not only the structure and composition of separate pegmatite bodies and their conglomerates, but also the formation of pegmatite-bearing geoblocks of shields; this classification also allows one to answer certain fundamental general geological questions concerning the development of pegmatite-bearing territories and the earth's crust in general. Taking into account the link of pegmatites with both ultrametamorphic autochthonous granite complexes and intrusive granites, understanding of the laws of their formation will help clarify a set of important questions concerning the evolution of granitoid magmatism in the Pre-Cambrian.

Analysis of recent papers. Since the first scientific description and study of pegmatites (by E.Patrin in 1791 and V. Severin in 1798) and the singling out of graphic granite as a separate mineral called "pegmatite" by R. Gauyi in 1801, several important stages of its study can be distinguished. The first important stage in pegmatite study started in the early 20th century and lasted till 1931, the year when "Pegmatites" – a fundamental monograph by O. Fersman – was published. This period was characterized by the build-up of published research on the geology of pegmatites – from the description of mineral forms and internal structure of bodies, to definition and characterization of pegmatite fields.

The next stage of pegmatite study, which started right after the above mentioned monograph and reached its climax in the mid 1940s, was connected with the expansion of commercial demand for rare metals, during which pegmatites, being the ores for these metals, were available and easily identified. The huge amount of scientific papers published in this period made it possible to create a separate branch of geological science – the study of pegmatites. At that time, on the basis of different viewpoints on the genesis of pegmatites there formed three scientific schools in the study of pegmatites. The representatives of the first school considered pegmatites to be the products of crystallization of residual molten-dilution of its intrusion from the main massif and gradual crystallization in the isolated system without significant introduction of external matter. V.Bregger, A.Lacrios, I.Gott and others were among the advocates of this theory, O.Fersman developed this idea, later supported by the research of K.Vlasov, I.Ginsburg, M.Solodov, I.Nedumov and others. Representatives of the second school regarded the formation of pegmatites as stemming from metamorphic and ultrametamorphic transformations. These include P.Eskola, D.Korzhynski, N.Sudovikov, Yu.Sokolov and other researchers mainly studying Pre-Cambrian pegmatites. The third school interpreted pegmatites as the product of recrystallization and metasomatic transformation of aplites, bastard granite and formation of pegmatite bodies under the influence of postmagmatic solutions in the open system. The most well-known representatives of this school are V. Sheller, F. Hess, K. Lendon, O. Zavarytski, A. Nikitin and others.

Since the 1960s, a range of fundamental studies dedicated to the study of pegmatites has been published. The most important generalizing works that actually formulated the modern study of pegmatites are connected with names of I. Ginsburg, K.Vlasov, M. Solodov, I. Nedumov, M. Kuzmenko, A.Nikitin, V.Arhangelska, Yu. Sokolov, V.Petrov, A. Kalita, Ye.Lazarenko, V.Pavlyshyn, G. Rodionov, K. Babaiev, B. Shmakin, S. Shavlo, Yu. Yurk, L.Feldman and others. The appearance of fundamental works by the above researchers was the turning point indicating the beginning of the fourth generally theoretical period of development of the study of pegmatites. These works

formulated the main points of the pegmatite question, in particular: the geological structure of pegmatite belts, fields, nodes; the regularities of their occurrence and development; granite magmatism and pegmatite formation; influence of metamorphic, metasomatic, hydrothermal processes on the pegmatite formation; internal structure of pegmatite bodies and the conditions of their formation; mineral composition of pegmatites; geochemistry of pegmatites and evolution of geochemical processes; physical and chemical conditions of pegmatite formation; experimental modeling; practical issues of pegmatite exploration and use.

Historical study of pegmatites of the Ukrainian Shield dates back to the first quarter of the 20th century; however, serious research on them started only 70 years ago. During 1930-50s the research works were scattered and mainly aimed at the study of pegmatites as ceramic raw materials, except for the Korostensky pluton, where starting from 1931 geological-prospecting operations of chamber pegmatites began. Systematic research on pegmatites as rare metal raw materials started in the 1960s. Thanks to the joint efforts of industrial and research groups, in 1960-90s and at the beginning of the 21st century, large- and medium-scale geological and prognostic-metallogenic maps of the Eastern part of the Ukrainian Shield were created, a huge amount of factual material about different types of pegmatites was collected, the main directions of prospecting works for rare-earth metals, quartz and jewelry raw materials (topaz, beryl), and ceramic raw materials in pegmatites were determined. The following outstanding researchers of pegmatites should be mentioned: L.Lavrynenko, V.Kychurchak, L.Isakov, O.Koval, G.Lepigov, N.Viatkin, P.Shramko, S.Shutov, V.Kyshurchak, V.Pustovoitov, V.Kinshakov, V.Shpilchak, B.Ivanov, O.Lysenko, V.Lysenko, O.Makivchuk,V.Bezvynni, G.Lepigov, V.Mokiets.

At the same time, pegmatites of the Ukrainian Shield were studied by the following scientists and researchers; E.Lazarenko, M.Semenenko, Yu.Yurk, V.Pavlyshyn, B.Zatsiha, L.Isakov, M.Ivantyshyn, G.Kniazev, V.Kichurchak, L.Lavrynenko, K.Lytovchenko, K.Rozanov, S.Shavlo, N.Yashchenko and others. Their findings are presented in numerous papers and monographs, in particular: E.Lazarekno, V.Pavlyshyn, Yu. Sorokin.“Mineralogia i genesis kamernyh pegmatitov [“Mineralogy and genesis of chamber pegmatites”], 1973; Ye.Lytovchenko.“Granitnie pegmatity Zapadnogo Priazovia” [“Granite pegmatites of Western Pryazovia”], 1976; K.Rozanov, L.Lavrynenko.“Redkometalnie pegmatity Ukrainy” [“Rare metal pegmatites of Ukraine”], 1979; S.Shavlo, G.Kniaev, S.Kirikilitsa.“Granitnye pegmatity Ukrainy” [“Granite pegmatites of Ukraine”], 1984; “Kriterii prognozirovania mestorozhdeni Ukrainskogo shchita i ego obramlenia” [“Criteria of forecasting deposits of the Ukrainian Shield and its margins”], 1980 (ed. by M.Semenenko); “Mineralogia Priazovia” [“Mineralogy of Pryazovia”], 1980 (ed. by Ye.Lazarenko); L.Isakov “Polia granitnyh pegmatytiv Zakhidnogo Pryazovia” [“Granite pegmatite fields of the Western Pryazovia”], 2007 and oth. Under the supervision of S.Shavlo, Institute of Mineral Resources, maps of the pegmatite fields of the Ukrainian Shield were created and criteria of forecasting pegmatite related mineralization were developed (1973, 1980); in 2004 this work was resumed under the supervision of L. Isakov in Ukrainian State Geological Prospecting Institute, resulting in 2008 in a topical report on pegmatites of the Western Pryazovia and Middle Prydniprovia. Unfortunately, further work was suspended due to the lack of financing.

Geological-prospecting and scientific research work resulted in the discovery of a group of Volyn deposits of chamber pegmatites (quartz, topaz, beryl) within the Korostensky pluton of the Volyn megablock (in the 1930s – 1940s); in the 1960s came the discovery of the rare metal deposit of pegmatites “Krutaia Balka” attributed to the central part of Sorokynska tectonic zone; in the 1980s – 1990s, the Shevchenkivske deposit of lithium pegmatites within the Shevchenkivsko-Fedorivska structure was discovered; discoveries included a range of prospective occurrence of rare metals in pegmatites of the Sorokynska structure, the Shevchenkivska and Fedorivska structure and rare earth metals in pegmatites of the Gaichur structure of the Western Pryazovia megastructure; occurrences of rare-metal pegmatites of the Komendantivska and Zhovtovodska structure of the Middle Prydniprovia megablock; rare metal pegmatites of the Ingulski megablock: Polokhivske and Stankuvatske pegmatite fields (Polohivske, Nadia and Stankuvatske deposits);occurrences of rare-metal pegmatites of Mostove and Vys pegmatite fields.

General information and regionalization of Ukrainian pegmatite province. The generally accepted hierarchy scheme of pegmatites is as follows: pegmatite > pegmatite node > pegmatite field > pegmatite belt > pegmatite region> (pegmatite area)>pegmatite province. According to this scheme, the Ukrainian Shield is a pegmatite province encompassing seven regions: Middle Prydniprovia, Western Pryazovia, Eastern Pryazovia, Ingulski, Rosynsko-Tikytski, Dnistersko-Buzki and Volyn (Fig.1, geological basis (Tectonic map, 2006, Drannyk, 2003), respectively encompassing megastructures of the same names.

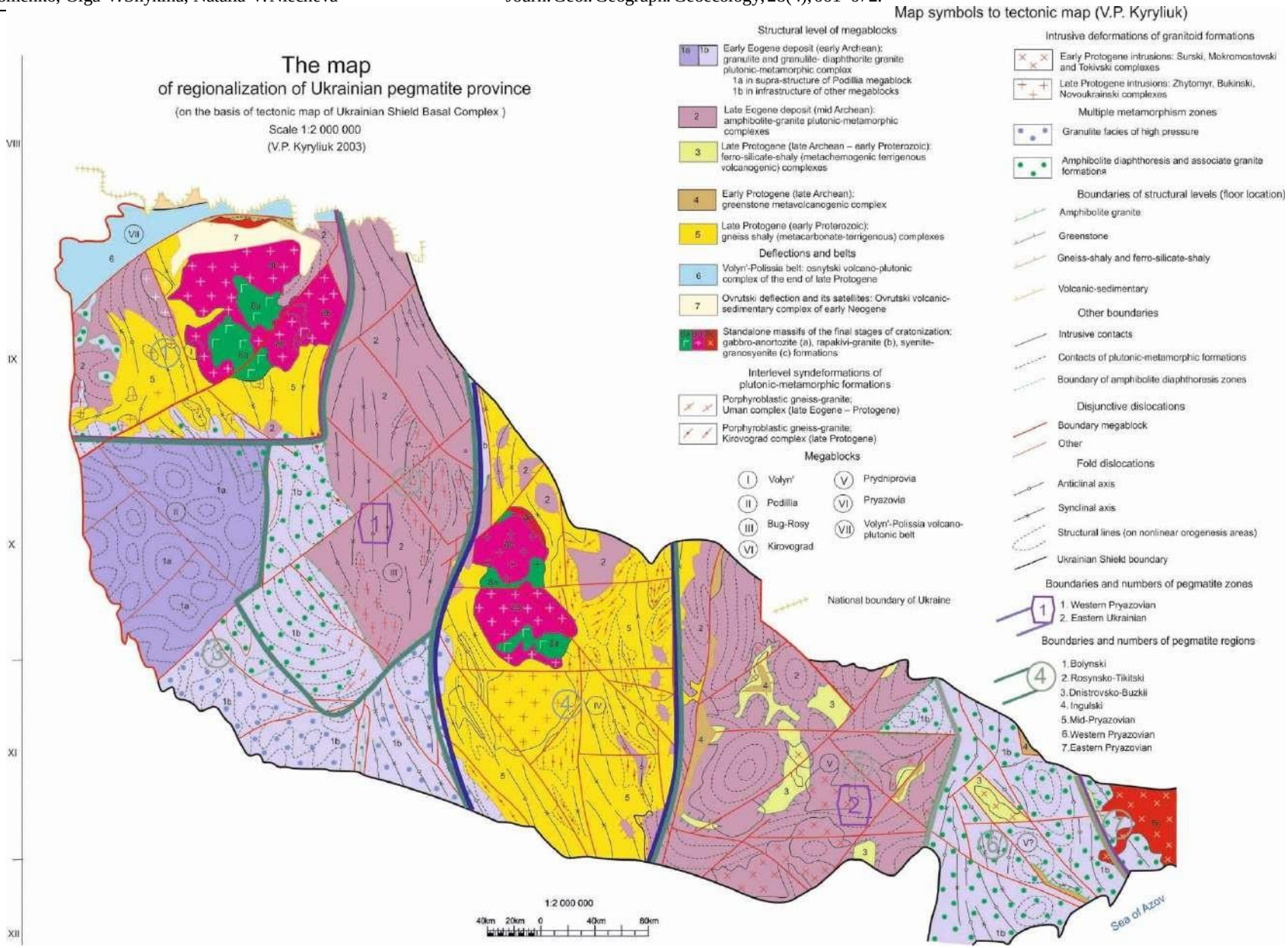


Fig. 1 The map of regionalization of Ukrainian pegmatite province [28]

We combine the Western Pryazovia and Middle Prydniprovia regions (Isakov, 2013) into the Eastern Ukrainian pegmatite area, as both these structures had a similar or probably common development during its mass formation of pegmatites, which resulted in the formation of pegmatite belts (Fig.2).

We also, for our purpose, have combined the Rosynsko-Tikytski and Dnistersko-Buzki regions into the Western Ukrainian pegmatite area. These regions at the moment are associated with ceramic specialization with rare earth geochemical specialization .However, on the basis of separate geological-structural constructions of the Rosynsko-Tikytski megastructure (greenstone formations are not excluded), and taking into account the considerable influence of granite massifs of the Korostenski pluton in its northwestern part, the development of pegmatite fields of rare metal specialization is quite possible within the structure. Nevertheless, the pegmatites discovered within the boundaries of this area are homogeneous and are attributed to ultrametamorphic migmatite and granite complexes. We are not going to focus on these two areas except for the above statement. Taking into account the geological-structural development of the Eastern Pryazovia area, and the presence of complex granite and alkaline intrusions within its boundaries, this area also belongs to the promising areas containing rare-earth pegmatites, although, unfortunately, considerable occurrences have not been found so far.

The Volynski, Ingulski, Middle Prydniprovia, Western Pryazovia regions have rare-earth and rare-metal specialization. These structures can be considered as having formed as a result of abyssal magmatic plumes. The geological-structural position of these megastructures with obvious signs of influence of abyssal processes on their formation is

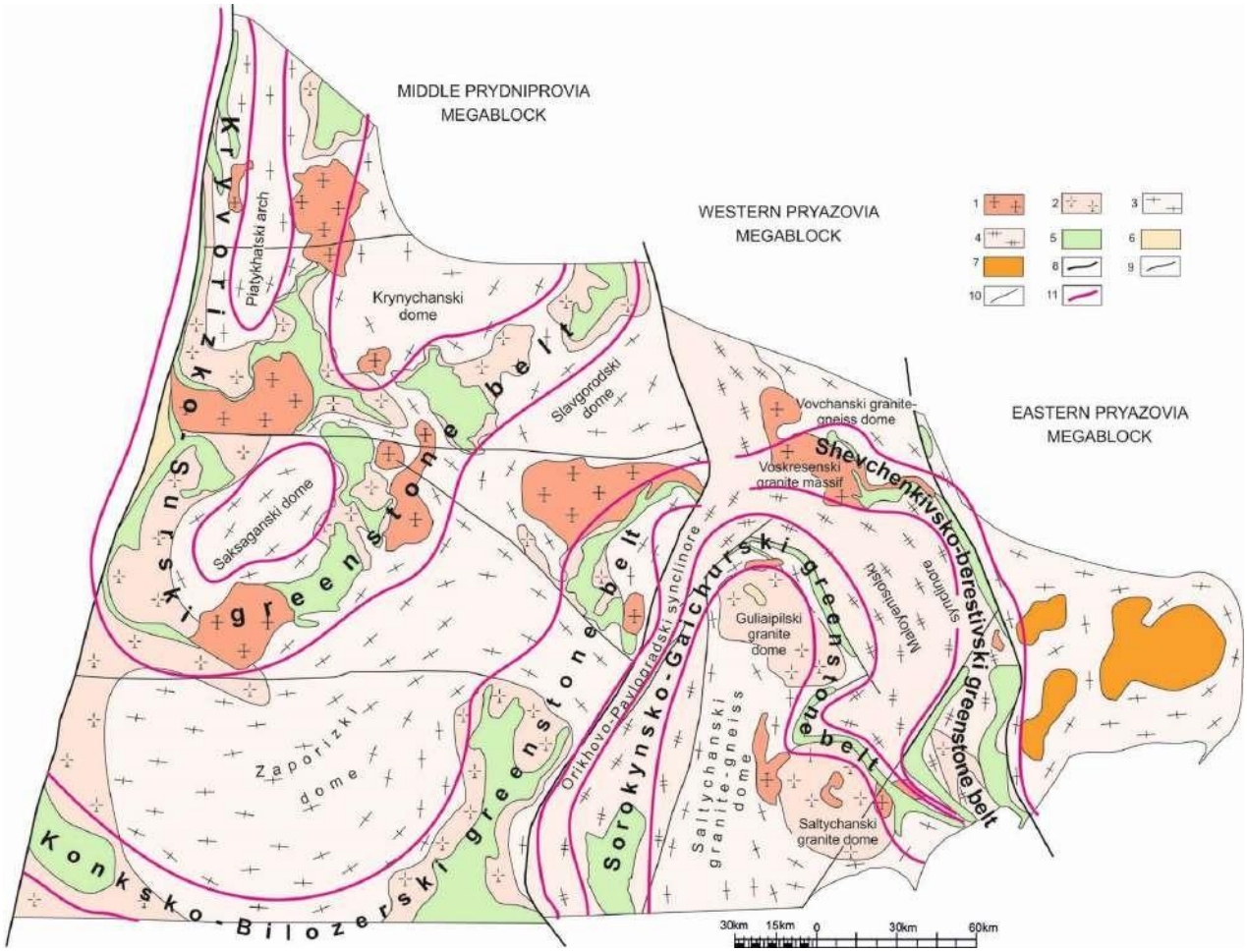


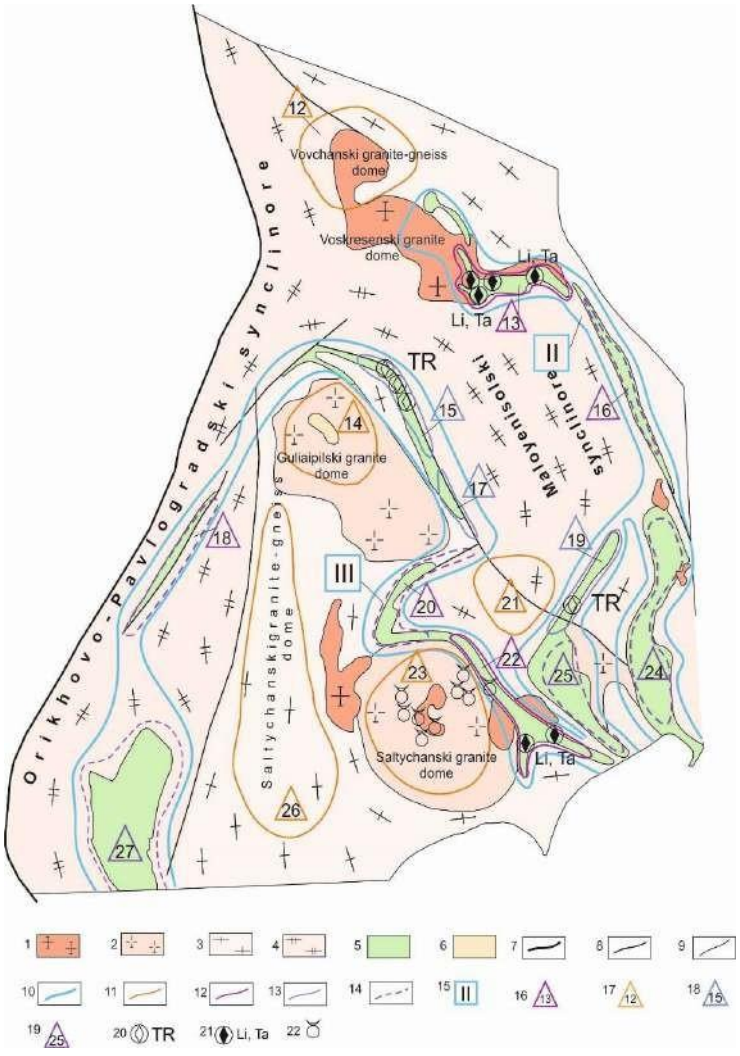
Fig. 2. Contour map of geological structure of the Eastern part of the Ukrainian Shield.

1 – two-feldspar granites of the Demurski, Tokivski, Mokromoskovski, Dobropilski, Saltychanski and Yanvarski complexes; *2* – plagiogranites, tonalites of Surski, Saksaganski and Shevchenkivski complexes; *3* – metamorphic series (Aulska and Western Pryazovska) and ultrametamorphic complexes (Slavgorodski, Novopavlivski and Dnipropetrovski) of dome structures; *4* – metamorphic formations (Vovchanska and Dragunska), Central Pryazovia series and ultrametamorphic complexes (Remivski and Tokmatski) of sutural zones; *5* – metamorphized igneous-terrigenous complexes of trough structures of greenstone type (Konkska, Bilozerska, Osypenkivska series and Novogurivska, Ternuvatska, Kosivtsivska formations); *6* – terrigenous complexes of fault-line superimposed structure (Kryvorizka series, Guliapilska suite); *7* – gabbro, monzonites, syenites of Southern Kalchytski and Oktiabrski alkaline intrusive complexes; *8* – local abyssal fracture; *9* – other fractures; *10* – geological boundaries; *11* – notional boundaries of greenstone belts.

in favour of this assumption. The formation process of these megastructures from the point of view of abyssal magmatic plumes is considered in our previous publications (Isakov, 2017). It should only be noted that the structural-geological body of the above mentioned megastructures is determined by granite-gneiss domes with the development (in some structures) in their central parts with large granitoid batholites of complex internal structure and wide range of material composition, surrounded by synclinal- and graben-like trough structures composed of igneous-sedimentary formations metamorphosed in the conditions of greenschist and amphibolite facies of regional metamorphism. The analysis of reconstruction of the sequence of geological processes resulting in the formation of these interrelated structures allows us to assume there was a series of stages in the formation of pegmatite fields, which can be divided into two main periods. The first period was associated with ultrametamorphic processes and led to the formation of ceramic pegmatites in ancient granite-gneiss dome structures with the formation of large areas, mostly of isometric fields; while the second period of pegmatite formation is clearly associated with the process of forming granite intrusions and batholiths- pegmatites of this period are mostly associated with narrow trough structures developed around granite batholiths and granite-gneiss domes, and they could be formed in several stages.

The main factors influencing the formation and composition of pegmatites of the Ukrainian Shield. Based on the above considerations, we look at characteristics of four pegmatite regions (Volynska, Ingulska, Middle Prydniprovia and Western Pryazovia megastructures) presented by pegmatites of different origin and petrological and mineral composition and occurring in different structural and tectonic conditions, having different ages of formation, which allows us to make a full classification scheme of the pegmatites of the Ukrainian Shield.

Western Pryazovia megastructure. The gradual interrelated development of the megastructure (Isakov, 2011, Isakov, 2012) respectively affected the formation of its tectonic structures of a higher order,



1 – two-feldspar granites of Dobropilski, Saltychanski and Yanvarski complexes; *2* – plagiogranites, tonalites of Shevchenkivski complex; *3* – metamorphic Western Pryazovia series and ultrametamorphic Novopavlivski complex of dome structures; *4* – metamorphic formations (Vovchanska and Dragunska), Central Pryazovia series and ultrametamorphic complexes (Remivski and Tokmatski) of sutural zones; *5* – metamorphized igneous-terrigenous complexes (Osypenkivska series and Novogurivska, Ternuvatska, Kosivtsivska formations) of trough structures of greenstone type; *6* – terrigenous complexes of fault-line superimposed structure (Guliapilska suite); *7* – local abyssal fractures; *8* – other fractures; *9* – geological boundaries; *10–14* – notional boundaries: *10* – of pegmatite belts; *11* – of ceramic pegmatite fields; *12* – of rare metal pegmatite fields; *13* – of rare earth pegmatite fields; *14* – of pegmatite fields of unspecified specialization (presumably rare metal, rare earth specialization); *15* – pegmatite belts: II – Shevchenkivsko-Vislynski; III – Sorokynsko-Gaichurski; *16* – ceramic pegmatite fields: 16 – Kamensko-Vovchanske; 18 – Guliaipilske; 25 – Temriuk-Korsakske; 27 – Yeliseivske; 8 – Tokmachanske; *17* – rare metal pegmatite fields: 17 – Shevchenkivske-Fedorivske, 26 – Sorokynske; *18* – rare earth pegmatite fields; 19 – Gaichurske, 21 – Kuibyshevske, 23 – Vislynske; *19* – specified pegmatite fields and fields of unspecified rare metal, rare earth specialization: 17a – Vovchanske, 20 – Pavlilvske, 22 – Chystopilske, 24 – Dragunske, 29 – Molochanske; *20* – deposits and ore occurrences of rare earth associated with pegmatites: 5 – Gaichurska group, 6 – Kuibyshevske, 7 – Mogyla Visla; *21* – deposits and ore occurrences of rare metals associated with pegmatites: 1 – Voskresentki, 2 – Voskresentki-2, 3 – Shevchenkivske, 4 – Mokroialynski, 9 – Kruta Balka, 10 – Golubi Skeli; *22* - deposits and ore occurrences of ceramic raw materials associated with pegmatites: 8 – deposit group (Balka Velykogo Taboru, Dalnia Kamchatka, Balka Glyboka, Dolynske, Yelisiivske and others.)

Fig. 3 Geological map of Western Pryazovia pegmatite region.

the granitoid formations and the pegmatites associated with them. Due to the influence of the deep processes caused by the action of the magmatic plume, the Ovchanskiy and Saltychansky middle granitoid-gneiss domes were formed; and as compensatory structures around them, the Oryhivsky-Pavlogradsky and Maloenysolsky synclinores are represented by a narrow isocline folded structure (Fig. 2). Granite-gneiss domes are composed by the formations of the Western Priazovian series of the early Archaean and heterogeneous granite rock masses – Saltychansky and Gulyaypilsky represented by plagiogranites, tonalites, diorites, occasionally gabbro of the Shevchenkivsky and Obotoknovsky complexes of the late Archean age (2.8 billion years). The syncline structures, united into a single zone in the central part, are composed of the Vovchanska, Dragunska, and Novopavlivska formations of crystalline schist and gneisses of different composition of the amphibolite stage of metamorphism, and the Central Pryazovian series of high-alumina formations, whose age varies from the early Archaean to the Early Proterozoic, which may explain the complex structure of the synclinores. Greenstone structures are located in the junction zones of synclinores and dome structures and form two sub-parallel segmental semicircular greenstone belts – the Shevchenkivsko-Berestovsky and the Sorokinsky-Gaichursky. The former consists of the following trough structures: Shevchenkivska, Fedorivska, Vovchanska and Dibrovska surrounded by the Vovchansky dome; and the Pavlivska and Berestovska structures within the Maloyansilsky synclinoria. The Sorokinsko-Gaichursky greenstone belt is composed of the Sorokinska and Dragunska trough

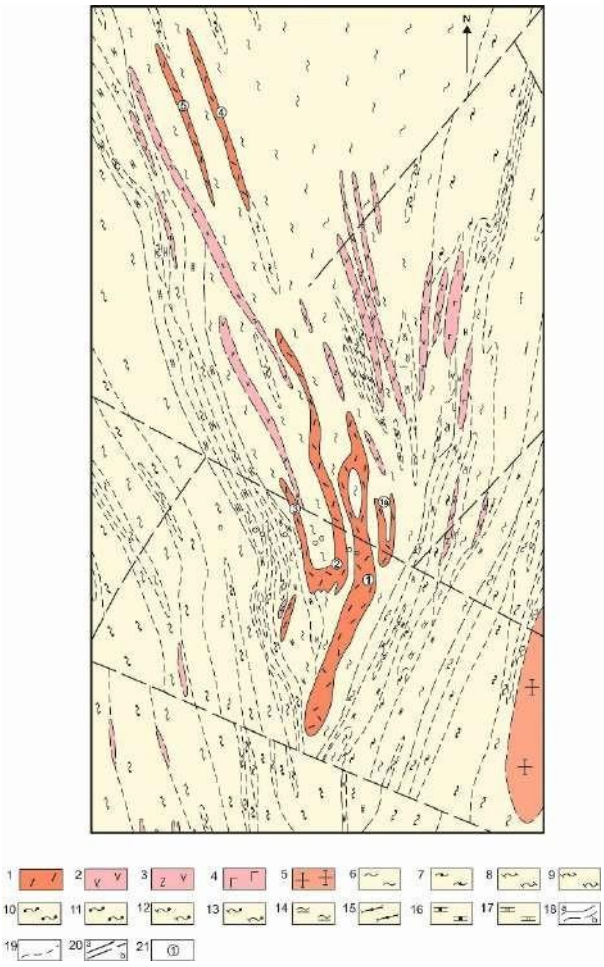


Fig. 4 Geological map of Shevchenkivski node of rare metal pegmatites:

1–4 – pegmatites: *1* – albite-spodumene, albite-petalite-spodumene; *2* – albite; *3* – albite-microcline; *4* – microcline and microcline-oligoclase; *5* – muscovite-biotite, amphibole-muscovite-biotite fine- and medium-grained, muscovite-biotite pegmatoid granites; *6–17* – Ternuvatska rock mass, crystal slates: *6* – biotite, *7* – amphibol-biotite, *8* – muscovite-biotite, *9* – sillimanite-muscovite-biotite, *10* – garnet-biotite, *11* – garnet- sillimanite-biotite, *12* – garnet-muscovite-biotite, *13* – sillimanite-garnet-muscovite-biotite, *14* – biotite tourmalin bearing, *15* – quartz-sericitic; *16* – epidote- and quartz bearing scarified calciphyre; *17* – quartz-garnet-epidote-pyroxene calc-silicate hornfels; *18* – boundaries between subsections of different age: а – determined, б – anticipated; *19* – boundaries between lithological types of rocks; *20* – fractures: а – determined, б – anticipated; *21* – numbers of pegmatite bodies.

structures surrounded by the Saltychansky granite dome and Kuibyshevska, Gaichurska, Kosivtsivska ones–surrounded by the Guliaipilsky granite dome. They are close to the composition of volcanogenic-terrigenous rocks of the Osipenkivska series and the Kosivtsivska and Ternuovatsky formations of the Meso-Neoarchean era, metamorphized in conditions from the greenstone to the amphibolite facies of the regional metamorphism. Along these structures are developed granite masses of the Yanvarsky and Saltychansky complexes, whose age according to various estimates is 2.6-2.2 billion years. The structures that form these green-stone belts are the main reservoir for rare-metal and rare-earth pegmatites (Fig. 3).

Concerning the pegmatite formation stages within the Western Pryazovia megastructure, *the first stage* of pegmatite formation is ultrametamorphism that developed intensely in the final stage of forma- tion of the dome-synclinore structure of Western Pryazovia (Remivski ultrametamorphism). In this period pegmatites were formed as neosoms in the process of partial melting of rock complex of both the ceramic pegmatite field around it and within autochtonous granite massifs.

Pegmatite formation of the *second stage* is associated with the establishing of granite-gneiss domes and bedding of Shevchenkivski plagiogranite massifs. The establishment of allochtonous plagiogranite massifs of this complex was accompanied by bedding of the bulk of ceramic pegmatites with wide fields of formation (Yeliseivske, Temriuk-Korsakske, Vovchanske and Guliaipilske) located both in granite massifs and in rock complexes of the Western Pryazovian, and sometimes in Vovchanska and Dragunska rock masses.

The establishment of multi-stage intrusives of two-feldspar granites of Yanvarski, Dobropilski and Saltychanski complexes (*the third stage*) was accompanied by intrusion and penetration of a significant mass of pegmatite matter in the weakened zones of trough structures of greenstone belts with the formation of pegmatites of different types (in particular, rare metal and rare earth) depending on the time, depth of their intrusion and specialization of the massifs. Resulting from these processes there formed the fields of rare metal and rare earth pegmatites: Shevchenkivske, Fedorivske, Vovchanske, Sorokynske, Gaichurske and others, in their turn forming the Sorokynsko-Gaichurski and Shevshenkivsko-Berestivski pegmatite belts. They are associated with such well-known deposits of rare metal pegmatites as Shevchenkivske (Isakov, 2013) (Fig. 4) and Kruta Balka (Rozanov, 1979) (Fig. 5).

Middle Prydniprovia megastructure is attributed to the category of specific lower Pre-Cambrian geostructural elements of the Earth crust – granite-greenstone areas or folded-dome greenstone belts (Bobrov, 2002, Sivoronov, 1983, Shcherbakov, 2005) associated with large pegmatite provinces in other shields –Yilgarn in Australia, Winnipeg-Nipigon Abitibi in North America and others. The megablock is characterized by relative time sequence of change of geo-

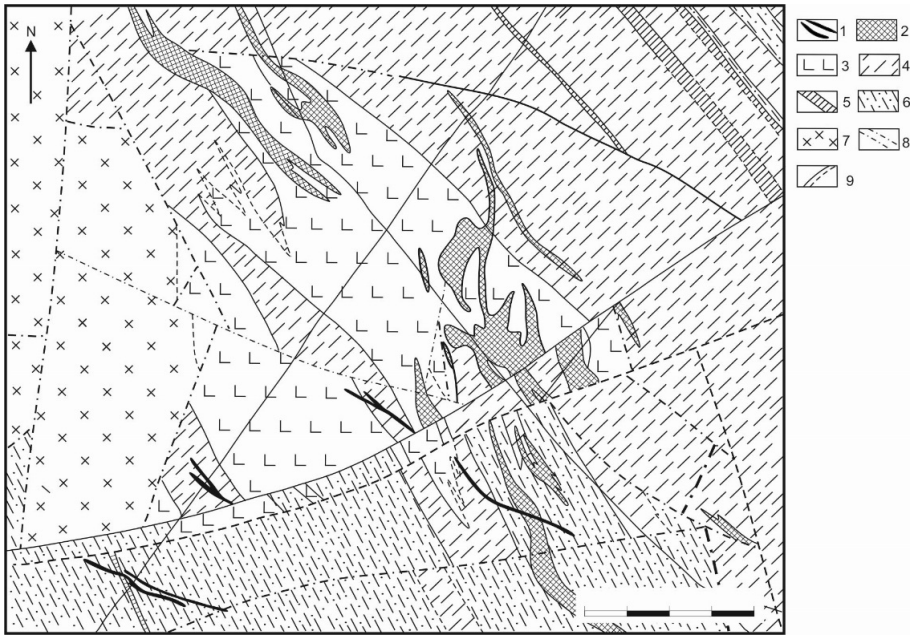


Fig. 5 Schematic geological map of Kruta Balka pegmatite node [14]:

1 –quartz veins; *2* – pegmatite bodies; *3* – metaultrabasite; *4* – slightly metamorphized biotite, amphibolic and other types of slates; *5* – quartzites; *6* – metagravelite and metaconglomerate; *7* – diorite-granodiorite; *8* –fractures; *9* –geological contours.

logical conditions similar to the above provinces in the formation of rock complexes as well as their effect on the development and establishment of pegmatite fields.

The megastructure includes the following closely interconnected structural units (Fig. 6): 1) Saksaganskу, Zaporizky, Pyatihatsky, Demurinsky, Slavgorodsky and other granite-gneiss and migmatite-gneiss domes made of supracrustal formations of the Aulska series and Dnipropetrovsk and Slavgorod plagiogranite-migmatite and endebit-charnokytoid complexes; 2) the Krivorizko-Kremenchutsky, Bazavlutsky and Konksko-Belozersky green-stone belts are composed by the Vysokopilsky, Chortomlitsky, Sofievsky, Verkhovtsy, Sursky, Zhovtovodsky and other green-stone downfolds composed of apo-volcanogenic formations of the Konkska series and apo-sedimentary formations of the Bilozerska series; 3) plagiogranite rock masses of the Saksagansky and Sursky complexes connected with green-stone structures; 4) multi-phase granite massifs: Demurinsky, Mokromoskovsky, Tokivsky, Orilsky and others related to green-stone structures. By structural form and history of its formation, the Middle Pridniprovian megastructure is the plume structure of the Ukrainian Shield (Isakov, 2017).

The lower age limit of the Konkska series is de-

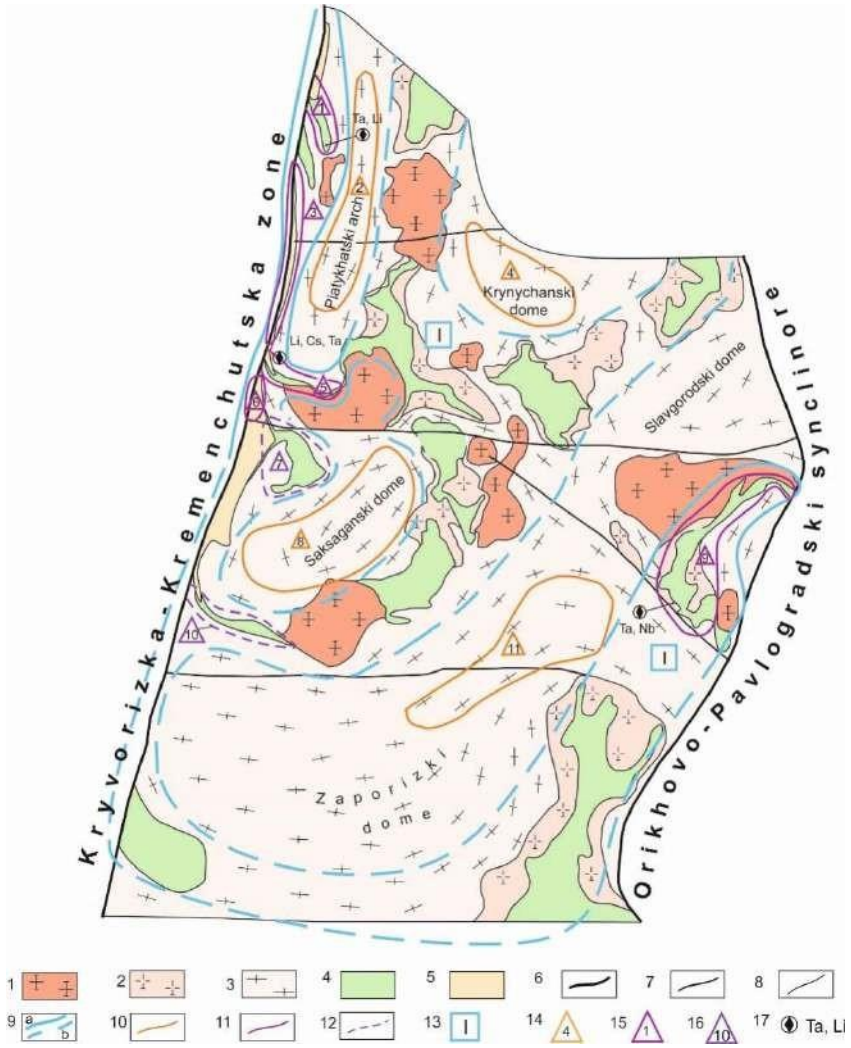


Fig. 6 Schematic geological-structural map of Middle Prydniprovia pegmatite region

1 – two-feldspar granites of Demurski, Tokivski, Mokromoskovski complexes; *2* – plagiogranites, tonalites of Surski and Saksaganski complexes; *3* – metamorphic series (Aulska) and ultrametamorphic complexes (Slavgorodski and Dnipropetrovski) of dome structures; *4* – metamorphized igneous-terrigenous complexes of trough structures of greenstone type (Konkska and Bilozerska series); *5* – terrigenous complexes of fault-line superimposed structures (Kryvorizka series); *6* – abyssal regional fractures; *7* – fractures; *8* – geological boundaries; *9* – notional boundaries of pegmatite belts that encompass: а – established pegmatite fields; б – conditionally established and anticipated pegmatite fields; *10–14* – notional boundaries of pegmatite fields: *10* – ceramic, *11* – rare metal, *12* – unspecified (presumably of rare metal and rare earth) specialization; *13* – pegmatite belts: I – Komendantivsko-Zhovtovodsko-Mokromoskovski; *14* – ceramic pegmatite fields: 2 – Piatyhatske, 4 – Krynychanske, 8 – Bazavlutske, 11 – Tokmatske; *15* – rare metal pegmatite fields: 1 – Komendantivske, 3 – Mykolaivke, 5 – Zhovtovodske, 6 – Gannivske; *16* – pegmatite fields of specified and unspecified (presumably) of rare metal, rare earth specialization: 7 – Ternivske, 10 – Vysokopilske; *17* – mineral occurrence of rare metals associated with pegmatites.

termined by the age of zirconium from the metavolcanites of the Surska suite– 3177 Ma upper age limit – by the age of zirconium from plagiogranites of the Sursky complex - up to 2960 Ma. The lower age limit of the Bilozerska series is determined by zirconium from meta-keratophyres – 3000 Ma. The upper age limit of the entire green-stone rock mass is determined by the age of the youngest granite of the Demurinsky and the Mokromoskovsky complexes that transect it – 2850-2700 Ma (Shcherbak, 2005).

The fields of ceramic pegmatites located immediately within granite-gneiss domes indicate the *first stage* of formation of pegmatites in the period of ultrametamorphism of dome structures of rock complexes. In outcrops there is discovered close or immediate location of these pegmatites in migmatites and granit-

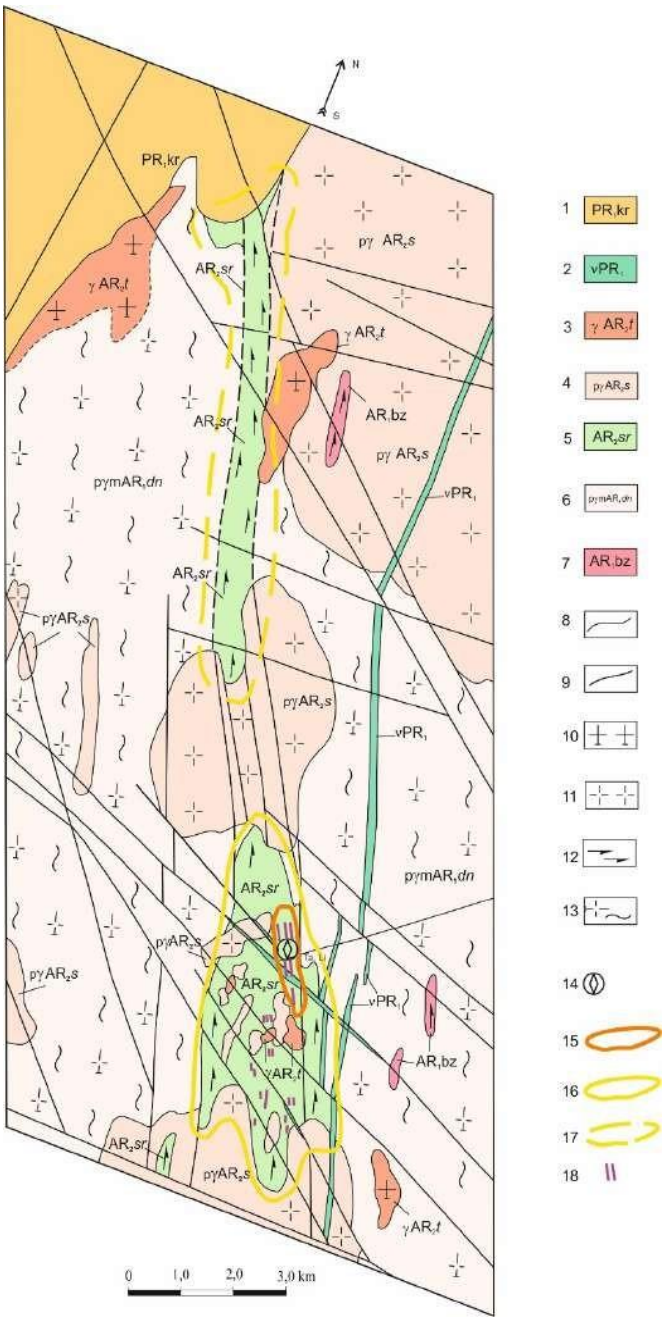


Fig. 7 Geological map of the Komendantivska greenstone structure and location of the same-name pegmatite field, node and ore occurrence within in:

1 – formation of the Kryvorizka series; *2* – diabase dikes; *3* – granites of the Tokivski complex; *4* – plagiogranites of the Surski complex; *5*–gabbro-diabase*6-8* – formation of Surska suite: *6* – amphibolites; *7* – amphibole, amphibole-biotite crystal slates; *8* – talk-tremolite-serpentine slates; *9* – plagiomigmatites of the Dnipropetrovsk complex; *10* – formation of the Bazavlutska rock mass; *11* – geological boundaries; *12* – fractures; *13* – Komendantivski node of rare metal pegmatites; *14*а – Komendantivske field of rare metal pegmatites; *14*б – anticipated field of rare metal pegmatites; *15* – pegmatite veins; *16* – Komendantivski ore occurrence of tantalum and lithium.

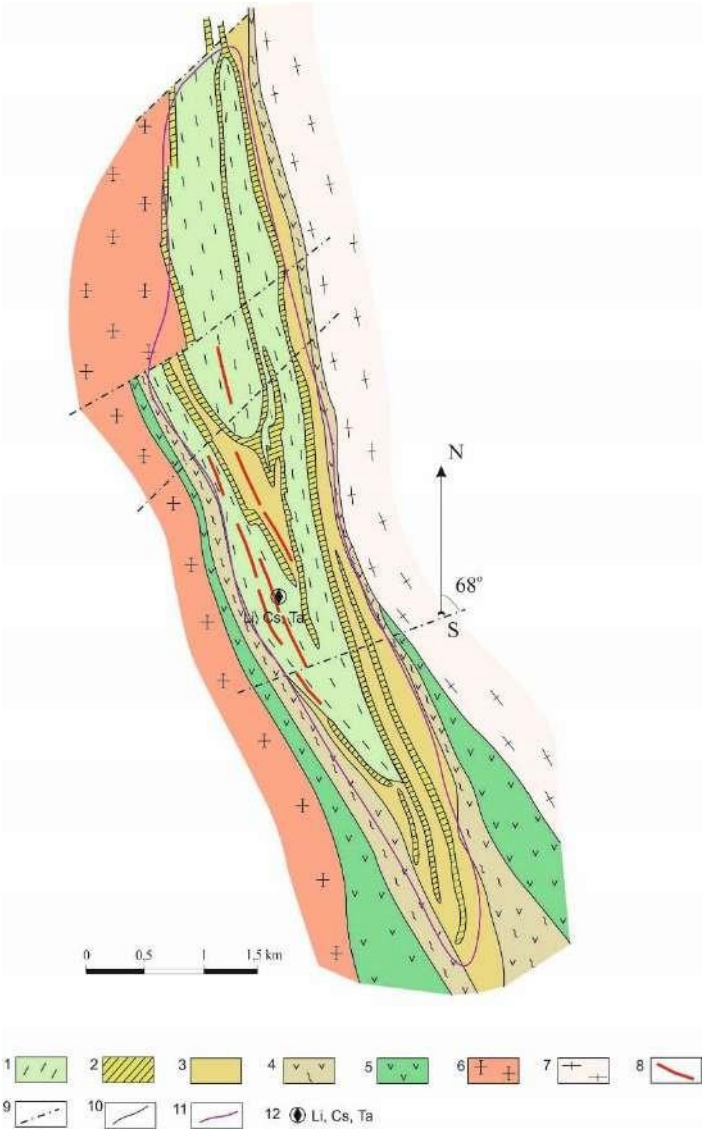


Fig. 8. Geological map of the Zhovtianski pegmatite field:

1–4 – formation of Kryvorizka series: *1* – dolomite, quartz-biotite rock mass with graphite of microschist, diopside quartzites, actinolite shales; *2* – magnetite-hematite jaspilite, magnetite-hematite hornfels; *3* – rock mass of amphibole, mice, mice-amphibole shales; *4* – sericitic quartzite with fuchsite, amphibole-biotite gneiss; *5* – amphibolites of Konkska series; *6* – Demurivski granites; *6* – Dnipropetrovsk plagiomigmatites; *8* – pegmatites; *9* – fractures; *10* – geological boundaries; *11* – notional boundaries of Zhovtianski field of rare metal pegmatites; *12* – Zhovtianski ore occurrence of rare metals.

oid formations of the Dnipropetrovsk complex, which indicates their genetic connection with this complex, as well as their ultrametamorphic nature.

In the *second stage* within granite-gneiss domes there formed large fields of ceramic pegmatites as derivatives of buried plagiogranite pegmatites (the most well-known are the Bazavlutske pegmatite fields located in the central part of the Saksaganski dome).

Pegmatite formation of the *third period* is associated with the establishment of greenstone structures and the Kryvorizko-Kremenchutska structural-facial areas. Pegmatite formation is associated with the formation of multi-stage intrusives of two-feldspar granite complexes (Demurski, Mokromoskivski, Tokivski, Orilski massifs) and was accompanied by the intrusion and inflow of a considerable mass of pegmatite matter into weakened areas of trough greenstone structures with the formation of pegmatites of different types, in particular rare metal and rare earth depending on the time, the depth of its separation and specialization of the massifs themselves. The absence of pegmatite fields within the majority of greenstone structures is explained by only one reason – insignificant erosional truncation of these structures. The fields of rare earth pegmatites are discovered within the Kryvorizko-Kremenchutska structural-facial ar-

eas where they form the Petrovske and Mykolaivske long fields. Pegmatite fields of rare metal specialization (Zhovtovodske, Komendantivske, Mokromoskovske) are traditionally "attached" to separate greenstone trough structures and their aureole. Grouping with fields of rare earth specialization, they form the long (up to several hundred kilometers) Komendantivsko-Zhovtovodsko-Morkomoskovski pegmatite belt. Here are manifested such ore occurrences of rare metals as Komendantivske (Fig.7) and Zhovtovodske (Fig.8) (Isakov, 2013). The fields are formed by the following types of pegmatites: microcline, oligoclase-microcline, oligoclase; albite rare metal: 1) without lithium minerals; 2) with lithium minerals.

Ingulska and Volynska megastructures. The key structural-geological position in the structure of these megablocks is taken by thick granitoid batholites of complex internal structure and wide range of composition. Analysis of the restored sequence of geological processes causing their formation gives an opportunity to regard these megablocks based on the hypothesis of abyssal convection current and magmatic plumes (Isakov, 2017).

In the formation of ***Ingulska megastructure*** the following tightly connected structural unites are involved: 1) the Novoukrainski and Korsun-Novomyrgorodski plutons (magmatic dome); 2) the system of synclinore structures (Bratska and Pryingulska),

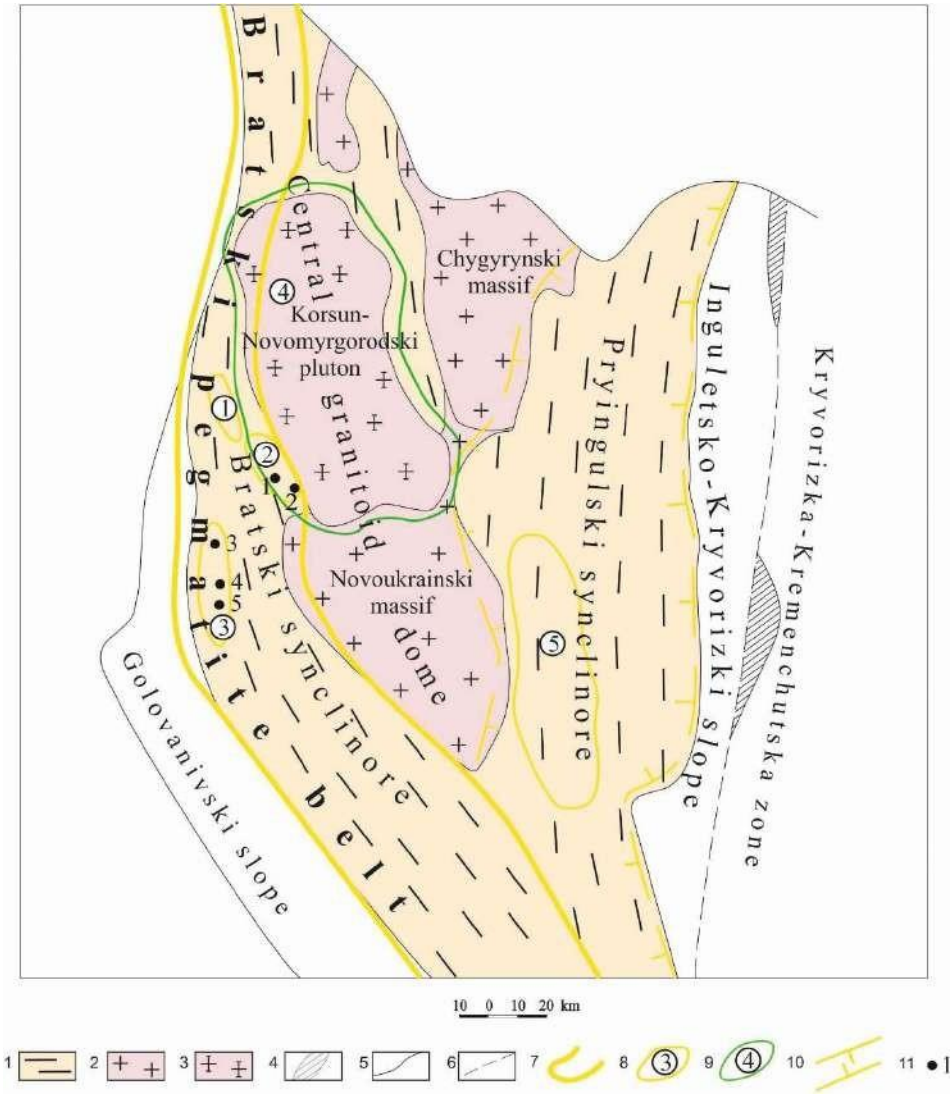


Fig. 9 Contour map of Ingulski pegmatite region

1. Small-dome structure of the Bratski and Pryingulski synclinore formed by rock formations of the Ingulo-Inguletska series and granites of the Kirovograd complex. *2*. Intrusive formations of the Novoukrainski complex. *3*. Intrusive formations of the Korsun-Novomyrgorodski complex. *4*. Metaterrigenous formations of the Kryvorika series. *5*. Geological boundaries. *6*. Fractures. *7*. Notional contours of the Bratski pegmatite belt. *8*. Notional contours of rare metal pegmatite fields: 1-Vys, 2-Mostove, 3-Lypniazke, 5-Kirovogradske. *9*. Notional contour of anticipated contour of development of pegmatite fields of chamber pegmatites: 4-notionally contoured Korsun-Novomyrgorodske field. *10*. Notional contour of anticipated development of rare metal pegmatite fields. *11*. Ore occurrences and deposits of rare metal pegmatites: 1-Mostove, 2-Polohivske, 3-Lypniazke, 4-Stankuvatske, 5-Nadia.

their fringing; 3) Golovanivska and Kryvorizko-Kremenchutska inclining (suture, according to (Isakov, 2017)) zones fringing the megablock (Fig.9).

Within the ***Bolynska megastructure*** tightly connected structural units are singled out : 1) Gorognytsko-Korostenski ultrametamorphic magmatic dome (Gorodnytsko-Yemilchynski granite-migmatite dome and Korostenski pluton); 2) the system of synclinore structures forming the Pivdennovolynski synclinore (Teterivski dip, after V.A. Riabenko, or the Zhytomyrski synclinore, after V.M. Klochkov); 3) Ovrutska graben-synclinal with its Bilokorovytski and Vilchanski branches (Fig.10).

The process of granite and pegmatite formation as the main generator of pegmatite matter within megablocks was rather similar and realized in at least three stages.

The first stage is the formation of proper ceramic pegmatites of quartz-oligoclase microcline, quartz-oligoclase, quartz-microcline composition among old ultrametamorphic rock complexes of dome structures (Sheremetivski and Inguletski complexes).

The second stage. The first sub-stage is bedding of granites of Kirovogradski and Zhytomyrski complexes presented by biotite, garnet-biotite, muscovite-biotite two-feldspar granites, aplite-pegmatoid

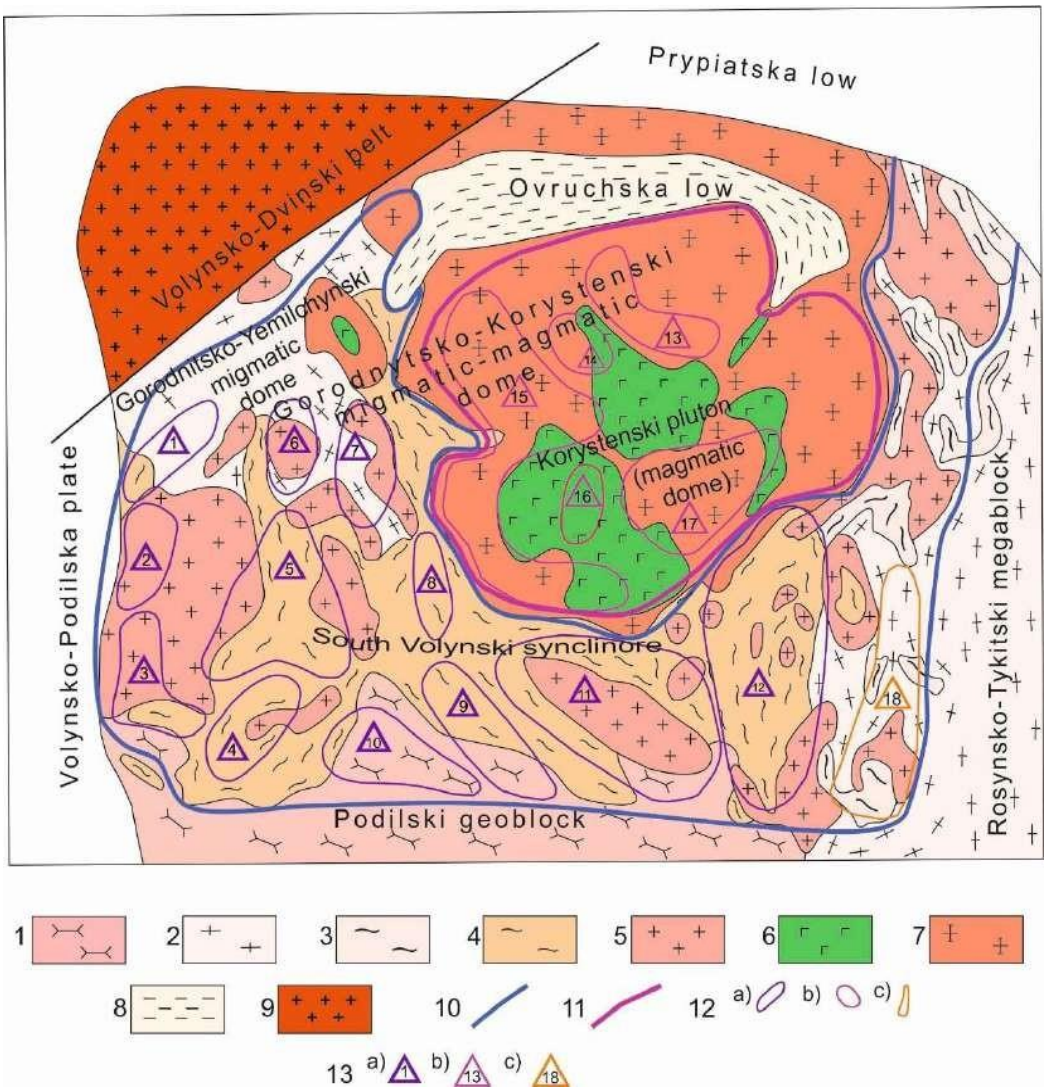


Fig. 10 Contour map of Volynski pegmatite region.

1 – migmatites and granites of the Pobuzki complex; *2* – migmatites of the Sheremetivski and Tetiivski complexes; *3* – rock complexes of the Rosynsko-Tikytska series; *4* – rock of Teterivska series complex; *5* – granites of Zhytomyrski complex; intrusive formations of complex (*6* – gabbro, *7* – granite); *8* – rock of Ovrutska series complex; *9* – granites of Perzhanski complex; *10* – notional contour of Volynski pegmatite belt; *11* – notional contour of Korostanski stockwork of chamber pegmatites; *12* – notional boundaries of pegmatite fields: a – rare metal and rare earth; b – chamber; c – ceramic; *13* – Pegmatite fields: a – rare metal pegmatites: 1 – Gorodnitske; 2 – Koretske; 3 – Shepytivske; 4 – Polonno-Baranivske; 5 – Novograd-Volynske; 6 – Serbivske; 7 – Barashenske; 8 – Tesnivske; 9 – Kodynynske; 10 – Berdychivske; 11 – Zhytomyrske; 12 – Kocherivske; b – chamber pegmatites: 13 – Ignatpilske; 14 – Behinske; 15 – Volodarsko-Volynske; 16 – Irshanske; 17 – Malynske; c – ceramic pegmatites: 18 – Yablunovsko-Volodymyrske.

granites, aplites and pegmatites that form a range of massifs within synclinore structures, including rather large ones. Their age is estimated at 2 000 mln years and older (Shcherbak,2005). These granite complexes are associated with the majority of ceramic, rare earth and rare metal pegmatites. The absence or low occurrence of rare metal pegmatites within the Volynska megastructure can be explained only by its insignificant erosive level. This didn't allow us to sort out these pegmatite fields, and in the given scheme (Fig.10) all of them are highlighted as potentially rare metal fields.

The second sub-stage is a further formation of central magmatic dome and bedding of two large massifs (plutons) of complex structural and material composition within the Ingulski megablock: Novoukrainski and Chygyrynski plutons composed mainly by granites of biotite and granite-biotite with bodies of gabbronorite, norites, monzodiorite, monzonite, quartz syenite of frequent occurrence. The age of rock formations of the Novoukrainski complex is estimated at 2030 – 2000 Ma (Shcherbak, 2005), that is the granites of the Kirovogradski complex and associated granites

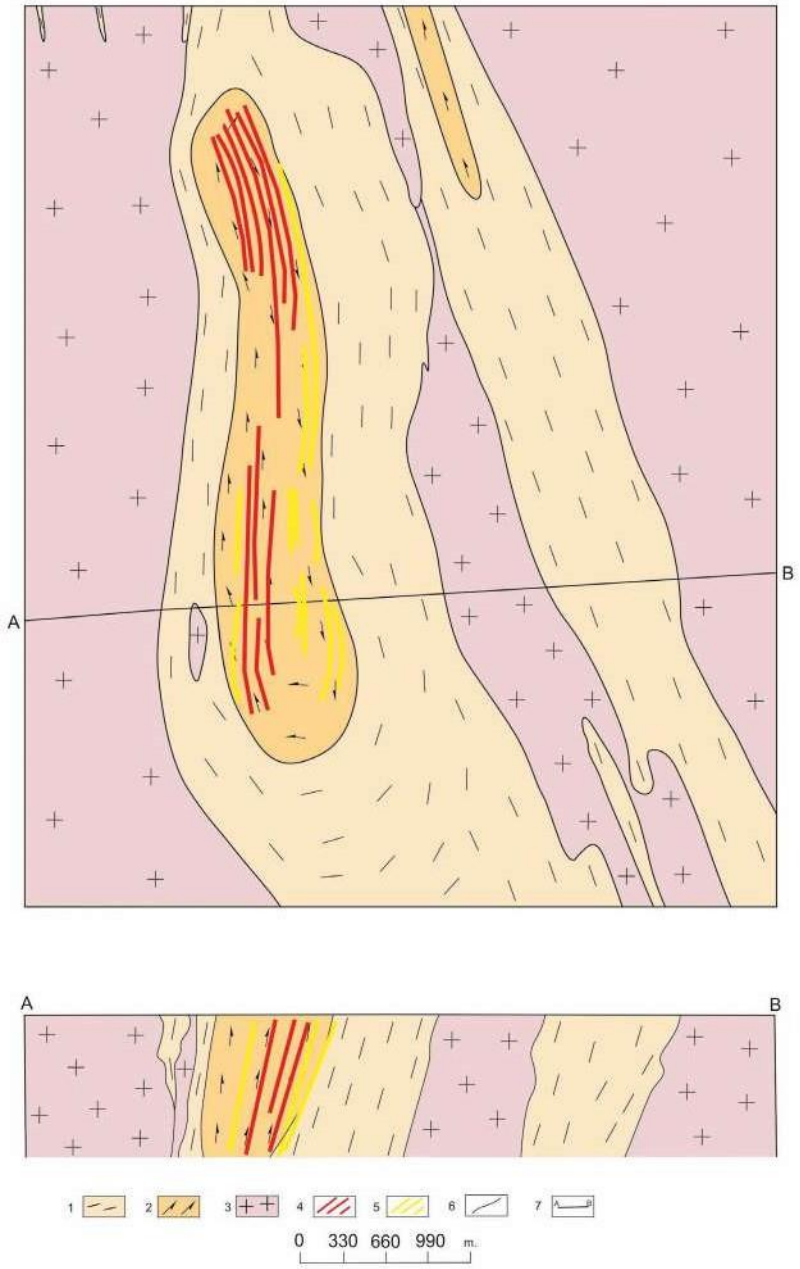


Fig.11 Schematic formation of Stankuvatski and Nadia nodes of rare metal pegmatites.

1 – gneiss and shale of biotite, garnet-biotite, cordierite-biotite, graphite-cordierite-biotite, amphibol-biotite, pyroxene-biotite nature; *2* – amphibolites; 3- biotite granites with garnet and cordierite; *4* – pegmatites: petalite-spodumene, albite rare metal; *5* – quartz two-feldspar ceramic pegmatites; *6* – geological boundaries; *7* – cross-section line.

and aplites are derivates of a common magmatic environment that were separated at the early abyssal stage of its establishment, which after some period of time were moved and formed the Novoukrainski and associate massifs. Thus, pegmatites within the Ingulska megastructure (rare metal ones in particular) associated with both the Kirovogradski and Novoukrainski granite complexes have common genetic nature and are divided by the formation stages. This complex is associated with pegmatites of the Polohivske deposit of petalite pegmatites, the Lipniazhska group of deposits (Stankuvatske, Nadia, Lipniazhske) (Fig.11) and Mostova group of deposits (Mostove-3, in particular) (Fig. 12) of rare metal pegmatites (Voznyak, 2001, Yeryomenko, 1996, Ivanov, 2002).

The third stage is the final stage of formation of the central magmatic dome – bedding of the Korsun-Novomyrgorodski and Korostenski plutons of complex structural and material composition formed by mainly granites of rapakivia and gabbro-anorthosite. Granites of these plutons are also associated with pegmatites, chamber ones in particular (known Volynska

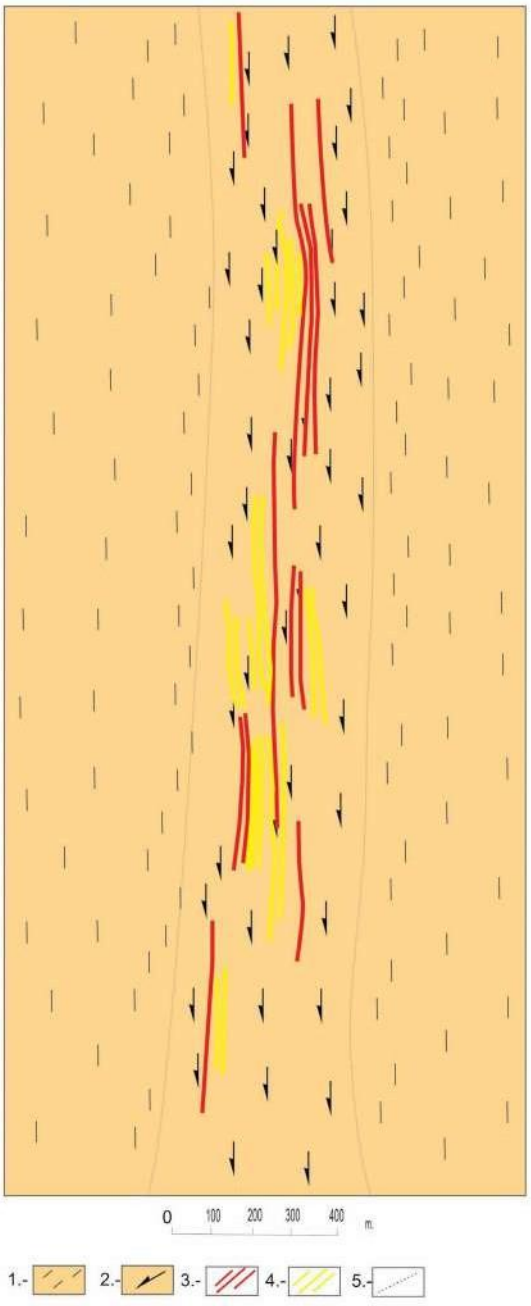


Fig.12 Scheme of formation of Mostove-3 pegmatite node

1 – Biotite-gneiss; *2* – Biotite gneiss with silimonite, cordierite, muscovite, garnet; *3* – Quartz-albite rare metal pegmatites; *4* – Quartz two-feldspar pegmatites.

group of deposits of chamber pegmatites (Mineralogy, 1973). Their absence or insignificant occurrence within the Ingulska megastructure can be explained by the significant erosive level of the massif, which resulted in the destruction of the majority of chamber pegmatites.

Thus, within the Ingulska and Volynska megastructures we observe such pegmatites that both in common and separately form independent pegmatite fields: proper ceramic, rare earth and rare metal, as well as chamber pegmatites. The time sequence of the formation of the indicated types of pegmatites appears as follows: ceramic pegmatites → rare earth and accompanying barren pegmatites → rare metal and accompanying barren pegmatites → chamber pegmatites

Systematization of pegmatites of the Ukrainian Shield. Pegmatites are not original or unique either for the Ukrainian Shield or for other Early Pre-Cambrian structures of the world. This is explained, first of all, by geological and structural conditions of this period that were favourable for the development of different types of granitoid formations which, in their turn, were the main generators of pegmatite matter not only in early but also in later periods of earth crust development. Different depth of origin and establishment of magmatic environments and variety of forms of granitoid manifestations in their turn gave origin to the variety of forms, composition, geochemistry, metallogenic specialization of pegmatites. Their form, composition, geochemical and metallogenic specialization were also greatly influenced by Pt-condition of the surrounding environment, composition of the hosted rocks, tectonic conditions and a range of other factors occurring in the process of their establishment and formation. All the above conditioned significant differences of pegmatites in composition of both basic rock-forming mineral and in internal structural and texture characteristics, as well as in microelement composition and the presence of a large range of accessory and rare minerals that reach percentage composition in pegmatites or become rock-forming. This characteristic of formation and internal structure, as well as the composition of pegmatites resulted in the appearance of different, often opposite, working hypotheses about their genesis and formation (Ginzburg, 1979, Kuz'menko, 1978, Nikanorov, 1979, Petrov, 1975, Shavlo, 1984, Shmakin, 1987 and oth.). For instance, O. Fersman and K. Vlasov considered pegmatites to be the result of the crystallization process of residual magmatic melting enriched by volatile components; while D. Korzhynski and V. Nikitin thought it to be the result of influence of post-magmatic melting on re-crystallization and replacement of magmatic genesis rocks. This, in its turn, caused a large number of classification systems and classifications developed by different authors in different years. The majority of these classifications are built on classification features – typomorphic, rock-forming and ore minerals, structural and textural characteristics of pegmatites, abyssal establishing, or economic value.

Sometimes classification systems are composed by a range of genetic and geological-structural features and conditions of pegmatite formation. The principles of their classification are acceptable with one provision: the desire of these authors to build the general holistic concept of singling out pegmatites by the primary characteristic (gradual change of depth or the level of regional metamorphism, processes of re-crystallization and replacement during metamorphism and metasomatosis, rare metal mineralogical and geochemical specialization etc) resulted in significant simplification of the process of formation and establishment of pegmatites of different associations, as well as in the loss of a range of important factors of this process. That is, the role of separate and, in the authors' opinion, major and only factors in the establishment of pegmatite associations is not so significant and in many cases exaggerated.

Without going deep into general critical analysis, for it is already presented in the above mentioned researchers and authors in (Isakov, 2006), on the basis of genetic and geological-structural factors of formation of pegmatites of the Ukrainian Shield , we will try to construct a general scheme that would reflect general regularities of pegmatite formation in early Pre-Cambrian structures and would reconstruct the general logical chain of abyssal processes of their formation (Table 1). It is based on the characteristic features of formation and development of pegmatite-generating environments and pegmatite-bearing structures, tectonic-structural characteristics of pegmatite-bearing areas during the process of their establishment, as well as the influence of external metamorphogenic-metasomatic processes on the already formed pegmatites.

By the development of pegmatite-generating environments we single out:

– three genetic groups of pegmatites: ultrametamorphogenic, magmatogenic and metamorphogenic-metasomatic;

– six genetic sub-groups of pegmatites: migmatite; autochtonous granite massifs; metamorphogenic and metasomatically replaced and formed pegmatites; multi-phase intrusive granite massifs; multi-phase in-

Table 1. Classification of pegmatites of Pre-Cambrian shields (on the example of the Ukrainian Shield)

Groups of pegmatites			Genetic subgroups of pegmatites	Associations (formations) of pegmatites	Types of pegmatites	
Genetic	Geological-structural	Subgroups			Mineralogical (by ore-formation minerals)	Geochemical-metallogenic
Magmatogenic	Dome-synclinoreanddome-trough plume-structures	Intrusive domes and batholiths	Multi-phase granite batholiths	Miarolitic and chamber pegmatites	By different classifications offered by M.P.Yermakov (1957) and Ye.K.Lazarenko, V.I.Pavlyshyn (1973)	
				Rare-metal pegmatites	Microcline Microcline-albite Microcline-albite and spodumene	Rare metal, ore specialization in Li, Rb, Cs, Ta, Nb, Be, Sn
				Ceramic pegmatites	Microcline Microcline-oligoclase	Rare geochemical and insignificant rare specialization in Nb
			Multiphaseintrusive alkaline massifs	Thorium-rare-earth pegmatites	Albite-amazonite Microcline Albite-microcline Albite-quartz Oligoclase-microcline	Rare earth, ore specialization in TR, Y, Ta, Nb, Zr
				Ceramic pegmatites	Microcline Microcline-oligoclase	Barren;
		Intradome synclinore and trough structures including greenstone ones	Multi-phase intrusive granite massifs	Rare-metal pegmatites	Microcline-spodumene Albite-spodumene Albite-petalite-spodumene Albite Albite-microcline Microcline	Rare metal and ore specialization in Li, Rb, Cs, Ta, Nb, Be, Sn
				Rare-metal muscovite-feldspar pegmatites	Muscovite-albite-microcline-oligoclase Muscovite-microcline-oligoclase	Rare metal,geochemical and ore specialization in Ta, Nb, Be, Li, Rb, Cs
				Muscovite-feldspar pegmatites	Muscovite-microcline-oligoclase Muscovite-oligoclase	Barren, possible (?) geochemical specialization in Nb, Zr, TR, U
				Ceramic pegmatites	Microcline Microcline-oligoclase	Ditto
Metamorphogenic-metasomatic	Specific tectonic zones of stress		Metamorphogenic-metasomatic replaced and formed pegmatites	Beryl-muscovite pegmatites	Muscovite-albite-microcline-oligoclase Muscovite-oligoclase	Beryl-bearing, geochemical specialization in Be, Nb, Zr, TR, U, ore specialization In Be
				Muscovite pegmatites	Muscovite- microcline-oligoclase Muscovite-oligoclase	Barren, possible (?) geochemical specialization in Nb, Zr, TR, U
	Granite-gneiss regional structures and domes			Ceramic pegmatites	Microcline Microcline-oligoclase	Barren, possible (?) geochemical specialization in Nb, Zr, TR, U
Ultra-metamorphogenic			Autochthonous granite massifs	Ceramic pegmatites	Oligoclase Microcline-oligoclase Microcline Albite- microcline-oligoclase	Barren; Ceramic raw material; geochemical specialization in Nb, Zr, TR, U
			Migmatite			

trusive alkaline massifs; multi-phase granite batholites.

By the nature of pegmatite-bearing structures, we distinguish the following structural groups: granite-gneiss regional structures and domes; dome-synclinore and dome-trough plume-structures (subgroups: intradome synclinore and trough, in particular greenstone structures; intrusive domes and batholites); specific tectonic zones of stress.

Associations (according to (Ginzburg, 1979) – formations) and mineralogical-geochemical and ore types of pegmatites are singled out after (Ginzburg, 1979, Kuz'menko, 1978, Nikanorov, 1979, Petrov, 1975, Shavlo, 1984, Shmakin, 1987and others) on the basis of characteristic mineralogical and geochemical features of pegmatites.

The offered scheme is rather cumbersome; however it allows us to present gradual development of pegmatite formation with the change of associations and types of pegmatites in the full tectonic-magmatic cycle of megastructure formation, as well as the development of the pegmatite process in one range of pegmatite associations connected with the development of granitoid process within megastructures (ceramic pegmatites → uranium-rare earth → rare metal → thoria-rare earth →miarolitic and chamber pegmatites) and ranges of types of pegmatites associated with the development of pegmatite associations during one period of megastructure establishment.

Wesingleoutaseparategroupofmetamorphogenic-metasomatic pegmatites spread within specific tectonic zones of stress (pressure structures in edge zones of shields and zones of tectonic-metamorphic activization of granite-gneiss domes and others) and composed of formations of muscovite and beryl-muscovite pegmatites. These pegmatites within the Ukrainian Shield, in our opinion, are not revealed, as those pegmatites with high (up to 30%) content of muscovite (Mokromoskovske pegmatite field), that we personally researched, are obviously primary unchanged rocks with abnormal content of muscovite that formed during crystallization in the closed system of pegmatite vein separated from parent massif.

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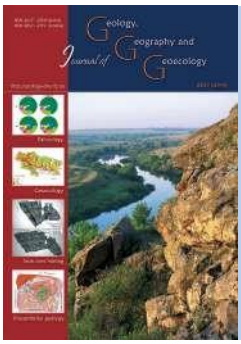

JOURNAL of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(4), 692–705.
doi: 10.15421/111965

Geographic analysis of the condition of tourism of Luhansk region (Ukraine) in the context of the conflict

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Received: 17.02.2019
Received in revised form:04.03.2019
Accepted: 20.09.2019

Annotation. The article is devoted to the geographic analysis and evaluation of the development of tourism in Luhansk region in the context of the current conflict. The aim of this report is to monitor the state of tourism in Luhansk region, which is especially relevant in this transformational period. We used research methodology which combines the philosophical and general scientific principles that form the methodological principles of scientific research and include a number of laws and categories. Analytical, statistical, comparative-geographical, historical methods of research were used. We considered in chronological order the formation of tourism in the region. The state of tourism in the region under the conditions of the conflict is analyzed. It is revealed that the current state of tourism is that of crisis, but there are positive prospects for development. The geographical possibilities of tourism development at the present stage are substantiated. It is proposed to develop the most promising types of tourism. The scientific novelty is due to choice of theme itself, because geographers devote insufficient attention to the study of tourism development issues in the context of the conflict. For the first time , a geographic analysis of the status of tourism of Luhansk region in the conditions of the conflict is presented. The methods of comprehensive assessment of tourism development at the regional level have been improved with the use of quantitative and qualitative indicators, which allows us to determine the directions of tourist development in the region. The existing information on the influence of the conflict period on tourism development is supplemented.For the first time, a comprehensive analysis of the status of tourism in Luhansk region was carried out for different periods: at the beginning of the conflict and during the conflict, which showed that Ukraine's image as a place of conflict led to the emergence of new social-geographical features of the development of tourism in the east of Ukraine. It is revealed that the conflict has led to instability in the development of tourism, tourists who are worried about their safety refuse to visit a conflicted country or region. This inevitably leads to a decrease in the number of international tourist arrivals and revenues from tourism, a decrease in the number of objects of tourism and of collective accommodation facilities. It is determined that the attractiveness for tourism and image of the eastern region is almost lost as a result of the conflict. It is proved that the conflict negatively impacted the development of the tourism industry in the region, namely, all types of tourism suffered, significantly reducing the total number of tourists.It is determined that tourism in the post-conflict period may become a promising direction of economic development of the eastern regions of Ukraine. The main provisions, factual material and conclusions of the article can be used for further research on the development of tourism in Luhansk region and the creation of a concept for overcoming the negative consequences of the conflict of 2014-2019 in Ukraine for the development of the national tourism industry.

Keywords: tourism, analysis, geography, conflict, post-conflict, tourist flows.

Географічний аналіз стану туризму Луганської області (Україна) в умовах конфлікту

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Анотація. Стаття присвячена географічному аналізу та оцінці розвитку туризму в Луганській області в умовах конфлікту. Метою цієї роботи є моніторинг стану туризму в Луганській області, що особливо актуально в цей трансформаційний період. Використоно аналітичний, статистичний, порівняльно-географічний, історичний методи дослідження. Розглянуто хронологічний порядок формування туризму в регіоні. Проаналізовано стан туризму в регіоні в умовах конфлікту. Виявлено, що нинішній стан туризму є кризовим, але є позитивні перспективи розвитку. Обґрунтовано географічні можливості розвитку туризму на сучасному етапі. Запропоновано розвивати найбільш перспективні види туризму. Наукова новизна обумовлена

самою темою, оскільки географи приділяють недостатню увагу дослідженню питань розвитку туризму в контексті конфлікту. Вперше представлений географічний аналіз туристичного статусу Луганської області в умовах конфлікту. Методи комплексної оцінки розвитку туризму на регіональному рівні були покращені з використанням кількісних і якісних показників, що дозволяє визначити напрями для туристів регіону. Доповнено інформацію про вплив конфліктного періоду на розвиток туризму.Вперше комплексний аналіз туризму Луганської області було проведено в різний час: на початку конфлікту і в контексті конфлікту, який показав, що знаходження України у стані конфлікту призвело до появи нових соціально-географічних особливостей розвитку туризму на сході України. Виявлено, що конфлікт призводить до нестабільності в розвитку туризму, туристи турбуються про свою безпеку, відмовляючись відвідувати країну або регіон. Це неминуче веде до зниження числа міжнародних туристських прибуттів і надходжень від туризму, зменшення кількості туристичних об'єктів і об'єктів колективного розміщення. Визначено, що в результаті конфлікту туристична привабливість і імідж східного регіону практично втрачені.Визначено, що туризм у постконфліктний період може стати перспективним напрямком економічного розвитку східних регіонів України. Основні положення, фактичний матеріал та висновки статті можуть бути використані для подальших досліджень з питань розвитку туризму в Луганській області та створення концепції щодо подолання негативних наслідків конфлікту у 2014-2019 роках в Україні для розвитку вітчизняної туристичної галузі.

Ключові слова: туризм, аналіз, географія, конфлікт, постконфліктний, туристичні потоки.

Introduction. The problems of sustainable tourism development, which include conflicts and possible risks, have been considered using the special foreign and domestic literature. These are works of S. Huntington, O. Spengler, A. Toynbee, I. Vynnychenko, O. Beidyk, A. Oleksandrovoy, O. Lyubitseva and O.Travina.

In studies of international scientists, there is no consensus about the definition of "conflict". The variety of interpretations is determined by the ambiguous understanding of the nature of this phenomenon.

The only thing which we can guarantee: it is inherent in all aspects of social life. Such a situation has inevitably stimulated interest in the issue of conflict in the professional literature, especially among foreign scientists.

As per R. Dahrendorff, the author of the conflict model of society, the main question in conflicts is who and in what form commands the resources, in whose hands is the power which allows one group of people to direct the activities of others (Dahrendorff, 2002).

For the initial classification of conflicts, the American researcher M. Kaldor thought it was enough to compare new wars with previous ones according to programme goals, methods of fighting, as well as ways of financing them (Kaldor, 2001).

Huntington argued that there will not be a "universal civilization" in the world; individual civilizations will continue to exist, and the success of international relations will depend on how these civilizations will coexist with one another. According to the researcher, being a "modern" civilization does not necessarily mean being a "Western" civilization, and therefore the West must take into account the persistent attempts of non-Western societies to modernize and, at the same time, not "westernize". The value of the concept of S. Huntington is based in the fact that he drew the attention of politicians, researchers, journalists to the problem of cultures and civilizations as participants in the world historical process. Huntington's work is an invaluable material for understanding the political processes of our time. The researcher's recommendations for avoiding conflicts deserve attention and discussion (Huntington, 1996).

Spengler's concept consists in the allocation of cultural worlds that have an identical life cycle that resembles the body's life cycle: origin, growth, development, decay and death. Each phase in any culture ,according to Spengler, automatically passes into the next as soon as its time comes. In his opinion, each culture is a "living organism" and has its own history. He denied the existence of universal culture, arguing that world history consists of the history of eight large cultures, each locked in its own development.Each culture, according to the scientist, has its destiny and lives about 1000-1500 years. Then the culture dies and traces of it remain in the form of civilization. The concept of fate is fundamental to the O. Spengler's philosophy of culture. O. Spengler realized the threat to world history in overly rationalized and highly pragmatised activity of people (Spengler, 1998).

A. Toynbee sharply criticized western civilization for the loss of spirituality and the excessive development of mercantile interests and consumer psychology. Unbridled industrialization and the arms race, according to the scientist, will lead to an aggravation of the ecological crisis and intensification of the struggle for raw materials. Industrialized countries will face the hostile position of technically backward countries, which inevitably will end in a global conflict, and will eventually lead to economic decay. The concept of A. Toynbee is also interesting because it contains quite clearly formulated criteria for defining civilizational identity. He terms them religion, history, language, customs and culture.

A. Toynbee attaches particular importance to religion, which he considers "one way and one direction in comparison with the diverse and repetitive history of civilizations" (Toynbee, 1996).

Tourism in Lugansk region officially began to develop after the adoption of the Decree No. 743 of November 29, 2002 "On Approval of the Tourism Development Program in Luhansk region of 2002-2010" (The programme of tourism development in Lugansk region of 2002-2010, 2002).

During this period, the status of tourism in Luhansk region was considered as stable when the number of tourist organizations began to grow at a high rate, and in crisis when the volume of tourism services fell due to the reduction of the material base in the field of tourism and the existence of conflict.

In the last few pre-conflict years, tourism began to play a prominent role in the life of eastern Ukraine. Tourism in Luhansk region has developed in several directions: medical-improvement tourism, sport tourism, religious and industrial tourism. However, the conflict situation did not allow for their development to the appropriate extent.

Thus, the dynamic changes in the economic and geographical situation of Luhansk region at this stage require further development of these issues.

Problem formulation. A great deal of work is devoted to the study of tourism in the context of conflict in the world and in Ukraine by the following authors : Averina A., Aziz Kh., Baidyk O., Drakos K., Zavarika G., Zelenko O., Tkachuk L. and others. Most of these authors describe aspects of the impact of conflict situations on tourism activities.

Thus, the Russian philosopher A. Averin, while investigating the issues of state regulation of demographic and migration processes, notes that migration can be caused by political, economic, social and spiritual processes. Reasons may include military, national, ethnic, religious conflicts, terrorism, environmental and climatic factors (Averin, 2017).

There is no doubting the conclusions of O. Beidik, N. Koroma and S. Syrovets, who argue that armed conflicts of various size and sterngth always have a proportional "effect" on the development of tourism, which consists in reducing the image of the country, destroying the tourist infrastructure and leading to destruction in historical and natural heritage (Beidik et. al 2016a).

The author agrees with the opinion of L. Tkachuk that the tourism sector faces serious challenges due to the serious political instability which is growing rapidly and that the flow of tourists to the country has declined because of the negative image the country has acquired (Tkachuk, 2016 a).

During the pre-conflict period, the tourist possibilities of the region were investigated by the following Ukrainian researchers: O. Lyubitseva, V. Zaleshchik, G. Myshechkin, A. Anosov, G. Sorokin. They emphasized the necessity of using and developing the tourism sector.Thus, O. Lyubitseva and V. Zaleshchyk investigated the recreational and tourist zoning of Lugansk region and established the tourist opportunities of the territory (Liubitseva, Zaleschik, 2012). G. Mishechkin and O Anosova analyzed the tourism and recreational potential of the Donbas and argued for the prospect of its development despite the existing problems (Myshechkin, Anosova, 2013).

A feature of Luhansk region is the insignificant development of its tourism sector during the pre-conflict period, which makes it difficult to prove the feasibility of restoring tourism activity . Perhaps this explains the small number of publications on tourism in the region over the past four years. The author of the publication investigated tourism in the region both in pre-conflict and conflict periods and emphasized the possibilities of tourism development there (Zavarika, 2016a).

O. Zelenko mentioned that prospects of tourism development in Luhansk region in the conditions of military-political instability, the author noted that various types of tourism have the right to exist and emphasized the necessity of development of tourism in the region, including rural green, medical-health, religious, industrial tourism (Zelenko, 2015a).

The tourism sphere can affect to development of the region. Ukraine has not enough experience in restoring tourist activity after armed conflict, therefore, the developing of both theoretical and practical, challenges is a new issue in public geography. Thus, the issue of analyzing the status of tourism in order to restore it during post-conflict period is extremely relevant and requires detailed study.

Research methods. The methodological foundations for the study of conflicts are poorly developed in contemporary social geography. The high level of objective complexity of this research is connected with the fact that at one and the same time methods of social geography, political science, conflict science, sociology, political economy, economics, philosophy, cultural studies, anthropology, psychology, and marketing are used, since the object of research is at the junction of sciences, that is, has an interdisciplinary character. Therefore, most of the existing works are designed by political scientists, sociologists, psychologists.

In conclusion, the issue of developing a methodological tool for investigating the impact of the conflict on tourism development has not been studied in detail, but it needs to be done as soon as possible. This is primarily due to changes that have taken place recently in the country and the lack of readiness of the

tourist industry to work in a conflict situation. Therefore, this study is a very important task of social geography.

The need for a holistic description of the factors contributing to the emergence of conflicts, their drivers and participants, the prediction of the occurrence of conflict actions and measures to prevent them, in order to preserve and develop tourism, requires a problem-oriented approach.

The philosophical basis of socio-geographical study is a dialectic that examines phenomena in the process of development and interconnection. The theoretical and methodological basis of the research is the fundamental provisions of the theory of social geography.

The most important element in the study of conflicts, predicting their possible occurrence and warning is political marketing. Political marketing is a young branch of knowledge that emerged from the depths of classical marketing.

Armed with the classic marketing tools in the field of market study, political marketing has improved it, enriched by various methods of political science, sociology, anthropology and psychological research. There is a need for a comprehensive, deeper, and thorough study of political processes. "Every social process or state," wrote G. Zymmel, "which we make our object, is a definite phenomenon and, consequently, is the result of the action of innumerable deeper partial processes. Since the same actions may have their source in very different causes, it is possible that precisely the same phenomenon will be caused by completely different complexes of forces, which, combined in one point for the same action, in its further development, going beyond its boundaries, take completely different forms again"(Zymmel, 1996).

«Forecasting,» says R. Dautt, «is called causal (causative) modeling,» is an attempt to predict a behaviour called a dependent variable, by analyzing its causes, which are called independent variables (Daft, 2002). Precise forecasting is the main goal of the study, because we need to know how tourism will develop in the post-conflict period.

This report uses detailed analysis, a technique was used that combines the philosophical and general scientific principles that serve the methodological principles of scientific research. In this research analytical, statistical, comparative-geographical and historical methods were used.Thus, the method of time series was used to identify the dynamics of tourism growth and its decline due to conflict. In order to track the transformational changes in tourism, the monitoring organization method deserves attention. The tasks of identifying negative changes in the structure of tourism have been helped by statistical methods of research. Using sociological research methods, the analysis of the state of tourism was carried out in order to solve problems related to the identification of factors of a conflict character.

In order to carry out a geographic analysis of the place of tourism in Luhansk region in the all-Ukrainian rating, on the basis of official statistics, the main indicators were calculated reflecting the state of tourism for the beginning of the XXI century.

As was mentioned, official statistics from different sources have significant differences, which is caused by different methodological bases of accounting, and also by the significant shadow economy turnover in the industry. It is currently impossible to accurately determine the volumes of the market for tourist flows.

It should be noted that today the existing form of state statistical reporting is obsolete, informatively imperfect, and does not take into account current needs. Based on this, it is impossible to isolate the share of consumer goods and services taken up by the tourism industry for any particular period. Today tourism is not defined as a separate type of economic activity in the international classifier of economic activities and the National Classifier DK 009: 2010.

One of the important problems is the unification of statistical surveys of indicators of the tourism industry between different state bodies or public organizations. For example, the State Service for Tourism and Resorts, has counted all foreign citizens who arrived in the territory of Ukraine as tourists, regardless of the true purpose of their visit. The State Statistics Service of Ukraine names only those foreigners as tourists who officially took advantage of tourist services.

A similar situation regarding the discrepancy between statistical data and between different state bodies and agencies leads to a distortion of the assessment of basic tourism indicators and gives the chance to unscrupulous market participants to organize shadow turnover in the tourism industry. All this causes a slowdown in the growth of the domestic tourism industry and a lack of understanding of its importance in the context of the development of the national economy as a whole.

The peculiarity of the above analysis is that up to 2014 all the territory of Luhansk region was involved in the statistical data, while from that year to the present the data are given without taking into account the territory beyond the control of the Ukrainian government.

Achieved results. Tourism is one of the most profitable branches of the world economy and is gradually becoming a priority sphere of national development. However, in Ukraine, it faces many problems on the path to its development.

Consideration of the main obstacles to tourism development is directly related to the domestic economic problems of the country's sustainable development. Indeed, for all the complexities and contradictions inherent in the conflict period, the country's sustainable development must testify the viability of the idea, its conformity to national interests and priorities.

According to the world rating of the number of foreign tourists, compared to the data of 2013, Ukraine has lost half of its position, dropping from 14th to 25th place, the number of visitors falling from 24,671 thousand people to 12,721 thousand people. According to the State Statistics Service in 2016, the regions of Odessa, Kyiv, Lviv and Ivano-Frankivsk were developed tourism regions as before. Thus, 43,355 tourists were served in Odessa region, in Kyiv region and Kyiv – 1,825,652, in Lviv – 138,048, and in Ivano-Frankivsk regions – 74,919. Totally in Ukraine 2,250,997 people were serviced (Statistical Yearbook of Ukraine, 2016) (Table 1).

Unfortunately, in 2017, Ukraine was not ranked in the list of countries attractive for tourism; its leaders were Spain, France and Germany (World Tourism Organization, 2017).

Table 1. Distribution of tourists serviced by tour operators and travel agents according to the purpose of trip and types of tourism in 2016 by region, persons

	Served tourists, all	Including the purpose of travel						Of these, children are 0-17 years old
		service, business, training	leisure, rest	treatment	sport	special	Others	
Ukraine	2,250,107	176,230	1,902,900	79,412	2,982	768	87,815	199,956
Regions								
Vinnitsa	11,348	5	11,321	22	-	-	-	1,681
Volyn	16,525	6	15,648	871	-	-	-	1,448
Dnipropetrovsk	24,296	207	23,037	918	134	-	-	4,143
Donetsk	9,753	69	9,240	56	7	-	381	1,550
Zhytomyr	2,597	2	2,595	-	-	-	-	398
Zacarpathiy	6,705	76	6,532	12	-	-	85	1,267
Zaporozhye	21,016	278	19,789	949	-	-	-	2,458
Ivano-Frankivsk	74,919	-	72,273	334	-	-	2,312	3,587
Kyiv region	11,001	6	10,815	151	7	22	-	1,763
Kirovograd region	2,181	20	2,137	24	-	-	-	315
Luhansk	577	4	535	38	-	-	-	40
Lviv	138,048	658	74,267	61,645	406	127	945	9,291
Mikolaiv	5,575	2	5,561	10	2	-	-	610
Odesa	43,355	12,721	30,002	35	74	276	247	2,854
Poltava	3,383	123	3,076	122	22	40	-	689
Rivne	4,266	3	4,247	16	-	-	-	595
Sumy	5,665	1,559	3,862	27	-	-	217	283
Ternopol	2,934	41	2,764	-	129	-	-	914
Kharkiv	19,122	89	18,529	455	12	37	-	2,386
Kherson	4,647	2	2,987	1,646	-	-	12	544
Khmelnitsky	9,319	10	8,782	24	-	-	503	1,088
Cherkassy	2,624	1	2,542	63	-	-	18	566
Chernivtsi	11,731	185	11,309	29	51	1	156	1,275
Chernihiv	3,869	4	3,861	4	-	-	-	340
Kyiv	1,814,651	160,159	1,557,189	11,961	2,138	265	82,939	159,871

[1] Excluding the temporarily occupied territory of the Crimea Autonomous Republic, the city of Sevastopol and parts of ATO zone.

Source: done by the author on the basis of (Statistical Yearbook of Ukraine, 2016)

So, it can be noted that the favourable geographical location, attractive tourist resources, the presence of potential tourist sights, developed tourist infrastructure and skilled labour resources do not guarantee the successful development of tourism. In fact, a paradoxical situation arises when countries with less attractive natural and cultural-historical backgrounds than Ukraine have a significantly higher ranking of tourist attractiveness in the world market for tourist services. It is a fact that in the conditions of globalization, in order to increase the rating of tourist attraction, it is necessary not only to monitor the indicators of tourism development, but to use actively the levers of geo-differentiation and positioning of the tourist space to reflect the distinctive features of national tourist product offer.

Analyzing the above factors which are hindering the development of tourism in Ukraine and the formation of a competitive national tourism product, may include:

insufficiently developed tourist infrastructure in the regions; insufficient awareness of the tourism potential, its impact on the regional economy;

insufficient attention of local and regional authorities to tourism in their territories;

low investment and business activity in organizing activities that can attract local and foreign tourists;

shortage of skilled personnel in the field of tourism;

lack of information on events in the regions and the low efficiency of the systems for promoting tourist product to the market;

high travel prices for major tourist destinations;

most important for Ukraine in the present and immediate future: fear of terrorism, crime; unstable political situation (Fig. 1).

According to market research, conducted by the World Tourism Organization for tourist services, the reasons for the decline of Ukrainian tourism are as follows:

neglect of experience of international tourism development;

lack of consistent state policy in the industry;

ineffective government activity in the field of tourism;

lack of proper conditions for the development of tourism, tax and financial incentives by the state to export tourism services and domestic tour operators;

unsatisfactory work on the formation and strengthening of Ukraine's tourist image, development and promotion of the national tourism product in the international and domestic markets.

Signs and effects of decline:

decrease in the number of tourists in comparison with the indicators for 2012-2013;

a significant reduction in the share of tourism in the country's GDP;

falling incomes from tourist services and hotel services, tourist fees, currency revenues from exports of tourist and hotel services, investments in tourist infrastructure, jobs (Site of the World Tourism Organization, 2018).

Today, Ukraine needs significant investment in tourism development, first of all, in tourism infrastructure, which is one of the main reasons preventing the growth of the tourist sector due to its obsolete nature and the inability to meet the needs of potential consumers. But, in recent years there has been a decline in investment in the tourism industry.

The share of tourism in the Ukrainian GDP is only 2%, and in developed countries - this figure reaches 8%(Statistical Yearbook of Ukraine, 2018).In our country, tourists arrive mainly from Germany, the United States, Great Britain, China and Japan (Fig. 2).

Territorial hardships, economic problems and political uncertainty have led the tourist industry of Ukraine to a disastrous state: in 2014-2015 the tourism market fell by 40% (Tourist activities in Ukraine, 2017).

In the structure of income from tourism in developed countries, domestic tourism gives 80-90%, and on average in the world - more than 72%. In Ukraine, about 64% (Figures 3 and 4) (UNWTO, 2018).

Domestic tourism in Ukraine is underdeve-loped and needs state support.

About six million people make more than 10 million tour-trips within the country. During 2001-2011, investment in the hotel and restaurant sector increased from 469 to 4,908 million US dollars, a 10.5 times increase. During 2011-2014, capital investment in tourist accommodation and catering decreased to 1.5 bln. UAH. 70-80% of tourist flow is provided by foreign tourists and only 20-30% by domestic tourists. During 2000-2014, the share of domestic tourists in the market tended to decrease, and even a sharp decline in entry tourism in 2014 did not significantly affect the structure of tourist flows, which may indicate an insufficient development of domestic tourism in Ukraine (Tourist activities in Ukraine, 2017).

As a result of the analysis, it turned out that during the period of stable development of tourism, namely in 2006-2008, Luhansk region took one of the leading places among 25 regions of Ukraine (Table 2).

During 2008, increase in the number of outbound tourists was observed in Ukraine, and the share of

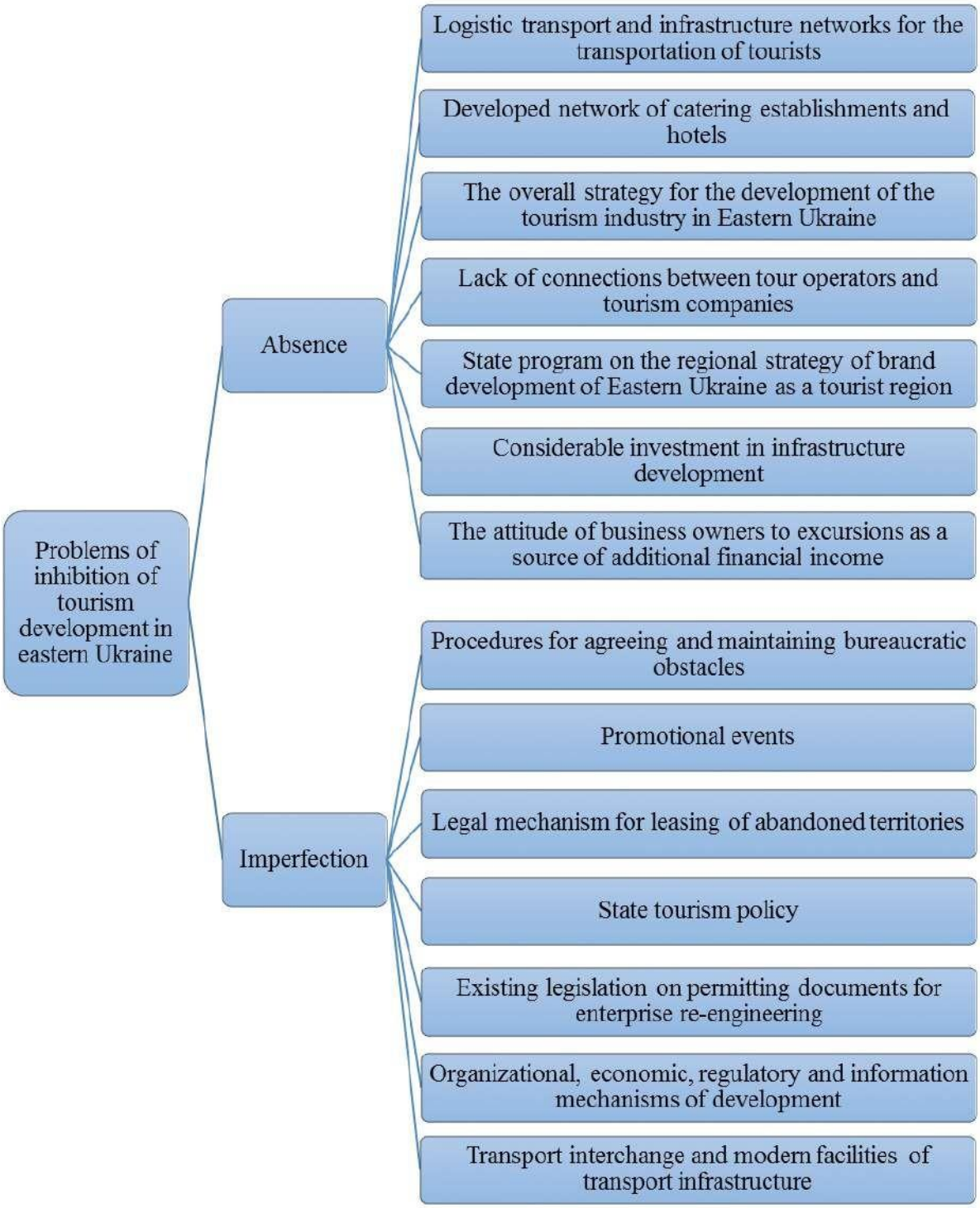

Fig. 1. Factors hindering the development of tourism in Ukraine

Source: done by the author on the basis of (Ukrainian tourism)

Luhansk region was 50% from the total (The statistical bulletin «Tourism in Luhansk region (2001-2006)» 2007).

Due to the increased income in Luhansk region, the number of outbound tourists grew rapidly. According to the Main Department of Statistics in Luhansk region, the average wage in all districts of the region was higher than the minimum living wage for an able-bodied person (UAH 669), however, only in 10 of the districts do the wages exceed the average in the region: Rovenky - 2745 UAH, Sverdlovsk - 2427 UAH, Krasnodon - 2217 UAH, Alchevsk - 2027 UAH, Perevalsky district - 2021 UAH, Antratsit - 2005 UAH, Lutuginsky district - 1988 UAH, Krasny Luch - 1873 UAH. , Lisichansk - 1856 UAH., Pervomaisk - 1855 UAH (Luhansk region in figures in 2008,

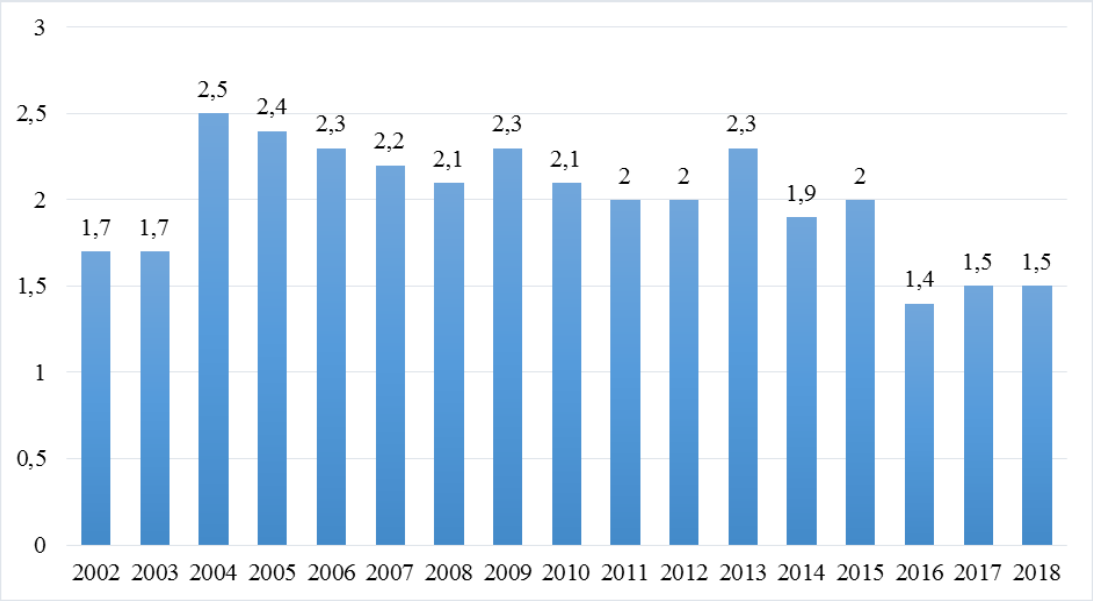

Fig. 2. Total contribution from tourism to GDP of Ukraine, %Ukrainian tourism
Source: done by the author on the basis of (Statistical Yearbook of Ukraine, 2018)

2009a). Also, in 2008 the growth of the number of outbound tourists was due to an increase in the types of tourist products and the quality of tourist services.

The lowest rate of entry tourism was recorded in 2005 and amounted to 17 people. In 2008, this figure

Dynamics of tourist activity in Ukraine and Lugansk region is presented in Fig. 5.

An analysis of the size of payments to the budget by subjects of tourism activity showed an increase of almost 4 times and amounted to 2,081 thousand

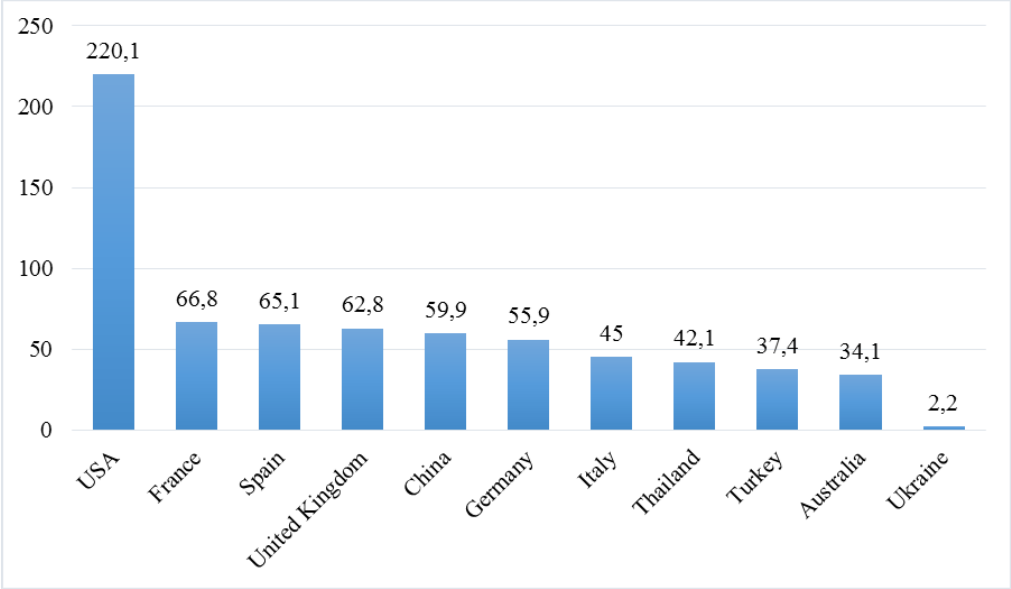

Fig. 3. Tourism Profit Rating, billion dollars USA
Source: done by the author on the basis of (UNWTO, 2018)

increased 7-fold and amounted to 126 people. After analyzing this indicator in other regions of Ukraine, it was found that Zhytomyr region ranked last in the overall ranking, with 56 people. The development of excursion activities in the Luhansk region has decreased by 18.9 thousand people, or 47%, compared to 2007 (Main Department of Statistics in Luhansk region, 2018b).

UAH against 2007. Such changes in payments to the budget can be explained by an increase in the number of registered entities of tourism activity in Luhansk region (Luhansk region in figures in 2008, 2009b).

Luhansk region had considerable economic potential before the conflict and was one of the five most significant industrial and economic regions in Ukraine (Lugansk Regional State Administration,

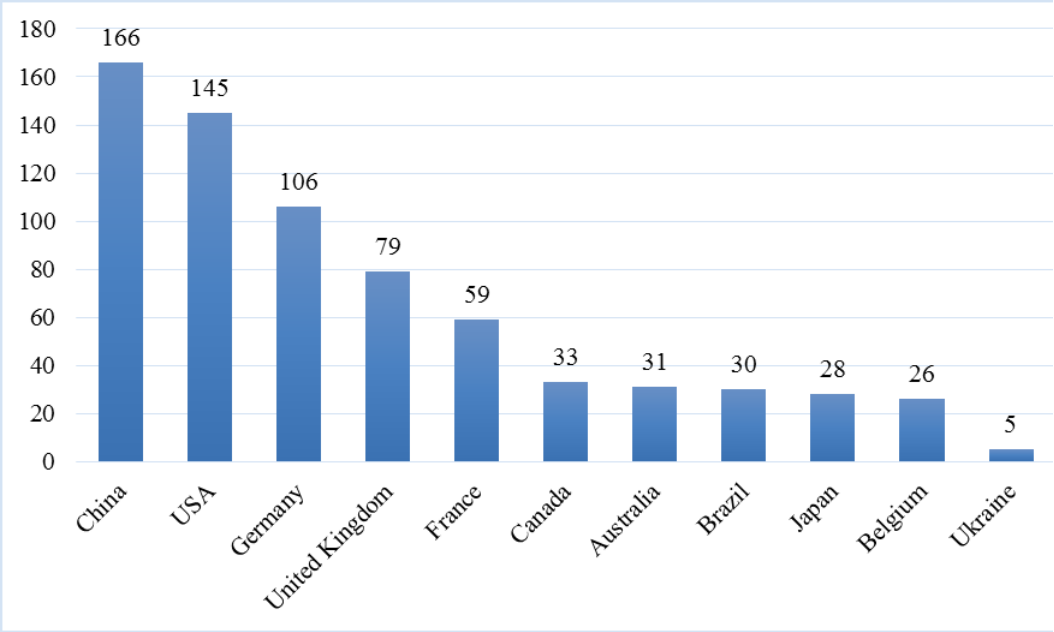

Fig.4. Tourism spending rating, billion dollars USA

Source: done by the author on the basis of (UNWTO, 2018)

Table 2. Rating of Luhansk region on the main indicators of tourism development in Ukraine for 2006 – 2008

Key Indicators	**2006**	**2007**	**2008**
1. Number of enterprises providing services			
Units	75	96	-
Share in %	2.5	2.5	-
2 Total tourists served	50,881	59,096	53,279
Share in %	1.4	1.11	-
Rating	17	16	-
2.1. Entry	162	158	126
Share in %	0.01	0.02	-
Rating	25	25	-
2.2. Departure	10,761	14,088	15,487
Share in %	0.8	0.85	-
Rating	11	12	-
2.3 Domestic	39,958	44,850	37,666
Share in %	2.1	1.49	-
Rating	16	14	-
3. Number of excursion tourists	30,993	39,984	21,022
Share in %	1.8	1.67	-
Rating	13	9	-
4. Scope of service provision (thousands uah)	37,505	12,825	
Share in %	1.0	0.24	-
Rating	12	25	-
5. Payments to the budget (thousands uah)	761	555	2081
Share in %	0.6	0.52	-
Rating	23	23	-
6. Average number of employees	245	272	283
Share in %	1.1	1.2	-
Rating	19	19	-

Source: done by the author on the basis of (The statistical bulletin "tourism in Lugansk region (2001-2006)", 2007).

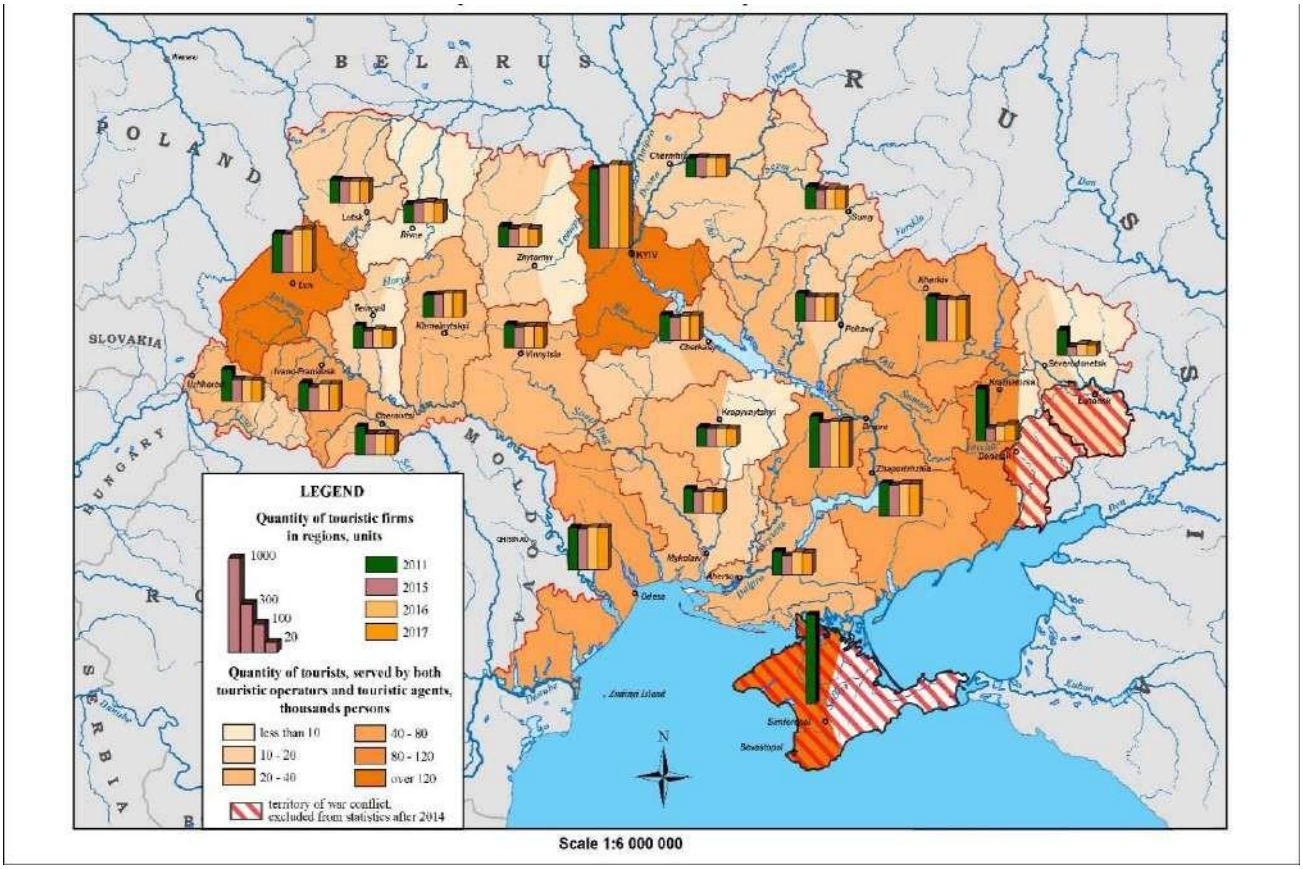

Fig. 5. Dynamics of tourist activity of Ukraine

Source: done by the author on the basis of (Tourist activities in Ukraine, 2017).

2018). As a result of the conflict , the tourism industry in the region has declined and the situation has changed negatively. Historically, Luhansk region developed as an industrial land. However, in the pre-conflict period in the eastern regions, structural changes in the economy began, including the formation of regional tourism (Zavarika, 2018). The conflict has brought a promising direction for economic development of the eastern regions of Ukraine to the brink of permanent disappearance.

For Luhansk region, tourism development is relevant, because it can improve the socioeconomic situation. The region has favourable natural and climatic conditions, flora and fauna, mineral water springs and other resources for the development of tourism (Zavarika, 2018).

As we can see from Table 3 below, Luhansk region lost its position in tourism activity and by 2017 occupied the last (24th) place among the regions of Ukraine. Among the outsiders in Ukraine are Donetsk, Kirovograd, Zhytomyr, Ternopil, and Chernihiv regions (Main Department of Statistics in Luhansk region, 2018d). Luhansk region in 2011 ranked 11th by the number of subjects of tourism activity among the regions of Ukraine, which was less than 3% of the overall Ukrainian total.

Since 2015 there has been a rapid decline in the number of tourists, the region has taken the last place for this indicator and, despite a small amount of growth , continues to occupy this low position. By 2017, this figure was 0.5% in absolute terms.

In 2011 The number of tour operators in the region was too low and amounted to only 0.28%, and at this time they are completely absent (Main Department of Statistics in Luhansk region, 2018e).

The number of travel agents in the pre-conflict period was quite high, the region ranked 9th in the country by this indicator, which was 2.8%. Now the situation has not changed in favour of the region, but it can be stated that there has since been a slow growth in the number of travel agents, so in 2017 their number was 17, or 0.6% of the total.

With regard to the indicator of the number of subjects carrying out excursion activities in the region even during the pre-conflict period the situation was difficult , they did not function at all, now the situation has unfortunately not changed for better (Main Department of Statistics in Luhansk region, 2018g). Sightseeing activity is very important for the formation of a positive tourist image and the attractiveness of the territory. Unfortunately, we did not have time to form this in the pre-conflict period,

Table 3. Tourist activity of Luhansk region

Key indicators	2011	2015	2016	2017	2018
1.Number of subjects of touristic activity	94	11	19	17	17
Share in %	2.26	0.34	0.54	0.49	0.49
Rating	11	24	24	24	24
2. Number of tour operators	2	–	–	–	-
Share in %	0.28	–	–	–	-
Rating	24	24	24	24	24
3. Number of travel agents	92	11	19	17	17
Share in %	2.80	0.43	0.67	0.60	0.60
Rating	9	24	24	24	24
4. Number of subjects carrying out excursion activities	–	–	–	–	-
Share in %	–	–	–	–	-
Rating	24	24	24	24	24
5. Number of tourists serviced by tour operators and travel agents	15,558	939	1,896	2,825	6,261
Share in %	0.84	0.04	0,07	0.10	0.13
Rating	18	24	24	24	24
6. Number of tourists serviced by tour operators	1,199	–	–	–	-
Share in %	0.08	–	–	–	-
Rating	18	24	24	24	24
7. Number of tourists serviced by travel agents	14,359	939	1,896	2,825	6,261
Share in %	1.80	0.10	0.24	0.33	0.13
Rating	11	24	24	24	24

Source: done by the author on the basis of (Tourist activities in Ukraine, 2017)

and now a considerably greater amount of work will need to be done to convince a potential tourist that there is something to look at in Luhansk region. So this is one of the main tasks of tourism development of the region during the post-conflict period.

Indicators of the number of tourists served by tour operators and travel agents are clearly depicted in Fig. 6. The highest indicator of the number of

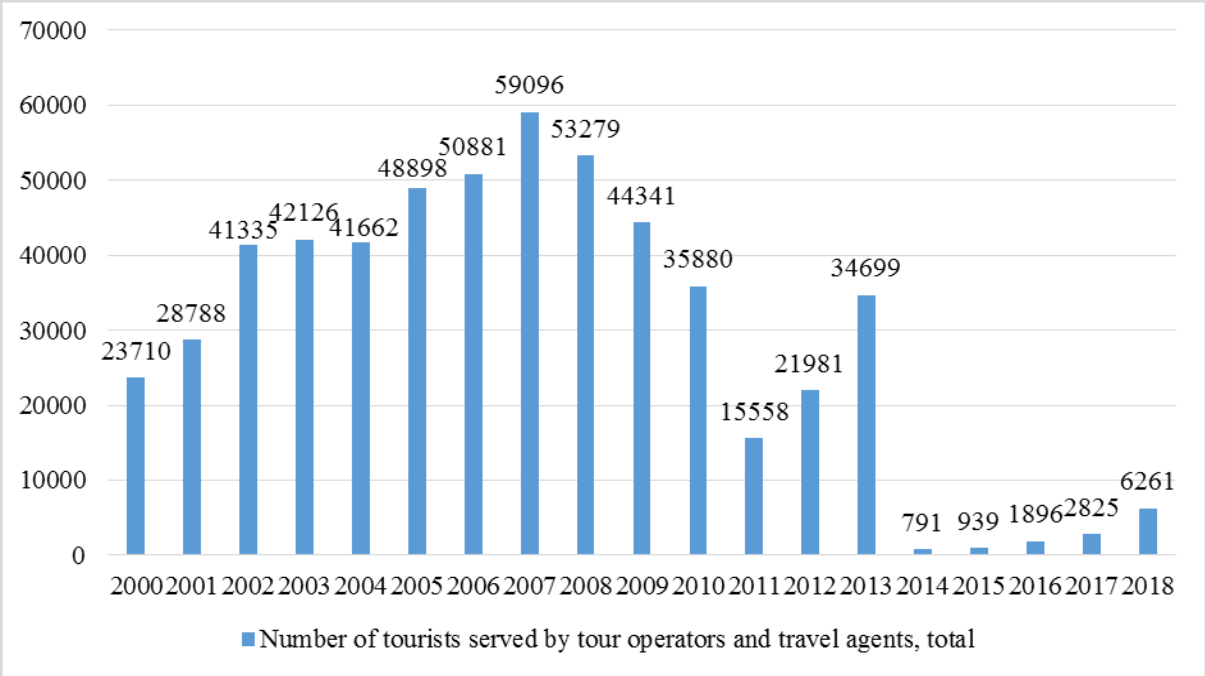

Fig. 6. Number of tourists serviced by tour operators and travel agents (in total)

Source: done by the author on the basis of (Main Department of Statistics in Luhansk region 2018h)

tourists in the region was noted in 2007. After 2007 the level varied depending on various economic and geographical factors. And from 2014, the crisis period associated with the conflict in the region begins when the number of tourists was the lowest in the history of tourism development in the region.

It will also be interesting to analyze tourists by type, namely: foreign tourists, local tourists in Ukraine who traveled abroad and domestic tourists, which is presented in Fig. 7. It turned out that the number of foreign tourists has always been low, and during the conflict they have been completely absent. The number of local tourists in Ukraine who traveled abroad and domestic tourists was the highest in the region during 2006 to 2013, which we consider to be the most successful for the entire period of development (Main Department of Statistics in Luhansk region, 2018i).

The decrease in the number of tourists in the region is due to the decision of the Luhansk Regional State Administration to ban tourist activity in 2014 on account of the safety of tourists (Zavarika, 2018). Also that after 2014 the statistics only take into account

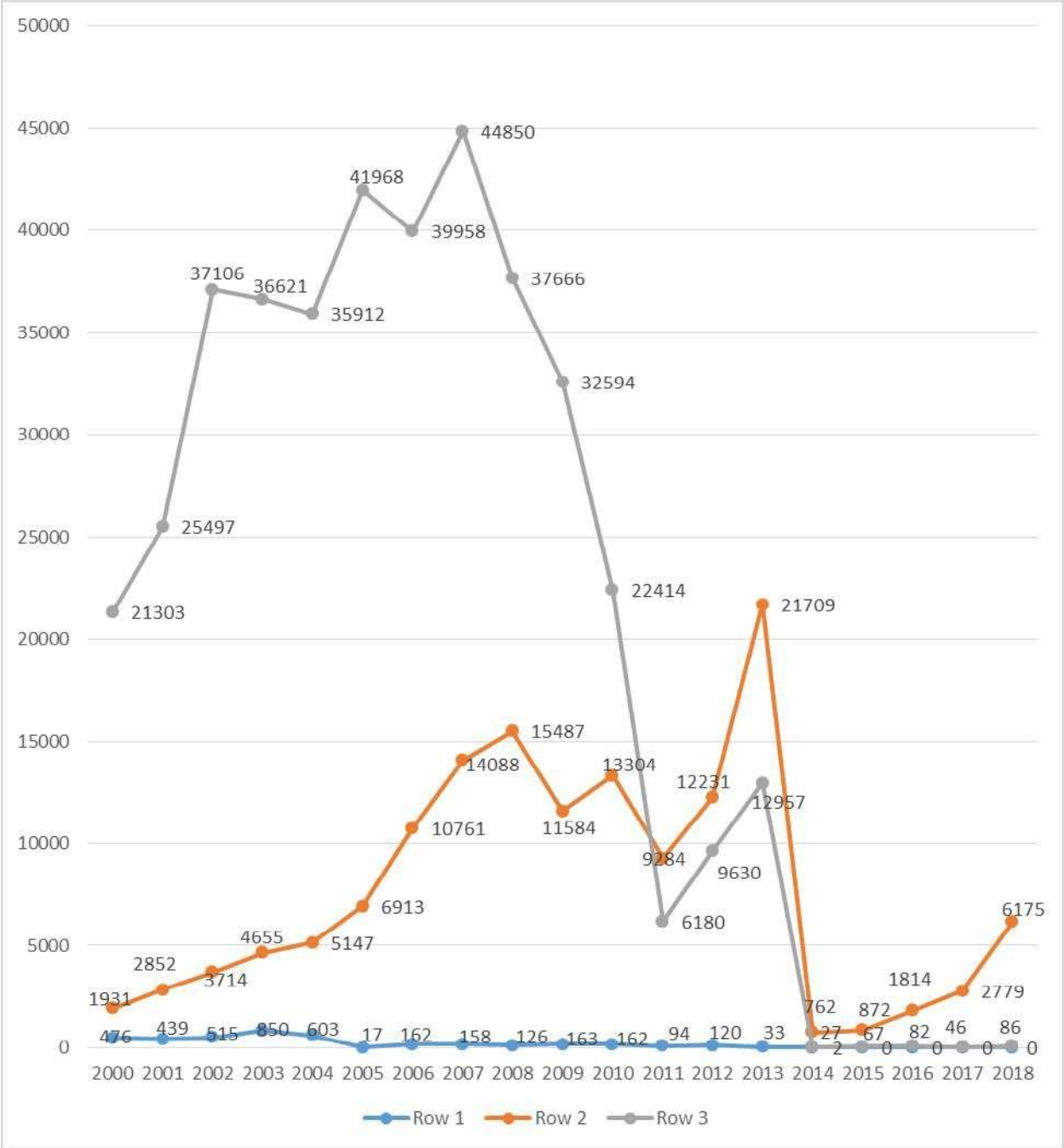

Fig. 7. The number of tourists by type: Series 1-foreign tourists, series 2- local tourists who traveled abroad and series 3- domestic tourists

Source: done by the author on the basis of (Main Department of Statistics in Luhansk region 2018j)

information concerning the territory under the control of the Ukrainian government.

It is important to note that the potential of tourism opportunities in the Luhansk region is quite rich. Each district of Luhansk region has a huge tourist potential and a wide range of tourist resources, historical and cultural heritage, and traditions of hospitality (Zavarika, 2018).

During 2017, the Luhansk Regional State Administration implemented measures for inventory of available tourist resources, developed and updated a Tourist Passport of the region, which includes 606 tourist facilities, 25 hotels, 11 estates, 27 travel agents (Luhansk regional state administration, 2018a).

Among the attractions there are 152 religious institutions, 21 museums, 1 landscape park, 95 nature reserves of Luhansk region, 1 cave, 19 springs, 14 recreation complexes, 20 recreation centers, 11 recreation and entertainment establishments, 3 cultural leisure establishments, 194 monuments, and 30 objects of tourist activity which at the moment do not function due to the ongoing military action or the need to be restored (Luhansk regional state administration, 2018b).

Conclusions. The analysis of statistical data allows us to assert that in the pre-conflict period, attention was not paid to tourism in the region. Tourism in Luhansk region was not perceived as a strategic sphere, the development of which would contribute to the revitalization of the social situation and economic growth. This was due to its low growth rate, which was manifested in abandoned infrastructure, a relatively small number of hotels, lack of legislative guarantees of the activities of local tour operators. As a result, the number of tourists visiting the region during the pre-conflict period was relatively small compared to other regions. The conflict between 2014 and 2018 only deepened the existing problems and contributed to the emergence of new ones.

The conflict in the Donbass negatively affected the development of the tourism industry in the region. First of all, it caused important negative economic changes that completely changed the "face" of the region. From 2014, the socioeconomic model in Luhansk region was completely destroyed and the main task of the scientists in the post-conflict period should be the creation of a new system, which, according to the basic parameters, will differ from the previous one. Tourism in the post-conflict period may become, if not a "locomotive" of change, an important component of it. All efforts are aimed at ensuring that the tourist industry becomes one of the leading ones in the post-conflict era.

Prospects for further research are the identification of measures for the development of tourism in Luhansk region by the local authorities and the geographical study of similar situations in different countries of the world.

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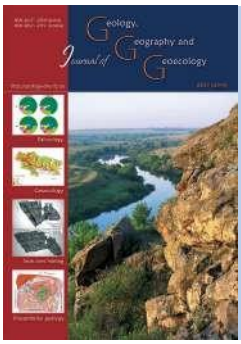

JOURNAL of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(4), 706–716.
doi: 10.15421/111966

Peculiarities of the underground mining of high-grade iron ores in anomalous geological conditions

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Received: 22.02.2019
Received in revised form: 10.03.2019
Accepted: 03.09.2019

Abstract. This paper is dedicated to research into the geological peculiarities, shape of the ore body and the occurrence of the host rocks in the hanging wall of the Pivdenno-Bilozerske deposit , as well as their influence on the degrees and quality of high-grade iron ore extraction. It is noted that in the interval of 480 – 840 m depths, a decrease is observed in the stability of the natural and technogenic massif, which is caused by the increase in rock pressure with depth, the influence of blasting operations on the massif and the difference in geological conditions. This has led to the collapse of hanging wall rocks and backfill into the mined-out space of chambers in certain areas of the deposit, the dilution of the ore and deterioration of the operational state of the underground mine workings. Attention is focused on the causes and peculiarities of consequences of the collapse of the hanging wall rocks during ore mining, which reduce the technical and-economic indexes of the ore extraction from the chambers. A 3D-model of an ore deposit with complex structural framework has been developed, which makes it possible to visually observe in axonometric projection the geological peculiarities and the shape of the ore body. The parameters have been studied of mining chambers in the 640 – 740 m floor under different changing geological conditions of the ore deposit and hanging wall rocks occurrence – the northern, central and southern parts. The difference in the iron content in the mined ore relative to the initial iron content in the massif has been defined as an indicative criterion of the influence of changing conditions on the production quality. The reasons have been revealed which contribute to the collapse of the rocks and the subsequent decrease in the iron content of the mined ore in ore deposit areas differing by their characteristics. It has been determined that within the central and half of the southern ore deposit parts with a length of 600 m, an anomalous geological zone is formed, the manifestation of which will be increased with the depth of mining. It was noted that within this zone, with the highest intensity and density of collapse of hanging wall rocks, the influence of decrease in the slope angle and change in the strike direction are of greatest priority, and such geological factors as a decrease in hardness, rock morphology, deposit thickness increase this influence significantly. To solve the problems of the hanging wall rocks' stability, it is recommended to study the nature and direction of action of gravity forces on the stope chambers in the northern, central and southern parts, as well to search for scientific solutions in regard to changes in the geometric shapes of stope chambers and their spatial location, improving the order of reserves mining in terms of the ore deposit area, the rational order of breaking-out ore reserves in the chambers with changing mining and geological conditions of the fields' development.

Keywords: iron-ore deposits, dilution, iron content, collapse of rocks, hanging wall, geological structure, angle of slope and strike

Особливості підземної розробки багатих залізних руд в умовах аномального геологічного середовища

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Анотація. Стаття присвячена дослідженню геологічних особливостей і форми залягання рудного тіла й вміщуючих порід висячого боку Південно-Білозерського родовища та їх впливу на показники і якість вилучення багатих залізних руд. Відзначено, що в інтервалі глибин 480 – 840 м спостерігається зниження стійкості природно-техногенного масиву, викликане гірським тиском, що посилюється з глибиною, впливом на масив вибухових робіт, відмінністю геологічних умов, що призвело до обвалення порід висячого боку та закладення у вироблений простір камер на певних ділянках родовища, засмічення руди й погіршення експлуатаційного стану підземних гірничих виробок. Акцентовано увагу на причини та особливості наслідків обвалення порід висячого боку при видобутку руди, що погіршують техніко-економічні показники видобутку руди з камер.

Побудована об'ємна 3D-модель складнопобудованого рудного покладу, що дозволяє наочно спостерігати в аксонометрії геологічні особливості та форму залягання рудного тіла. Досліджено показники відпрацювання камер у поверсі 640–740 м у різних мінливих геологічних умовахрудного покладуі порід висячого боку – північній, центральній та південній частинах. Як критерій-показник впливу умов, що змінюються, на якість видобутку обрана різниця вмісту заліза у видобутій руді по відношенню до вихідного вмісту заліза в масиві. Виявлено причини, що сприяють обваленню порід і подальшому зниженню вмісту заліза у видобутій руді в різних за характеристиками ділянках рудного покладу. Визначено, що у межах центральної та половини південної частинрудного покладу довжиною 600 м формується аномальна геологічна зона, характер прояву якої буде зростати з глибиною розробки. Відзначено, що в цій зоні, де найбільш висока інтенсивність і щільність обвалень порід висячого боку, вплив зменшення кута падіння та зміни напрямку простягання маютьпереважаюче значення, а такі геологічні фактори як зниження міцності, морфології порід, потужності покладу значно посилюють цей вплив. Рекомендовано для вирішення проблем стійкості порід висячого боку вивчити характер і напрям дії сил гравітації на очисні камери як у північній, так і в центральній з південною частинами, а пошук наукових рішень вести відносно зміни геометричних форм очисних камер та їх просторового розташування, вдосконалення порядку відпрацювання запасів за площею рудного покладу, раціонального порядку відбиваннязапасів руди в камерах при гірничо-геологічних умовах розробки родовищ, що змінюються.

Ключові слова: залізорудні родовища, засмічення, вміст заліза, обвалення порід, висячий бік, геологічна будова

Introduction. Ukraine holds the first place in the world in terms of geological reserves of iron ores, which are assessed at 30 billion tons, and per pure iron content it holds the fourth place after Russia, Brazil and Australia (Peregudov, Gritsina, & Dragun, 2010; USGS, 2018). The significant iron ore reserves are concentrated mainly in the 5 largest iron-ore basins and regions – Kryvorizkyi, Kremenchutskyi, Kerchenskyi, Bilozerskyi and Pryazovskyi (Shatokha, 2015). Among the specified fields, the Bilozerskyi iron-ore region, which consists of the Pivdenno-Bilozerske, Pivnichno-Bilozerske and Pereverzivske fields, is the leader by the average iron content in the ore (61%), the explored total geological reserves of which are 2.5 billion tons (Gnatush, 2009). Currently, the enterprise PJSC "Zaporizhzhia Iron Ore Plant" is actively developing the hematite-martite ores of the Pivdenno-Bilozerske field and the extraction of the Pereverzivske field was begun. The enterprise has introduced a highly effective chamber system of mining with the subsequent filling of the mined-out space with a consolidating mixture, which is unique among the Ukrainian iron ore deposits. This made it possible to prevent lowering of the earth surface, to improve the safety level of mining operations and the completeness of ore reserves extraction, to reduce their dilution (Kuz'menko, Furman, &Usatyy, 2010; Kononenko, Petlovanyi, &Zubko, 2015), as well as to recover the mining waste products in the underground space and to prevent their accumulation (Petlovanyi&Medianyk, 2018; Petlovanyi et al., 2019).The significant volumes of smelter slags, flux production wastes and rocks refuse are recovered as a portion of the filling mixture(Kuzmenko &Petlovanyi, 2015).

When developing the thick ore bodies of high value by means of the systems of development with consolidating backfilling, the stope and backfilling works, as a rule, are spread out over a period of time and mining is performed by a"chamber – pillar" scheme (Li, 2013; Emad, Vennes, Mitri, & Kelly, 2014). Taking into account the high value of the ores in the Pivdenno-Bilozerske field (the iron content is more than 60%), the production of finished products to consumers is performed without technological cycle of enrichment. Being extracted, the ore is processed at the crushing and screening plant to a certain granulometric composition,sorted by iron content and delivered by rail to the metallurgical enterprises of Ukraine and to the European Union countries. The issue of minimum ore dilution is constantly relevant for the enterprise, which is conditioned by high requirements to the mined ores' quality. The market price for iron ore is set by the iron content in it, and by the successful export and, thus, profitability. Thus, it is necessary to maintain quality characteristics in order to avoid losing competitiveness of the iron ore in the market (Fu, 2018).

Despite the use of an effective mining system with a consolidating backfill, when developing the ore reserves in the range of 480 – 840 m depths, serious problems of the natural and technogenic massif stability have arisen, caused by the increase in rock pressure with depth, the influence of blasting operations and the difference in geological conditions. This leads to the collapse of rocks and backfill into the mined-out space of chambers in certain areas of the deposit. This results in the ore's dilution and, consequently, an increase in production costs, which is studied in a number of scientific works (Forster, Milne, & Pop, 2007; Henning & Mitri, 2007; Urli & Esmaieli, 2016; Liu, Li, Yang, & Guo, 2017).At the same time, the operational state of the underground mines through which people and underground transport constantly move has also deteriorated.

In the world practice of developing steeply dipping ore deposits in cases when the similar problems arise, a solution is found by means of application the

technology of strengthening the hanging wall rocks with cable bolts using special drilling units for fastening the mine workings (Bondarenko, Kovalevs'ka, & Cherednychenko, 2010; Zhan & Ye, 2014; Vivcharenko, Ruskykh, &Sotskov, 2015). However, in the conditions of development of the Pivdenno-Bilozerske field, the designed cross section of drifts laid down in the hanging wall of the deposit is insufficient in the operation of drilling units in them for fastening the mine workings, and an increase in the section of drifts entails additional costs, which at the present moment makes the application of cable bolt strengthening quite doubtful.

The stability of the massif depends not only on the extent of rock pressure and seismic impact, but also on a number of geological factors related to the conditions of the ore body and host rocks' formation, the rocks being of the magmatic type. The geological structure of the Pivdenno-Bilozerske field is characterized by significant variation of the geological structure of the ore body and host rocks, their morphological composition, physical and mechanical properties, as well as elements of occurrence, which to different extents have an effect on the degrees of the extraction of the ore reserves. The difficulty is in the fact that the previously designed and currently applied technology of mineral resources extraction is not always capable of ensuring high efficiency in unstable mining and geological conditions. The issues of negative influence of complex mining and geological conditions, when developing the various types of mineral resources are covered in the works of domestic and foreign scientists (Timoshuk, Demchenko, & Sherstuk, 2010; Villegas, Nordlund, & Dahnér-Lindqvist, 2011; Lozynskyi, Saik, Petlovanyi, Sai, & Malanchuk, 2018; Petlovanyi, Lozynskyi, Saik, & Sai, 2018; Xia et al., 2019).

This paper further deals with the peculiarities of the ore body and host rocks occurrence in the Pivdenno-Bilozerske field, which form a very complex geological environment, and also their influence on the quality of the mined iron ores is assessed.

Research methods. An integrated analysis of the geological structure of the Pivdenno-Bilozerske field has been carried out in order to study the influence of the highly complicated geological structure of the ore deposit and host rocks on the technological aspects of extraction and quality of the mined iron ore. The influence of the geological environment on the ore quality can be observed only when mining the chambers of the first stage, surrounded by ore and rock massifs, without contacting with the backfill massif. The floor of 640 – 740 m was chosen in the research, the reserves of which are currently in the final stage of mining, where the most complete information is available on the parameters of mining the first stage of chambers .Along the ore deposit strike, according to exploration reports and excavation chambers' passports, the morphological composition of the hanging wall rocks, the hardness, the degree of fracturing, the angle of slope of the ore deposit and rocks, the thickness of the ore deposit were analysed. The data on the ore dilution was also analysed, according to the results of reserves' extraction from the chambers on contact with the hanging wall, as well as the places and volumes of rock collapse into chambers along the strike of ore deposit.

The values of subsidence and horizontal displacements with the development of stope works in the chambers were determined quarterly by surveying measurements in metering stations set in the drift of the hanging wall of the 740 m horizon, which made possible to define the nature of the rock massif displacement around the operating and laid chambers.

To visualize the data of the complex structural framework of Holovna ore deposit by digitizing its geological sections along the 305 – 840 m horizons, a 3D-model has been developed with the use of the Autocad 2017 and 3D MAX software packages that makes it possible to present in detail the geological peculiarities of complex anomalous areas of the field.

Research results and discussions.

Problematic aspects of mining the ore reserves on contact with the hanging wall. In the process of ore extraction under effect of the rock pressure and depending on the geological peculiarities, the hanging wall rocks to different extents are collapsed into the stope space of the first stage chambers. With an increase in the mining depth, stress intensity of the rock massif increases, which in conditions of reduced stability of the rocks leads to their collapse into the chamber, as well as deterioration of the operational state of drifts in the hanging wall, which are located in the rocks at a distance of 20 – 25 m from the ore deposit contour (Khomenko, Kononenko, & Danylchenko, 2016).

For effective planning of developing the mining operations, the ore deposit of the Pivdenno-Bilozerske field from the centre to the flanks is conventionally divided every other 30 m into surveying axes with the designations "с"– north, "0"– centre, "ю"– south, respectively, the stope chambers are also numbered in consecutive numbers, according to the surveying axis and the sequence of mining (for example, 1/7ю, 2/7ю). At present, the main mining operations are carried out in the interval of 640 – 940 m depths, while

the 640 – 740 m floor is at the final stage of mining, the 740 – 840 m floor is halfway mined-out, the 840 – 940 m floor is at the initial stage of mining.

As a result of quarterly instrumental observations of the state of the hanging wall drift of the 740 m horizon in the deposit area in the surveying axes from 10с to 10ю, which were performed in the period from July 24, 2007 to February 24, 2010, it was determined that the values of rock massif subsidence reached 70 – 195 mm. The rate of the massif subsidence in certain areas has reached a value of 4 – 6 mm/month.

The character and forms of the rock pressure manifestations made it possible to establish that the disturbance of the stope space contours occurs in chambers located close to the hanging wall of the ore deposit. The chambers of the lying deposit wall are in the zone of reduced stress state conditioned by the protective (unloading) backfilling effect of the overlying mined-out and laid down chambers, as a result of which their structural elements, while located in the zone of reduced stresses, preserve their stability. Therefore, in the chambers close to the lying wall of the ore deposit, the disturbances of the stope space contours were practically not observed or there were minor dumps of the backfill out of bottoms above the mined-out and laid down chambers. A lower intensity of rock dilution in the lying wall in comparison with the hanging wall is also noted in the work (Petlovanyi, 2016).

In Fig. 1*a*, there is an extract from the mining operations plan on the 740 m horizon within the surveying axes 0 – 6ю, where the protrusions can be observed of already mined-out and laid down chambers beyond the limits of the ore deposit contour (indicated by red arrows). This testifies to the collapses of the hanging wall rocks into the excavation chambers, which dilute the ore, and the formation of an increased stress state in the hanging wall rocks, which leads to deterioration of a state of the drift of the 740 m horizon (Chistyakov, Ruskih, & Zubko, 2012). The field investigations of the rock massif stress intensity, based on the fixation of visual signs of rock pressure manifestation in the drift of the hanging wall of the 740 m horizon, are evidence of an intensive process of balmstone formation. Shears and chipping off the rocks occur on the outcroppings of the drifts from the side of the mined-out chambers and are external signs of increased massif stresses. These phenomena acquire the most evident character in the drifts of the hanging wall in the central and southern parts of the ore deposit. The consequences of rock pressure impact in the case of unstable rocks bedding in the hanging wall drift can be observed in the photograph (Fig. 1*b*).

Collapses of the hanging wall rocks lead to a number of consequences, which reduce the technical-and-economic indexes of the ore extraction from the chambers, from which the main ones should be distinguished, represented in Fig. 2.

As a result of collapses of the hanging wallrocks into the excavation chamber, there is an unexpected increase in the design volume of a chamber and in order to fill the newly formed cavities an additional amount of backfill mixture for imbedding is required, which leads to unforeseen expenses.The mined ore quality is reduced due to mixing of broken ore reserves and collapsed rock (quartzites, shale rock), in which the iron content varies at an average from 20 to 35%. The ore's dilution by rock reduces its value, since there is a direct correlation between the iron content in the ore and its market selling cost. Simul-

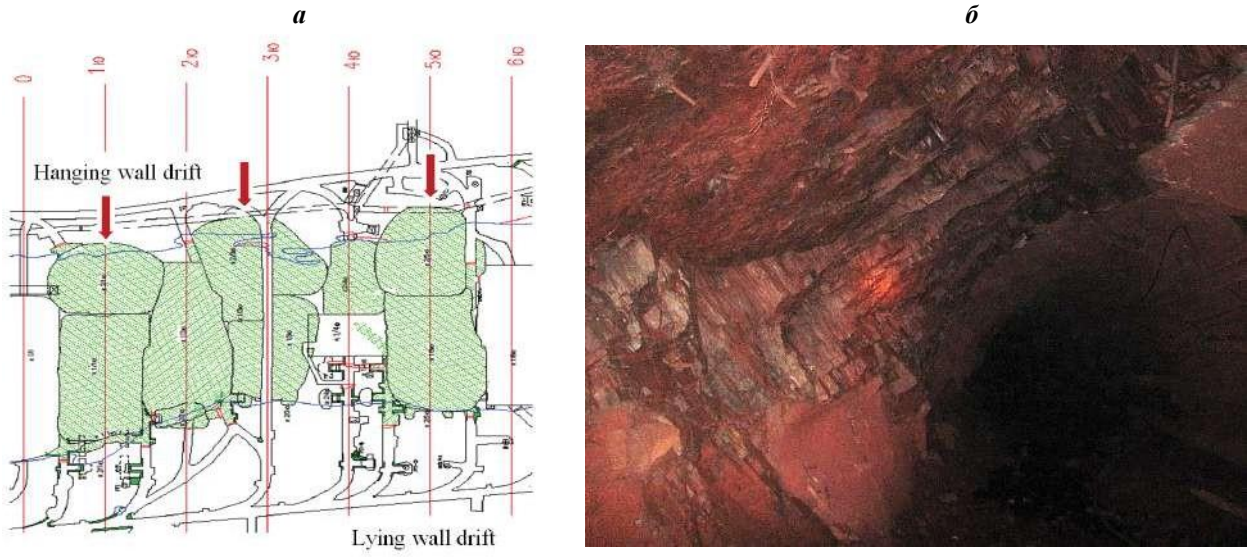

Fig. 1. Consequences of rock pressure manifestation in an unstable geological environment: (a) collapses of rocks of the hanging wall, when mining the ore from chambers; (b) chipping off and shear formation in the hanging wall drift of the 740 m horizon

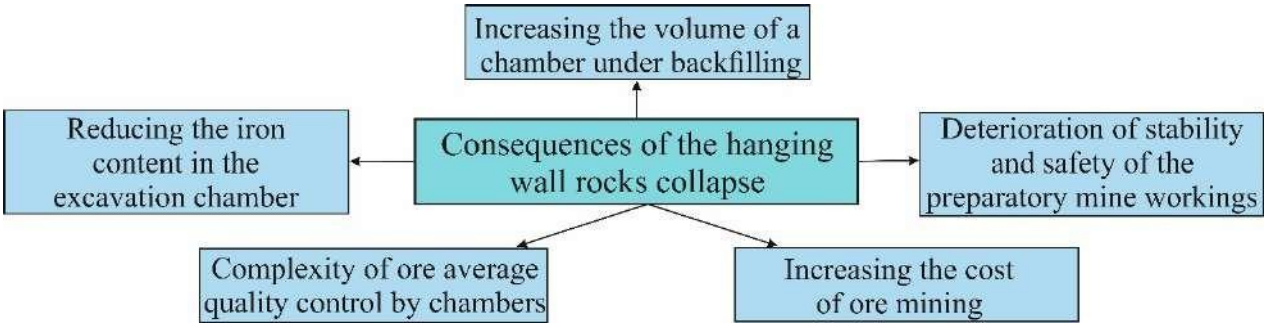

Fig. 2. Problematic aspects related to consequences of the hanging wall rocks collapse into the chamber

taneously with weakening of the quality of ore mined from the chamber, there arises the complexity of controlling its quality as a whole at the enterprise, as well as the necessity of mixing the streams of ore mass.

During the simultaneous mining, there may be 2 – 3 chambers within the floor, the iron content of which may be different, and to achieve the required iron content quality, the ore mass streams should be mixed. In case of major collapse of the rocks of the hanging wall into the stope space of the chamber, large rubble stones can plug up the funnels emptying the chambers, therefore, the ore production is suspended. In such cases, an additional grinding by explosion of rock rubble stones is applied, which affects the cost of ore mining. The problems of collapse of the rocks of the hanging wall reduce the stability and safe operation of mine workings of the hanging wall, since in the case of a high stress state and the presence of complex geological zones during rock collapse, these mine workings can be destroyed and the drift distance from the chamber contour, usually applied as 20 – 25 m, can be insufficient.

Due to the increased influence of the hanging wall rocks on the mining technology, only the geological structure of the ore deposit and of the hanging was rocks, the formation of complex geological zones and their influence on the ore quality are analysed further in this paper.

Research into quality of mined iron ore in changing geological conditions along the strike of the deposit. The geological environment in which mining of iron ores reserves is conducted is represented directly by the ore body, as well as by host rocks of the lying and hanging walls. The detailed ore body characteristic along the strike of the Pivdenno-Bilozerske field indicates significant changes in both its physical-mechanical properties and its peculiarities of occurrence, as well as its morphological composition (Petlovanyi, Lozynskyi, Zubko, Saik, & Sai, 2019). For convenient planning of mining operations, it is customary to divide the ore body of the Pivdenno-Bilozerske field into the northern, central and southern parts.

The deposit is a banded iron formation curving inward in a western direction (from north-west to north-east) with a total sub-meridional strike of banded iron formations which include rich iron ores. On the southern flank the strike is north-western (310º), and from the middle of the ore deposit it changes to the north-eastern direction (40º). In the same direc-

Table 1. Characteristic of the geological environment and its properties in the 640 – 740 m floor

Indicator	Area along the strike of the ore body		
	Northern part	Central part	Southern part
Length of area,	650	400	450
Hardness of rocks, *f*	14 – 15	10 – 14	6 – 9
Angle of slope of the ore body, degree	70 – 75	67 – 70	63 – 67
Angle of slope of the hanging wall rocks, degree	68 – 71	67 – 68	65 – 70
Characteristic and thickness of the ore body, m	Ore body is broken into a number of veins, 25 – 50	Continuous ore body	
		35 – 110	50 – 160
Fracturing	High, medium		Medium
Stability	Medium, low		Medium
Morphological composition of the hanging wall rocks	Quartzites with hematite-martite composition	Quartzites with hematite-martite composition,shale rocks of quartz-peach-sericitic composition	Shale rocks of quartz-peach-sericitic composition

tion, the angle of slope of ore deposit is changed, increasing its value from south to north – from 60 – 65º to 70 – 80º. In the ore massif and host rocks, there is an intense fracturing and frequent replacement of rocks with varying strength characteristics within the technological parameters of the stope chambers. There are no disjunctive breaks, but separate fractures are disclosed in vertical and gentle planes with incidence angles of 10 – 20º over the entire area of the field. The strike of vertical fractures prevails in the direction of 350º, and gentle fractures – 250 – 275º. The density of fractures varies from low (up to 2 fractures per meter) to very high (20 fractures per meter).The geological peculiarities of variability of the ore body and hanging wall rocks along the strike have been systematized and summarized in Table 1.

The data in Table 1 indicates the significant variability of the geological structure and conditions of occurrence along the strike and in depth of the northern, central and southern ore deposit areas. Thus, from the northern ore body flank of the deposit to the southern flank, the values of the hanging wall rock hardness and the slope angle of the deposit decrease significantly. The morphological composition of the rocks changes, which is characterized by structure and texture, while the deposit thickness increases.

To visualize the data of the complex structural framework of Holovna ore deposit by digitizing its geological sections along the 305 – 840 m horizons, a 3D-model has been developed (Fig. 3). The model makes it possible to visually observe in axonometric projection the following geological peculiarities and forms of the ore body occurrence, as well as their change along the strike: the deposit thickness, the angle of slope and strike, the presence of folded contacts from the side of the hanging wall.

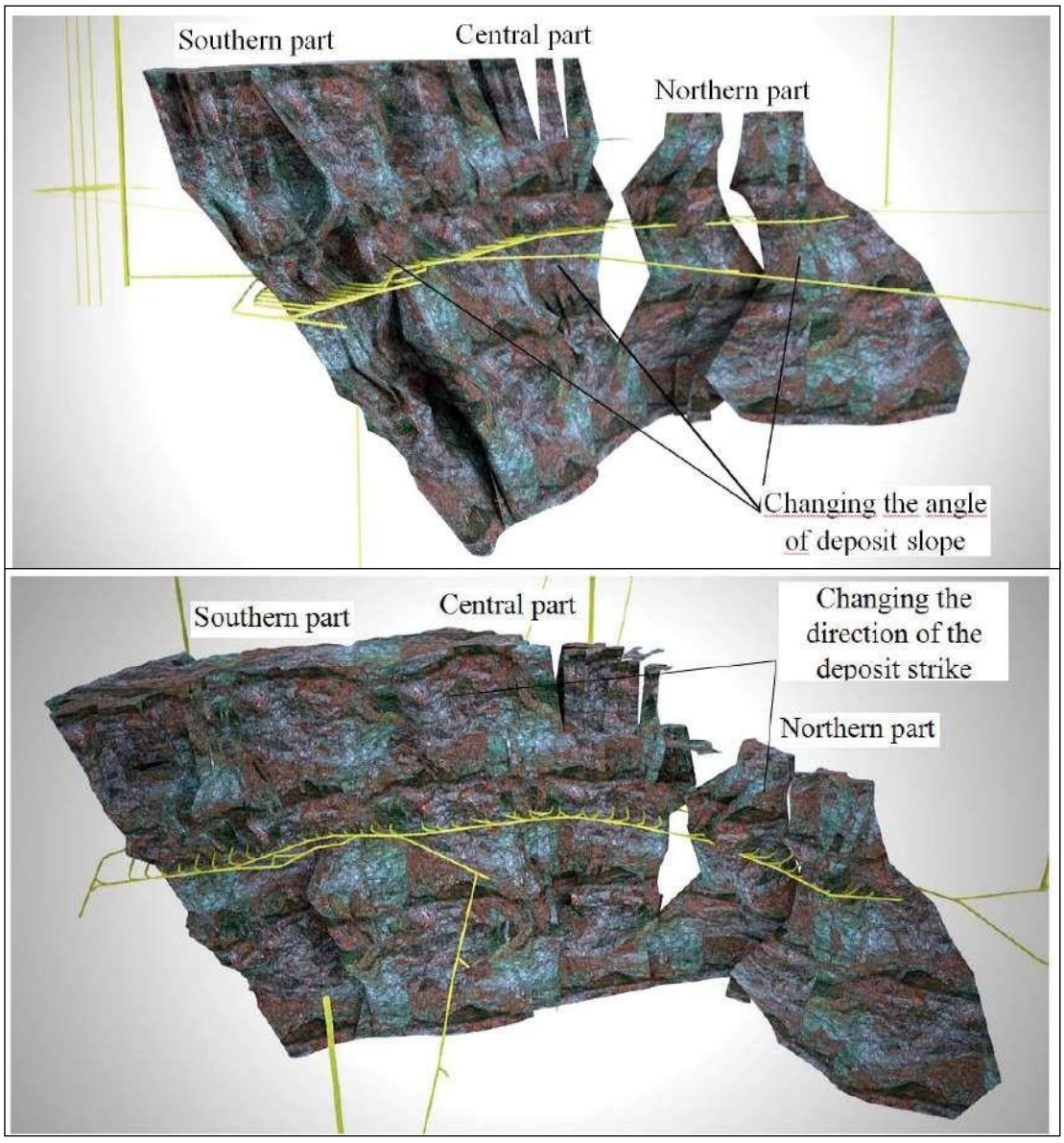

Fig. 3. 3D-model of the ore body visualization in the Pivdenno-Bilozerske field

In order to determine the influence of changing geological conditions of the ore deposit and of the hanging wall rocks on the efficiency of iron ore mining, the parameters have been studied of chambers mining in different conditions of the ore deposit areas, varied by character – northern, central andsouthern (Fig. 4). The difference in the iron content in the mined ore relative to the initial iron content in massif of the chamber, according to the geological exploration data, has been defined as an indicative criterion of the influence of changing conditions on the production quality.The analysis provided for a comparison of the dynamics of changes in the average parameter of iron content (Fe, %) in the mined ore of 5 mined-out chambers in the ore deposit parts with different geological conditions.

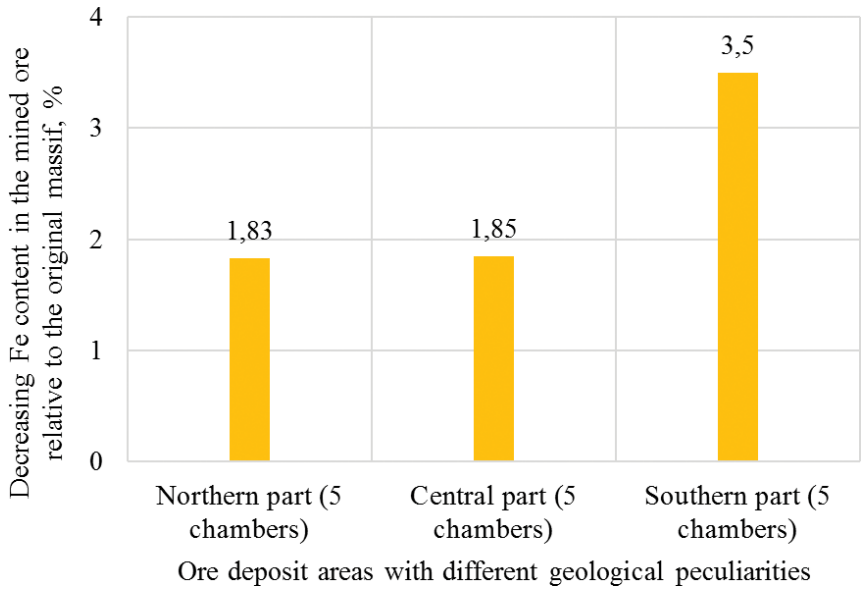

Fig. 4. Degree of the iron content variation in the mined ore relative to the original content in the massif with a change in the geological structure of the ore deposit along its strike

Besides, only the chambers of the first mining stage on contact with the hanging wall rocks were considered. Their side contacts are represented by the ore massif and the chambers, where a decrease was recorded in the iron content from the design content. The facts of the backfill massif collapse were excluded from the analysis. The width of each chamber was 30 m, that is, the area of the inclined outcropping of the hanging wall rocks in the compared chambers was sufficiently alike and their height was 100 m.

Analysing Fig. 4, it can be argued that the decrease in the iron content in the mined-out chambers, caused by penetration or collapse of the hanging wall rocks, is enhanced with a simultaneous change in its geological peculiarities and form of occurrence, as well as of the hanging wall rocks from the northern part of the ore deposit to the southern part. Further on, a detailed analysis is performed of the reasons for the decrease in the iron content in each area.The decrease in the iron content in the mined ore within the northern area, despite the more favourable conditions for the stability of the hanging wall rocks, often complicated by a high level of fracturing, is primarily conditioned by the complex structure of the ore deposit. There is no serious collapse of the hanging wall rocks, represented by quartzite.The thickness of the ore deposit in the northern area, beginning with the surveying axis 7c, is decreased sharply and, beginning with the axis 15c, it splits into a set of ore bodies. The ore bodies are divided by quartzites, predominantly of hematite-martite composition, 7 – 20 m thick, with an iron content of 35 – 40%.The dilution occurs in the northern deposit due to the fact that along the deposit thickness, one chamber is located across the strike.Therefore, within the deposit, both ore bodies and quartzite interlayers with a low iron content are delineated. Because of the explosive breaking of the hematite-martite ore reserves in the chamber, the quartzite veins are simultaneously beaten off, which leads to a decrease in the iron content.Moreover, in the northern part, the contact with host rocks often has a folded shape, sometimes there is an ore interstratification with host rocks, which, when the chamber is mined, influences the ore dilution.

The decrease in the iron content in the mined ore within the central deposit area is caused by the influence of geological factors, the form of occurrence of the ore deposit and rocks as a result of their collapse, since in this part there is a continuous thick deposit without quartzite interlayers. A decrease in the hard-

ness in this deposit part along with a gradual replacement of quartzites with quartz-peach-sericitic shale rocks reduces the stability of the hanging wall rocks, and a change in the slope angle and direction of its strike from the north-eastern to the north-western direction changes and enhances the nature of the applied load on the stope chambers from the pressure of the overlying rock column. In the central deposit part, the collapses and dumps of rocks into the stope chambers are manifested. An increase in the horizontal chamber spacing (its length),caused by an increase in the thickness of the ore deposit up to 110 m, where 2 – 3 chambers across the strike are located, also influences the stress state of the hanging wall rocks, which increases the probability of collapse and slabbing of the hanging wall rocks. For the northern part, the stope chambers with 25 – 40 m length are specific, for the central and southern parts – 40 – 60 m. An important fact is the irregularity of the slope angle of the ore deposit with slope of the hanging wall rocks, which can serve as a concentrator of increased stresses in the hanging wall rocks.

The decrease in the iron content of the mined ore within the southern deposit part is characterized by a rapid change in hardness of the hanging wall rocks caused by the complete replacement of ferruginous quartzite with shale rocks, predominantly of the quartz-peach-sericitic composition with medium and coarse degree of schistosity, sometimes with interlayers of grey quartz and which are often folded. This type of rock has a lower iron content (25 – 30%), a layered structure and cannot withstand significant outcrops in time. An increase in the deposit thickness to 160 m also leads to an increase in the horizontal spacing of chambers (their length) and an increase in stress intensity of the hanging wall rocks, as in the central deposit part.This southern deposit part is the most flattened compared to others, and its angle of slope decreases to 60 – 63º, the direction of the strike is similar to that in the central part, which also enhances the nature of the applied load on the stope chambers from the pressure of the hanging wall rocks. It appears that irregularity of the slope angle of the ore deposit with slope of the hanging wall rocks here acquires the most significant influence on the phenomenon of the shale rocks' collapse, because the difference in the slope angles of rocks and ore is at its maximum and reaches 7º. The frequent folded shape of the shale rocks and the irregularity of the slope angle can serve as a concentrator of increased stresses in the hanging wall. This is confirmed by the fact that the irregularity of the slope angles of ore and rocks was observed both in the northern (where quartzites occur) and in the central parts (where the hanging wall is represented by quartzites and shale rocks). However, at the same time, during the mining of chambers with irregular slope angles of ore and rocks in these deposit areas, a decrease in the iron content caused by collapse was of isolated occurrence. With the depth of the ore body occurrence, there is an increase in the zone of distribution of semi-resistant quartz-peach-sericitic shale rocks with low hardness in the hanging wall rocks of the southern deposit part, which is represented in Fig. 5.

Given the negative tendency of influence of the shale rocks occurrence in the hanging wall of the southern deposit part, as well as a number of other geological factors mentioned above, during the transition of mining operations to 840 – 1040 m depth interval with the existing ore mining technology, a reduction of the hanging wall rocks stability should be expected, and, therefore, an increase in dilution as early as in the central part of the ore body.

The high intensity and density of collapse of the

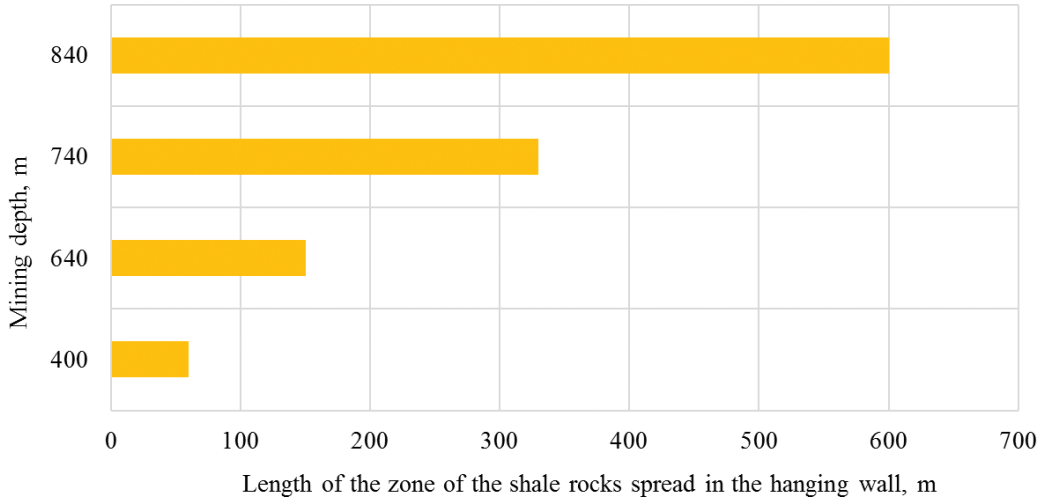

Fig. 5. Spread of the shale rocks zone in the hanging wall of the southern deposit part with the depth

hanging wall rocks in the 640 – 740 m floor, which are shale rocks by 80%, is observed in the zone covering almost the entire central and half of the southern ore deposit part with a length of 600 m, which has a complex geological structure described above.The collapse phenomena were also observed earlier when mining the overlying floors: when mining 480 – 580 and 548 – 640 m throughout the entire mine field from north to south, contour disturbances of the stope space were recorded in 62 chambers, of which 37 (60%) were located in the central and southern parts of the ore deposit. In view of the sharp impact of geological factors and elements of the ore body and host rocks occurrence, the rock collapse manifestations and, as a result, dilution of high-grade ores, it can be argued that an anomalous geological zone is formed in this area along the strike of the ore body, distinguishing it from the northern deposit part. It should be noted that with the depth of the ore body occurrence, the length and character of this zone manifestation has a tendency to an increase, conditioned by the significant spread of shale rocks in the hanging wall of the deposit and an increase in the rock pressure impact. Within this zone, the influence of decrease in the slope angle and change in the strike direction are of greatest priority, and such geological factors as a decrease in hardness, morphology of the rocks, and deposit thickness increase this influence significantly.Under the conditions of a changing geological environment, it is necessary to study the nature and direction of action of gravitational forces on the stope chambers in the northern, central and southern parts, which are likely to be different.

The mining of iron ore in an anomalous geological environment should be based on a new scientific approach for ensuring the massif stability, which involves the consideration of a set of influencing mining and geological factors. Accounting for the above aspects will lay the foundations of technological optimization of ore deposits mining, which is required under the complex conditions of its central and southern parts.

In order to reduce the indicator of ore dilution with collapsed rocks, taking into account the complications of mining the chambers in the southern part of the 640 – 740 and 740 – 840 m floors, the ore reserves located under the bottom of the inclined chambers (775 – 825 m floor) are customarily mined by chambers with lowered parameters in order to avoid large areas of outcropping of the unstable shale rocks– height – 50 m, width – 15 m (Russkikh, Lapko, & Zubko, 2012). Despite the lower delineation of the ore reserves by reduced chambers, their mining in the 775 – 825 m floor showed admissible dilution values, that is, the collapses have decreased significantly. However, the question arises of mining the next lower 840 – 940 m floor, where the chambers of the first stage according to the project again have a height of 100 m and a width of 30 m. This means that the phenomenon of the hanging wall rocks collapse, taking account of the experience of mining 640 – 740 – 840 m floors, is more likely to be repeated.

Therefore, for the chambers of the subsequent 840 – 1140 m floors, it is necessary to make new scientific and technical decisions in regards to changes in the geometric shapes of the stope chambers and their spatial location, improving the order of reserves' mining in terms of the ore deposit area, the rational order of breaking-out ore reserves in chambers with changing mining and geological conditions of field development.

Conclusions. When developing the Pivdenno-Bilozerske deposit of high-grade iron ores by the underground method in the depth range of 480 – 840 m, problems arose in the stability of the natural and technogenic massif caused by rock pressure increasing with depth, the impact of explosive operations on the massif and the difference in geological conditions. This led to the collapse of hanging wall rocks and backfill into mined-out space of chambers in certain areas of the field. As a result of these phenomena, the ore dilution and deterioration of the operational state of underground mine workings occur.

The field investigations of the rock massif stress intensity, based on the fixation of visual signs of rock pressure manifestation in the drift of the hanging wall of the 740 m horizon, evidence an intensive process of balmstone formation. Shears and chipping off the rocks occur on the outcroppings of the drifts from the side of mined-out chambers and are external signs of increased massif stresses. These phenomena acquire the most evident character in the drifts of the hanging wall in the central and southern ore parts of the deposit. The character and forms of the rock pressure manifestations made it possible to establish that the disturbance of the stope space contours occurs in chambers located close to the hanging wall of the ore deposit.

Attention is focused on the causes and peculiarities of the consequences of collapse of hanging wall rocks during ore mining, which reduce the technical and-economic indexes of the ore extraction from the chambers. These include an increase in the volume of a mined-out space for backfilling; decrease in quality and increase in the cost of ore mining; complexity of quality control of iron-ore products in excavation chambers; diminution of the safety of preparatory mine workings in the hanging wall of the deposit.

To visualize the data of the complex structural framework of Holovna ore deposit by digitizing its geological sections along the 305 – 840 m horizons, a 3D-model has been developed. The model makes it possible to visually observe in axonometric projection the following geological peculiarities and forms of the ore body occurrence, as well as their change along the strike: the deposit thickness, the angle of slope and strike, the presence of folded contacts from the side of the hanging wall.

We have studied the parameters of mining chambers under different changing geological conditions of the ore deposit and hanging wall rocks' occurrence – the northern, central and southern parts. The difference in the iron content in the mined ore relative to the initial iron content in the massif according to the geological exploration data has been defined as an indicative criterion of the influence of changing conditions on the production quality.

The reasons have been revealed which contribute to the collapse of the rocks and the subsequent decrease in the iron content of the mined ore in ore deposit areas differing by their characteristics. There is a dilution in the northern part due to the occurrence in the ore deposit of quartzite interlayers with a lower iron content.In the central area, the ore dilution is caused by collapse of rocks conditioned by a decrease in their hardness, a gradual replacement of quartzites with quartz-peach-sericitic shale rocks, and a change in the slope angle and direction of its strike from the north-east to the north-west. In the southern deposit part, the dilution is caused by rock collapse due to a rapid change in their hardness, complete replacement of ferruginous quartzite with shale rocks with a lower iron content, the smallest slope angle of the deposit, irregularity of slope angle of the ore deposit and the slope angle of hanging wall.

It has been established that the high intensity and density of collapse of the hanging wall rocks in the 640 – 740 m floor is observed in the zone covering almost the entire central and half of the southern ore deposit parts with a length of 600 m, which are 80% shale rocks. In view of the sharp impact of geological factors and elements of the ore body and host rocks' occurrence, the rock collapse manifestations and, as a result, a dilution of high-grade ores, it can be argued that in the specified parts of the ore deposit an anomalous geological zone is formed, distinguishing it from the northern deposit part, and the manifestation of which will be increased with the depth of mining.Within this zone, the influence of decrease in the slope angle and change in the strike direction are of greatest priority, and such geological factors as a decrease in hardness, rocks morphology, deposit thickness increase this influence significantly.

To solve the problems of stability of the hanging wall rocks, it is recommended to study the nature and direction of action of gravitational forces on the stope chambers in the northern, central and southern parts, as well to search for scientific solutions in regards to changes in the geometric shapes of the stope chambers and their spatial location, improving the order of reserves mining in terms of the ore deposit area, the rational order of breaking-out of ore reserves in chambers with changing mining and geological conditions of field development.

Acknowledgement. The authors are grateful to Zubko Andrii Mykolaiovych, the technical director at PJSC "Zaporizhzhia Iron Ore Plant", for his guidance in mining the main ore reserves in the 301 – 840 m floors, for valuable advice when preparing this paper. The studies have been conducted under the framework of performing the scientific work of the "Young scientists of Dnipropetrovsk region" competition with support of the Dnipropetrovsk Regional State Administration.

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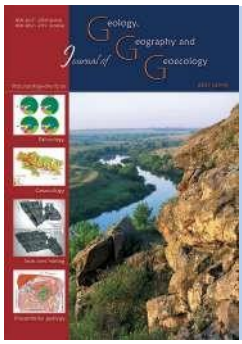

Journal of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(4), 717–726.
doi: 10.15421/111967

Functioning of the fuel-energy complex of Lviv Oblast in modern conditions

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Received: 10.05.2019
Received in revised form: 04.06.2019
Accepted: 18.11.2019

Abstracts. The article provides a general characteristic and detailed analysis of the main spheres of the fuel and energy complex of Lviv Oblast. The paper proves the importance of development of the fuel and energy complex for the economy of Lviv Oblast and the welfare of its residents, for it fulfills the needs of the entire economic complex in fuel and energy, creates preconditions for development of various types of production, forms the basis for improvement of energy security of the region and country in general. The peculiarities of development of the fuel and energy complex were determined, the main of which are: large amount of coal extracted by mining, small-scale extraction of peat, absence of major electric power stations and high percentage of incoming electric energy from other regions. The paper gives a characterization of the energy balance in the Oblast, and also structure of reserves of coal mines and oil deposits. Areas promising for extraction of bituminous and brown coal, oil, gas, peat and other fuel resources were determined. The structure of consumption of fuel-energy resources by types of organic fuel was determined. Patterns of consumption of the main types of energy carriers in the region were distinguished. The structure of capacities of alternative energy resources in Lviv Oblast was determined. We determined the reasons for the low efficiency of use of natural resources and peculiarities and problems of the development of the energy sphere in the region, the main of which are the unsatisfactory technical condition of the objects of the fuel and energy complex, non-effective system of management in the sphere, absence of new sources of providing primary energy resources. We suggested recommendations on increasing the efficiency of functioning of the fuel and energy complex on the basis of use of non-traditional types of energy sources, i.e.: energy of sun, wind, biomass of solid fuel and others, which would allow natural and financial resources to be saved.

Keywords: fuel and energy complex, energy resources, energy sphere, energy balance, alternative energy.

Функціонування галузей паливно-енергетичного комплексу Львівської області в сучасних умовах

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Анотація. У статті наведено загальну характеристику та проведено детальний аналіз основних галузей паливно-енергетичного комплексу Львівської області. Обґрунтовано важливість розвитку паливно-енергетичного комплексу для економіки Львівської області та добробуту її жителів, оскільки він забезпечує потреби всього господарського комплексу в паливі та енергії, створює передумови для розвитку різноманітних виробництв, формує базис для підвищення енергетичної безпеки регіону та держави в цілому. Визначено особливості розвитку паливно-енергетичного комплексу в області, основними з яких є: значна частка видобутку вугілля шахтним способом, невеликі масштаби видобутку торфу, відсутність потужних електростанцій та висока частка надходження електроенергії з інших регіонів. Охарактеризовано енергетичний баланс області, а також структуру запасів вугільних шахт та нафтових родовищ. Виділено перспективні ділянки для видобутку кам'яного та бурого вугілля, нафти, газу, торфу та супітніх паливних ресурсів. З'ясовано структуру споживання паливно-енергетичних ресурсів за видами органічного палива. Виділено закономірності споживання основних видів енергоносіїв у регіоні. Визначено структуру потужностей альтернативних джерел енергії у Львівській області. Висвітлено причини низької ефективності використання природних ресурсів та особливості і проблеми розвитку енергетичної галузі регіону, серед яких основними є незадовільний технічний стан об'єктів паливно-енергетичного комплексу, неефективна система управління галуззю, відсутність нових джерел постачання первинних енергоресурсів. Запропоновано рекомендації підвищення ефективності функціонування паливно-енергетичного комплексу на основі використання нетрадиційних видів джерел енергії, а саме: енергії сонця, вітру, біомаси твердого палива та інших, що дозволить зекономити природні та фінансові ресурси.

Ключові слова: паливно-енергетичний комплекс, енергетичні ресурси, енергетика, енергетичний баланс, альтернативна енергетика.

Relevance of the topic. The socio-economic development of Ukraine in general, and its regions in particular, is closely related to the level of the development of all structural units of the fuel and energy complex (FEC). Development of this sphere has a significant impact on the tempi of increase in the production and its scales. In modern economic conditions, fuel and energy are considered at the same time a resource and a factor of production. This conditions the relevance of the study of the peculiarities of the development of the fuel-energy complex of Ukraine at the regional level.

Analysis of studies and publications. The conditions and perspectives of development of the fuel and energy complex as an important component of the economy of the country have been studied in many research and scientific publications by both domestic and foreign authors. At the state level, the main aspects and perspectives of development of FEC in Ukraine and its regions are described in a number of legal acts, the Conception of State Energy policy of Ukraine for the period to 2020 (Kontseptsiia derzhavnoi enerhetychnoi polityky Ukrainy na period do 2020 roku), and the main directions of reforms in the energy sector have been included in the Energy Strategy of Ukraine to 2035 (Kontseptsiia Enerhetychnoi stratehii Ukrainy na period do 2030 roku (proekt), 2014).

Notable specialists in studying the fuel and energy sphere are V. H. Burlaka, H. H. Burlaka, V. O. Vershynina, O. Vlasiuk, V. S. Kudlai, L. S. Seliverstova, Z. K. Sidnieva, O. M. Riabchyn, I. Chukaeva, A. K. Shydlovsky, R. V. Sherstiuk, Y. V. Yaskovets and others.

The objective of the study was determining modern tendencies in development of the main spheres of the fuel-energy complex in Lviv Oblast.

Main material. The fuel and energy complex of Lviv Oblast is a component of the fuel and energy complex of Ukraine. Peculiarities of structural organization of the FEC in the Oblast are determined by the presence of two elements: fuel, which is the main, and the energy, which performs service functions in provision and distribution of energy. The structure of the FEC forms on the basis of its own fuel and energy resources (oil, free gas, associated gas, condensate, bituminous coal, methane of coal deposits, peat) which accounts for 37.8% of the entire mineral-raw material base of the Oblast.

Among the peculiarities of the FEC of Lviv Oblast we should distinguish the following: large share of extraction of coal in mines; insignificant scales of peat extraction; absence of major electric power stations and high percentage of incoming electric energy; impossibility of development of hydroenergetics; insignificant use of oil products imported to the Oblast.

Currently, energy balance in the Oblast forms on the basis of gas, bituminous coal, firewood for heating, peat and electric energy (Table 1). In Ukraine, share of Lviv Oblast in extraction of coal accounts for 2.6% of coal, 6.2% of raw oil, 3.4% of natural gas. If for the first two types of fuel resources, an increase in the share is observed, the share of gas is seen to decrease.

Table 1. Energy balance in Lviv Oblast*

Type of fuel	Consumption of energy resources	Production of energy resources
Gas	1,850.9 M m^3	670.1 M m^3
Coal	1,264.0 thou T	1,150.1 thou T
Peat	No data	No data
Electric energy	4,577.0 M of kWh	3,067.5 M of kWh
Firewood	201.6 thou m^3	218.5 thou m^3
Raw oil	2.4 thou T	141.2 thou T

Source: Mineralni resursy Ukrainy. Shchorichnyk (2018)

The Oblast is self-sufficient in terms of peat, coal and firewood for heating. Its own extraction of gas and generation of electric energy fulfill 40% of needs in gas and 46% in electricity.

Within Lviv Oblast, the Chervonohrad coal-industrial region (Zabuzke, Mezhyrichia, Busk deposits) and South-Western coal-bearing area (Tiahliv and Liubelia deposits) of the Lviv-Volyn bituminous coal basin are located.

The Chervonohrad coal-industrial district

concentrates around 80% of all balance reserves of coal, most operating mines and almost all coal fields prepared for further industrial development. Maximum coal-bearing is in the south part of the district in the Velykomostivska group of mines.

Currently, in the territory of the Oblast, six mines operate. Balance reserves of coal in the operating mines equals around 164 M T. Most of them are situated in the Stepova, Chervonohradska and Lisova mines, and the largest determined industrial capacities are located in the Stepova and Chervonohradska mines (Table 2).

Table 2. Structure of reserves of coal mines in Lviv Oblast*

Name of the mine	Capacity, thou T	
	Projected	Determined productive capacity for 01.01.2018
Velykomostivska	450	300
Mezhyrichanska	750	300
Vidrodzhennia	750	350
Lisova	600	250
Stepova	2400	500
Chervonohradska	900	500

Source: Mineralni resursy Ukrainy. Shchorichnyk (2018)

An important factor of increase in the extraction of coal is combining maximum extraction of coal reserves and protection of deposits. For reducing waste of coal during extraction, which can reach 20-40%, new highly efficient technologies of processing should be introduced. Also, a promising aspect is involvement of deep horizons.

The resource base of the coal basin allows creation of a powerful FEC which can provide the region with energy resources, and also contribute to the development of the economy of the entire country. A promising area is South-West district with coal-bearing areas with discovered reserves of over 1,000 M T within its limits. Coal within this district is of highest quality, lowest ash and sulfur content and best property for enrichment. Also, within the Chervonohradsk geologic-industrial district, areas were prospected for constructing mines, reserves in which account for almost 200 M T. Furthermore, there is a possibility of extracting up to 500 b m^3 of coal-mine methane (Ofitsiinyi veb-portal Enerhetyka Ukrainy. Statystyka).

Prospects for further development of the Lviv-Volyn bituminous coal basin are related to presence of methane in the coal seams and coal-bearing rocks, as an additional fossil fuel. By component composition of gases within the basin, three gas zones are distinguished: methane-nitrogen (depth to 400 m), nitrogen-methane (400-500 m) and methane (below 500 m). Total resources of methane in the mines are estimated to be 10 b m^3. Degassing works are performed in three mines. Extraction of coalbed methane requires conducting significant scientific studies, introduction of efficient technologies for survey and extraction from coal deposits.

Deposits of brown coal in Lviv Oblast are related to Neogene deposits. Five brown coal deposits have been explored – Rava-Ruske, Nesterivske (Zhovtnivske), Maherivske, Zolochivske and Yasenivske.

However, it should be noted that the technical equipment of enterprises in the region is outdated, by its technical and economical parameters it is quite inferior to the level of countries abroad and requires complete modernization. Technical re-equipment of the operating mines and construction of new ones in a short period would allow doubling of coal extraction in Lviv-Volyn basin, which can completely fulfill the needs in FEC in the Western region (Lvivsko-Volynskyi kamianovuhilnyi basin).

Lviv Oblast is one of nine regions in Ukraine, in which oil is extracted. Oil in the territory of the Oblast was found in 20 deposits with extractable industrial deposits of 216.4 M T, though it is extracted only in ten.

The structure of oil reserves in the deposits of Lviv Oblast is demonstrated in Table 3.

In terms of reserves, the biggest deposits are Boryslavske, Stynavske, Orliv-Ulychnianske, Orhovske, Semyhynivske and Starosambivske. 70-75%, of oil reserves in the region have been used though potential resources in the region exist, of which only 30% are developed.

The main pipelines runs across the territory of the Oblast. Thus, from the north-east to the south west, the Oblast is crossed by the Druzhba pipeline which provides oil to Europe. The Odesa-Brody pipeline is not operated at full capacity.

Table 3. Structure of oil reserves in deposits of Lviv Oblast, thou T*

Extracted since the exploration started	Total	Balance	Conditionally balanced	Off-balance	With undetermined industrial value
44,980	245,936	22,813	0	185,103	38,026
	100 %	9 %	0	75 %	16 %

Source: Mineralni resursy Ukrainy. Shchorichnyk (2018); Ofitsiinyi sait Holovnoho upravlinnia statystyky u Lvivskii oblasti

By gas reserves Lviv Oblast is on the third position after Poltava and Kharkiv Oblasts. The main potential of Lviv Oblast was used in the 1950-60s. However, in the territory of the region, non-explored gas deposits remain, making the Oblast promising for development of gas extraction. Particularly, its territory has 64 deposits of natural gas, 37 of which are being developed. The extractive deposits account for 73.1 b m^3. The territory of the Oblast is crossed by gas pipelines, the network of which is quite ramified and covers five gas-compressor and dozens of gas-dividing stations.

In 2018, in Lviv Oblast, two new deposits of natural gas were discovered – in Drohobych and Zhydachiv district. Predicted reserves of each of these deposits equal around 1 b m^3.

Gas-like fuel-energy fossil fuels include free gases and methane in gas deposits. In the territory of the Oblast, there are 36 deposits of free gas, extracted deposits of which account for 114.7 b m^3, which is 8.4% of the total reserves in Ukraine. Out of them, three deposits, Haiivske, Bilche-Volynske, Hidnovytske, are the largest by the amounts of gas extraction (almost 5% of all Ukrainian reserves). In total, in the Oblast, 33 deposits of methane are being exploited. For the five deposits, industrial reserves of ethane, propane and butane are estimated. They are extracted in the Boryslavske and Zavadivske deposits.

The territory of the Oblast has 47 potential oil-gas objects which are prepared for deep boring, in which potential resources of free gas are estimated at 37.527 b m^3, and oil – 20.825 b t.

Over the recent years, the oil and gas industries in the Oblast have provided stable extraction, supply and transport of hydrocarbons both for export and to domestic consumers. During 2018, 11 new wells were put into operation. In addition, the natural decrease in extraction of gas in exhausted deposits which have been operated since the last century has been stopped.

Gas condensate is represented by nine deposits with reserves of 724 thou t. The largest deposits are Ivanykivske, Zaluzhanske and Haivske.

In the territory of Lviv Oblast the deposits of oil shales have been explored. By qualitative parameters, conditions of bedding and reserves, the following deposits have been distinguished ; Verhnie Synievydne, Boryslav, Shidnytsia. In the process of semi-cocking, out of them crude shale oil, aqueous distillate and fuel gas can be obtained. Artificial fuel obtained from oil shales is economically profitable during high oil prices.

Peat resources in Lviv Oblast have significant energy and agrotechnical potential. Peat can be used as a municipal-domestic local fuel and can be a source of raw material for other branches of th national economy.

In the territory of the Oblast, 74 deposits of peat are located, among which five are being periodically developed. By area, the largest industrial peat deposits are Stoianivske (4,138 ha), Solokiiske (3,881 ha), Radehivske (1,646 ha), Polonychna (1,566 ha) Lvivske (2,226 ha), Leshnivske (2,816 ha), Smilnenske (2,036 ha). Maximum thickness of peat deposits ranges 2.3-11.0 m, average thickness – 1.15 to 4.37 m. Today, peat is extracted only in the Lopatynske and Stoianivske deposits for the needs of peat briquette plants. General energy potential of peat in Lviv Oblast equals 690.6 M of MWh. According to this parameter, the region is inferior to such Oblasts as Kyiv, Rivne, Volyn, and Chernihiv, though it significantly exceeds the energy potential of the rest of the oblasts (Table 4).

Peat fuel granules, briquettes, and also sod peat can be used as solid fuel in industrial enterprises, for gas generators, heat-only boiling stations at plants, railway transport. Complex use of peat simultaneously for the needs of agriculture and industry is conditioned by large variety of its types even within one deposit (Atlas enerhetychnoho potentsialu vidnovliuvanykh ta netradytsiinykh dzherel enerhii Ukrainy, 2001). In perspective, peat can be used as fuel for thermal power stations, currently it is used as municipal-domestic fuel and as organic fuel for agriculture. On its basis soils are used for seedlings of vegetables, slabs and blocks for thermal and sound insulation are pressed to be used in construction.

Electric energy in the Oblast is powered by the Dobrotiv Thermal Electric Power Station, which generates half of the electric energy the Oblast requires, Novoshychi and Yavora Hydroelectric Power

Table 4. Energy potential of peat in Oblasts of Ukraine

Oblast	Total energy potential of peat, M of MWh	Economically practical potential, M of MWh
Vinnytsia	136.4	34.6
Volyn	1,378.1	761.8
Dnipropetrovsk	0.25	-
Zhytomyr	290.5	159.2
Zakarpattia	0.2	-
Zaporizhia	1.08	-
Ivano-Frankivsk	45.2	17.19
Kyiv	716.5	146.5
Kirovohrad	8.7	-
Lviv	690.6	244.1
Mykolaiv	1.26	-
Poltava	364.3	143
Rivne	1,176.2	575.3
Sumy	331.0	575.3
Ternopil	384.3	114.8
Kharkiv	15.7	-
Kherson	11.3	7.96
Khemelnytsk	236.6	99.04
Cherkasy	191.6	79.7
Chernihiv	818.5	356
Total	6,801.0	2,941

Source: Atlas enerhetychnoho potentsialu vidnovliuvanykh ta netradytsiinykh dzherel enerhii Ukrainy (2001)

Stations. Also, combined heat and power plant Lviv CHP-1 and Lviv CHP North, Novoiavorivsk CHP operate.

Production of electric energy provides around 25% of the total volume of the realized industrial production of the Oblast. The dynamics of the production of electric energy in the Oblast, represented in Fig. 1, up to 2017, indicate a tendency towards increase, though over the last year its production fell by 10%.

Analysis of the structure of consumption of fuel and energy resources in 2019 by types of organic fuel shows that the share of natural gas accounts for 56%, oil and oil products – 21.4%, coal – 19%, other types of fuel – 3.6% (including firewood for heating 1%) (Fig. 2).

Over the recent period, consumption of firewood has increased due to the rise in prices of energy providers. Firewood is used for heating homes,

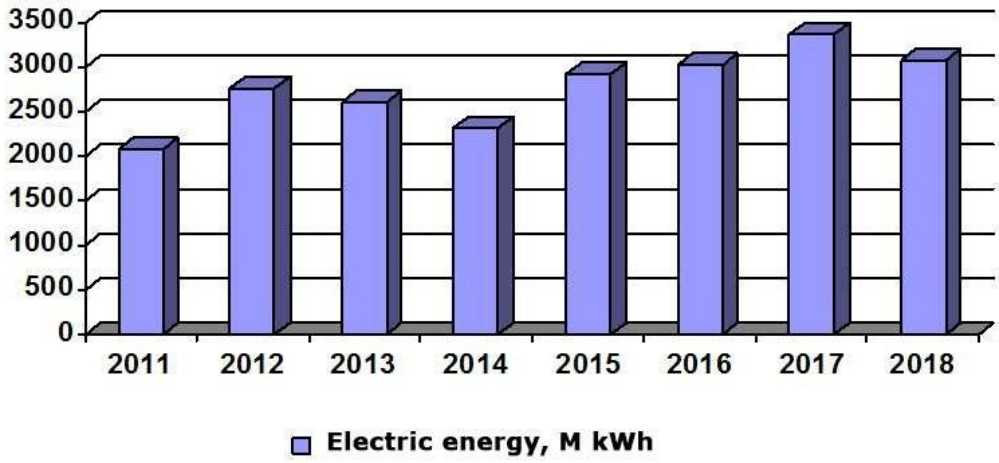

Fig. 1. Generation of electric energy in Lviv Oblast in 2011-2018.

Source: Ofitsiinyi sait Holovnoho upravlinnia statystyky u Lvivskii oblasti

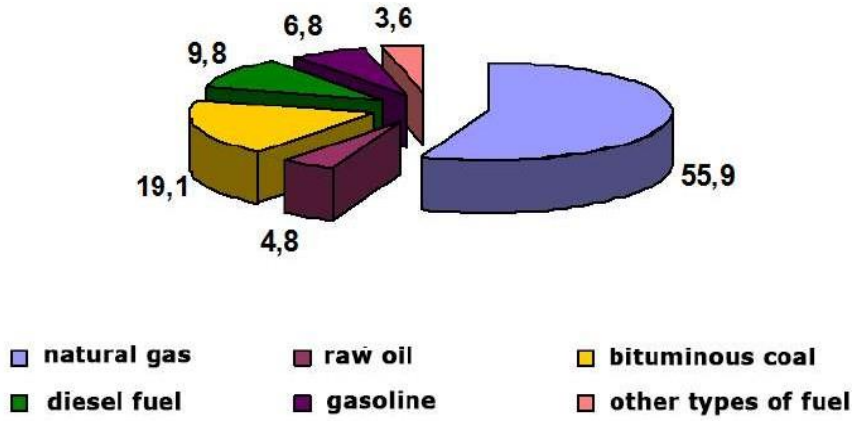

Fig. 2. Structure of use of fuel in Lviv Oblast, %

Source: Ofitsiinyi sait Holovnoho upravlinnia statystyky u Lvivskii oblasti

especially in rural areas. As fuel, wastes of the logging, sawing and wood-working spheres are used. The largest amount of fuel-energy resources is used by the local population, and the most power-consuming spheres are economic activities involved in generation and distribution of electric energy, gas, water, and also spheres of processing industries and transport and communication.

In general, in the region, a certain pattern in consumption of the main types of energy sources is seen: coal, natural gas and firewood for heating are used the most by industrial enterprises, institutions of state management and defense; at the same time, gasoline and diesel fuel are consumed mostly by transport, communication services, in agriculture and forestry (Fig. 3). (Ofitsiinyi sait Holovnoho upravlinnia statystyky u Lvivskii oblasti).

By amount of use of electric resources, the leaders are city of Lviv (43.2 %) and Kamianko-Byzky district (23.5 %). A high amount of consumption of

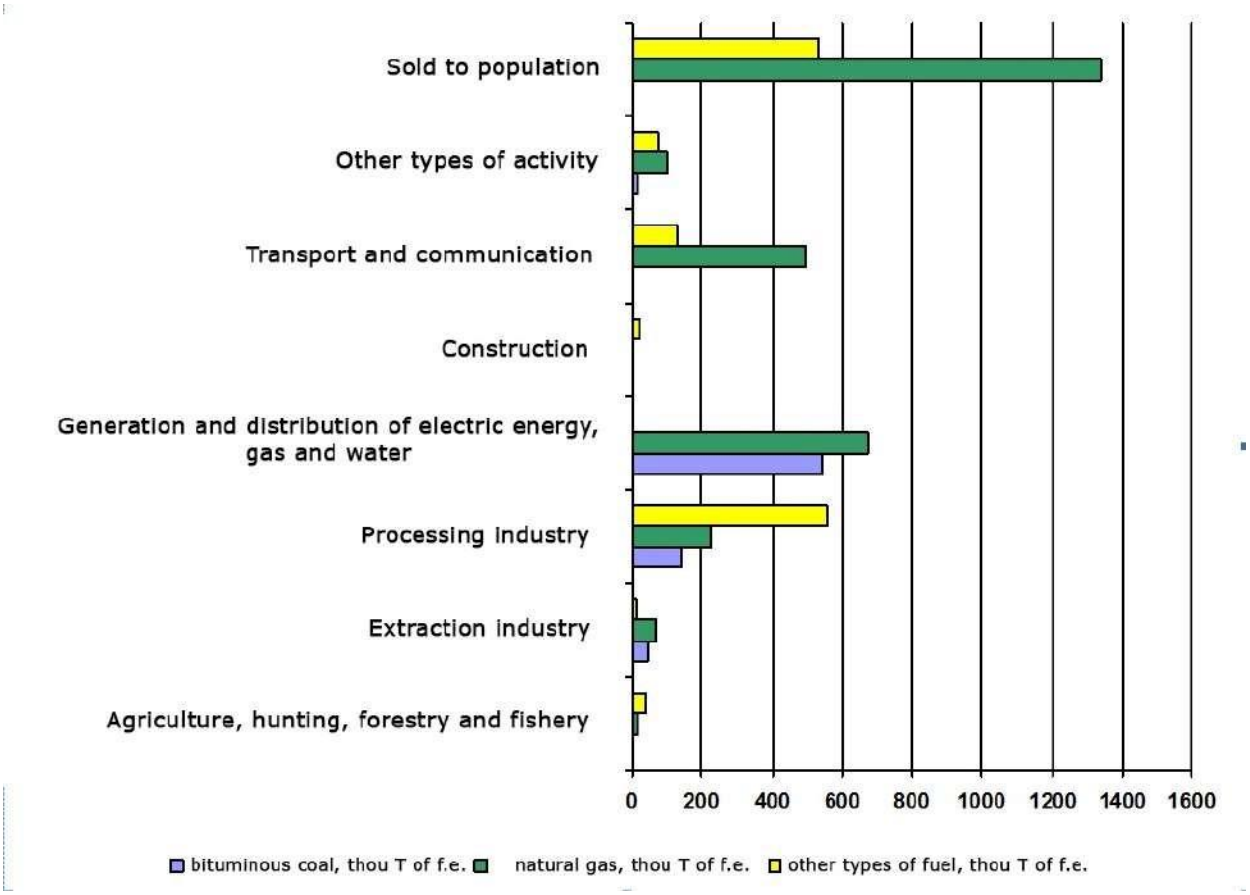

Fig. 3. Structure of amounts of consumption of fuel-energy resources in Lviv Oblast

Source: Ofitsiinyi sait Holovnoho upravlinnia statystyky u Lvivskii oblasti

resources is seen also in Radekhiv, Sokal, Yavoriv, Mykolaiv districts, and also in the cities Novyi Rozdil, Drohobych and Chervonohrad (4.5 %, 3.1 % 2.8 % 2.3 %, 3.2 %, 2.6 % and 2.1 % respectively).

The territorial peculiarities of consumption of different types of fuel-energy resources in Lviv Oblast should also be mentioned. Particularly, bituminous coal is used the most by enterprises and organizations in Kamianka-Buzka, Mykolaiv, Sokal, Zhydachiv administrative districts, and the city of Chervonohrad. Natural gas is used the most in the cities Lviv and Novyi Rozdil, and also Radekhiv and Yavoriv districts.

A characteristic feature of the modern energy industry is development of technologies on the basis of non-traditional and renewable sources of energy, the use of which contributes to solving problems of effective provision of energy, and also problems of an ecological, economic and social character in Ukraine and its regions.

Today, Lviv Oblast is considered one of the most active regions of Ukraine in terms of development and introduction of alternative energy. According to the results of the assessment of energetic potential of renewable resources of energy, the Oblast has a sufficient natural potential of renewable sources for production of thermal and electric energy in industrial amounts (Syrotiuk, 2014).

Taking into account the rather high parameters of potential of energy of wind, small rivers and biomass in the Oblast, there is a possibility of replacing organic fuel with energy from renewable sources practically by 50%, and some districts, in perspective, can become energy-independent due to local renewables (Netradytsiini ta vidnovliuvani dzherela enerhii v Ukraini u svitli novykh yevropeiskykh initsiatyv, 2013).

Total technically achievable potential of renewables in Lviv Oblast accounts for 4.27 M T of fuel equivalent (f.e.)/year, measuring 4.3% of the total indicator in Ukraine, which is the highest among the Oblasts of the Carpathian Region. The structure of theoretically achievable energetic potential of renewables in the Oblast equals 299.4 thou T of f.e./year (Table 5).

The energy of biomass is understood as wastes of forestry and agricultural plants, energetic plants (maybe better energy crops), and the environmental energy – geothermal energy and energy of drainage water.

Lviv Oblast is second in Ukraine in the number of small mountain rivers and the possibility of constructing hydroelectric stations on them. Their potential is estimated in 500 M kWh per a year, that is 10% of all consumption of electric energy in the Oblast. The main share of the energy belongs to the rivers Dnister, Stryi, Opir and their tributaries. Small hydroelectric stations could become an important source of providing energy in the Oblast, especially in its mountain regions, to which the largest share of the energy potential of the small rivers belongs.

For the development of the biomass in Lviv Oblast, there is significant resource potential in wastes from wood, agriculture, and also free areas of land for planting energy plants, particularly energetic willow, energetic poplar, silvergrass, etc.

The amount of forest wood wastes which can be used for energetic purposes equals around 30-40% of the amounts of lumbering. The largest amount of sawdust and firewood is provided by Drohobych, Zhovkinsky, Skole, Staryi Sambir, Turka districts. Wood wastes are supplied to special enterprises which produce pellets in industrial amounts, though they can be processed directly on the spot.

Among the wastes of agriculture, initial wastes are distinguished – those which remain in the fields as byproducts after harvest of initial agricultural crops. They include straw of cereals and rapeseed, stems of sunflower and maize. Secondary wastes include beet pulp of sugar beet, shells of sunflower, nut shell

Table 5. Structure of potential of renewable in Lviv Oblast

Type of energy	Energy potential, thou of T of fuel equivalent
Solar energy	40.6
Wind Energy	74.6
Small-scale hydro energy	8.9
Environmental energy	71.7
Biomass energy	98.4
Biogas energy	5.2
Total	299.4

Source: Atlas enerhetychnoho potentsialu vidnovliuvanykh ta netradytsiinykh dzherel enerhii Ukrainy (2001)

and other types of biomass of similar type, manure – organic substance used as organic fertilizer in agriculture. Wastes of livestock, manure, can be used as organic substance in agriculture.

Initial wastes of agriculture are potentially important for those administrative districts of Lviv Oblast, which have large areas with cereal crops – Sokal, Zolochiv, Zhydachiv, Radekhiv and Brody. Secondary wastes of agriculture are most often concentrated in processing enterprises, where it is practical to use them for their own energetic needs.

The energy potential of biomass from wastes of livestock in the Oblast is estimated as high and economically practical for use, though it is closely associated with number of animals. Highest populations of cattle are located in Brody, Zhydachiv, Sokal and Sambir districts, of swine – in Stryisky, Busk, Sambir and Sokal, poultry – Pustomyty, Sambir and Zhydachiv. On average, around 665 M m^3 of biogas a year can be produced from livestock biomass, allowing replacement of almost 600 thou of conventional fuel.

If considering the existing structure, over half of it is the capacities of wind energy, less significant are the capacities of bioenergy and solar energy (Fig. 4).

tant complex of solar electric stations in the territory of Western Ukraine.

Potential of geothermal energy of Lviv Oblast equals around 7.0% f the total parameter in Ukraine. Particularly, in Yavoriv and Mostyska district, the deposit of geothermal water of 95-130 °C temperature has been explored; the water is embedded at the depth of 3 km, creating favourable conditions for building a combined heat and power plant. Also, abandoned oil, gas and oil-gas wells could be used as sources of geothermal energy.

As for wind energy, the highland territories of Yavoriv, Mostyska and Zolochiv districts are considered promising. The promising plans for Lviv Oblast include construction of wind energy stations of general power of 400MWT. Electric stations Stary Sambir-2 and Sokalsky Wind Park are planned to be put into operation.

Also, in Lviv Oblast, energy of the environment can be used. It can be used in two ways. The first is related to the extraction of energy from natural flow of thermal groundwater to the Earth`s surface or from corresponding geothermal wells. For this purpose, for extracting energy, special geothermal stations should be built for use of thermal energy by consum-

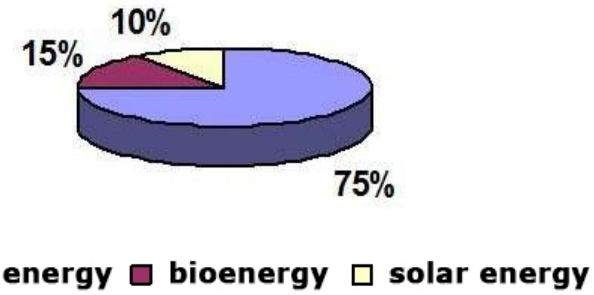

Fig. 4. Structure of capacities of alternative sources of energy in Lviv Oblast
Source: Netradytsiini ta vidnovliuvani dzherela enerhii v Ukraini u svitli novykh yevropeiskykh initsiatyv

Over the last few years, all these branches showed notable increase and increase is predicted again in the next years.

Despite the fact that the territory of Lviv Oblast, compared to other regions of Ukraine, has a small level of energy of solar flow, use of solar energy in the region has been started and further development is planned. Particularly, in 2017, four solar electric power stations were put into operation: Ozerna, Boryslavska Solar Electric Station, Energetic fields of Solar Power Stations Ternovytsia 2 and 4, Leo-Solar-Energy, and in 2018 in Yavoriv District, the first stage of development of the solar energy station Yavoriv-1 was opened, which is a component of the most impor-

ers in close proximity to geothermal sources. Today, in the Oblast, there are no conditions for development of thermal groundwater, therefore their energetic resource is not currently being considered (Kudlai, V., Seliverstova, L., 2013.).

The other way is related to use of thermal pumps for air-surface or well extraction of energy from soil and atmosphere. Thermal pumps are mostly used for heating individual buildings, hotels, kindergartens, etc. Particularly, in the cities of Drohobych and Rava-Ruska, geothermal thermal pumps have been installed for heating kindergartens, reducing costs of heating and supply of hot water by three times.

Despite its considerable natural potential, in Lviv

Oblast, renewable energy is being developed at low tempi and the share of the used potential of renewables is insignificant. Therefore, 5.0% energy of biomass, 2.1% of sun, 1.1% of wind energy, 0.5 of energy of small rivers, and less than 0.1% of geothermal energy are used.

Conclusions. In the territory of Lviv Oblast, deposits of practically all types of oil-energy and fossil fuels are located - bituminous coal, natural gas, oil, peat. Reserves of coal in mines in operation account for around 170 MT. Furthermore, promising objects are the South-West and Chervonohrad geological-industrial districts, within which, areas for constructing mines were found with significant deposits. Also, scientific developments have confirmed the presence of large deposits of oil and natural gas at great depths.

In general, subsurface of the Oblast is sufficient for balanced development of industry and agriculture and can fulfill the needs of the Oblast for mineral raw materials. However, there is a number of disadvantages which significantly reduce the efficiency of use of the subsurface, failing to provide the protection required, causing discrepancies between the use of subsurface and protection of the natural environment.

Also, Lviv Oblast has a high natural potential in renewable sources of energy. In particular, the region has significant perspectives for industrial development of bioenergetics, wind and hydroenergy. Wind-energy potential first of all can be practically exploited in highland areas for the potential of these areas is one of the highest in Ukraine. A significantly promising sphere is bioenergetics, because total energy potential of biomass in the Oblast is over two times higher than the amounts of consumption of natural gas. For contributing to the development of bioenergy, enterprises for processing wood and organic wastes should be created. The region has significant potential for growing energy plants (willow, poplar, silvergrass) and their use for production of fuel. The region has high potential for small hydroenergy plants. However, for construction of new electric stations, not only should the features of rivers and surrounding territory be taken into account, but also new technologies for preserving species diversity and populations of river fish must be used.

Renewable energy can become one of the main directions of economical development of Lviv Oblast. Particularly the development of renewable energy in the region must be based on strategic planning with consideration of the total of factors of regional and local level.

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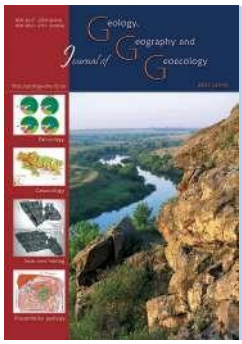

JOURNAL of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(4), 727–737.
doi: 10.15421/111968

Palynological data on the description of the Gelasian and Calabriane analogues in the stratotype section of the Kuyalnik deposits near Kryzhanivka village (Odessa region)

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Received: 07.10.2019
Received in revised form: 20.10.2019
Accepted: 06.11.2019

Abstract. The state of paleontological study of the Kuyalnik deposits of Odessa region, in particular the stratotype section near Kryzhanivka village was analyzed. Attention is paid to the absence of the palynological description of the Krizhanivka climatolith in the section and the insufficient palynological study of the liman-marine Kuyalnik sediments. The goal of the presented research was to obtain a detailed palynological description of the subaerial Eopleistocene and the liman-marine Kuyalnik sediments of the stratotype section near Kryzhanivka village. Based on the results of the research, the palynological description of rocks of the upper part of the section of the liman-marine Kuyalnik sediments is presented for the first time, as well as the materials to substantiate the correlation of the studied sediments with the Beregove and Siversk climatolyths of the continental Upper Cenozoic section of Ukraine, which correspond to the Gelasian of the International Stratigraphic Scale (ISS). For the first time, palynological description of the Kryzhanivka climatolith correlated with the Calabriane of the ISS is presented for the studied section. Three subcomplexes are described in the composition of the Kryzhanivka complex. The characteristic features of the Kryzhanivka spore-pollen complex (SPC) and the changes in the ecological structure of each subcomplex are determined. Correlation of the established complex with the even-aged SPC of the Kryzhanivka deposits of the southern part of the Ukrainian Shield (the Eastern Azov Sea region). Outstanding questions of stratigraphic division of different facial deposits of the section based on palynological data are outlined. The necessity of further palynological studies of deposits of the section near Kryzhanivka village is substantiated.

Keywords: Gelasian, Calabriane, continental deposits, liman-marine sediments, spore-pollen analysis, Ukraine.

Палінологічні дані до характеристики аналогів гелазію та калабрію у стратотиповому розрізі куяльницьких відкладів біля с. Крижанівка (Одеська область)

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Анотація. Проведено аналіз стану палеонтологічної вивченості куяльницьких відкладів Одеського регіону, зокрема у стратотиповому розрізі біля с. Крижанівка. Акцентовано увагу на відсутності палінологічної характеристики крижанівського кліматоліту у розрізі та недостатню палінологічну вивченість лиманно-морських куяльницьких відкладів. Метою представленого дослідження було отримання детальної палінологічної характеристики субаеральних еоплейстоценових та лиманно морських куяльницьких відкладів стратотипового розрізу біля с. Крижанівка. За результатами проведених досліджень вперше наведено палінологічну характеристику порід верхньої частини розрізу лиманно-морських куяльницьких відкладів, а також представлено матеріали до обгрунтування кореляції досліджених відкладів з берегівським та сіверським кліматолітами континентального верхньокайнозойського розрізу України, які відповідають гелазію Міжнародної стратиграфічної шкали (МСШ). Вперше для вивченого розрізу наведено палінологічну характеристику крижанівського кліматоліту, що корелюється з калабрієм МСШ. У складі крижанівського комплексу описано три підкомплекси. Визначено характерні особливості крижанівського спорово-пилкового комплексу (СПК) та відміни екологічної структури кожного з підкомплексів. Проведено кореляцію встановленого комплексу з одновіковим СПК крижанівських відкладів південної частини Українського щита (Східне Приазов'я). Окреслено невирішені питання стратиграфічного розчленування різнофаціальних відкладів розрізу за палінологічними даними. Обгрунтовано необхідність проведення подальших палінологічних досліджень відкладів розрізу біля с. Крижанівка.

Ключові слова: гелазій, калабрій, континентальні відклади, лиманно-морські відклади, спорово-пилковий аналіз, Україна.

Introduction. The Kuyalnik deposits of Odessa region have long been of considerable interest to research paleontologists, lithologists, and paleomagnetologists. The Kuyalnik deposits were first described by I.F. Sintsov (Sintsov, 1875) on the right bank of the Kuyalnik liman near Odessa. Later, based on the faunal data, I.F. Sintsov (Sintsov, 1897) dated the established deposits to the Upper Pliocene and divided them into two horizons: the Lower horizon with cardiidae and the Upper horizon with freshwater forms.

At the subsequent stages of the research, the paleontological description of the Kuyalnik deposits of Odessa region were significantly expanded and supplemented by T.A. Mangikian (Mangikian, 1929), I.Ya. Yatsko (Yatsko, 1954), V.N. Semenenko (Semenenko, 1987), and P.D. Frolov (Frolov, 2013) based on the study of mollusk fauna; V.G. Sheremeta (Semenenko, Sheremeta, 1963), G.I. Karmishina (Karmishina, 1973), K.N. Negadaev-Nikonov, A.V. Karelina, N.M. Ilnitskaya (Negodaev-Nikonov, Karelina, Ilnitskaya, 1977) with ostracode; I.M. Gromov and A.I. Shevchenko (Gromov, Shevchenko, 1961), A.S. Tesakov (Tesakov, 2002), Topachevsky V.A., Skorik A.F., Rekovets L.I (Topachevsky, Skorik, Rekovets, 1989) Krokhmal' A. I. (Krokhmal', 2009) with small mammals. Based on the fauna of freshwater mollusks, G.I. Popov compared the lower horizon of the Kuyalnik deposits of Odessa region with the Upper Akchagyl of Caspian region (Popov, 1962), and K.V. Nikiforova (Nikiforova, 1962) based on the fauna of vertebrates – with Villafranca of Western Europe. Subsequently, detailed correlation comparisons between the Kuyalnik deposits of Odessa region and the Akchagyl rocks of Caspian region for mollusk fauna were carried out by P.F. Gozhik (Gozhik, 2006, Gozhik, 2019) and A.L. Chepalyga (Chepalyga, 1992).

It should be noted that in spite of the well-studied Kuyalnik deposits of Odessa region, the age of the rocks in the section near Kryzhanivka village as well as their correlation with even-aged continental sediments is still the subject of discussion. Particularly, based on the study of ostracods, G.I. Karmishina (1973) concluded that the upper part of the section of the Kuyalnik deposits near Kryzhanivka village dates back to the Pleistocene. Unfortunately, magnetologists do not also have a single opinion on the paleomagnetic characteristics of the Kuyalnik deposits of the studied section. (Pevzner, 1989; Tretyak, 1967; Tretyak, Volok, 1974).

The section of subaerial deposits near Kryzhanivka village overlapping the Kuyalnik deposits is also of considerable interest since it is a stratotype of the Kryzhanivka pedohorizon (Veklich, 1982).

Unfortunately, the palynological characterization of the Kuyalnik deposits of the section under consideration is fragmentary. N. A. Shchekina (Shchekina, 1964) studied single samples from the lower section of the Kuyalnik deposits by spore-pollen analysis. Based on the obtained data, it was suggested that according to palynological data, the rocks of the upper part of the Kuyalnik deposit section of the North Azov Sea can be correlated with the deposits of the lower part of the section near Kryzhanivka village. The upper part of the liman-marine sediments has not been studied palynologically up to date.

Despite the fact that the section near Kryzhanivka village is a stratotype of the Kryzhanivka pedohorizon, palynological studies of rocks have not been conducted. S.I. Turlo reconstructed the vegetation of the Kryzhanivka time based on the study of the Kryzhanivka soils of the Azov, Middle Dnieper and Donets Basin sections (Sirenko, Turlo, 1986).

The author made an attempt to fill in this gap.

Materials and methods of research. The studied section is located within the coastal cliff of the Black Sea at the southeastern margin of Kryzhanivka village of Odessa region (Fig.1). The deposits of the studied

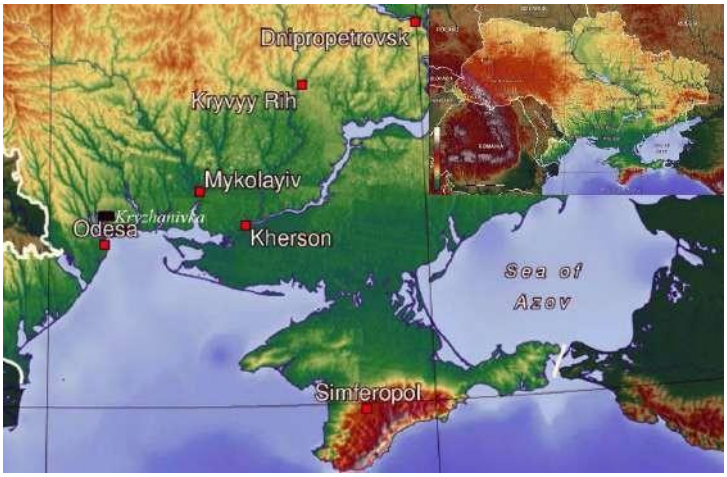

Fig. 1. The section location

Fig. 2. General view of the outcrop uncovering the upper part of the section near Kryzhanivka village

Fig. 2a. Clearance 1 – the Kryzhanivka pedohorizon

Fig.2b. Clearance 2 – the Berezan deposits underlying the Kryzhanivka pedohorizon and the upper part of the section of liman-marine sediments

section were lithologically described repeatedly. The most detailed lithological description of the liman-marine rocks of the studied section is given in INQUA Guidebook edited by Nikiforova, 1982 while the subaerial Pleistocene deposits overlapping them is given in the monograph (Veklich, Sirenko, 1972). Taking into consideration all of the above, we will not give a detailed lithological description of the studied deposits. The section was studied in two outcrops (Fig. 2 and Fig. 3).

Fig. 4 shows the lithological columns of deposits of the investigated section.

The first outcrop (Fig. 2) is located in the coastal cliff near the boat station. Studied rocks were uncovered by two clearances. The first clearance (Fig. 2a) revealed a pedohorizon consisting of three soils, which we previously dated to the Kryzhanivka, as well as heavily sandy loess-like clay underlying it. The red-colored soil is overlain by the Eopleistocene and Lower Neopleistocene deposits. The second

Fig.3. General view of the outcrop uncovering liman-marine sediments

Fig 3a. Clearance 1 – the upper part of the section

Fig 3b. Clearance 2 – the middle part of the section

Fig. 3c. Clearance 3 – the bottom of the section

clearance (Fig. 2b) revealed clay traced at the bottom of the red-colored Kryzhanivka pedohorizon, which is strongly sandy, thinly laminated with thin layers of red-colored fossil soils, between which there is a sand lens. The liman-marine deposits lie below.

The second outcrop (Fig. 3) is located on the coastal cliff on the left side of the ravine on the southeastern outskirts of Kryzhanivka village. Deposits were investigated by three clearances. The first one (Fig. 3a) revealed the uppermost part of the liman-marine sediment section represented by gray dense clays with tiled carbonate nodule lenses, which apparently extends the gray clay section revealed in the lower part of the second clearing of the first outcrop. The second clearance (Fig. 3b) revealed the middle part of the section: shell rocks, sand interlayers with pebbles, as well as gray, light gray and light brown heavily sandy clays with a pronounced lamination in some places. The third clearance (Fig. 3c) revealed the lowest part of the section represented by gray and brownish-gray clays with carbonate nodules.

Main results. The palynological description of the studied deposits is presented (bottom-up). Unfortunately, the clay revealed by the third

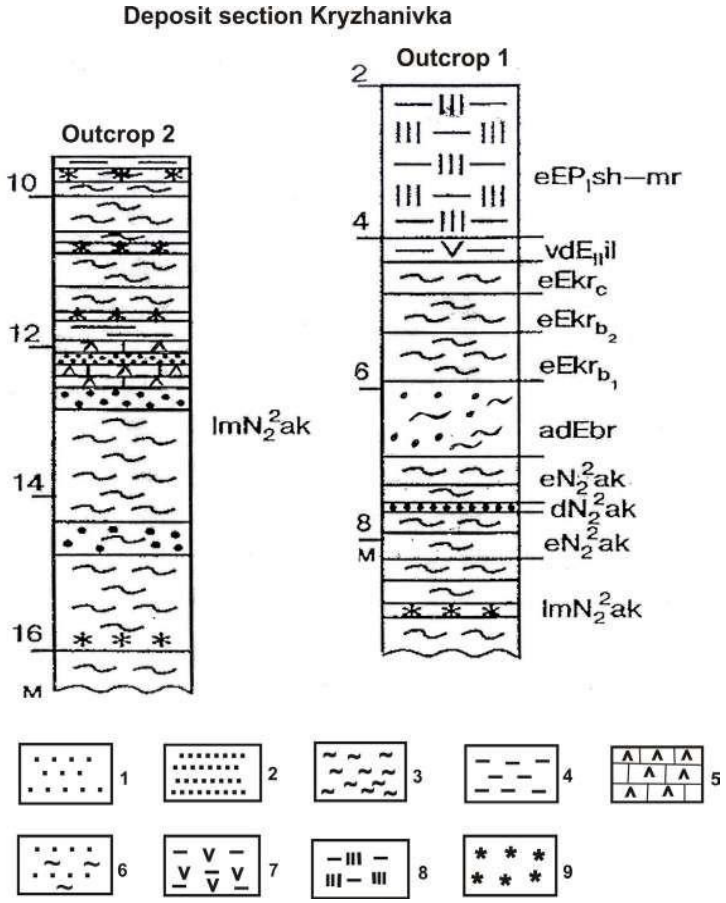

Fig. 4. Studied outcrops of the section near Kryzhanivka village

1 ─ sands, 2. ─ sandstones,3. ─ clay 4. ─ mudstones, 5. ─ shell rock; 6 ─ clay sands; 7. ─ loamy loams 8. ─ heavy loams 9. ─ phosphate rock

clearance of the second outcrop (Fig. 3c) did not allow obtaining representative materials to establish spore-pollen complexes (SPC). The following were distinguished from the rocks of the uppermost part of the stratum: pollen grains of *Pinus* subg. *Diploxylon* Koehne. (prevail), single *Pinus* sp. sect. *Cembrae* Spach., pollen in small amounts: *Alnus* spp., *Betula* spp., *Carpinus* cf. *betulus* L., *Tilia* cf. *cordata* Mill., *Tilia* sp., *Comptonia* sp., *Juglans* cf. *regia* L. Pollen grains of herbaceous plants belong to Poaceae, Chenopodiaceae, Asteraceae, and *Sparganium* sp.

The rocks revealed by the second clearance were more informative (Fig. 3b). According to the results of palynological studies of light brown clays (a range of 12.0-13.0 m), which were traced in the middle part of the stratum uncovered by this clearance, a SPC was established. Its composition consisted of an approximately equal amount of the pollen of wood species (53.4–55.9%) and herbaceous plants (47.6–44.1%). In the group of wood species, *Pinus* pollen grains mainly belonging to *Pinus* subg. *Diploxylon* Koehne. predominate (42.0-42.3%), and the content of *Pinus* sp. sect. *Cembrae* Spach. pollen does not exceed 2.4%. Single pollen of *Picea* sect. *Omorica* Willkm. is observed. In the group of deciduous plants (11.4-12.7%), pollen of plants of the moderate-warm zone (6.7-7.3%) prevails: *Quercus* cf. *pubescens* Willd., Q cf. *robur* L., *Quercus* sp. (in the amount of 3.8-4.6%); pollen grains of *Tilia* cf. cordata Mill., *Tilia* sp. (in the amount of 2.9-1.8%) were also found, and single Corylus cf. *cornuta* Marsh. Thermophilic plants (up to 1.9%) are represented by pollen of *Juglans* cf. *regia* L. and *J.* cf. *cinerea* L. In the group of small-leaved plants of the temperate zone (2.8-3.6%),*Alnus* cf. *incana* (L.) Moench., *Alnus* sp., *Betula* sp. sect. *Albae* were established.

Herbaceous plant pollen is 47.6-44.1% and mainly refers to Chenopodiaceae (30.4-27.7%). Pollen grains of Poaceae (2.9-3.7%), Asteraceae (6.7-5.5%) and miscellaneous herbs (6.7-5.4%): Polygonaceae, Lamiaceae, Ranunculaceae, Rosaceae occurred in smaller amounts. Small dwarf shrubs are represented by single pollen of *Ephedra* sp. The taxonomic composition of the established SPC as well as a high content of herbaceous plant pollen in its composition belonging mainly to Chenopodiaceae

family approaches it to the complexes of the middle part of the Kuyalnik deposit section of the Azov Sea as well as their continental analogues – the Siversk deposits of the Platform Ukraine.

Taking into consideration the incompleteness of the obtained palynological materials (representative data on the results of studies of rocks revealed by the third clearance were not obtained) as well as the fact that not all the layers revealed in this clearance were palynologically characterized, we cannot determine for the present which part of the section of the Middle Kuyalnyk (Siversk) deposits includes the studied rocks. The participation of thermophilic plant pollen is typical for the spore-pollen spectra characterizing the Intra-Siversk fossil soils. Thus, it can be assumed that the established complex characterizes deposits correlated with the Middle Siversk, however, this conclusion is preliminary.

We obtained more complete palynomaterials when studying the upper part of the section of the second outcrop revealed by the first clearance (Fig. 3a).

Based on the results of the studies, a SPC is described, in which two subcomplexes are traced. A characteristic feature of the established complex is the dominance of wood species in pollen spectra as well as the increased pollen content of *Pinus* sp. subg. *Haploxylon* Koehne. and thermophilic plants in comparison with the previous SPC.

In the composition of the first subcomplex (a range of 12.0-11.6 m), wood species pollen reaches 70.0-71.7%. In this group, the pollen grains of *Pinus* (57.6-60.4%), related mainly to *Pinus* subg. *Diploxylon* Koehne. subgenus, predominate. At the same time, the amount of *Pinus* subg. *Haploxylon* Koehne. pollen increased up to 5% in comparison with the previous complex. The content of pollen of thermophilic plants such as *Juglans* cf. *regia* L., *J.* cf. *cinerea* L., *Pterocarya* sp. increased up to 2.9%. The amount of pollen of deciduous species of the temperate and moderate-warm zones practically remained at the level of the previous SPC, however, its taxonomic composition expanded and was replenished with the representatives of the warm-moderate zone. In addition to the taxa established in the previous SPC, pollen of *T.* cf. *platyphyllos* Scop., *Carpinus* sp., *Myrica* sp., and the group of shrubs – Tamaricaceae and Thymelaeaceae appeared. Pollen of deciduous plants of the temperate zone is not numerous (0.9-1.9%) and belongs to *Betula* sp. Dwarf shrubs are represented by single pollen grains of *Ephedra* sp.

In contrast to the previous SPC, the amount of herbaceous plant pollen markedly decreased (29.1-26.4%). The dominants also changed in this group. The dominant position was taken by *Artemisia* spp. pollen (10.7-9.5%) and other representatives of *Asteraceae*

Table 1.The pollen composition of plants of moderate-warm, warm- moderate zones and thermophilic plants in the spore-pollen complex from Beregove pedogorizon of the sections near the villages of Kulikovske and Kryzhanivka

Spore-pollen complex	section Kulikovske	section Kryzhanivka
Beregove	*Juglans* cf. *cinerea* L.	*Juglans* cf. *cinerea* L.
	J. nigra L.	*J.* cf. *regia* L.
	Pterocarya sp	*Pterocarya* sp.
	Carpinus cf. *betulus* L.	*Carpinus* sp.
	Fagus cf. *sylvatica* L.	*Fagus* cf. *sylvatica* L.
	F. cf. *taurica* L.	*F.* cf. *orientalis* Lipsky.,
	Quercus cf. *robur* L.	*Quercus* cf. *robur* L.
	Q. pubescens Willd.	*Q. pubescens* Willd.
	Q. cf. *petrae* L.	*Quercus* sp.
	Tilia cf. *cordata* Mill.	*Tilia* cf. *cordata* Mill.
	T. cf. *platyphyllos* Scop.	*T.* cf. *platyphyllos* Scop.
	Tilia. sp.	*Tilia* sp.
	Zelkova sp.	–
	Rhus sp.	–
	Nyssa sp.	–
	Corylus sp.	*Corylus* sp.
	Myrica sp.	*Myrica* sp.
	Moraceae	Moraceae

family (6.8-6.6%). The amount of Chenopodiaceae pollen decreased to 4.9-3.8%. The content of Poaceae pollen does not exceed 1.9%. Miscellaneous herbs are represented by Caryophyllaceae, Polygonaceae and Ranunculaceae. Spores of Sphagnum sp. and Bryales appeared.

pollen in the moderate-warm zone (11.7-9.3%) as well as thermophilic plants (6.9-5.7%), an increase in the content of *Pinus* sp. sect. *Strobus* Schaw. and *P.* sp. sect. *Cembrae* Spach. pollen (in the amount up to 8.1%), and the appearance of *Picea* sp. sect. *Eupicea* Willkm. pollen grains. Among the deciduous plants,

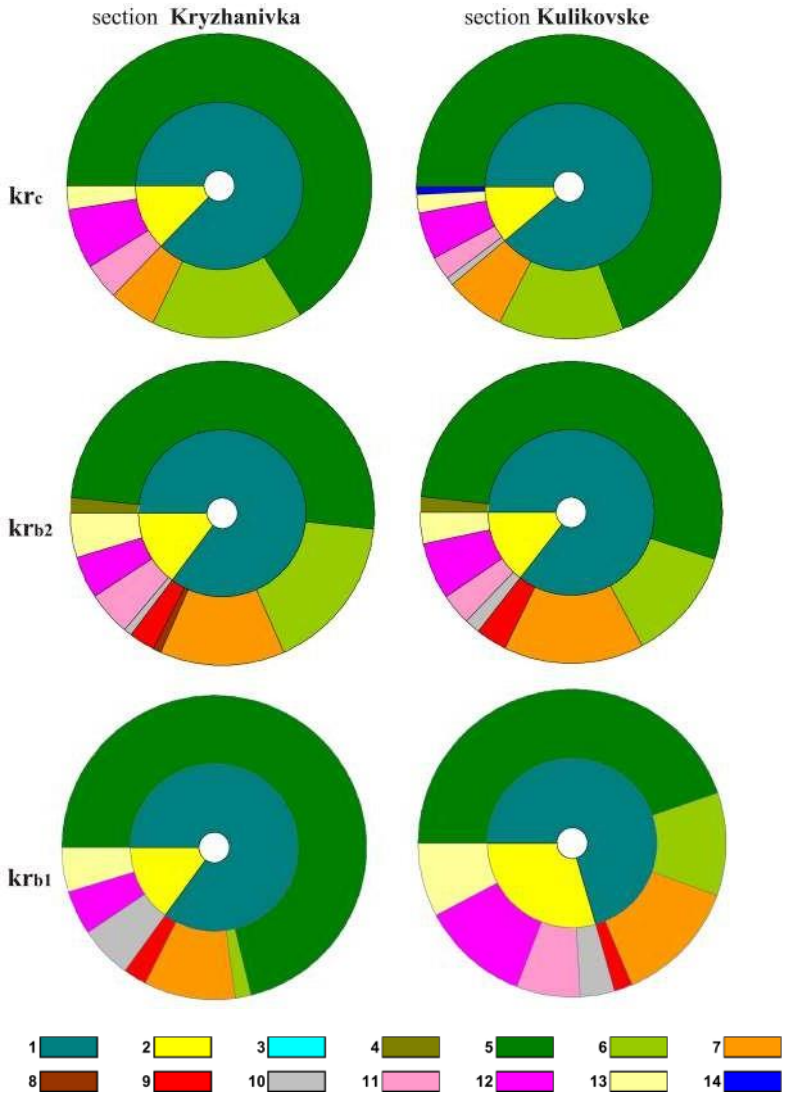

Fig 5. Ecological structure of spore-pollen complexes of the Kryzhanivka deposit sections near Kryzhanivka village (the Black Sea Depression) and Kulikovske village (the southern part of the Ukrainian Shield).

1– pollen of wood species
2– herbaceous plants
3– spores
4– Picea
5– Pinus
6– deciduous plants of the temperate zone
7– deciduous plants of the moderate-warm zone
8– deciduous plants of the warm- moderate zone
9 – thermophilic plants
10– Poaceae
11– Chenopodiaceae
12– Asteraceae
13– Miscellaneous herb
14– hydrophilic plants

The second subcomplex was established for species in the range from 11.6 to 10.0 m and is characterized by a further increase in the content of wood species pollen (80.9–83.8%) including a number and taxonomic diversity of deciduous plant

in addition to *Quercus* spp., *Tilia* spp., and *Juglans* cf. *cinerea* L. pollen occurred in the first subcomplex, pollen grains of *Fagus* cf. *sylvatica* L., *F.* cf. *orientalis* Lipsky., *Juglans* cf. *sieboldiana* Maxim., *Juglans* sp., and Moraceae also appeared. The pollen content of

deciduous plants of the temperate zone is in the range from 2.8 to 3.6%.

In comparison with the first subcomplex, the role of herbaceous plant pollen decreased still more (19.1–16.2%), especially due to pollen grains of *Artemisia* spp. (4.8-2.9%) and Asteraceae (1.9-3.8%). The content of Chenopodiaceae pollen remained at the level of the previous subcomplex. The amount of miscellaneous herb pollen did not change in comparison with the first subcomplex, but only its taxonomic composition somewhat expanded including Ranunculaceae, Primulaceae, Polygonacea, and Urticaceae. Dwarf shrubs are represented by single pollen grains of *Ephedra* sp.

Analogs of the established complex among the SPC of the marine sediments of the Azov Sea were not ascertained. The dominance of wood species in the pollen spectra including the high content and taxonomic diversity of broad-leaved species pollen of the moderate-warm zone and thermophilic plants approaches the described complex to the SPC characterizing the coastal sediments of the section near Kulikovske village (the Eastern Azov region) (Tab. 1.). However, this comparison also requires further confirmation since at this stage of the research we were not able to isolate pollen and spores from rocks exposed by the second clearance (Fig. 2b) of the first outcrop traced at the bottom of the red-colored Kryzhanivka pedohorizon, which is strongly sandy, thinly laminated with thin layers of red-colored fossil soils.

It should be noted that the studied deposits were apparently formed in shallow conditions as evidenced by a significantly higher percentage of *Pinus* pollen in the composition of the spectra as well as a low pollen concentration in macerates. According to E.Z. Isagulova (Isagulova, 1974) precisely for the spectra of the deposits of the shallow part of the basin, a highest amount of pine pollen is typical. According to the materials of E.S. Malyasova (Malyasova, 1986), the lowest concentration of spores and pollen was recorded in the samples taken on the coastal strip.

Thus, the presented palynological data as well as the lithological composition of the studied sediments indicate that the rocks of the studied section were formed under slightly different conditions as compared with those of the East Azov Sea. Because of the fact that most of the sediments of the studied section were formed mainly in shallow water, the established SPC are already close in composition to complexes of the continental Pliocene deposits.

Representative palynospectra are established of a red-colored pedohorizon in a range from 5.9 to 4.5 m (Fig. 2a). Two soils of early and late optimums of pedogenesis are clearly traced in the composition of the pedohorizon. The soil of early optimum (a range from 5.9 to 5.25 m) is reddish-brown with a distinct reddish tinge, the brightest in color, and has a fine-lumpy structure impregnated with Mn. The soil of late optimum (a range from 5.25 to 4.7 m) is reddish-brown, dense, argillic, and has a comminuted-prismatic structure with shiny structural elements, films and spots of manganese without visible carbonates. In the range from 4.7 to 4.5 m, a brown soil interlayer with a reddish tint, and a less dense structure than an underlying soil was traced. A spore-pollen spectrum characterizing the indicated interlayer is typical for spectra corresponding to soils of the final pedogenesis stage. Three subcomplexes are clearly traced in the complex characterizing the described pedohorizon. A common feature of all the SPC subcomplexes is the dominance of wood species pollen in their composition; however, they differ in the ecological structure.

As a part of the first subcomplex characterizing the lowest soil of the pedohorizon (a range of 5.9-5.25 m), wood species pollen is 84.9-85.4%. The dominant role in this group belongs to the pollen grains of *Pinus* (71.0-72.9%), which mainly refer to *Diploxylon* subgenus species with the participation of *Haploxylon* subgenus representatives (7.2-6.4%). In the group of deciduous plants (12.9-15.3%), pollen of moderate-warm zone plants dominates (8.8-10.6%): *Quercus* spp., *Tilia* cf. *cordata* Mill., *T*. cf. *dasystyla* Stev., *Tilia* cf. *tomentosa* Moenh. In comparison with the previous SPC, the amount of thermophilic plant pollen decreased to 2.4-3.7%: *Juglans* cf. cinerea L., Moraceae. Deciduous plant pollen of the temperate zone is small (0.9–1.6%) and belongs to *Betula* spp. Herbaceous plant pollen is also not numerous (13.6-14.6%). Poaceae pollen grains dominate in this group (4.0–6.1%). Miscellaneous herb pollen: Apiaceae, Polygonaceae, Cannabaceae, Ranunculaceae, and Rosaceae acts as a subdominant (4.0–4.8%). Asteraceae (1.8–2.4%) and *Artemisia* spp. pollen grains occurred in smaller amounts (0.9-1.6%).

In the spectra of the second subcomplex characterizing the second optimal soil of the pedohorizon (a range of 5.25-4.7 m), wood species pollen also dominates (85.6-84.2%). However, in comparison with the first subcomplex, the role of deciduous species pollen significantly increased (up to 30.7-33.1%), which mainly belongs to small-leaved plants of the temperate zone (15.2-18.7%): *Betula* spp. (11.2-13.9%), *Alnus* spp. (2.4-3.9%), and *Salix* sp. (0.9-1.6%). The dominants in the group of

broad-leaved species of the moderate-warm zone remained at the level of the first subcomplex, and only the amount and species diversity of *Tilia* pollen: *Tilia* cf. *cordata* Mill. and *T.* cf. *dasystyla* Stev. decreased (2.9-3.2%). In addition, pollen grains of *Fagus* sp. singly occurred as well as *Myrica* sp. of the moderate-warm plant group. *Corylus* spp. pollen also appeared (2.9-1.6%). In comparison with the first subcomplex, the role of *Pinus* spp. pollen significantly decreased (49.7-50.2%) although its species did not change, and *Picea* sp. pollen grains (0.9-1.6%) appeared. In the group of herbaceous plant pollen (15.2-15.8%), as compared with the first subcomplex, a change in dominants occurred, notably Chenopodiaceae (4.0-4.9%) and Artemisia sp. (4.0-4.9%) pollen grains prevailed. The amount of miscellaneous herb pollen remained at the level of the previous subcomplex.

In the composition of the third subcomplex corresponding to the soil of the final stage of pedogenesis (a range of 4.7-4.5 m), the highest content of wood species pollen (87.2%), which belongs mainly to *Pinus* spp., occurred. *Picea* pollen was not found. A number of deciduous plants decreased to 19.0% as compared with the second subcomplex. *Betula* spp. pollen (15.8%) dominates in this group. Among the deciduous plants of the moderate-warm zone, pollen grains of *Quercus* cf. *robur* L. (2.4%), and single *Tilia* cf. *cordata* Mill. and *Corylus* cf. *avellana* L. occurred. Dominants in the group of herbaceous plants (12.8%) did not change in comparison with the second subcomplex, only the role (2.4%) and taxonomic diversity of miscellaneous herb pollen decreased.

According to the taxonomic composition of pollen, the established SPC is close to the Kryzhanivka deposit complex of the section near Kulikovske village (the southern region of the Ukrainian Shield, the Eastern Azov region), (Sirenko, 2017). The compared SPCs are united by the presence of *Picea* pollen in the subcomplexes of the middle part of the pedohorizon and the growing role of small-leaved plant pollen from the first subcomplex to the second one (Fig. 5). These patterns are indicative of the Kryzhanivka SPC of most sections of the Plain Ukraine.

The individual features of the established SPCs specified by the location of the section in the coastal zone include a markedly high content of *Pinus* pollen in the spectra, which is always typical for the complexes of sea coast sediments. We noted the same feature for the SPC of the Pliocene and Eopleistocene deposits of the section near Kulikovske village.

Conclusion. The conducted studies enabled to perform a palynological characterization of rocks of the upper part of the Kuyalnik deposit section near Kryzhanivka village as well as obtain arguments in favor of the correlation of the studied sediments with the Beregove and Siversk climatoliths of the continental section. However, this conclusion still requires further confirmation. Previously, according to the palynological data (Sirenko, 2017), it was found that of the Beregove and Siversk climatolith deposits of the continental Upper Cenozoic section of Ukraine correspond to the Gelasian of the International Stratigraphic Scale (ISS). According to the decision of the International Union of Geological Sciences to drop the lower boundary of the quarter to a level of 2.58 million years, the ISS Gelasian deposits are already attributed to the Pleistocene. Consequently, the upper part of the Kuyalnik deposit section in the studied section can be dated by the Pleistocene.

According to the stratigraphic scheme of the Quaternary deposits of Ukraine (the Stratigraphic Code, 2012), the Kryzhanivka pedohorizon refers to the Eopleistocene and correlates with the Calabriane in the ISS. The conducted studies provided to obtain the detailed palynological characteristics of Odessa region for the first time as well as correlate it with coeval deposits of the Azov Sea region.

Palynological studies of subaerial and liman-marine sediments of the section near Kryzhanivka village must be continued in the future in order to obtain a more detailed description of all the traced horizons of different-facies deposits.

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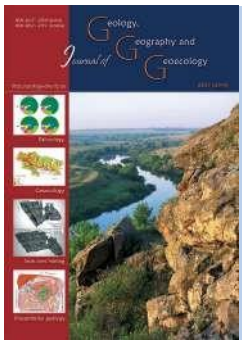

JOURNAL of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(4), 738–746.
doi: 10.15421/111969

Ecological and geological determination of the initial pedogenesis on devastated lands in the Kryvyi Rih Iron Mining & Metallurgical District (Ukraine)

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Received: 03.06.2019
Received in revised form: 12.06.2019
Accepted: 10.11.2019

Abstract. In our time, a very urgent problem is the cessation of negative impacts on the environment and the return to the practical use of the territories of devastated lands. In this regard, it is important to find out the basic laws of primary soil formation in the area of these man-made neoplasms. The initial soil formation conditions were analyzed on 19 experimental sites which represent the main varieties of devastated land in the Kryvyi Rih Iron Mining and Metallurgical District (Central Ukraine): (i) waste rock dumps of old iron mines (old name "Forges"), (ii) tailing storage facility of underground iron mines, (iii) waste rock dumps of the Iron Ore Mining and Dressing Plant, (iv) waste rock dumps of the Granite Quarry Plant. It was established that on the devastated lands in Kryvyi Rih District, the initial soil formation occurs in very difficult conditions. Therefore, over 25-100 years only very primitive soils were formed. The following features are inherent to them: (1) primitive soil profile (thickness 10-100 mm), (2) low levels of soil organic substance content (9.5-11.5 %), (3) alkaline indicators of the soil solution (pH_{H2O} – 8.08-8.92, pH_{KCl} – 7.42-8.23), (4) low levels of cation exchange capacity (6.34-8.47 mMol /100 g). By results of correlation calculations, among the factors of soil formation time (duration of soil formation) and input of plant ash elements' fall are characterized by the maximum number of statistically significant correlation coefficients and their numerical values. In terms of chemical composition of the technosol, the values of organic matter content and exchangeable acidity (pH_{KCl}) were the most predictable soil formation factors. Generally physical / chemical characteristics of geological rocks (as parent material) and time were the two most important factors in determining the initial pedogenesis on devastated lands in the Kryvyi Rih Iron Mining & Metallurgical District (Ukraine).

Keywords: devastated land, initial pedogenesis, technosol, embryozems, Kryvyi Rih Basin

Екологічна та геологічна зумовленість ініціального педогенезу на девастованих землях Криворізького гірничо-металургійного регіону (Україна)

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Анотація. Дуже актуальною проблемою сьогодення залишається припинення негативних впливів на довкілля людини та повернення у практичне використання територій девастованих земель. У зв'язку з цим важливим є з'ясування провідних закономірностей первинного ґрунтоутворення на теренах цих техногенних новоутворень. Умови початкового ґрунтоутворення було проаналізовано на 19 дослідних ділянках, які репрезентують основні різновиди девастованих земель Криворізького гірничо-металургійного району (Дніпропетровська область, Центральна Україна): (i) породні відвали старих залізних копалень (старі назви «кавалери»), (ii) хвостосховища залізорудних шахт, (iii) породні відвали залізорудного гірничо-збагачувального комбінату, (iv) породні відвали гранітного кар'єру. Встановлено, що на девастованих землях Криворізького гірничо-металургійного району початкове ґрунтоутворення відбувається в дуже складних умовах. Тому за 25-100 років утворилися лише дуже примітивні ґрунти. Для них притаманно: (1) малопотужний ґрунтовий профіль (товщина 10-100 мм), (2) низький вміст органічної речовини ґрунту (9,5-11,5%), (3) лужні показники ґрунтового розчину (pH_{H2O} – 8,08-8,92, pH_{KCl} – 7,42-8,23), (4) низькі рівні ємності катіонного обміну (6,34-8,47 ммоль / 100 г). Ці молоді ґрунти девастованих земель Криворізького гірничо-металургійного району можна класифікувати як Сполік Техносол (за даними Всесвітньої референтної бази для ґрунтових ресурсів) або Ембріоземи (згідно з українською системою класифікації). Серед факторів формування ґрунту час (тривалість формування ґрунту) та надходження зольних елементів рослин характеризується максимальною кількістю статистично значущих коефіцієнтів кореляції та їх числовими значеннями. Результати кореляційних розрахунків довели, що серед показників

хімічного складу Техносолу значення вмісту органічної речовини та обмінної кислотності (pH_{KCl}) були найбільш передбачуваними. Загалом, фізико-хімічні характеристики геологічних порід (як материнського матеріалу для ґрунтоутворення) та час були двома найважливішими чинниками, що детермінують початковий педогенез на девастованих Криворізького гірничо-металургійного району.

Ключові слова: девастовані землі, ініціальний педогенез, техносол, ембріозем, Криворіжжя

Introduction. Devastated lands are a widespread phenomenon in all industrial regions of the world, Europe and Ukraine. Their area reaches impressive values. In particular, in Ukraine the area of devastated lands is hundreds of thousands of hectares, in the Dnipro industrial region it is more than 50 thousand hectares, in the Kryvyi Rih Iron Mining & Metallurgical District (Kryvorizhya) more than 20 thousand hectares (Antrop, 2006; Cortina-Segarra et al, 2016; Malahov, 2003).

Devastated land negatively affects the quality of human life. They are a source of additional pollution of atmospheric air, groundwater and soils. In addition, they negatively affect the microclimate and the aesthetics of industrial regions (Aronson & Alexander, 2013; Hlava et al, 2015; Malahov, 2009).

However, in our country virtually no large-scale and complete restoration of the devastated lands in accordance with the current legislation and the available scientific achievements has been carried out. The main reason for this is the lack of funds and non-compliance by industry with current legislation (Berger et al, 2011; Demidov et al, 2013 Kumar, 2013; Mazur et al, 2015; Savosko, 2011a).

As a result of this situation, the land devastated has been left entirely neglected. On their territories there are spontaneous processes of self-healing of the vegetative cover and the processes of initial soil formation (initial pedogenesis) proceed gradually. An important component of such vegetation is trees and shrubs, which have a positive effect on the state of the environment in industrial regions (Lykholat et al, 2016a; Lykholat et al, 2016b; Savosko & Tovstolyak, 2017; Savosko et al, 2018; Tereschenko, 1992). However, the processes of self-healing of the film of life on devastated lands are exceedingly slow sometimes taking hundreds of years. Therefore, it is very important to identify the patterns of initial soil formation and to find out the leading factors of this process (Resulović & Čustović, 2007; Savosko, 2011a; Savosko et al, 2010; Savosko, 2011b).

On the devastated lands of the Kryvyi Rih Iron Mining & Metallurgical District the elucidation of the laws of ecological and geological processes of initial pedogenesis has fundamental scientific and practical significance. The consideration of this problem was chosen for the purpose of our work.

Materials and methods. The materials of our research were the results of the surveys conducted by us during 2006-2018 on the devastated lands in the Kryvyi Rih Iron Mining & Metallurgical District (Figure 1).

The objects of research were the primitive soils from the devastated lands, which appeared on Kryvyi Rih during the twentieth century: 1) waste rock dumps of old iron mines (old name "Forges"), 2) tailing storage facility of underground iron mines, 3) waste rock dumps of the Iron Ore Mining and Dressing Plant, 4) waste rock dumps of the Granite Quarry Plant.

Methods of research - classical field and laboratory research by soil science, agrochemistry and biogeochemistry (DSTU-ISO 10381-8:2006; DSTU-ISO 10390:2001; DSTU-ISO 10694-2001; DSTU-ISO 11664:2006; DSTU-ISO 11260:2001; DSTU-ISO 11664:2006).

The obtained results of researches were processed by classical mathematical statistical methods at the level of significance $P < 0,05$ (Lakin, 1990; MCdonald, 2014).

Results and discussion. *The pedogenetic features on devastated lands*. In natural conditions, soils, soil properties and soil formation are strongly affected by: 1) parent material, 2) vegetation, 3) climate, 4) topography, 4) man and 5) time (Jenny, 1994; Breemen, & Buurman, 2003). *Therefore, to understand* the *pedogenetic features on* the devastated lands, at first it is necessary to analyze the actions of soil formation factors under these conditions.

Parent material. I*nitial soil formation on* devastated lands in the Kryvyi Rih area *occurs* on different rocks. According to the estimation technique, rocks on the devastated lands are organized into three groups: 1) highly favourable to i*nitial soil formation,* *2) moderately favourable* to i*nitial soil formation,* *3) minimally favourable* to i*nitial soil formation.* The rocks which are highly favourable to initial soil formation are represented mainly by loess and loess-like loams, as well as by loams and sandy loams from the sedimentary cover. The rocks that are moderately *favourable* to i*nitial soil formation* are represented by medium clay, heavy clay from the sedimentary cover, as well as finely fractional (less than 10 mm) rocky deposits of different genesis. The rocks which are most favourable to initial soil formation are following: large-fragment rocky rocks (over 10 mm), phytotoxic rocks by various genesis, as well as waste from the mining and metallurgical industry. It is important to note that on the devastated lands in

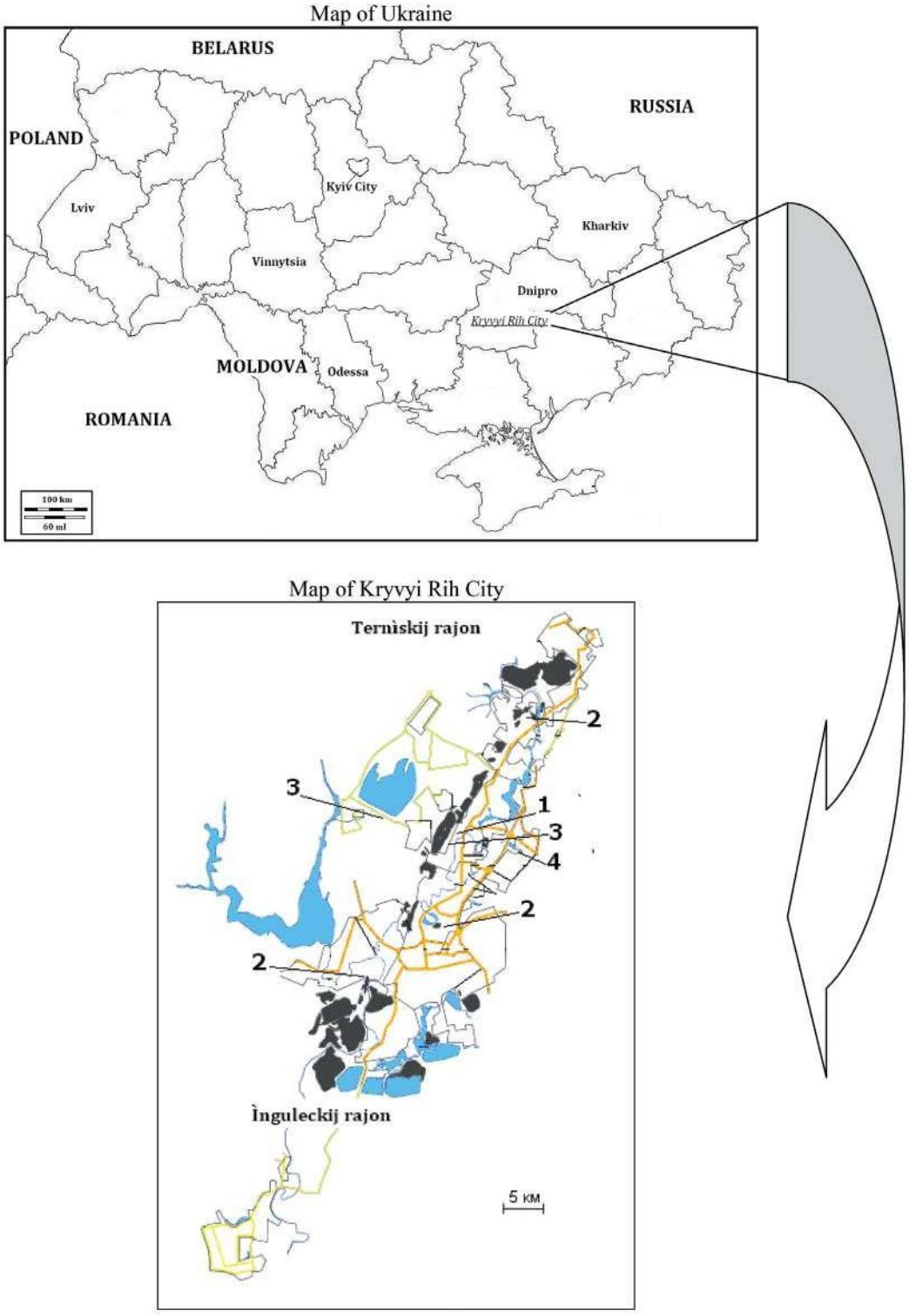

Fig. 1. Location of study areas
1 – waste rock dumps of old iron mines (old name "Forges"), 2 – tailing storage facility of underground iron mines, 3 – waste rock dumps of the Iron Ore Mining and Dressing Plant, 4 – waste rock dumps of the Granite Quarry Plant

the Kryvyi Rih area, there are various variants of rock prevalence (Manyuk, 2016; Savosko et al, 2018; Shvaiko & Manyuk, 2017). Thus, in some cases, an extraordinary mosaic and chaotic pattern of soil-forming rocks is observed (e.g. dumps, dams and different embankments).

However, on other devastated lands, even and uniform parent material are widespread (e.g. tailings and sludge storage). It was *established that on devastated lands in the* Kryvyi Rih Iron Mining & Metallurgical District t*he initial pedogenesis is carried out on the following* parent material (Table 1):

1) iron quartzite (various geological composition and granulometric size), 2) loess loam (non-carbonate and carbonate), 3) shist (usually a large particle size – more than 100 mm).In general, the parent materials on the devastated lands in the Kryvyi Rih area form different conditions for i*nitial soil formation. L*oess and loess-like loams, as well as loams and sandy loams from the sedimentary cover, are highly favourable to initial soil formation.

Vegetation. On the devastated lands in the Kryvyi Rih area, there are three main vegetation types. These vegetation types determine the main three soil formation strategies: petrophilic, woody and grassy plant community. The main vegetation features as a factor of i*nitial soil formation* can be mentioned as follows: 1) grasses are dominant *in the plant community*, 2) *vegetative communities have a syngenetic character*, 3) type of vegetation determined by rocks. We have found that (Table 1) input of plant litter fall on these devastated lands varied from 100 $g*m^{-2}*year^{-1}$ to 600 $g*m^{-2}*year^{-1}$ (average values: 170-270 $g*m^{-2}*year^{-1}$). These values are 3-5 times less in comparison with the steppe ecosystem values. Also we established (Table 1) that input of fall of plant ash elements on these devastated lands varied from 7.50 $g*m^{-2}*year^{-1}$ to 22.10 $g*m^{-2}*year^{-1}$ (average values: 12-17 $g*m^{-2}*year^{-1}$).In general, the vegetation on the devastated lands in the Kryvyi Rih area form do not very strong or favourable conditions for i*nitial soil formation.*

Table 1. Factors of soil formation on devastated lands in Kryvyi Rih Iron Mining & Metallurgical District

Devastated lands	Parent material	Characteristics of herbaceous vegetation		Topography	Time, years
		Input of plant litter fall	Input of plant ash elements fall		
		$g*m^{-2}*year^{-1}$			
Waste rock dumps of old iron mines (old name "Forges")	Hydrohematite iron quartzite – 90 % Loess loam – 10 %	250	14.2	Dump plateau	90-100
Tailing storage facility of underground iron mines	Hydrohematite iron quartzite	100	7.50	Tailings beach	50-55
		230	17.1	Tailings beach	50-55
	Martite & hematite-martite iron quartzite	100	8.95	Tailings beach	30-35
		150	12.8	Tailings beach	30-35
		120	10.7	Tailings beach	30-35
		140	12.1	Tailings beach	25-30
	Loess loam	160	10.4	Tailings beach	25-30
	Martite & hydrohematite iron quartzite	200	13.1	Tailings beach	40-45
		180	12.9	Tailings beach	40-45
		140	8.12	Tailings beach	40-45
Waste rock dumps of Iron Ore Mining and Dressing Plant	Loess loam	240	21.6	Foot of dump	55-60
	Poor magnetite iron quartzite 50% Loess loam 50 %	330	16.4	Dump berm	55-60
	Shist 40-45%, Poor magnetite iron quartzite 20-30%, Loess loam 20-25%	380	21.3	Dump berm	40-45
	Shist 45-50%, Poor magnetite iron quartzite 20-30%, Loess loam 15-20%	270	14.4	Dump berm	30-35
	Poor magnetite iron quartzite 60-70%, Shist 10-20%, Loess loam 5-10%	110	9.11	Dump plateau	25-20
Waste rock dumps of Granite Quarry Plant	Loess loam	420	22.1	Dump plateau	40-50
	Carbonate loess loam	380	18.8	Dump plateau	40-50

Climate. The Kryvyi Rih area is located in the semi-arid climate zone, called the northern steppe. The average annual precipitation is 450 mm, concentrated between April and October. Average temperatures vary between -6°C in January and 21°C in July. But on devastated lands of this region a special microclimate was formed. This microclimate naturally has an impact on initial soil formation. In most cases, this effect has a negative effect on soil formation: since there is an elevated temperature of the devastated land surface, which in turn drains the atmospheric air very much. But there is another opinion, as shown by studies by V.K. Tereshchenko (Tereshchenko, 1992), rocky rocks can condense moisture from the atmospheric air during darkness. As a result, their humidity significantly increases, which has a very positive effect on soil formation. In general, the microclimate on the devastated lands at Kryvyi Rih area forms very severe conditions for *initial soil formation.*

Topography. The *unique mesorelief* forms are an important feature of the devastated lands in the Kryvyi Rih area. In these territories, the main forms of mesorelief are: a smooth surface and micro-depressions of the waste rock *dumps* berms, low hills (1.0-1.5 m) of the waste rock *dumps, steep slopes* of the waste rock *dumps and a* perfectly flat surface of the tailings pond beaches. It should also be noted that the exposure of the waste rock *dumps* slopes determines the redistribution of heat fluxes while micro-depressions and low hills determine the redistribution of water flows. By topography, the most favourable areas for initial soil formation are micro-depressions on berms and on the plateau of the waste rock dumps, as well as in the lower part of the slopes at waste rock dumps. It is here that the accumulation of precipitation occurs. On devastated lands of the Kryvyi Rih Iron Mining & Metallurgical District, initial soil formation was investigated by us in the following topographies: 1) the foot of the *dump,* 2) *dump berm, 3) dump plateau and 4) tailings beach (Table 1).*In general, the topography of the devastated lands in the Kryvyi Rih area is an important factor that limits the success of initial soil formation.

Man. We believe that the primary and secondary effects of human activity on the initial soil formation on devastated lands should be distinguished. The primary effect of humans determined the geological and topographical "framework" on devastated lands. Therefore, this human influence predetermines the basic conditions for initial soil formation on devastated lands. The secondary human effect has a positive and negative impact on the initial soil formation in these areas. The positive secondary human impact is possible by the implementation of the restoration and reclamation of these lands. The negative secondary human impact is possible with air pollution and storage of garbage in these areas.

Time. In Kryvyi Rih region, the first devastated lands began to form in 1881. Due to archival materials and scientific publications, it is possible to assume the starting time of the soil formation with an accuracy of up to 5 years. This fact is very important for basic soil science. In general, the duration of soil formation on the devastated lands is known, and the soil is very young in these areas (table 1).

Chemical composition of young soils from devastated lands. The data in Table 2 indicate that the chemical and physical properties of young soils from devastated lands in the Kryvyi Rih Iron Mining & Metallurgical District are characterized by unfavourable indicators. Thus organic matter content varied from 7.93 % to 22.10 % (on average – 9.10 %-12.88 %). These values are 2.5-3.5 times lower than in the zonal soils of chernozems. It should also be noted that the accumulation of organic matter in the soil from the tailing storage facility of underground iron mines does not occur. This fact can be explained by the geological characteristics of the parent material materials, in particular, their grain size distribution.

In the zonal soils of the Kryvyi Rih Iron Mining & Metallurgical District, soil acidity is 7.00-7.15 in ordinary chernozems and 7.25-7.55 in southern chernozems. But in soils from devastated lands these characteristics have higher values: for actual acidity – from 7.08 to 9.19 (on average – 8.18-8.81), for exchangeable acidity – – from 7.60 to 8.06 (on average – 6.74-8.59). Thus, initial pedogenesis on devastated lands is carried out in very alkaline conditions. This fact significantly slows down the humus accumulation in the soil profile .

As is known, cation-exchange capacity (CEC) is a measure of how cations can be retained on soil particle surfaces. CEC is defined as the amount of positive charge that can be exchanged per mass of soil, usually measured in mMol /100 g soil. In the zonal soils of the Kryvyi Rih Basin, CEC can obtain 35-40 mMol /100 g in ordinary chernozems and 30-35 mMol /100 g in southern chernozems. But in soils from devastated lands this characteristics is 2-20 times less, it varied from 2.01 mMol /100 g to 25.12 mMol /100 g (on average – 5.62 – 10.18 mMol /100 g). It is important to note that in natural soils 75–80% of CEC is calcium and, 15–25% is magnesium. As the results of our research show, in the young soils the

share of calcium varied from 35.77 % to 89.03 % (on average – 56.16-71.81%) and the magnesium portion varied from 10.97 % to 64.23 % (on average – 28.19-43.84%). In some soils, the amount of magnesium was greater in comparison with calcium.

Soil classification of the devastated land. Soil classification is a very important and very difficult task at the same time (Charzynski et al, 2013; Sere et al, 2010; Sobocka, 2008). At present, the introduction of the ideas and philosophy of World Reference Base for soil resources (WRB) in the classification of world soils is taking place. According to WRB, the soils on devastated lands in the Kryvyi Rih Iron Mining & Metallurgical District can be classified as "Technosols" (WRB, 2015).

When specified, these soils are termed: 1) spolic technosol (ochric) on the waste rock dumps of the old iron mines (old name "Forges"), 2) spolic technosol (phytotoxic, arenic, aridic, magnesic) on the tailing storage facility of underground iron mines, 3) spolic technosol (humic, loamic, calcaric), spolic technosol (ochric, loamic) and spolic technosol (arenic, aridic, magnesic) on waste rock dumps of the Iron Ore Mining and Dressing Plant, 4) spolic technosol (ochric, loamic, dolomitic, calcaric) on waste rock dumps of the Granite Quarry.

In our opinion, the concept of embryozem and its groups is the most acceptable among the classification systems common in Ukraine for young soils on devastated lands. The word "embryozem" is formed by analogy with the word "chernozems" and means "young soil" (from Greek "ἔμβρυον, fetus or germ and from Ukrainian "zem", earth or soil).

In our opinion (Savosko, 2010; *Savosko, 2011a*), there are four groups of embryozems on devastated lands in the Kryvyi Rih Iron Mining & Metallurgical District: Initial embryozems, organic-accumulative embryozems, turf embryozems and humus-accumulative embryozems. It should be noted that the basis of this differentiation is the intensity and quality of humus formation. This is naturally reflected in the structure of the soil profile. We believe that these young soils have the following distribution: 1) turf embryozems on the waste rock dumps of old iron mines (old name "Forges"), 2) initial embryozems on the tailing storage facility of underground iron mines, 3) initial embryozems, organic-accumulative embryozems and humus-accumulative embryozems on the waste rock dumps of the Iron Ore Mining and Dressing Plant, 4) turf embryozems on the waste rock dumps of the Granite Quarry.

Determination of initial pedogenesis on the devastated lands. An analysis of the mathematical calculations results showed that between factors of soil formation and chemical composition of the technosol from devastated lands in the Kryvyi Rih

Table 2. Chemical composition of the technosol from devastated lands at Kryvyi Rih Iron Mining & Metallurgical District (M±m)

Devastated lands	Organic matter content, %	pH		Cation-exchange capacity		
		pH_{H2O}	pH_{KCl}	Total, mMol /100 g	Ca, % from total	Mg, % from total
Waste rock dumps of old Iron Mines (old name "Forges")	9.97 ± 1.05	7.58±0.01	6.74±0.02	6.62±0.26	59.67	40.33
Tailing storage facility of Underground Iron Mines	-	8.81+0.02	8.10+0.01	7.80+0.35	85.88	14.12
	-	8.79+0.01	8.09+0.02	7.93+0.32	89.03	10.97
	-	8.92+0.01	7.92+0.01	8.47+0.38	88.55	11.45
	-	9.01+0.01	8.23+0.02	7.00+0.31	83,86	16.14
	-	9.14+0.02	8.23+0.01	6.34+0.21	73.66	26.34
	-	9.19+0.01	8.59+0.02	6.00+0.19	62.17	37.83
	-	8.90+0.01	8.38+0.01	6.74+0.25	60.39	39.61
	-	7.72+0.01	8.06+0,02	2.60+0.13	35.77	64.23
	-	7.51+0.02	7.64+0.01	2.06+0.11	54.85	45.15
	-	8.82+0.01	8.34+0.02	4.14+0.19	45.17	54.83
Waste rock dumps of Iron Ore Mining and Dressing Plant	16.20+0.89	8.83+0.01	7.88+0.01	25.12+1.25	52.75	47.25
	11.16+0.86	8.51+0.02	7.35+0.02	6.66+0.20	68.32	31.68
	12.85+1.02	8.08+0.01	7.22+0.04	9.57+0.38	56.53	43.47
	9.53+0.78	7.66+0.02	7.49+0.01	9.14+0.39	53.06	46.94
	8.75+0.99	8.57+0.01	7.79+0.01	11.56+0.42	49.05	50.95
	7.93+1.11	8.45+0.01	7.99+0.01	7.72+0.23	43.91	56.09
Waste rock dumps of Granite Quarry Plant	11.44±1.14	8.72±0.02	7.42±0.02	7.42±0.27	73.58	26.42
	11.09±1.19	9.18±0.02	7.35±0.02	7.30±0.25	79.45	20.55

M – arithmetic mean (average), m – mean absolute error, «–» – organic matter is absent in the roots soil layer (0-20 cm)

Iron Mining & Metallurgical District statistically significant correlation dependence was established (Table 3). Thus 8 coefficients (from 18 theoretically possible) were statistically significant ($P<0.05$). Among these coefficients, 4 (50 %) were greater than 0 ($r>0$) and indicated a positive relationship between two phenomena (values of two variables changing with same direction). While the other 4 (50 %)

Conclusions. In the devastated lands at Kryvyi Rih Iron Mining & Metallurgical District (Ukraine), the initial soil formation occurs under very severe and difficult conditions. Parent material is very unfavourable for the vegetation's development. Therefore, the vegetation cover is fragmentary and is characterized by very insignificant values of plant litter fall and of input of plant ash elements fall. During 25-

Table 3. Pearson Correlation between factors of soil formation and chemical composition of the technosol on devastated lands of the Kryvyi Rih Iron Mining & Metallurgical District

Chemical composition of the technosol		Factors of soil formation		
		Time, years	Characteristics of herbaceous vegetation	
			Input of plant litter fall	Input of plant ash elements fall
			$g*m^{-2}*year^{-1}$	
Organic matter content, %		0.461*	0.643**	0.662**
pH	pH_{H2O}	-0.382*	-0.112	-0.089
	pH_{KCl}	-0.719***	-0.568**	-0.474*
Cation-exchange capacity	Total, mMol /100 g	0.173	0.161	0.453*
	Ca, % from total	0.061	0.001	0.018
	Mg, % from total	-0.061	0.001	-0.019

* – level of statistical significance $P<0.05$; ** – level of statistical significance $P<0.01$;

*** – level of statistical significance $P<0.001$

coefficients were less than 0 ($r<0$) and indicated a negative relationship between two phenomena (the values of variables change with opposite direction).

The numerical values of correlation coefficients analysis established the following patterns for degree of correlation: 4 correlation coefficients indicate a weak degree of relationship between phenomena ($0.3<|r|<0.5$); 3 correlation coefficients indicate a moderate degree of relationship between phenomena ($0.5<|r|<0.7$); 1 correlation coefficients indicate a strong degree of relationship between phenomena ($|r|>0.7$). Among factors of soil formation time (duration of soil formation) and input of plant ash elements fall are characterized by the maximum number of statistically significant correlation coefficients and their numerical values. While another factor of soil formation (input of plant litter fall) is characterized by lower numerical values and approximately the same number of statistically significant correlation coefficients and their numerical values. Among chemical composition of the technosol, the values of organic matter content and exchangeable acidity (pH_{KCl}) were the most predictable by chemical composition of the technosol.

100 years only very primitive soils were formed. For these soils the following features are characteristic: (1) unformed soil profile (only thickness 10-100 mm), (2) low levels of organic substance content, (3) alkaline indicators of the soil solution, (4) low levels of cation exchange capacity. According to the World Reference Base for Soil Resources (WRB, 2015), young soils in the devastated lands can be classified as spolic technosol with different supplementary qualifiers such as arenic, aridic, calcaric, dolomitic, humic, loamic, magnesic, ochric, phytotoxic. However, according to the Ukrainian young soils' classification system, these soils can be classified as embryozems which are represented by: (1) initial embryozems, (2) turf embryozems, (3) organic-accumulative embryozems, (4) humus-accumulative embryozems. Among factors of soil formation , time and input of plant ash elements' fall are characterized by the maximum number of statistically significant correlation coefficients and their numerical values. In chemical composition, the values of organic matter content and exchangeable acidity (pH_{KCl}) were the most predictable soil formation factors.

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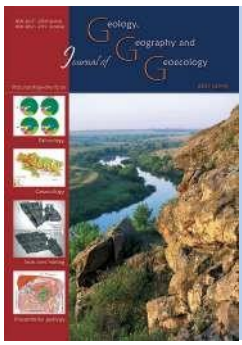

JOURNAL of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(4), 747–756.
doi: 10.15421/111970

Features of territorial organization of population resettlement of the coastal strip of the Ukrainian Black Sea Region

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Received: 07.05.2019
Received in revised form: 21.05.2019
Accepted: 17.11.2019

Abstract. This article deals with the features of population settlement within the Ukrainian Black Sea region and its coastal zone. It is emphasized that the problems of coastal resettlement, the factors that determine it, are highlighted in the works of foreign and Ukrainian scientists. The purpose of the work is to find out the features of the population settlement in the region of the Ukrainian Black Sea region. In the studied region, due to the territorial differentiation of economic activity, change in the intensity of economic use of the territory and the population density can be distinguished by the coastal, middle and peripheral economic zones. It was established that the supporting framework of urban settlement in the Ukrainian Black Sea region is characterized by a fairly sparse network, and the settlement process itself is in many respects still in the stage of formation, incompleteness. Unlike the whole region, for the coastal zone, the more prevalent network of urban settlements, which are represented within the coastal zone not only by small and medium, but also large cities (Odesa, Mykolaiv, Kherson), has contributed to the formation of urban agglomerations with wide distribution functions. In the zones of attraction of large cities, a new type of settlement was formed - in fact, suburban. In the Odesa metropolitan area, there are two powerful, fast-developing planning axes - Odesa-Chornomorsk and Odessa-Yuzhne. Seaside-facade linear planning organization agglomeration repeats the restructuring of the territorial structure of Odesa itself, which in the second half of the twentieth century turned from a city with a compact building pattern into a linear city, stretching along the sea bay. In the coastal zone of the Ukrainian Black Sea region, which occupies one third of the region's area, live 65.0% of the total number of inhabitants of the region. The density of urban settlement network here is 1.5-2.0 times higher than the average indicators of the region, urban processes in the coastal zone are characterized by greater intensity. Small cities of the coastal zone in genetic typing are mainly seaport cities, urban-type settlements, and resort and recreation in character. More than 40% of the rural population is concentrated in the coastal regions and tends to agglomeration, which, in its turn, causes a steady flow of the settlement network from areas remote from the centers of economic activity. In the last 5 years, the demographic situation, both in the region as a whole and in the coastal zone, has deteriorated significantly, and here, as in other districts, depopulation is evident. The prospects for the development of the coastal resettlement system are directly related to the further intensification of maritime and recreational activities, and, first of all, with the development of recreational, tourist and port infrastructure.

Keywords: coastal zone, seaside strip, population resettlement, territorial organization of the economy, suburban areas.

Особливості територіальної організації розселення населення приморської смуги регіону Українського Причорномор'я

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Анотація. В статті розглянуто особливості розселення населення в межах регіону Українського Причорномор'я та його приморської смуги. Наголошено, що проблематика приморського розселення, фактори, що його обумовлюють, висвітлені в працях зарубіжних та вітчизняних вчених. Мета роботи полягає в з'ясуванні особливостей розселенської мережі в регіоні Українського Причорномор'я. В досліджуваному регіоні завдяки територіальній диференціації господарської діяльності,

зміні інтенсивності господарського використання тириторії та за густотою населення можна виділити приморську, серединну та периферійну господарські смуги. Встановлено, що опорний каркас міського розселення в регіоні Українського Причорномор'я характеризується досить рідкою мережею, а сам розселенський процес в багатьох відношеннях знаходиться ще в стадії формування, незавершеності. В приморській смузі регіону Українського Причорномор'я, яка займає третину площі регіону проживає 65,0 % від всієї кількості жителів регіону. Для неї характерна більш сформована мережа міських поселень, які представлені малими, середніми і великими містами (Одеса, Миколаїв, Херсон). У зонах тяжіння великих міст сформувався новий тип розселення - власне приміський. В Одеській агломерації виділяються дві потужні планувальні осі, які швидко розвиваються - «Одеса-Чорноморськ» і «Одеса-Южне». Приморсько-фасадна лінійна планувальна організація агломерації повторює перебудову територіальної структури самої Одеси, яка в другій половині XX ст. з міста з компактною забудовою перетворилася в лінійний місто, витягнуте уздовж морської затоки. Більше ніж 40% сільського населення зосереджено в районах приморської смуги та тяжіють до агломерацій. Встановлено, що в останні 5 років спостерігається депопуляція населення, Перспективи розвитку приморської системи розселення на пряму пов'язані з подальшою активізацією морегосподарської та рекреаційної діяльності, і, в першу чергу, з розвитком рекреаційно-туристичної та портової інфраструктури.

Ключові слова: берегова зона, приморська смуга, розселення населення, територіальна організація господарства, приміські зони.

Introduction. Interest in the problems of coastal resettlement, the factors that determine it, arose among domestic scientists in the 1960s. The strengthening of the role of the sea-related sectors of the economy has affected the increase in the population growth of the coastal zone, in particular, its seaside part. The need for scientific substantiation of the development of coastal territories and their territorial planning has increased.

Researchers state that 37% of the world's population lives in the strip 100-kilometers from the Ocean, and about 50% within 200 km; the density of the coastal population is 2.5 times higher than the global average density (Druzhinin, 2016). Considered as one of the priority factors of the territorial organization of society ,as announced in numerous publications both domestic (Dergachev, 1980, Posibnyk, 2009, Studennikov, D'jakov, 2012, Topchijev et al., 2013) and foreign (Integrated Coastal Zone Management, 2005, Pelling, Blackburn, 2013, Post, Lundin, 1996), "sea attraction" receives its actual embodiment in the phenomenon of "coastal zone", "sea-side zone", "coastal strip", "coastal area", "sea coast", "contact zone "land-sea", "seaside region".

The Ukrainian Black Sea region is a highly specific region in connection with its coastal economic and geographical situation, historical and geographical features of the settlement of the region, the peculiar ethno-national composition of the population, which have all together imprinted on the formation of a settlement system. Therefore, the purpose of the study is to identify the characteristics of the resettlement of the population of the coastal zone of the Ukrainian Black Sea region.

Materials and methods. To date, some aspects of the modern territorial organization of the population of the Ukrainian Black Sea region are covered in the works of O.G. Topchiev, O.I. Polos, V.G. Pizhova, V.O. Dergachev, V.L. Smolsky, V.V. Yavorskaya, D. S. Malchikova; historical features of the settlement of the coastal areas of the Ukrainian Black Sea coast are covered by the research of D. I. Bagalii, V. M. Kobuzan, A. S. Skalkovsky, K. I. Druzhinina, V. A. Dergachev, O. G. Topciyeva.

In this study, we used cartographic, field, cameral and, comparative-geographical methods. The statistical information and mapping materials, as well as the developments described in scientific papers (Pokshishevskij, Fedorov, 1988, Fedorov et al., 2017, Topchijev et al., 2013, Pelling, Blackburn, 2013) served as the information base of the study.

Results and their analysis. In Ukraine, a separate document regulating the use of land in the coastal zone does not exist, and also its legislative boundaries are not defined. Scientists indicate the boundaries of coastal zones in different ways. For example, S. S. Sal'nikov defined it as a distance of up to 80 km from the coast (Sal'nikov, 1988), other authors defined a distance of 50-200 km (Slevich, 1988). It is noted (Integrated Coastal Zone management, 2005) that the border of coastal zones can be established in three different ways: linear-geometric - related to the criterion of actual distance from the sea, the coastal zones are fixed by the isolines on the maps (the oldest and easiest method). Another way is the allocation of administrative boundaries (Karamushka, 2009) for the purpose of management of this territory. The least common approach to the allocation of coastal zone is the approach based on establishing its natural-ecological, landscape specificity. The main landmarks here are the orographic boundaries, as well as the dominant types of economic activity (for example, recreation, certain types of agriculture, reproduction of biological resources, sea-economic complex) adapted to the landscape-resource uniqueness of the coastal areas.

In the situation of the Ukrainian Black Sea region, the coastal zone can be identified within its limit (up to

200 km) width. The region expresses the natural and economic separation of the territory. This feature of the seaside region has been repeatedly emphasized in research works (Topchijev et al., 2013, Kolomijec et al., 2017). The territorial differentiation of economic activity, the distribution of economic functions and the change in the intensity of economic use in the region are observed in the following directions: conventionally perpendicular to the coast line; in a horizontal direction along the sea coast; according to the centers of greatest concentration and zones of their influence. Such separation may be based on differences in intensity and types of economic use of territory and water area, as well as population density - on land. So within the region, these features distinguish the following economic strips : *seaside (facade)* (up to 50 km), in which the concentration of population, infrastructure and economy continues to grow steadily. The port economy is intensively developing, new specialized terminals and transshipment complexes are being built, and sea-side resorts, dacha and residential development are expanding along the coast. Here, port-industrial complexes were formed - Odesa, Danube, Dnipro-Bug, which in the market conditions turn into port-logistics centers. In the *seaside (facade)* zone are the largest recreational areas of the Ukrainian Black Sea region: Odesa, Bilhorod-Dnistrovsky, Ochakivsky, Skadovsky, Genichesky.

From this *seaside (facade)* strip inland to the land and to the sea, the intensity of economic activity falls and takes another direction. But on the example of the port economy, we see that in the rear zones of the ports - suburban areas, a network of transport and distribution centers serving the ports is formed. At present, such centers are Rozdilna, Berezivka, Artsiz, Bilhorod-Dnistrovsky (Nefedova, 2014). The ports are also closely tied to agro-industrial sites, urban-type settlements (uts), small and medium-sized cities, whose economic activity is somehow indirectly linked to the port-sea facade of the southern seaside part of the region. The population living within the suburban areas goes to work in large cities and other intensive economic ties take place. Further from the coast, the *seaside (facade)* is replaced by a *middle (transitional)* strip (50-100 km), where there are no types of economic activity associated with the sea, but a general orientation towards the economic centers located on the coast remains. The northern districts, most distant in relation to the seaside, form a *peripheral (outskirts) strip* (100-200 km), characterized by poorly developed social infrastructure, constant outflow of population and unfavourable gender and age structure of the population (high proportion of pensioners, small employable population, including few young people (Topchijev et al., 2013, Kolomijec et al., 2017).

In our study, we used the boundaries of the administrative units to allocate the boundaries of the *seaside (facade)* strip, because the statistical data is collected precisely in the administrative districts. Thus, 19 districts of Odesa, Mykolaiv and Kherson regions, which have direct access to the sea, or, such as Reni, located near the mouths of a great river are attributed to the *seaside (facade)* strip.

In general, the Ukrainian Black Sea region as a result of its maritime position stands out as a kind of territorial organization of economy and population resettlement. The main economic centers are the port-industrial complexes and sites, as well as recreation centers and largest cities, are located along the sea coast and downstream of the Danube, Dniester, Southern Bug and Dnipro (Fig. 1).

This attraction of the population and the economy forms a polycentric (multi-core) seaside-facade type of territorial organization of the economy, which causes a huge unevenness and contrast of economic development of the region. According to M. M. Baransky, "The city plus the road network is a framework, a skeleton on which everything else is kept, the skeleton that forms the territory, gives it a certain configuration." To a large extent, this thesis is valid in relation to coastal settlements and the special role in it of urban centers. The dominant role in the resettlement systems, in this case, is played by the coastal strip.

As of 01.01.2018, the regional urban settlement system of the Ukrainian Black Sea region is represented by 37 cities and 81 urban type settlements (UTS). The number of urban population at that date was 3023.3 thousand people, or 66.1% of the total population of the region of the Ukrainian Black Sea region, which was 4,571.4 thousand people (Table 1).

The number of urban settlements in the Ukrainian Black Sea region is dominated by small towns (30 out of 37). One should note the unevenness of their placement in the territory of the region. The largest number of them is concentrated in Odesa region (15 units), followed by 7 in Mykolaiv region and 8 in Kherson region. On the other hand, their population is only 19.1% of the total urban population of the Ukrainian Black Sea region.

Features of economic development and settlement of the Ukrainian Black Sea region formed the main typological features of small cities. In the Ukrainian Black Sea region, five genetic types of small cities are identified: 1) seaports - Reni, Kilia, Vilkove, Gola

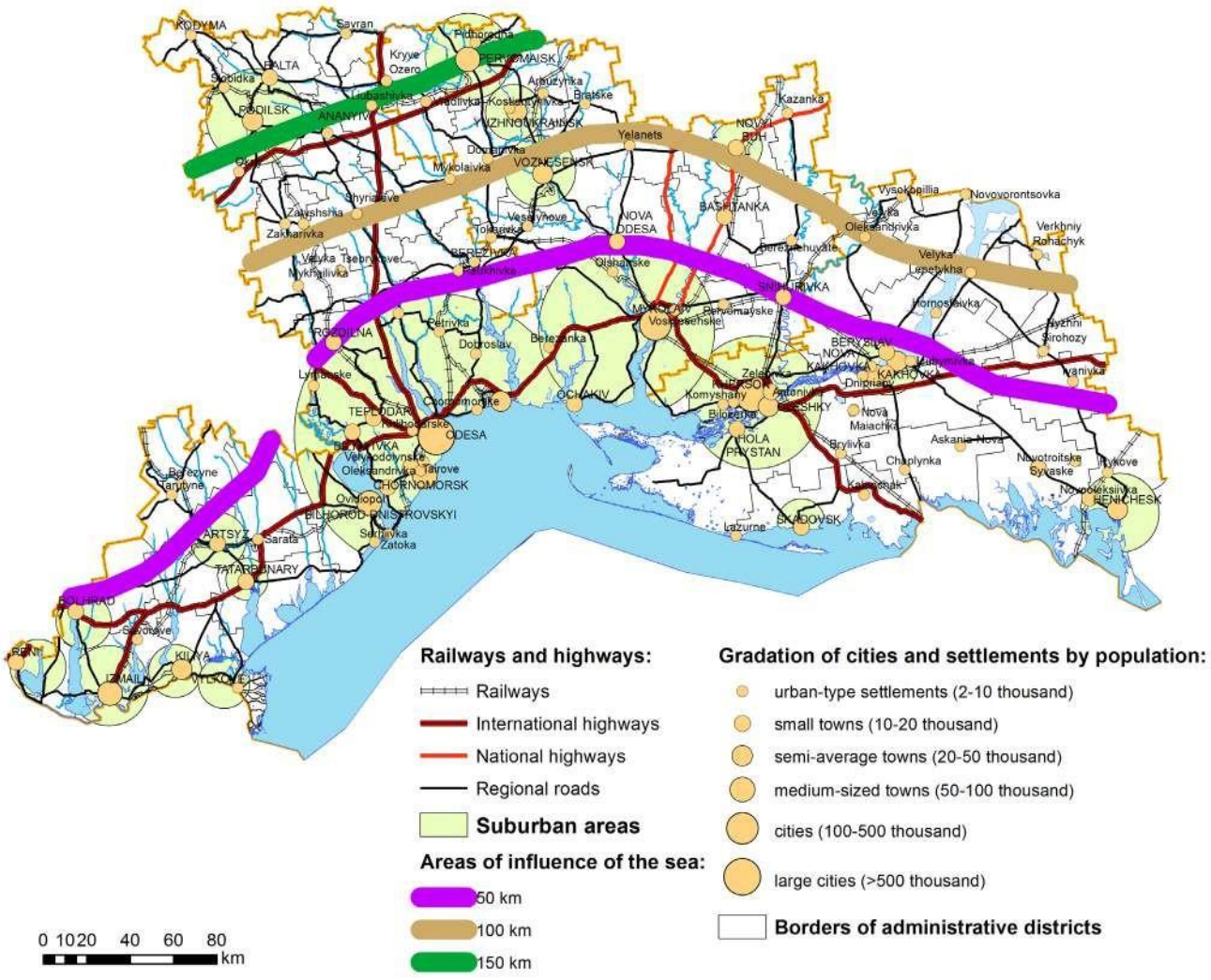

Fig. 1. Seaside system of resettlement and zone of influence of the sea

Prystan, Oleshki, Ochakiv, Skadovsk, Genichesk; 2) fortress cities - Beryslav, Kakhovka, Balta; 3) cities of foreign settler colonization - Bolgrad, Artsiz; 4) the cities of new construction - Rozdilna, Yuzhne, Yuzhnoukrainsk, Tavriysk, Teplodar; 5) city-agricultural settlements - Ananiev, Bashtanka, Berezivka, Bilyaivka, Voznesensk, Kodima, Podilsk, Nova Odesa, Novy Buh, Snigurivka and Tatarbunari (Javors'ka, 2013).

Large cities (to this category we attributed regional centers - Odesa, Mykolaiv, Kherson, where the population exceeds 100 thousand people) and the category of medium-sized cities (50-100 thousand people) in the region are few (respectively, 3 and 4 units - in Odesa region, the medium sized cities are Izmail, Chornomorsk, Bilhorod-Dnistrovsky, in Mykolaiv - Pervomaysk, in Kherson - there are none, since Nova Kakhovka moved from the middle category to that of small city). In large cities, 59% of the total urban population live, while in the middle sized cities – 8.1%.

The Odesa agglomeration is outlined by the administrative boundaries of the cities of regional significance such as Odesa, Chornomorsk, Teplodar and Yuzhne and five districts of Odesa region: Bilyaivsky, Ivanivsky, Limansky, Ovidiopolsky and Rozdilnyansky, which together form the Odesa suburban area (Fig. 1). In the Odesa agglomeration, there are two powerful, fast-developing planning axes - Odesa-Chornomorsk and Odesa-Yuzhne. The seaside-facade linear planning organization of the agglomeration repeats the reorganization of the territorial structure of Odesa itself, which in the second half of the twentieth century, changed from a city with a compact building pattern into a linear city, stretched along the sea shore.

The comparative analysis of the population density of the suburban area and Odesa region gives the following indicators of population concentration. The average population density of the suburban area (together with Odesa) is 265.9 people / km^2, while the overall population density of Odesa region is 71.9

Table 1. Distribution of population by cities of different categories in the Ukrainian Black Sea region (2018, ths. people)

Category of urban settlements	Odesa region		Mykolaiv region		Kherson region		Ukrainian Black Sea region
Big cities (more than 100 thousand people)	Odesa	1,011	Mykolaiv	493.6	Kherson	291.4	1,796.0
Medium cities (50-100 thousand people)	Chornomorsk	59.5	Pervomaysk	65.6			245.8
	Bilhorod-Dnistrovsky	50.1					
	Izmail	71.6					
Small cities (up to 50 thousand people)	Podilsk	40.7	Voznesensk	35.1	Kakhovka	36.3	574.0
	Teplodar	10.2	Ochakiv	14.2	Nova Kakhovka	46.0	
	Yuzhne	32.3	Yuzhnoukrainsk	39.8	Tavriysk	10.7	
	Ananiev	8.2	Bashtanka	12.6	Beryslav	16.4	
	Artsiz	14.9	Novy Bug	15.4	Genichesk	19.7	
	Balta	18.7	Nova Odesa	12.0	Gola Prystan	14.3	
	Berezivka	9.7	Snigurivka	12.6	Skadovsk	18.2	
	Bilyayevka	12.3			Oleshki	24.7	
	Bolgrad	15,1					
	Kilia	19.7					
	Vilkove	8,1					
	Kodima	8.6					
	Reni	18.7					
	Rozdilna	17.9					
	Tatarbunari	11.0					
Cities		1,437.3		700.9		478.0	2,616.2
Urban-Type Settlement	33	156.4	17	86.2	31	163.5	406.1
Total		1,593.7		787.1		641.5	3,022.3

Compiled for (Statystychnyj shhorichnyk Hersons'koi ', 2012, Statystychnyj shhorichnyk Nikolai'vs'koi', 2012, Statystychnyj shhorichnyk Odes'koi ', 2012, Statystychnyj, 2018)

people / km^2, that is, the population concentration in the coastal zone is 3.6 times higher than the average indexes for the region. The population density of the five districts of the suburban area without Odesa is 78.9 people / km^2, which is higher than the average regional indicator (Table 2).

A similar situation is observed with the concentration of urban population: the density of the urban population, along with Odesa, is 4,844.4 people / km^2. Such a high concentration is due to the presence of a city of a million, although the concentration of urban population of OSZ (without Odesa) is also quite high at 2,100.0 people / km^2 and exceeds the regional index almost 50 times (the average population density of the urban population is 48.1 people / km^2). There are large differences in the concentration of the rural population. So, if the density of the rural population in the OSZ is 42.4 people / km^2, the average indicator in the region is 23.8 people / km^2, and in some peripheral districts, this indicator is 13.6 people / km^2. The obtained indicators characterize the population concentration in OSZ in various aspects and confirm

Table 2. Density of the population of Odesa suburban zone

Variants	Odessa suburban zone (OSZ)		
	Territory, thousand km^2	Population, thousand people	Population density, persons / km^2
The whole population of OSZ together with Odesa	5.37	1,428.2	265.9
Total population of four districts (without Odesa)	5.21	411.4	78.9
The urban population of OSZ together with Odesa	0.25	1,211.1	4,844.4
Urban population of OSZ (without Odesa)	0.09	84.0	2,100.0
Rural population of OSZ	5.12	217.1	42.4
Odesa region as a whole	33.31	2,396.3	71.9
Odesa Region - urban population		1,603.4	48.1
Odesa Region - rural population		792.9	23.8

Compiled for (Statystychnyj, 2018)

the general tendency of concentration of population around city of Odesa and Odesa agglomeration.

Over the last decades of the 20th century, the Kherson agglomeration was structured, which includes Kherson and the surroundings of Oleshky, Gola Prystan and a number of settlements - Belozerka, Kamyshany, Zelenivka, Antonivka, Naddnipryanske, as well as villages under Kherson city council and in Belozersky district. The total area of the agglomeration is about 1,500 km^2, in which more than 440 thousand inhabitants live.

Mykolaiv is located at the confluence of the River Ingul and the Southern Bug, 65 kilometers from the Black Sea with a population of 494 thousand people. The city agglomeration is formed on the basis of Mykolaiv, which consists of 6 urban settlements and 139 rural villages of Vitovsky, Mykolaiv, Novoodeisky, and Ochakivsky districts. Within the agglomeration there are 643.1 thousand people. The population is 54.8% of the total population of the region. The Mykolaiv agglomeration belongs to the classification large, monocentric and underdeveloped. Within the Mykolaiv agglomeration there is formed a rather powerful industrial agglomeration with industrial-port functions of national and international importance (Kolomijec', Javors'ka, 2015).

In general, in the Ukrainian Black Sea region, it is possible to predict with high probability the formation of the Mykolaiv-Kherson conurbation. This conclusion was made on the basis of the analysis of the dynamics of migration between the inhabitants of the adjacent suburban settlements located in the 30-40-kilometer zone around Mykolaiv and Kherson. The distance between these cities does not exceed 60 km, and they are the "most adjoining" regional centers in Ukraine, and therefore marked by significant economic interaction.

It should be noted that in recent years within the urban agglomerations there is a deepening of socio-economic differences between the cities that form them (the main activity is concentrated in the core of the agglomeration and in its immediate periphery). Against this backdrop, the interdependence of settlements, which are united by agglomerations, is growing (including in the significant growth of pendulum migration); the main city "pours out" of its administrative boundaries, expanding the range of its economic influence. Thus, suburban areas provide protection against excessive industrial and demographic pressure and perform "unloading" functions.

We could see now that in the region the structure of the coastal settlement system is undergoing changes - in the cumulative demographic potential, the share of small cities decreases due to the protracted increase in the population of large cities, which leads to the polarization of the settlement system and the formation of its agglomerative forms. According to its architecture, the important role of the agrarian sector and, ultimately, of mentality is predominant in the "semi-urban" environment with demographic characteristics that vary significantly depending on the season (the population in the period from June to September in all seaside settlements increases from 1. 5 to 2 times) and, accordingly, with conditions of doing business and income of the population. At the same time, the expressed existential differences (in the density of population, the degree of urbanization) are maintained between the actual coastal strip and other, adjacent territories of the region. The aforementioned agglomerations are dominated by environments typical of rural settlements, which are characterized by large settlements (the average size of rural settlements in the region, for example, in Transdniestria - 1000-1400 people). In the process of forming the suburban zone of Odesa, a growing role is played by the cottage resettlement (dacha). The phenomenon of "dachization" (increase in the area of cottage settlements) of the territory, on the basis of which "agro-recreational" forms of resettlement are formed, attracted the attention of researchers back in 1994, and at present it has become even larger.

It can be said that the coastal settlement system is more localized and covers only a certain group of administrative districts, which tend to (along with its location, socio-demographic and economic ties) hug the seacoast and outline the coasts with a "chain" of settlements (seaside towns and villages). In the coastal zone of the Ukrainian Black Sea region, with a total area of 32.118 thousand square kilometers, or 37.2% of the total territory of the region, as of January 1, 2018 lived 2,973.7 ths. people, or 65.0% of the whole number of inhabitants of the Ukrainian Black Sea region. Within the coastal zone there are 16 urban settlements, 31 urban-type settlements and 745 rural settlements. The general index of population density here is quite high - 94 people per km² (in general, it makes up 54 people per km²). More than 40% of the rural population is concentrated in the coastal regions, increasing the tendency to agglomeration.

Table 3 shows that 2335.4 ths. people of the urban population are concentrated within the *seaside (facade) strip*, accounting for 78.5% of all townspeople in the Ukrainian Black Sea region.

In general, the network of urban settlements in the Ukrainian Black Sea region is sparse. For

Table 3. Population of the *seaside strip* of the Ukrainian Black Sea region (as of January 1, 2018)

Names of indicators	Odesa region	Mykolaiv region	Kherson region	The Ukrainian Black Sea region
Administrative districts of the *seaside strip*	Renyiskiy Izmailsky Kiliysky Tatarbunarsky Belgorod-Dnistrovsky, Ovidiopolsky, Limansky	Berezansky, Ochakivsky, Mikolaiyvsky, Vitovsky	Belozersky, Oleshkivsky, Golopristansky, Skadovsky, Kalanchatsky, Chaplinsky, Novotroitsky, Genichesky	The total area of The Ukrainian Black Sea region – 86,360 km^2 Total population of the Ukrainian Black Sea region - 4,571,380 people (2018)
The area of the Seaside strip, km^2	9,564	6,027	16,527	32,118
In % of the total area of the region	28.7	24.5	58.1	37.2
Total population of Seaside strip, people	1,634,400	618,900	720,384	2,973,684
Urban population of Seaside strip, people.	1 351,600	515,900	467,967	2,335,467
In % to the entire urban population of the region	84.7	66.2	72.9	78.5
Population of Seaside strip without region centers	623,400	132,645	176,539	932,584
Rural population of Seaside strip, (person)	282,800	103,000	252,417	638,217
In % to the entire rural population of the region	35.8	28.5	62.2	41.1
Number of urban settlements	9	2	5	16
Number of urban-type settlements	11	4	16	31
Number of rural settlements	225	172	348	745

Calculated by (Statystychnyj, 2018)

every 10 ths. square km of the territory there are 13 city settlements (including urban areas), which is considerably less than in Ukraine as a whole (22 units). The most dense network of urban settlements is observed in Odesa region (15 units), and the smallest values of this indicator (10 units) are in Mykolaiv region. From the above quantitative indicators it can be concluded that the supporting framework of urban settlement in the Ukrainian Black Sea region is characterized by a fairly sparse network, and the settlement process itself in many respects is still in the stage of formation, incompleteness.

If we analyze the relevant settlement indicators of the *seaside strip*, then we will see that here they are much better, there is a denser, more mature network of urban settlements and they are represented within the coastal strip not only as small and medium, but also large cities (Odesa, Mykolaiv, Kherson), which contributed to the formation of urban agglomerations with wide distribution functions. The density of the urban settlement network here is 1.5-2.0 times higher than the average indicators of the Ukrainian Black Sea region, urban processes in the *seaside strip* are characterized by higher intensity. Small cities of the seaside strip in genetic typing mainly relate to seaport cities, urban-type settlements, resorts and centres of recreation.

In rural resettlements within the region there are noticeable territorial differences, both in terms of density of the settlement network, and in the population of rural settlements. For example, the highest indices of the population of rural settlements (1,063-2,626 people) are characteristic of the Transdnistrian districts of Odesa region, as well as for the districts included in the Odesa agglomeration (Bilyayevsky, Ovidiopolsky, Lymansky), the Mykolaiv agglomeration (Vitovsky district), and Pridneprovsky district of Kherson region (Belozersky, Beryslavsky, Oleshkovsky, Golopristansky). For Bilyayevsky and Ovidiopolsky districts the highest values are characteristic of the density of the rural population - 52.6 people / km^2. Note that the rural settlement network in the southern regions of the region is sparse. On average , for every 100 km^2 there are from 0.8 (the region's smallest index is in Reny district) to 3.1 rural settlements, and the average distance between rural settlements

is almost 6 km. At the same time, Genichesk district of Kherson region is characterized by the lowest population density indicators - 8.9-13.3 persons per 1 km^2 and low density of rural settlement - 1.8-2.3 settlements per 100 km^2.

More than 40% of the rural population is concentrated in the coastal zone districts and this increases the tendency to agglomeration. Residence in the suburban area gives the village population a number of advantages, including the sale of agricultural products in the city, better facilities and the possibility of receiving higher-ranking services; the formation of urban lifestyle through the processes of urbanization. Large villages are located near their district's center or town of district significance. Thus, there is a steady reduction of the network of settlements remote from the centers of economic activity. In the last quarter century, the rural population of suburban areas increased its size due to migratory inflows from other districts of the region. This also affected the fact of a significant increase in the average population of rural settlements. But it should be noted that in the last 5 years, the demographic situation, both in the whole Ukrainian Black Sea region, and in the suburban system of the settlement of Mykolaiv region and Kherson region, has deteriorated significantly, and here, as in other areas, there is a natural decrease of the population (Table 4).

Demographers and geographers traditionally divide the population into urban and rural areas, analyze the level of urbanization of the territory, allocate urban and rural settlement systems. In the zones of attraction of large cities, a new type of settlement was formed - in fact, suburban. Along with the usual urban and rural population, in the suburban area there is a mixed type of settlement, which modern statistics cannot attribute to either urban or rural. This phenomenon concerns zones of cottage, country and garden land use in the suburban area, which do not have a clear administrative link to either the big city or to certain administrative districts. In the world statistics, these territories are called «urbanized areas» and included in the urban population. In the long run, suburban areas may receive a certain administrative status in Ukraine. In the suburbs, however, it is necessary to take into account three types of population - urban, rural and suburban (Sych et al. 2015). Consequently, a new form of modern evolution of resettlement systems in the Ukrainian Black Sea region exists, improves, becoming more complex, it approaches the tertiary sphere, the sphere of agro-recreational components and needs thorough qualitative research.

Conclusions. Thus, the general features of resettlement suggest uneven resettlement, both in the region as a whole, and within the coastal zone. The poles of attractiveness to resettlement are the Odesa,

Table 4. Dynamics of the population of the Ukrainian Black Sea region (ths. people)

Territorial units	1990 p.	2001 p.	2011 p.	2012 p.	2013 p.	2018 p.
Odesa region	2,638.2	2,469.0	2,388.7	2,388.3	2,395.2	2,383.1
Mykolaiv region	1,330.0	1,264.7	1,183.3	1,178.2	1,173.5	1,141.3
Kherson region	1,249.4	1,175.1	1,088.2	1,083.4	1,078.2	1,046.9
Seaside strip	3,237.0	3,131.8	3,009.0	3,005.1	3,009.8	2,973.7
Ukrainian Black Sea region	5,217.6	4,908.8	4,660.2	4,649.9	4,646.9	4,571.3
Ukraine	51,838.5	48,457.0	45,778.5	45,633.6	45,553.0	42,386.4
Urban population						
Odesa region	1,746.1	1,624.6	1,594.8	1,595.0	1,602.1	1,594.9
Mykolaiv region	874.0	838.8	800.8	798.1	796.1	779.7
Kherson region	768.5	706.2	665.5	662.4	659.5	641.4
Seaside strip	2,555.7	2,465.8	2,361.7	2,357.5	2,362.0	2,335.5
Ukrainian Black Sea region	3,388.6	3,169.6	3,061.1	3,055.5	3,057.7	3,016.1
Ukraine	34,871.8	32,574.0	31,440.7	31,382.2	31,376.9	29,370.9
Rural population						
Odesa region	892.1	844.4	793.9	793.3	793.0	788.2
Mykolaiv region	456.0	425.9	382.5	380.1	377.4	361.6
Kherson region	480.9	468.9	422.8	420.9	418.7	405.5
Seaside strip	681.9	677.9	647.2	647.3	647.6	638.2
Ukrainian Black Sea region	1,829.0	1,739.2	1,599.2	1,594.3	1,589.1	1,555.3
Ukraine	16,966.7	15,883.0	14,337.8	14,251.4	14,174.4	13,015.4

Composed by (Statystychnyj shhorichnyk Hersons'koi' regioni,2013, Statystychnyj shhorichnyk Mykolai'vs'koi' regioni, 2013, Statystychnyj shhorichnyk Odes'koi' regioni,2013, Statystychnyj zbirnyk, 2018)

In the suburban areas of large cities of Ukraine there has been a special type of population settlement. Mykolaiv and Kherson agglomerations, as opposed to the low-populated depressed peripheral districts

of the region. The aforementioned disproportions also affect the distribution of the urban population in a spatial sense. The prevailing majority of the urban population is concentrated in large, middle-sized and small cities and towns of the urban type, namely, in the coastal zone of the region, another 8% of the urban population is concentrated in small and medium-sized cities in the northern part of the Ukrainian Black Sea region, and 4% live in small towns of the Novokahivsko-Kakhovka-Beryslavskaya agglomeration. Since urban settlements form the basis of a framework of a territorial organization, such territorial concentration leads to the separation of the territory of the region. The seaside-facade position of these cities and most urban settlements form a special seaside type of settlement system. The prospects for the development of the seaside resettlement system are directly related to the further intensification of maritime and recreational activities, and, first of all, to the development of recreational, tourist and port infrastructure.

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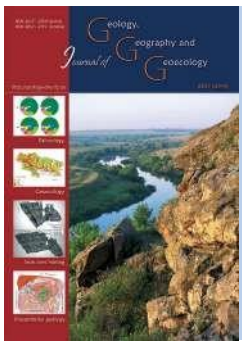

JOURNAL of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(4), 757–768.
doi: 10.15421/111971

About the functional typification of the Podilsk economic-geographical district mineral resources (Ternopil, Khmelnytskyi and Vinnytsia regions)

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Received: 10.03.2019
Received in revised form: 24.03.2019
Accepted: 03.10.2019

Abstracts. The article offers a functional typification of Podilsk economic and geographical area mineral resources (MR), based on taking into account their influence on the participation of certain industries in the territorial division of labor, complex-forming properties and the realized activity (degree of deposit development) of certain types of minerals and differs from the general Ukrainian (Syvyi, 2011) with several features. Thus, three groups of mineral resources are determined in particular, according to the first feature: international, national and local; according to the second all types of mineral raw materials are grouped into three classes a, b, and c; three types of mineral deposits a, b and c are identified depending on the degree of development. Besides, the criteria are proposed for classification of some raw materials as strategic. In the presented variant of typification of mineral resources of the region, an attempt was also made to approximate geographical and geological positions in classifications, which will help to define clearly the role and place of mineral resources in the territorial and sectoral structures of the economy, to determine national priorities in the development of mineral and economic resources of the country-raw materials experience in geological practice. The first group (raw material of international importance) in Podillia includes valuable mineral waters such as Naftusia, radon, and sulfide waters, kaolins, graphite, facing stones from magmatic rocks, i.e. raw materials with significant (modern or potential) export potential. The second group (raw material of national importance) is the largest, with the vast majority of mineral resources explored in the region: most types of mineral waters, cement raw materials, construction stones, agrochemical raw materials, some types of technological raw materials and so on. Many of them are characterized by high realized activity, a large number is developed in insufficient quantities or generally not developed because of various reasons (lack of demand, environmental problems, depletion or insufficient exploration of stocks, etc.). The local raw materials include a small number of mineral types - ameliorant, construction sands, and others. Mineral resources with high complex-forming properties are almost absent in the region (except for Naftusia mineral waters, where large recreational complexes are formed). Class B (medium complex-forming properties) includes mineral resources, small mining sites, and centers that are formed based on them (cement raw materials, agrochemical raw materials, kaolins, mineral waters with specific components, etc.). However, the largest amount of mineral resources of the region is not marked by explicit complex-forming properties and is classified as class C. The article draws generalized conclusions about the functional structure of mineral resources of the region, which are revealed by their typification, the priority directions of investments in geological prospecting are offered, which should help to increase and optimize the mineral base of the region.

Keywords: typification, mineral resources, strategic raw materials, classes of mineral resources, groups of mineral resources.

Про функціональну типізацію мінерально-сировинних ресурсів Подільського економіко-географічного району (Тернопільська, Хмельницька, Вінницька області)

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Анотація. В статті запропоновано функціональну типізацію мінерально-сировинних ресурсів Подільського економіко-географічного району, яка ґрунтується на врахуванні їхнього впливу на участь певних галузей в територіальному поділі праці, комплексоформівних властивостях та реалізованій активності (ступені освоєння родовищ) окремих видів мінеральної сировини й відрізняється від загальноукраїнської (Syvyi, 2011) низкою особливостей. Так, зокрема за першою ознакою виокремлено три групи мінеральних ресурсів: міждержавного, загальнодержавного та місцевого значення; за другою усі види мінеральної сировини згруповано у три класи А,Б і В; залежно від ступеня освоєності виділено три типи покладів мінеральної сировини: а, б і в. Окрім того, запропоновано критерії віднесення деяких видів сировини до стратегічної. У поданому варіанті

типізації мінеральних ресурсів регіону здійснено також спробу зближення географічних і геологічних позицій у класифікаціях, які будуть сприяти чіткому визначенню ролі й місця мінеральних ресурсів в територіальній та галузевій структурах господарства, визначенню загальнодержавних пріоритетів у розвитку мінерально-сировинного комплексу країни, наближенню економіко-географічних напрацювань до геологічної практики. До першої групи (сировина міждержавного значення) на Поділлі віднесено цінні мінеральні води типу Нафтуся, радонові й сульфідні води, каоліни, графіт, облицювальне каміння з магматичних порід, тобто сировину з вагомим (сучасним чи потенційним) експортним потенціалом. Друга група (сировина загальнодержавного значення) – найчисельніша, сюди віднесено переважну більшість розвіданих у регіоні видів мінеральних ресурсів: більшість типів мінеральних вод, цементну сировину, будівельне каміння, агрохімічну сировину, деякі види технологічної сировини тощо. Багато з них характеризуються високою реалізованою активністю, значна кількість розробляється у недостатніх обсягах чи загалом не розробляється з різних причин (відсутність попиту, екологічні проблеми, виснаженість чи недостатня розвіданість запасів та ін.). До місцевої сировини віднесено невелику кількість мінеральних видів – меліоранти, піски будівельні та ін. В регіоні майже відсутні мінеральні ресурси з високими комплексоформівними властивостями (за виключенням мінеральних вод типу Нафтуся, на базі яких формуються великі рекреаційні комплекси). До класу Б (середні комплексоформівні властивості) віднесено мінеральні ресурси на базі яких формуються невеликі гірничопромислові вузли та центри (цементна сировина, агрохімічна сировина, каоліни, мінеральні води зі специфічними компонентами та ін.). Однак найчисельніша кількість видів мінеральної сировини регіону не відзначається вираженими комплексоформівними властивостями й віднесена до класу В. У статті зроблено узагальнені висновки щодо функціональної структури мінеральних ресурсів краю, які розкриваються їхньою типізацією, запропоновано першочергові напрямки інвестицій в геологорозвідувальні роботи, які повинні сприяти нарощуванню й оптимізації мінерально-сировинної бази регіону.

Ключові слова: типізація, мінерально-сировинні ресурси, стратегічна сировина, класи мінеральних ресурсів, групи мінеральних ресурсів.

Introduction. The exploration and development of mineral resources are considered as one of the important factors in the formation of the structure of the social-territorial complex of Ukraine in general and the Podilsk region in particular. Historically, the exploration of mineral resources has been and is being done in several interrelated and independent ways. This is explained by the need for a comprehensive study of both the mineral itself concerning determining its future economic use and the processes involved in the prospecting, exploration, production, and processing of mineral resources. Today, there is a quite clear differentiation between such basic areas of study of the MR as geological-mineralogical, natural-geographical, economic-geographical, economic, environmental, historical and complex (structural-geographical). The last one is the basis of our studies (Syvyi, 2004; Syvyi, Paranko, Ivanov et al., 2013 and others). An important prerequisite for optimizing the areas of MR rational use is their economic and geographical studies as the part of structural and geographical ones. They allow establishing territorial geographical patterns of the location of mineral deposits, the degree of their exploration and development, the relationship between the enterprises of the mining industry, the structure of sectoral and regional consumption of mineral resources, the situation in raw material market, etc. The opportunities of mining- industrial combinations of the mineral resources direction on the basis of separate developed of deposits or their territorial groups are being explored. As noted by L. Rudenko, V. Palienko, L. Shevchenko and others (Rudenko et al., 2003), the formation of territorial-production complexes based on mineral resources deposits is extremely important for Ukraine, and their research should be a priority when choosing ways of optimization of the resources' use.

Mineral resources constitute a single natural-economic (geotechnical) system because they are characterized by all the features of any system: the integrity, relative autonomy of subsystems, certain stability of the structure, functionality or the presence of connections between subsystems, etc. (Syvyi, 2004). The system of "mineral resources" as a territorial object is characterized by a component, functional and territorial (geospatial) structure. Component and territorial structures of mineral resources of the Podilsk district with sufficient detail have been covered in our study (Syvyi, 2003, 2004, 2006).

Therefore, **the purpose of this work** was to analyze their functional structure, which would allow taking a holistic view of the specifics of mineral resources within the Podilsk economic and geographical area. The tasks, which were solved by this research, in general, were as follows: 1) to offer our variant of functional typification of mineral resources; 2) to classify the mineral resources of the region by the degree of their complex-forming ability; 3) to establish the nature of the impact of certain types of mineral resources of the region on the participation of the respective industries in the territorial division of labor; 4) to classify the types of mineral resources by the degree of development (realized activity); 5) to offer the main directions of exploration and investment in the region to increase reserves of strategic mineral resources, as well as resources with highly complex-forming and export potential, and raw material types scarce for region.

Materials and methods of research. Economic-geographical (as well as structural-geographical) studies of mineral resources in Ukraine are not among the priority ones for several reasons, so there has been relatively a few studies on these issues in the recent years. We can distinguish the studies which considered the problem from one or another sides (Horlenko, 1969; Palamarshuk M. et al., 1978; Mishchenko and Rjabokon, 1987; Palamarshuk M., 1987; Horlenko, 1990; Horlenko, 1995; Palamarshuk M., Palamarshuk O., 1998; Rudenko V., 1999; Mishchenko, 2001; Korzhnev et al., 2003; Rudenko L. et al., 2003, 2004; Syvyi, 2004; Kostachshuk, 2004; Hurskyj, 2008; Syvyi, 2009; Syvyi et al., 2013; Burka, 2015 and others).

Ukrainian researchers have proposed the classification of mineral resources according to their industrial use (Mishchenko and Rjabokon, 1987), a scheme of economic-geographical analysis of the MR with different variations (Horlenko, 1990; Palamarshuk M. et al., 1978; Palamarshuk M., Palamarshuk O., 1998; Syvyi, 2004), the territorial structure of mineral resources of Ukraine is analyzed (Palamarshuk M. et al., 1985; Palamarshuk M. and Palamarshuk O., 1998; Syvyi, 2003) and Podillia (Syvyi, 2004), the role of mineral resources information of industrial territorial complexes (Palamarshuk M. et al., 1978; Syvyi, 2004), the methodology for studying the potential of MR as an important component of the regional's natural resource potential has been worked out (Rudenko V., 1999; Syvyi, 2004), the problems of integrated use of the MR (Pedan and Mishchenko, 1981; Mishchenko, 1987; Syvyi, 2004, 2010) and others.

Concerning the economic and geographical typification of mineral resources of Ukraine, it was first proposed by M. Palamarchuk and O. Palamarchuk in 1998 (Palamarshuk M. and Palamarshuk O., 1998), a similar typification with slightly different approaches on the basis of the new factual material was also carried out later (Syvyi, 2011).

The stock materials of the State Scientific Research Institute of Geoinform of Ukraine and its Podilsk branche, literary sourcess became the basis for carrying out this research and writing the article. The studies were carried out in the context of the budget theme of the Geography Department of TNPU named after V. Hnatiuk "Complex geographical studies of natural-economic geosystems of Podilsk region". Traditional methods have been used: gathering factual material to form a data bank for the mineral deposits of the region; analytical work related to the systematization and generalization of the collected stock materials, drawing conclusions, etc.

Research results. M. Palamarchuk and O. Palamarshuk O. (1998) depending on the influence of mineral resources on participation of the relevant branches in the territorial labor division, allocated the following groups of resources for Ukraine: international (I), nationwide (II), regional (III) and local (IV) importance. The first group includes resources with high-quality indicators and significant reserves that can successfully compete in the global mineral markets. Groups II and III include resources that are effectively utilized, respectively, within the country or a separate region. IV-th group includes minerals that do not affect the international labor division for various reasons: due to small reserves, unfavorable (or unprofitable) mining conditions, distribution throughout the country, locality (limited) use, etc. Specifically, the belonging of a mineral deposit to a particular group is determined by the effective area of consumption of raw materials or products of its processing. It depends to some extent on the level of development of productive forces. The grouping of Ukraine mineral resources into four groups has been suggested by the authors instead of the previous grouping (Palamarshuk et al., 1985) when union, zonal, republican, district and local groups were distinguished. It's clear that at that time it was a union division of labor.

According to the level of complex-forming activity, as in the previous classification, the authors distinguish three classes – A, B, C.

Thus, the typification of mineral resources of Ukraine provides the distinguishing of 12 main groups by the level of their complex-forming activity and the activity of their specialization development: A-I, A-II, A-III, A-IV, B-I, B-II, etc. (Palamarshuk M. and Palamarshuk O., 1998).

In addition, depending on the nature of development, there are three types of minerals (Palamarshuk M. et al., 1978): a — minerals of the realized activity, which retain their value for the future; b — minerals with low level of activity realization due to insufficient level of development or incompleteness of the last one c - minerals of unrealized activity (those which are not currently developed).

Practicing geologists, engaged in the exploration and preparation of mineral deposits for operation, distinguish national and local minerals. In Ukraine, the attribution of minerals to national and local importance is carried out by the Cabinet of Ministers of Ukraine upon the submission of the State Committee of Ukraine for Geology and Subsoil Use (PKMU, 2011).

It is also accepted in the world practice to allocate strategically important types of mineral raw materials for each country. The list and the volume of reserves of the last ones are determined by the level of economic development of the country, the structure of material production, the geopolitical situation, the state of foreign economic relations and other factors. For example, in the USA, there are 94 names of strategic types of mineral raw materials, in France - 13, in Russia - 29, etc. In Ukraine, the strategy of certain types of mineral raw materials is determined by different criteria. Thus, in the Program of Integrated Scientific Research of NAS of Ukraine "Strategic Mineral Resources of Ukraine" (Koncepcia, 2012), the last ones are classified according to the industrial, economic and political aspects of their application and the importance of raw materials into six categories: 1) resources for strategic branches of energy and industrial sector: brown: brown, black coal and coking coal, zirconium, titanium, iron, manganese, graphite, piezo quartz, hafnium; 2) resources for high-tech production areas: silica, tantalum and niobium, rare earth elements of yttrium and cerium groups, thorium, indium; 3) imported resources for domestic strategic industries: oil, natural gas, copper, lead, zinc, nickel, bauxite, apatite, gold, silver, diamonds, uranium (in fuel cells), fluorspar, pure quartz raw materials, etc.; 4) resources with significant export potential: iron, manganese, titanium, partly uranium; 5) resources for strategic sectors of Ukrainian economy that have been explored but are not being developed: apatite-titanium ores, nepheline, fluorspar, lithium ores, etc.; 6) non-ferrous metals, which are imported into Ukraine in the presence of domestic prospective deposits requiring studies: copper, phosphorites, apatites, chromium, molybdenum, nickel, gold, etc.

Even not a very thorough analysis of the classification reveals its cumbersomeness and inconsistency: the same mineral types fall into different categories (copper, gold, fluorine, apatite, phosphorites, titanium, iron, etc.), the categories are partially duplicated.

D. Gurskyj (2008) divides all strategically important minerals for Ukraine's economy into four categories (A, B, C, D), the division of which is based on such categories as degree of intensity of the exploitation of some types of the mineral resources, it's export potential, explored reserves degree of exploration, the need of the raw materials for the country's economy: a) resources with significant export potential, significant reserves and highly realized activity; b) problematic resources which are extracted in limited quantities, with low cost, environmental problems, scarce or depleted reserves, insufficiently explored newly discovered fields that need strategically important industries for the country's economy and are covered by imports; c) explored deposits, the raw materials of which are extracted in limited quantities or not extracted at all for various reasons, but the need for them may be renewed in the future; d) insufficiently explored and undeveloped fields, with the prospect of becoming strategically important for the country's economy in the near future. The author proposes a targeted exploration of 48 types of strategic mineral resources.

In the National Program for Development of the Mineral Resources Base of Ukraine until 2030 (Zahalnoderzhavna .., 2011), all mineral resources are also divided into four categories, which are correlated with the categories proposed by D. Gurskyj for strategic raw materials.

Determining the list of strategic types of mineral raw materials involves the calculation of their current and prospective needs, ensuring reliable import of scarce types, as well as the priority budget financing for the creation and development of their base, identifying priority objects for investment, etc. In today's difficult economic environment, such measures cannot, of course, cover such a wide range of minerals and it is imperative to set national priorities. Therefore, we believe that the strategic types of mineral resources in Ukraine (as well as in the region) should be attributed primarily to a) energy resources that are extracted in insufficient quantities and are largely imported (oil and condensate, natural gas, uranium in fuel elements, coking coal) coal); b) a group of non-ferrous metals imported (lead, zinc, nickel, aluminium, etc.) and raw materials for high-tech industries (rare earth metals of yttrium and cerium groups, tantalum and niobium); c) a group of mineral species with high export potential, as a reliable source of foreign exchange earnings (iron, titanium, manganese, zirconium, kaolin, refractories, facing stones from magmatic rocks, etc.); d) some non-ferrous and precious metals (gold, copper, lithium) and non-metals (titanium-apatite ores, apatites, phosphorites, feldspar), which are currently imported, but there are significant reserves and prospective resources in the country (Syvyi, 2011).

The list of strategic mineral raw materials will vary depending on the needs of industrial consumption, the global market for mineral resources and other factors. Now, for example, the highest growth in the world is increasing production and consumption of energy resources, alloying metals, certain types of non-ferrous and precious metals, rare earth raw materials, diamonds, agrochemical raw materials.

We present our own variant of functional typification of mineral resources of the Podilsk region below, which generally preserves the approaches proposed by (Palamarshuk M. and Palamarshuk O., 1998), but attempted to converge geographical and geological positions in classifications (for example, reducing the number of groups), which will contribute to a clearer definition of the role and place of mineral resources in the regional and sectoral structures of the economy, setting priorities in the development of the mineral resources of the region (Fig. 1, Table 1).

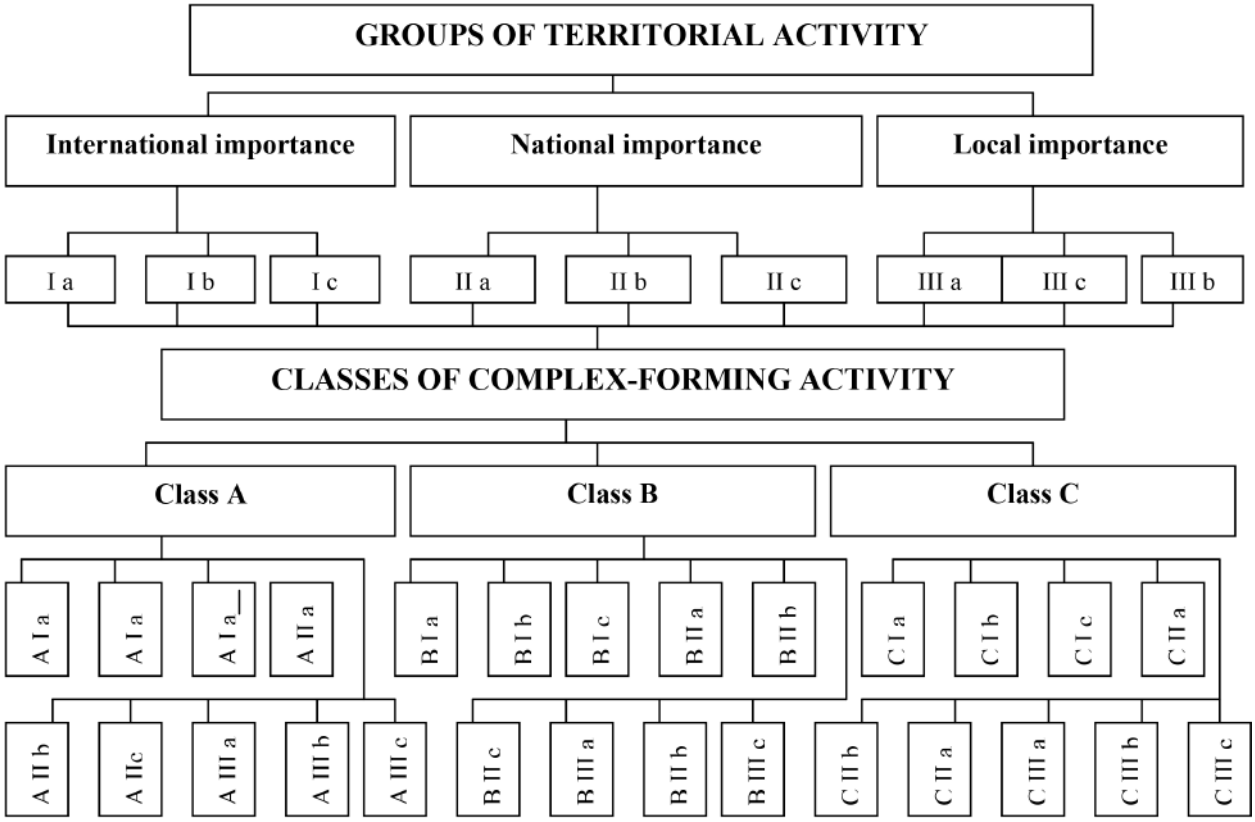

Fig. 1. Functional structure of the mineral resources typification of Ukraine (Syvyi, 2011)

We distinguish three groups of minerals, depending on their influence on the participation of the respective branches in the territorial division of labor (territorial activity): of international, national and local importance (Syvyi, 2011).

The *first group* includes resources with high-quality indicators and a significant level of territorial concentration of reserves and, accordingly, significant realized and potential export potential. Mineral deposits in this group may or may not be distinguished by powerful reserves, the last feature is quite capable of offsetting their rarity and uniqueness. Following Palamarchuk M. we believe that (Palamarchuk M., Palamarchuk O., 1998), it is useful to allocate the mineral resources of international importance, which will allow management structures of the regional and local level to approach the planning of development of their economic complexes more rationally and effectively, to use the available mineral raw materials, especially in the present conditions of the local government reform.

The *second group* includes the resources that are currently being effectively utilized, or that can be used in the long run within the state or in individual regions.

The *third group* includes mineral resources with a low impact on the interdistrict division of labor due to: 1) high prevalence; 2) small reserves, low-quality indicators or unfavorable development conditions. At the same time, there are several types of mineral resources that are of local importance, but, given their prevalence, they may be important for the development of individual administrative districts or integrated territorial communities, especially in the absence of deposits with significant reserves of high-quality indicators. Also, expanding the list of locally sourced raw materials would help local communities to invest in mining, as it greatly simplifies the process of putting the fields into operation.

Each group is divided into three subgroups: a, b and c. The sub-group "a" includes mineral deposits, which are being intensively developed now and will retain their importance for the future; sub-group "b" includes deposits with insufficient level of mineral exploration, limited production volumes due to environmental problems, high cost, low reserves, insufficient exploration, lack of technological schemes for raw material processing, etc; The sub-group "c" refers to mineral resources that are not currently being developed for various reasons, but retain their importance for the economy of a country or region and may become exploited in the near future.

Mishchenko (Michshenko, 2006), in some cases for the production of certain complex products, in other cases - for the creation of cascade-type enterprises, when waste or by-products of one of them are used as raw materials for others, etc. Class B covers minerals that provide complex formation mainly at the local level — small territorial-industrial complexes and centers are developed on their basis. Class B includes minerals that are not complex-forming. In the Table 1, the main mineral resources of the Podilsk region are classified according to the principles outlined above.

Thus, each type of mineral resources explored in the Podillia (Fig. 1, Table 1) can be designated by a

Table 1. Functional typification of mineral resources of Podillia

CLASSES/ GROUPS	GROUPS ACCORDING TO THE TERRITORIAL ACTIVITY						
	INTERNATIONAL (I)		NATIONAL (II)			LOCAL (III)	
	A	C	A	B	C	A	C
A	Mineral waters of Zbruchansk Naftusia type						
B	Mineral water: radon, sulfide **Kaolin ***		Cement raw materials: marls, limestones, clays, gypsum; gypsum for the production of plasterboard, binder mixes	Glauconite, saponite; mineral waters of Myrgorod type, silicic, Regina type, bromine water, sodium chloride brines, medical muds	Minerals water without specific components, brown coal, mica (phlogopite), garnet, opal, **fluorspar*, apatite*, phosphorite***		
C	**Facing stones made of magmatic rocks *: granites, granodiorites etc.**	Graphite; abrasive raw materials, layer silicic	Dolomites, building stones made of igneous rocks: granites, granodiorites, enderbites, blacks, limestone for sugar-plants, building stones of the sedimentary rocks, brick and tile raw materials (mudstones, fusible clays, forest, shales), facing stones (sandstone)	Silicate sands, concrete; natural drinking water, saw stones (limestone), buikding chalk	Expanded clay, abrasive (garnet), fieldsparrow raw, bentonite clays, sulfur, trembling, pelicanite, marble onyx; peat, glass sands; facing stones (travertines, plaster), sand-gravel mixtures (pebbles, gravel), refractory clays	Sands for construction, raw materials for production lime, gypsum (limestone, chalk, gypsum), raw materials bricktile (loam)	Raw materials for soil reclamation (limestone, gypsum, sapropel)

**Resources, defined by the author as the strategic*

By the level of complex-forming activity, there are three classes: A, B, C. Class A combines minerals, which development leads to the formation of territorial-production complexes of mineral resources or modern clusters built on the benefits of the territorial combination of mineral deposits as noted by

specific code characterizing the degree of its complex-forming and territorial activity (for example, A-Ia — mineral waters of the type Naftusia, i.e. raw material with high complex-forming properties, international importance, which is being intensively developed now and will retain its value for the future; B-IIb

— claydite raw material (mudstone) — raw material without pronounced complexing properties, national importance, growth known reserves which are not currently being developed, etc.).

Thus, the most valuable mineral raw material of the region is Naftusia mineral waters, which are assigned to the group I (Class A). These waters are exploited quite intensively for both balneological purposes and for bottling. They are of international importance, because of their vast reserves and unique balneological properties in the same time they are complex-forming - based on Sataniv-Makiv recreation unit in the Khmelnitskyi region, focused mainly on the use of waters such as Zbruchansk Naftusia, waters with other components for example – bromine and others. Unique combination of landscape and climatic conditions of Podilsk Tovtry, therapeutic properties of several types of mineral waters, ecologically clean territory and other favorable factors (creation of Tovtry resort with special investment regime) allow to predict further expansion and branching of functional structure, functional transformation of one of Ukraine leading resort areas and gaining international status in the near future. It's also worth mentioning that on the basis of the mineral waters of Naftusia type (similar to Zbruchansk Naftusia) in Truskavets and Skhidnytsia there are resorts of international importance, where citizens from different EU countries are being healed, i.e. these waters are classified by us (Syvyi, 2011) as resources of international importance. For these reasons, we believe that the mineral water is unique in its reserves and its therapeutic properties of the Podilsk region (Zbruchansk Naftusia, sulfide and radon) can also be classified as the first group resources but needs adequate infrastructure in the region and involvement of necessary investments. Moreover, the resort in Konopkivka (sulfide waters) used to have an international status in the 19th century.

The group I (Class B) includes radon and sulfide mineral waters. The Konopkivka Territorial and Recreation Center was formed in the Ternopil region and was based on sulfide (hydrogen sulfide) waters. There is "Medobory" sanatorium in the village of Konopkivka, a health complex for agricultural workers in the Nastasiv village and Mykulyntsi Water Treatment Hospital (based ontherapeuticmuddeposits, near Mykulyntsi village). There are also several water displays located near Mykulyntsi (Sorotsk, Kozivka etc.). The significant forecasted resources of hydrogen sulfide water and favorable environmental conditions make it possible to evaluate the prospects for the development of the recreation center. Another small recreational center (Khmelnitskyi) was formed on the basis of two radon water deposits in the Khmelnytskyi district of the Vinnytsia region - Khmilnytskyi and Novokhmilnytskyi. The waters of the fields are used by the "Khmilnyk" health resort of the "Ukrprofozdorovnytsia", the Central military clinical sanatorium "Khmilnyk", the inter-economic sanatorium "Podillia", the road clinical hospital №2, the medical rehabilitation center of the Ministry of Internal Affairs of Ukraine, the regional physiological hospital of the regional state administration. There are also opportunities to increase the production of radon water for balneological purposes.

Formation of small recreational complexes is possible in the future on the basis of the Nemyriv radon water deposit in the Vinnytsia region, the operation of which has recently started by the "Avangard" sanatorium, as well as in Shepetivsk and Polonsk districts of the Khmelnytskyi region after commissioning of the same deposits.

This group includes very rich deposits of primary kaolins of international importance, classified by us as strategic raw materials. Some of them have been explored and developed, some are ready for exploitation. Ukrainian deposits account for 95% of European reserves of this raw material. Ukrainian enterprises consume 20-25% of enriched kaolin (Korpan et al., 2018). Therefore, exporting it to the countries of Europe, the USA or even Africa is a very urgent issue. In contrast to some individual researchers (Palamarshuk M. and Palamarshuk O., 1998), we attribute kaolin to raw materials with medium complex-forming properties, because its extraction causes the emergence and functioning of several industrial enterprises for which the raw material is the main or auxiliary. Currently, 8 kaolin deposits are being developed in the Khmelnytskyi and Vinnytsia regions. Thus, based on the complex Shepetivka-Polonne area, an industrial site of the mineral orientation of the same name was formed and operates (Syvyi, 2004). It focuses on a whole network of diversified businesses oriented on the production and consumption of primary kaolins. Operations of the Maidan-Willa Group of Fields are undertaken by such enterprises as the Maidan-Willa Group of Refractories and the Burtyn Refractory Plant, municipal enterprise "Polonne Mayak Plant", Polonne Porcelain Factory and others. Kaolin concentrate is also used by the LLC "Poninkovka Paper and Cardboard Factory-Ukraine". Besides, some primary kaolin deposits, which are included in the Volyn sub-province (Dubrivka-Khmelivka kaolin district), are also operated in the vicinity of the Zhytomyr region. They are based on the Dubrivka Refractory Brick Factory and several

porcelain and faience enterprises in the Baranivka district of the Zhytomyr region. These enterprises, in our opinion, should be considered as a part of a single industrial unit of mineral resources, which covers the Shepetivka, Polonne districts of Khmelnytskyi region and Baranivka district of the Zhytomyr region. Also, in the Vinnytsia region, the mineral resources of the Kozyatyn- Illinetsky Macroscale are the basis for the functioning of a small Glukhivetsky-Turbivsky Mining Site with a distinct mineral-raw orientation (Syvyi, 2004). The base is the deposits of the Glukhivetsky-Turbivsky kaolin district, which have been the objects of intensive exploitation for a long time. Such powerful enterprises as Turbivsky Kaolin Plant, which supplies kaolin concentrate for filling rubber, artificial skins and for pesticide production and one of the most powerful in Ukraine - Glukhivetsky kaolin factory (extraction of kaolin for porcelain, chemical, radio and ceramics) as well as for the production of cable, rubber, ultramarine, refractories, perfumes); in addition, a short-spattered concentrate is produced at the plant from the main production screenings. AKW Ukrainian Kaolin Company has started the development of the Velikogadomynetsky deposit, which is characterized by the high quality of raw materials, suitable mainly for the production of expensive chalk paper. SOKA Ukraine LLC, which belongs to the French group of companies SOKA and was opened in 2014, is developing, in particular, the Zhezheliv deposit near Koziatyn. The uniqueness of the enterprise lies in the fact that the plant produces kaolin from raw materials obtained from more than one field, using the method of selective production and combination of different types of raw materials. It's production is 40,000 tons of enriched kaolin per year, 80% of which is exported to different countries of the world. The plant's products are used as raw materials for the production of plumbing, ceramic tile, porcelain, mineral fillers, facing bricks and mixes for construction.

Class B Group I is represented in the Podillia first of all by deposits of rocks facing from magmatic rocks: granites, granodiorites, labradorites, gabbro, etc., which are not marked by complexing properties, but have the high quality of raw materials and significant export potential. In total, 5 deposits of facing stones from magmatic rocks have been explored in Podillia, 4 deposits of which are being developed in the Vinnytsia region. Here, as facing stones, reserves of gray, biotite-cordierite, medium- and coarse-grained, porphyry-shaped grenades, medium in granite decorative qualities are used. The largest deposit is Zhezheliv.

The same class includes the large Burtyn deposit of graphite (Khmelnytskyi region), which is not being developed. Approved ore reserves amount to 113390 thousand tons (Korpan et al., 2018). The content of graphite in the ore is close to similar indicators in the Zavalla deposit and makes 6,3%. According to the geological-industrial estimation, the Burtyn deposit is considered to be a real raw material base of a new cost-effective enterprise.

Podnistrovsky seam flints (Grinchutsk deposit) belong to the first group because of their uniqueness. In chemical composition and physical and mechanical properties, it is a valuable natural raw material for the production of grinding balls and lining plates, which are widely used in porcelain and earthenware and other industries. Till the present time, they were the only natural supplier of raw materials to the UIC countries. Reserves of flints are quite considerable (2800 thousand tons), now they are not being developed.

The second group includes several types of minerals with realized activity (Table 1). Thus, cement b (limestone, clay, gypsum), which is extracted only in the Khmelnytskyi region, is included in Class B, but the balance of raw materials is also known in the Ternopil and Vinnytsia regions. Based on these deposits, Kamianets-Podilsk- Chemerovetsky Mining Unit (Syvyi, 2004) was formed, which is based on some mining enterprises producing products for the construction industry and several enterprises consuming mineral resources. Within the industrial site, there is a powerful cement plant (OJSC Podilsky Cement), which uses the raw materials of a large complex of the Gumenets deposit (limestones, clays). Besides, several sugar plants about a dozen small brick plants the Zakypnyansky Compound Feed Factory (the latter being a potential consumer of limestone for feed applications not currently under development), and Kamyanets-Podilsk Asphalt Concrete Plant operates here.

Recently, the Portuguese firm "C + PA - Cimentos e Produtos Associados, S.A." has expressed interest in the construction of a cement plant with an annual capacity of 1 million tons in Vinnytsia region. It was planned to use Riv and Tartak deposits as raw materials.

"Knauf Gypsum Rock" LLC extracts gypsum stone in the Shyshkivtsi quarry near Borshchiv, Ternopil region. Now a mining plant, a crushing and sorting section, a warehouse and a section for loading wagons with raw materials have been built based on the quarry. Products (gypsum and anhydrite) are shipped to the Knauf Gypsum Kyiv enterprise, partly exported to Belarus, Lithuania, Moldova. The explored volumes

of gypsum in the Shyshkivtsi deposit amount to more than 10 million tons, estimated resources — 70–80 million tons. The design capacity of the mining enterprise is 500 thousand tons of gypsum stone per year. In the Khmelnytskyi region Kudrynetske-1– the only field is being developed. Raw materials deposit is being developed. It is a single deposit suitable for obtaining gypsum of the first grade. The reserves amount to 1146,1 thousand tons. Gypsum stone is used by the porcelain and faience and cement industry, and also is going to produce gypsum blocks and gypsum boards.

The second group includes the fields, which are now actively exploited. First of all, it is mainly construction materials: stones made of magmatic and sedimentary rocks, brick-tile raw materials, dolomites, etc. Construction stone deposits (granites, granodiorites, chemokines, sandstones, limestones) are used for production of rubble stone and scree are widespread throughout the Podolsk region (187 deposits, 85 of which are now under development (Korpan et al., 2018)). This class also includes dolomites of the Korzhiv deposit in the Ternopil region, which are developed not only for the needs of the local construction and glass industry but also as flux raw material for metallurgy (after the loss of flux dolomite deposits in the occupied territory of Donbas). For the same reasons, the limestone of Novosilkivka and Maksymivka fields is shipped to metallurgy, which is listed on the balance sheet as raw materials for sugar-making and lime.

Different types of mineral waters, brought by us to group II (Class B) are characterized by the insufficient level of development of specific components (bromine, sodium chloride brines, siliceous, etc.), some types of agrochemical raw materials (Table 1). For example, in Khmelnytskyi, bromine waters are installed at two fields together with the Naftusia waters (Zbruchansk and Zaichykiv), they also form a separate field - Kamianets-Podilsk, which were met at the Naftusia water type in the Ternopil region. They are used in small quantities. The Mirgorod-type waters are used in the Makiv and Bronnytsky deposits for healing and at Theophipil – as drinking bottled water. Several mineral water deposits of various types (Naftusia, Krainsk, Kyshyniv, Makhachkala, Regina, Moscow, Izhevsk, etc.) are recommended by specialists for the establishment of drinking resorts r bottled water plants on their basis but are currently in operation.

A small mining site (Slavuta) was formed in the northern regions of Khmelnytskyi based on very densely concentrated sand deposits for silicate products, deposits of cement raw materials (Kryvyn deposit of clays) and deposits of saponites, agrochemical raw materials. Sand fields are being developed quite intensively here, saponites are exploited in small quantities.

Gluconate-raw material deposits for complex mineral fertilizers, feed additives and ameliorates are also distinguished by the average complex-forming properties. Significant reserves of Adamiv and Karachyivsk deposits have been explored in the Vinkovetsk district of the Khmelnytskyi region, fully prepared for operation, placed compactly and may become the basis of a small mining center shortly.

The Class B of the second group (subgroup «b») includes deposits of mineral resources, which are currently characterized by a certain unrealized potential (drinking water, saw stones, etc.). So, for example, deposits of saw limestones, which are concentrated mainly in Vinnytsia region and are characterized by significant industrial reserves (more than 12 million tons), are operated in very small volumes (2,3 thousand tons - production at 3 fields, which are currently being developed) (Korpan et al., 2018). Sands for silicate products are developed only at 3 fields with 9 explored with industrial reserves and scarcity of raw materials in the region. The same applies to sands, which are used as lightweight concrete fillers.

Class B of the same group includes deposits of several minerals that are not currently being developed (Table 1). These include the balance reserves of such strategic, in our view, minerals as fluorine, apatite, and phosphorites. The only Bakhtin deposit of Podolia of the fine spar is prepared for the exploitation with industrial supply of more than 4 million tons of ore.The total content of useful components (35-38%) and indicators of the cost of extraction and enrichment of Bakhtin ore are not inferior to fluorite ores, which are being developed in the USA, France and other countries of the world. The deposit is considered to be complex (except for fluorite, two feldspar and quartz concentrates are expected to be produced). The feasibility conditions for the possible development of the deposit can be improved by bringing into operation promising forecast resources of categories P_1 and P_2 (several tens of million tons with CaF_2 content of 11,9-17,0%) estimated at sites near Bakhtin deposit (Syvyi et al., 2013). It should be noted that all Ukrainian enterprises - consumers of smelter (metallurgical plants, shipbuilding, and aluminum enterprises) work on imported raw materials.

Apatite ores in the Podillia are represented only by ore manifestations. In particular, in the Letychivsk district of the Khmelnytsky region, prospective manifestations of apatite ores with estimated resources of 30 million tons of P_2O_5 were identified

within the limits of the Goloskivsky apatitonous area. Projections of ore resources in the Vinnytsia region are estimated at tens of million tons. Phosphate ores have been thoroughly developed only in two deposits - Zhvanivsk and Verbsk, in the middle of Zozulynske and Faschiivka deposits in the Khmelnytskyi region ith the forcasted resources of over 93 million tons of ore (Korpan et al., 2018). Chalk-like phosphate limestones of the Khmelnytskyi and Vinnytsia Podnistrov region may be perspective for the use as a complex agro-ore (phosphorite and limestone flour) with estimated resources of about 16 million tons.

The region's deficiencies are claydite, abrasive raw materials (garnets), bentonite clays (Class C), reserves of which are detected in the region but are not being developed. The situation is similar to peat deposits, which total balance reserves in the Podillia exceed 200 million tons, and production is actually stopped at all the deposits. The Slobidka deposit of garnet with reserves of 673 thousand tons with an average mineral content in granites – 15-18% is, which is explored in detail is another example in the Kalynivka district of Vinnytsia region. A large Ivaniv deposit of garnet-biotite granites is being developed for rubble near the Slobidka deposit in the same area. The content of garnet in the granites of the deposit is about 27%, the reserves of rocks are estimated at 25 million tons (for example, in the USA, the garnet is extracted from rocks with a content of more than 8-10%). Garnet of both fields is homogeneous pyrop-almandine. The micro hardness of the garnets is 1400-1500 kg / mm^2, the full abrasive ability against monocorundum is 45-52%, the initial one is 81-87%. At the Ivaniv deposit, garnet is present mainly in 2-5 mm grains, and the content rocks (granites) are composed of feldspar and quartz with a small admixture of other minerals, which facilitates the extraction of garnet concentrate and allows most of the waste after enrichment to be used as quartz-feldspar glass industry. It has also been found that garnet concentrate from the Ivanovo deposit is not inferior in quality to foreign analogs (Syvyi, 2004). Some types of raw materials have not yet been explored for various reasons: minor reserves (native sulfur, bentonite clays); lack of consumers (trembling, etc.); lack of investment (pelicanites, onyx marble, etc.), environmental problems (sand and gravel mixtures).

Local raw materials (Group III) are represented mainly in the region by construction materials and ameliorates, with the former (sands for construction, loam, sandy loam, etc.) being intensively exploited, while the last one is not being developed due to lack of demand.

Conclusions. Thus, functional typification of mineral resources of Podillia reveals their following features: a) in Podillia mineral species with low complex-forming properties predominate; b) there are some minerals (mainly mineral waters) where on their basis the large recreational complexes are formed. The last ones are currently formed and have great prospects for expanding and complicating the functional structure in the future; c) there is a number of types of raw materials that can serve (and serve) as a basis for the formation of small territorial-industrial complexes belonging to the mineral raw field of activity (kaoline, mineral waters of certain types, cement raw materials, brown coal, agrochemical raw materials); d) the region as a whole has a small amount of mineral resource of international importance with significant export potential. First of all, they are the rich deposits of primary kaoline, graphite, mineral waters, facing stones; e) most types of mineral resources of the region are of national importance; f) the realized activity (or degree of development) of the existing mineral resources (including raw materials of strategic, international and national importance) is generally insufficient - the whole number of deposits of scarce types of raw materials are not currently being developed or exploited for minor reasons. (insufficient study, inventory depletion, lack of investment, environmental factors, etc.); g) development in perspective of valuable raw materials explored in the region, especially agrochemical and technological ones, makes it possible to expect the formation of small mining centers and units of mineral resources at their base, which will positively affect the overall structure of the industrial complex of the region, provide localities and job creation; h) investments in geological prospecting in the territory of the region should help to identify and increase reserves of raw materials with high complex-forming properties, which are almost completely devoid of land, prospecting and exploration of fuel and energy raw materials, new valuable deposits of mineral ornamental materials, agrochemical stones and technological raw materials; i) the expansion of the list of local mineral resources, where the exploitation was being performed under the simplified permitting procedures, would encourage the interest of local communities to make investments into their development.

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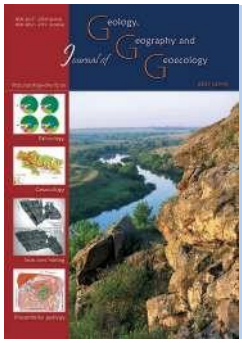

JOURNAL of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(4), 769–777.
doi: 10.15421/111972

Oleh A. Ulytsky, Viktor M. Yermakov, Oksana V. Lunova, Katherine E. Boiko, Dmytro G. Averin. Journ. Geol. Geograph. Geoecology, 28(4), 769–777.

Assessment of environmental risk of groundwater quality deterioration within Siversky Donets river basin

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Received: 07.05.2019
Received in revised form: 30.05.2019
Accepted: 04.12.2019

Abstract. An adaptation of the national water resources management system in accordance with the requirements of European legislation creates the legislative basis for reforms implementation in the field of monitoring and water use. The basin management principle started to be applied, according to which surface and groundwater arrays are the water resources management units. The preliminary groundwater array status assessment (both quantitative and qualitative) is a necessary procedure that enforces the development of appropriate monitoring program and measures elaboration in order to improve groundwater ecological status. This study tested a methodology of groundwater deterioration risk assessment as a tool for previous groundwater array cological status estimation. The research provides an approbation of the methodology in relation to groundwater arrays identified and delineated within Siversky Donets river basin (that covers Kharkiv, Donetsk and Lugansk regions). Surface water and groundwater are affected by significant anthropogenic pressures in form of pollution from point sources of heavy industry facilities. A risk model comprises groundwater vulnerability map and simulated model of anthropogenic pressure magnitude distribution reflecting the impact extent of the main sources of groundwater pollution. Vulnerability map was developed using the tool of input factors weight index estimation. Authors considered the following factors as determining – soils characteristic, aeration zone characteristics, geological environment of groundwater arrays of Cenozoic-Mesozoic group. The pollution load index was calculated. Input data for calculation are concentrations of hazardous substances (metals, semimetals, halogens and nitrates and phenol compounds) measured in groundwater samples during the 2017 monitoring year period. The results of the value interpolation of calculated pollution load index reproduce the focal (point) nature of groundwater pollution and indicates the significant groundwater pollution of Quaternary and Upper Cretaceous, both Carboniferous aquifers and corresponding groundwater arrays. A logical matrix is created on the basis of a combination of pressure magnitudes and vulnerability classes. The area of each class of risk is calculated within groundwater arrays with zonal statistic technique. Consequently, each groundwater array is assigned with preliminary estimated risk category. Created model enables to perform previous groundwater array status assessment. The proposed model expected to be more useful after the data on pollution from diffuse sources obtaining and its validation after the first stage of surveillance monitoring realization.

Keywords: groundwater body, ecological status, vulnerability, pollution load index, risk of pollution

Оцінка екологічного ризику погіршення якісного стану підземних вод у межах басейну р. Сіверський Донець

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Анотація. Адаптація національної системи управління водними ресурсами відповідно до вимог європейського законодавства створює основу для впровадження реформ у сфері моніторингу та водокористування. Здійснено перехід до басейнового принципу управління, згідно із яким, одиницями управління водними ресурсами є масиви поверхневих та підземних вод. Попередня оцінка статусу (якісного та кількісного) масиву підземних вод є необхідною процедурою перед розробкою та впровадженням моніторингу та заходів щодо покращення екологічного статусу підземних вод. У якості інструменту попередньої оцінки екологічного статусу масивів підземних вод запропоновано методику оцінки екологічного ризику погіршення якісного стану підземних вод. Оцінку здійснено для масивів підземних вод, виділених у межах річкового басейну Сіверського Дінця. З метою створення оціночно-ризикової моделі побудовано картографічну модель уразливості підземних вод до забруднення та створено модель розподілу амплітуди антропогенних навантажень, що відображає міру впливу основних об'єктів забруднення підземних вод. Модель уразливості побудовано із використанням індексної оцінки вхідних критеріїв, серед яких використано

– характеристику ґрунтового покриву, зони аерації, геологічного середовища масивів підземних вод кайнозойсько-мезозойської групи. Здійснено розрахунок індексу навантаження від забруднення. У якості вхідних даних для розрахунку використано концентрації небезпечних компонентів I та II класу небезпеки (металів, напівметалів, халькогенів), виявлені у пробах води. Результати інтерполяції розрахованих значень індексу навантаження від забруднення відтворюють вогнищеву (точкову) картину поширення забруднення у підземних водах алювіальних четвертинних та верхньокрейдових водоносних горизонтів у межах досліджуваної території. Створено логічну матрицю на основі поєднання амплітуд антропогенного тиску від забруднення із класами уразливості підземних вод. Створена модель оцінки екологічного ризику дозволяє попередньо віднести кожний масив підземних вод до відповідного класу ризику досягнення екологічних цілей.

Ключові слова: масив підземних вод, екологічний статус, уразливість, індекс навантаження від забруднення, екологічний ризик забруднення

Introduction. The process of Ukrainian legislative framework transition to the European-oriented direction of development creates necessary background for current and further reforming of all spheres of human activity. In particular, since the Association Agreement document between Ukraine and EU countries was signed and ratified in 2014, significant change has occurred to environmental management and protection policy. A series of legislative acts, documents and acts that regulate the basic principles of water resources management in accordance with the Water Framework Directive 2000/60 (European Commission, 2000), have been developed and implemented.

The Law of Ukraine (dated October, 2016) No. 1641 – VIII "On Amendments to Certain Legislative Acts of Ukraine on Implementation of Integrated Approaches in the Management of Water Resources Based on the Basin Principle" introduces the legal basis and sets new prerequisites for water management system reforming by cancellation the territorial principle and adoption the river basin management, where the river basin serves as a management unit for all water resources, including groundwater. As a result of mentioned law implementation the Water Code of Ukraine (1995), was amended. There have been important developments associated with new water management units' definitions – surface and groundwater arrays, as well as water resources management core provision according to the ecological objectives, required and established by European legislation, - good ecological status (both quantitative and qualitative) achievement for all water arrays (surface and groundwater).

The new groundwater resources management concept (in conformity with updated water legislation) focuses on the cycle of strategies and measures adoption, launched from the groundwater array identification and delineation procedure and expired by groundwater array status assessment (good or bad) and further appropriate measures development, aimed in groundwater array state restoration, if necessary. It is clear, that the status assessment reliability substantially depends on the appropriately and optimally designed monitoring program (Shestopalov, 2016; Davybida, 2018).

However, it is also important to recognize the role of the risk assessment phase of ecological objectives achievement failure in groundwater management structure, including the data and information preparation in order to develop monitoring network and monitoring program. In accordance with the new Procedure of state water monitoring (The order of Cabinet of Ministers of Ukraine, dated 19.09.2018, No. 758) statements, the development of a monitoring program is preceded by a procedure of identification of anthropogenic impact that can influence on groundwater quantitative and qualitative status. Actually, following the European experience – first cycle of surveillance monitoring focuses on actual targets emerged from preliminary performed risk assessment (European Commission, 2003). To date, however, the methodology of groundwater risk assessment that meets the requirements of European water legislation as well as reformed Ukrainian environmental legislation, has not been developed (Dovhanenko, 2017). Therefore, it should be expected that he first stage of groundwater state monitoring realization, in accordance with the reformed procedure, which will be organized in coming years for the Dnipro River basin, the Siversky Donets River Basin and the Dniester River basin, will probably produce a lot of methodological uncertainties while groundwater array status assignment.

Some concepts and methodological bases for environmental risk assessment, presented in the article and proposed by the authors, were carried out within the framework of the project "Assistance to the Ministry of Ecology and Natural Resources of Ukraine in improving the mechanisms of environmental monitoring" of the OSCE in Ukraine (Denisov, 2018, Ulytsky, 2018) .

Material and Methods. *Study Site Description.* The research provides an approbation of the methodology for groundwater pollution risk assessment in groundwater arrays, delineated within Siversky Donets river basin. The river basin territory (comprising a part of Kharkiv and Donetsk regions, and Luhansk region

entirely) is characterized by rich fuel and energy, mineral and raw material resources base, and, as a result, by high concentrations of facilities of heavy industry sector. The man-made impact in study region is the highest compared to the other regions of Ukraine, so the objects of critical infrastructure creates the environmental risk. During the entire period of human activity, surface and ground waters, increasingly, were exposed to impacts and negative effects.

The study proposes to estimate preliminary groundwater array status in terms of qualitative status criteria.

Groundwater arrays within Siversky Donets river basin area were identified and delineated following the requirements specified by the "Methodology for surface and groundwater arrays identification" (The Order of the MENR, 2019): groundwater array should be identified as a part of aquifer if it contains significant volume of water enabling to supply drinking water abstraction average rates in 10 m^3 per day; as a part of aquifer contoured by contamination borders, detected with previous monitoring data; and/or as a part of aquifer contoured by the poor quality groundwater flow boundaries in case it causes or can provoke significant deterioration of surface water and terrestrial ecosystems or underlying aquifers.

Spatial boundaries (horizontal dimension) of groundwater arrays respond to groundwater flow boundary settings, including hydrogeological and geological natural boundaries.

Three-dimensional delineation preformed based on three geological structural floors understanding. So, identified groundwater arrays refer to Cenozoic, Mesozoic and Paleozoic aquifers systems.

Thus, as a result of hydrogeological conditions analysis and mentioned above criteria application, groundwater arrays within Siversky Donets catchment area were identified and delineated (Table 1).

The analysis of groundwater array delineation outcomes within site area demonstrates that the largest number of groundwater array was identified and delineated in Cretaceous and Paleogene-Neogene system aquifers and aquifer complexes. Such an uneven division is based on exploitation value and significance of mentioned aquifers in sense of drinking water supply. Accordingly, these groundwater array requires application of appropriate ecological objectives with increased demands. The poor quality status of groundwater in Quaternary and Carboniferous aquifers, in turn, needs aquifers to be delineated into greater number of groundwater array, assuming and taking in the mind the necessity for further developing of operational monitoring program and measures in order to improve groundwater quality.

Anthropogenic pressure on groundwater quality within the Siversky Donets river basin is carried

Table 1. Groundwater arrays (GWA) identified and delineated within Siversky Donets river basin catchment area

GWA name	Aquifer environment	Number of GWA
GWAs in alluvial quaternary deposits (a,adH, $a^{1\text{-}5}P_{II\text{-}III}$, $a^{6\text{-}10}$,laP$_I$)	Irregular coarse sands with clay layers, sandy loams	8
GWAs in alluvial deposits of Pliocene terraces (aN_2)	Browish gray, gray and yellow clayey irregular coarse sands	1
GWAs in Paleogene and Neogene formations (P$_{2\text{-}3}$+N_1, P$_2$kv-P$_3$hr+N_1, P$_2$kn-bč, N_1pn)	Irregular coarse sands, sandstones, loams	5
GWAs in Cretaceous system deposits (K_2, $K_{1—2}$s)	Marls, sandstones, irregular coarse sands, chalk	12
GWAs in Jurassic system deposits and complexes (J_3, J_{3km}, J_{3ox}, J_2)	Sands, sandstones, limestones	2
GWAs in Triassic system deposits (T_3, $T_{1\text{-}2sr}$, T_{1dr})	Irregular coarse sands, sandstones	2
GWAs in Permian system deposits (P_1)	Sandstones with layers of mudstones, aleurolites, limestones and dolomites	1
GWAs in sandy-clayey deposits of carboniferous system (C_1-C_3)	Sandstones with layers of mudstones, aleurolites and thin layers of limestones and coals	3
	Total	**34**

out by point and diffuse sources. Main source of **diffuse** pollution is agriculture (in form of agricultural wastes) and urban land use (in the form of urban drainage from surface, including runoff and snow-melt). Groundwater quality deterioration happens because of contamination by nitrogen compounds - NO_3 and NH_4. Chemical composition data analysis for the 2017 monitoring year period demonstrated significant excess of ammonium TV (2,6 mg·L^{-1}) in groundwater of Quaternary and Upper Cretaceous aquifers located on the territory of Lugansk region (Krasna river, Bila river, Derkul river).

The screening procedure for relevant anthropogenic pressures and impacts on groundwater quality within basin area indicated significant role of point sources. Screening sources of anthropogenic loading on groundwater status within the basin indicates the significant impact of **point** sources of pollution. Powerful petrochemical, metallurgical, machine-building, facilities, as well as coal industry objects are concentrated on the territory of Siversky Donets river basin. So, the largest amount (compared to the whole territory of Ukraine) of sludge collectors and tailing ponds, industrial discharges tanks, dumping ground for solid household waste and rubbish heaps are situated here. Polluted wastewater produced by the coal, chemical and petrochemical industry, iron and steel industry, as well as household wastewater, according to preliminary estimates, is the main source of regional pollution not only of surface water but also of groundwater due to contaminants transport by filtration.

Particular attention should be paid to the impact analysis of the objects of high ecological hazard and critical infrastructure - coal mines – and their influence on groundwater quality and associated ecosystems status. In the current circumstances there has been a massive mines flooding. In future, it can probably cause such negative processes as land flooding, subsidence, as well as groundwater chemical state deterioration within territories adjacent to mine workings.

The risk assessment of groundwater quality deterioration aims to establish causal links between certain anthropogenic pressures (that can takes the form of pollution load) and corresponding impact on the environment and human health. For groundwater, the ecological risk assessment procedure should be based on analysis of the pollution sources, pollution pathways susceptibility (in form of groundwater vulnerability) regarding to aquifer and groundwater as a receptor.

In fact, the method of groundwater vulnerability estimation, as European (Voudouris, 2018) and national experience has shown (Koshljakov, 2014; Levonjuk, 2018), is limited to two possible approaches:

- direct estimation – based on groundwater array chemical status monitoring, as well as on certain contaminants' residence time calculation while reaching aquifer, taking into account the protective properties of water-bearing and low-permeable geological complexes and also physic-chemical contaminants properties.
- indirect estimation – based on the pollution load calculation combining aquifer vulnerability assessment.

In this study, the groundwater pollution risk assessment is based on a combination of cartographic models of vulnerability and the magnitude of anthropogenic pressure (Kozłowski, 2019):

Risk = Vulnerability + Pressure Load Magnitude

Groundwater vulnerability assessment

The pathway susceptibility can be defined with the same characteristics as aquifer vulnerability – the sensitivity of groundwater system to anthropogenic loads. At the same time, vulnerability value is inversely proportional to the value of groundwater protection level, which demonstrates the lithologic-filtration protective ability of the geological entire settings.

The approach of groundwater vulnerability cartographic model obtaining is a reflection of the DRASTIC model, built on the input factors index estimation method as a tool (Jang, 2017). The DRASTIC method, developed by experts from the US Environmental Protection Agency (Aller, 1987), has been widely used in Europe for recent years as a tool for groundwater vulnerability to pollution mapping. Groundwater vulnerability map is the result of overlay analysis of the layers characterizing input factors' values distribution (1) and the further division of the resulting surface of obtained total vulnerability index into classes. Each layer is divided into classes according to the rule of natural breakdown, a weight coefficient is given to each class.

$$DRASTIC\ Index = D_r \times D_w + R_r \times R_w + A_r \times A_w + S_r \times S_w + T_r \times T_w + I_r \times I_w + C_r \times C_w, \quad (1),$$

where *DRASTIC Index* – the resulting vulnerability map (computed surface of the total vulnerability index distribution); D - distribution layer of the ground water bedding level value; R - distribution level of the infiltration recharge value;

A – layer, that demonstrates the aquifer environment characteristics' distribution (sands, limestones, etc.); S – layer, that demonstrates soil types distribution; T - layer of the relief slope value distribution; I – layer, that demonstrates aeration zone characteristics' distribution; C – layer of hydraulic conductivity value distribution; r - parameter class; w - is the weighting coefficient for each parameter.

Pollution load index and pressure load magnitude calculationz

Taking into account that the main source of groundwater pollution within the Siversky Donets river basin are industrial facilities it was decided to perform the pollution load estimation basically on data analysis comprising concentration estimation of components of the 1st and 2d hazard classes in groundwater samples. The list of components includes - metals (Be, Cd, Hg, Co, Ni, Cu, Zn, Pb, Mo, Sr, Cr, Li), Chalcogen (Se), Halogens (Br), Semimetals (B). The analysis showed that in the vast majority of water samples the content of harmful components (each individually) does not exceed the maximum permissible concentrations determined by the sanitary norms for drinking water.

The analysis showed that in majority of water samples, the content of harmful components (individually for each component) does not exceed the TV concentrations determined by the sanitary norms for drinking water in Ukraine (Derivative Sanitary Norms and Rules document 2.2.4-171-10). Instead, in some water samples there is a wide range of components of the 1st and 2d hazard classes, although sometimes they are contained at low concentrations. Therefore, in order to assess the groundwater resistance in certain groups of chemical elements accumulation (Sobhanardakani, 2016; Bhutiani, 2017), the pollution load index (2) was used:

$$PLI = (CF_i \times CF_{i+1} \times \dots CF_n)^{1/n}, \quad (2),$$

where *PLI* – pollution load index;

CF_i – index of contamination by a certain substance;

n – the amount of hazardous substances identified in the water sample.

Index of contamination by a certain substance, identified in the water sample, is calculated by the equation (3):

$$CF_i = \frac{CA}{CN} - 1, \quad (3),$$

where *CA* – the estimated value of the hazardous substance;

CN – standard value of hazardous substance in drinking water sample (TV established by national standards).

Even if concentrations of hazardous substances in groundwater sample do not exceed the established TV, the value of pollution load index, which is always > 0, matches the presence of dangerous compounds with an appropriate distribution of concentrations.

In order to calculate the pollution load index, indicators of the maximum allowable concentrations (TV analogue in Europe) determined by the sanitary standards for drinking water (Table 2) were used.

Table 2. TV of compounds, used for PLI calculation under the study

Substance	TV, mcg·L^{-1}
Br	200
B	500
Cd	1
Zn	1000
Ni	20
As	10
Pb	10
Li	30
Cu	1000

In the course of the study, chemical composition data of water samples of the Mesozoic-Cenozoic groundwater aquifers of 2017 year were processed. Further, Kriging interpolation method was applied to each section of well-grouping with calculated pollution load index in order to obtain a simulation of index distribution. Accounting for the study specification, this method is more appropriate, since applying kriging assumes that the distance between the reference points reflects the spatial correlation that can be used to explain the change on the surface. The resulting interpolation surfaces are combined into one for further analysis.

Results and discussion. Based on the DRASTIC index tool applying, a map of groundwater vulnerability the most closed to the surface unconfined and partly confined aquifers was exposed. As an input criterion for vulnerability model constructing the preliminarily prepared reclassified surfaces (layers) of factors were used. Input layers describe slopes of relief, soil permeability (expressed by reclassified layer of soils mechanical composition), the distribution of rainfall values, recharge zones characteristics, aeration zone thickness values' distribution. The assignment of weight coefficient to each of the input factors was based on the analysis of the hydrogeological and geological conditions of the study area (Table 3).

Table 3. Initial parameters for building the vulnerability model

Input factor	Weight
Slope	1
Soils mechanical composition	2
Rainfall	4
Recharge zones	2
Vadoze zone thikness	5

The resulting vulnerability model built for groundwater in Cenozoic-Mesozoic aquifers is divided into 5 classes: of very low, low, medium, high and extremely high vulnerability (Fig. 1).

As a result of the application of equation (2), the pollution load index for groundwater in the Cenozoic and Mesozoic sediments was calculated (Table 4).

Additionally, pollution load indexes from phenols and nitrates in Cenozoic aquifers (and corresponding groundwater arrays were analyzed, calculated and mapped as a separate layer.

As a result of pollution load index calculating and the corresponding cartographic surfaces modeling, we found out that groundwater contamination has a focal nature and very accurately reflects the behavior of receptors in the system "Ground waters – inter-layer waters". For this reason, as well as due to the lack of input monitoring information on the groun-water chemical composition, it was decided to use the resulting surface of the pollution load index distribution as the basis for characterizing the magni-tude of anthropogenic pressure (Table 5).

Table 4. Concentration values of substances (in mcg·L^{-1}) identified in water samples from Cretaceous aquifers within Siversy Donets river basin and calculated value of pollution load index

Sample No.	Br	B	Cd	Zn	Ni	As	Pb	Li	Cu	**PLI**
1	300	-	-	-	-	-	-	-	-	**1.5**
2	-	-	2	-	-	-	-	-	-	**2.0**
3	0.95	0.40	-	-	-	-	-	-	-	**0.0019**
4	0.95	0.28	-	-	-	-	-	-	-	**0.0016**
5	0.63	0.40	-	-	-	-	-	-	-	**0.0025**
6	-	-	-	0.05	0.01	-	0.02	-	-	**0.0036**
7	1.37	0.37	-	-	-	-	-	-	-	**0.002251**
8	0.21	0.28	-	-	-	-	-	-	-	**0.000767**
9	0.20	0.36	-	-	-	-	-	-	-	**0.000849**
10	0.20	0.50	-	-	-	-	-	-	-	**0.001**
11	0.20	0.36	-	-	-	-	-	-	-	**0.000849**
12	0.20	0.19	-	-	-	-	-	-	-	**0.000616**
13	0.20	0.10	-	-	-	-	-	-	-	**0.000447**
14	0.42	0.28	-	-	-	-	-	-	-	**0.001084**
15	0.42	0.24	-	-	-	-	-	-	-	**0.001004**
16	0.84	0.90	-	-	-	-	-	-	-	**0.00275**
17	0.20	0.44	-	25	-	-	-	0.008	-	**0.001556**
19	2.53	0.56	-	-	-	-	-	-	-	**0.002381**
20	0.63	0.85	-	-	-	-	-	-	-	**0.01464**
22	-	-	-	0.012	-	-	-	-	-	**0.000012**
23	0.20	0.05	-	7	-	-	-	0.016	-	**0.000782**
25	0.32	0.40	-	23	-	-	-	0.016	-	**0.001991**
28	0.20	0.86	-	20	-	-	0.005	-	-	**0.001547**
29	-	-	-	0.413	-	-	-	-	-	**0.000413**
33	410	200	-	-	-	-	-	-	-	**0.905539**
40	-	-	-	0.06	-	-	-	-	-	**0.00006**
41	-	-	-	10	-	-	-	-	-	**0.01**
43	-	-	-	0.04	-	-	-	-	-	**0.00004**
44	3.38	0.32	-	-	-	-	-	-	-	**0.003289**
45	1.27	0.19	-	-	-	-	-	-	-	**0.001553**
47	200	100	-	-	-	-	-	-	-	**0.4472**
48	0.001	-	-	-	-	0,005	0.01	-	0.005	**0.0000059**

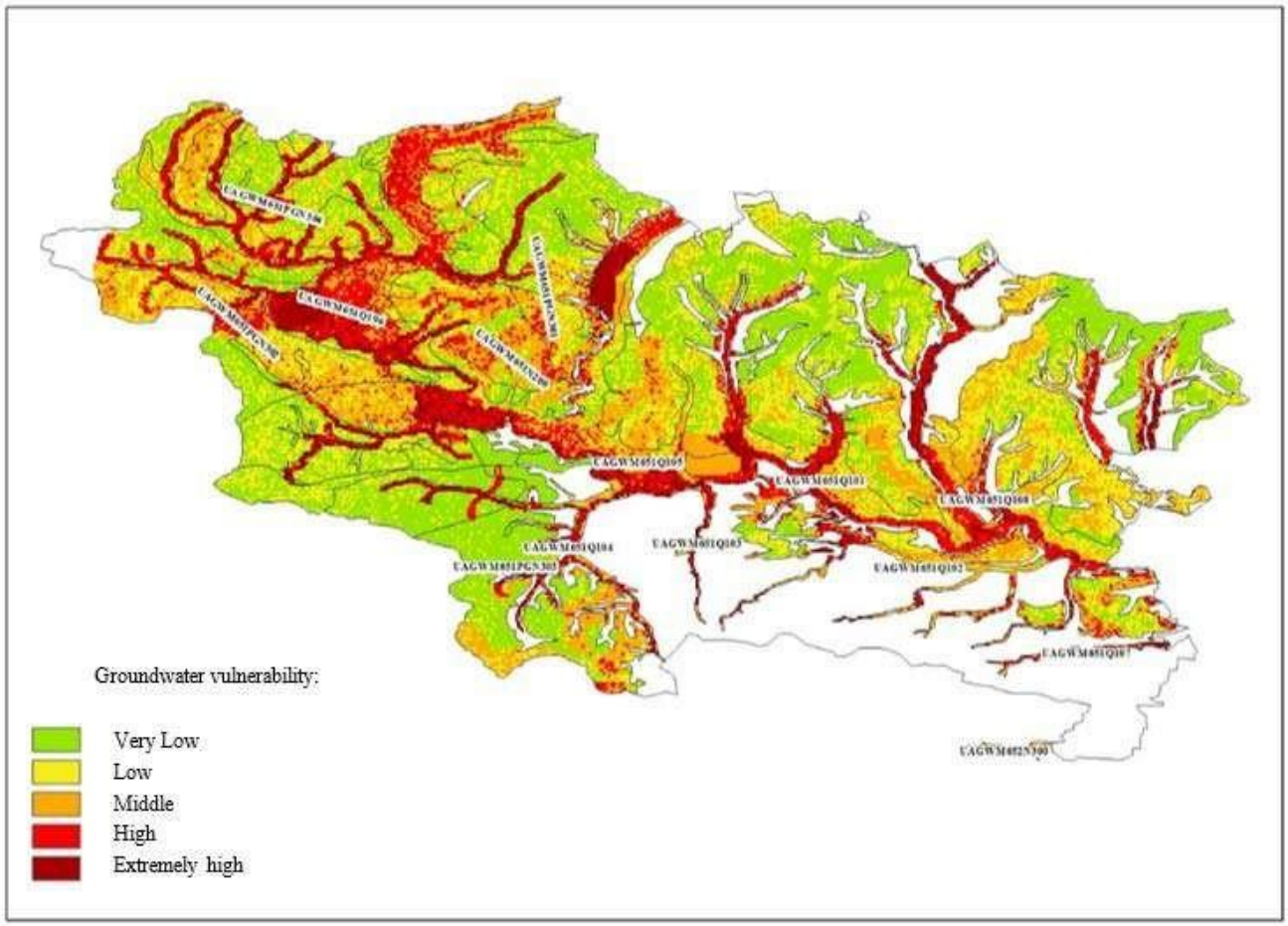

Fig. 1. Mapping model of Cenozoic-Mesozoic aquifers vulnerability within Siversy Donets river basin

Table 5. Anthropogenic pressure magnitude classes and corresponding ranges of pollution load index values

A range of calculated PLI values	Pressure Magnitude
0-0.2	Very low
0.2-0.8	Low
0.8-1	Middle
1-3	High
3-7	Extremely high

In order to build a model of risk assessment, the logical matrix of pollution risk classes developed based on vulnerability classes and anthropogenic load magnitudes combination (Table 6).

As a result of zonal statistics application, the area of each class of risk is calculated within groundwater arrays. A preliminary assessment of the groundwater array status is carried out on the basis of the predominant risk class according to the area criteria.

Conclusion. The risk of groundwater chemical status deterioration assessment referring to the new objects of water management system – groundwater arrays – was performed for the first time. It reflects the development of current negative phenomena affecting the groundwater status within the studied region. Validation of the performed estimation and calibration of the input parameters of the estimation-risk model seems to be feasible after the first stage of surveillance monitoring (that meets the requirements

Table 6. The matrix for groundwater pollution risk assessment

Pressure Magnitude	Vulnerability of ground waters				
	Extremely High	High	Middle	Low	Very Low
Extremely High	EH	EH	H	H	M
High	EH	H	H	M	L
Middle	H	H	M	M	L
Low	M	M	M	L	L
Very Low	L	L	L	L	VL

of updated State Water Monitoring Procedure) and obtained data analysis.

The calculated model, proposed under the study, and its application enables to make a preliminary pollution risk assessment for each groundwater array and, accordingly, to adjust the monitoring program. It has been established that the highest risk level (in grades "high" and "extremely high") is set for groundwater arrays in Quaternary and Upper Cretaceous aquifer systems, identified within Siversky Donets river basin catchment area. Also, according to the results of risk assessment, the poor quality status of groundwater arrays in Carboniferous aquifers was identified. However, the further groundwater vulnerability within Carboniferous aquifer system model elaboration is a subject of detailed and in-depth research.

The proposed methodology for risk assessment is based on the grounwater vulnerability model building combining the direct anthropogenic pressure magnitude calculation. Groundwater vulnerability model consists of input parameters weight index estimation and adopted for applying at following stages of groundwater resources management cycle as a screening tool for operational assessment of relative magnitude of other types of anthropogenic pressures (for example, from diffuse sources of groundwater pollution with nutrients, ammonium compounds and nitrate pollution from agricultural sources). Methodology can also be used for preliminary groundwater array status assessment. The possibility of the integrated consideration of proposed vulnerability model with direct characteristics of contamination behavior (migration properties) released from diffuse sources requires further detail investigations.

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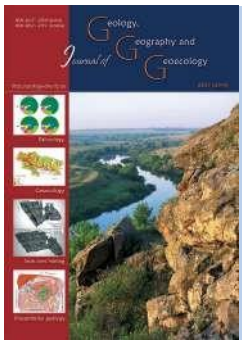

JOURNAL of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(4), 778–794.
doi: 10.15421/111973

Natalia V. Voroshylova, Valentina I. Chorna. Journ. Geol. Geograph. Geoecology, 28(4), 778–794.

Lithoecotopes and Vegetation on Dumps of the Central Mining and Ore Enrichment Combine (the central zone of Kryvbass)

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Received: 30.05.2019
Received in revised form: 14.07.2019
Accepted: 19.11.2019

Abstract. In the article, characteristics of development of vegetation communities under conditions of mine rock dumps of the Central Mining and Ore Enrichment Combine or their rocky components (lithoecotopes) were determined, namely only lithophilic vegetation. We classified various lithoecotopes and characterized vegetation communities of varying complexity growing on plateau tops, terraces and slopes, depending on specifics of their constituent rocks and typological features. In accordance with the state of lithoecotopes, including all typological characteristics and the geochemical nature of the rocks, plant lithophilic communities growing on the dumps of the Central Mining and Ore Enrichment Combine, were characterized by significant differences in analytical (floristic and ecomorphic composition, occurrence, layerage, aspect, abundance, cover) and synthetic (similarity, constancy) signs. A detailed survey of the state of plants and their communities within the lithoecotopes has allowed us to establish that their distribution and development have clearly expressed dependence on substrate and relief-exposure,which can be used in phytocoenic and phytocenotic melioration of such technogenic ecotopes. Native overgrowth of all dumps has a shrub-tree forest and grassy pattern in accordance with the typological characteristics and rock composition. In general, taxonomic composition of plant communities growing on the dumps of the Kryvbas central zone is characterised by 153 species belonging to 31 families, of which 66 species are petrophytes, and 18 species are typical only for zone surveyed.

Keywords: lithoecotopes, lithophilic plant communities, typology, taxonomic composition

Літоекотопи та рослинність відвалів Центрального гірничозбагачувального комбінату (центральна зона Кривбасу)

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Анотація. З'ясовано особливості розвитку літофільної рослинності, яка формується на скельних відвалах Центрального гірничозбагачувального комбінату або їх скельних складових (літоекотопах). Проблема досліджень літофільних рослинних угруповань під кутом зору прогнозування їх природного розвитку та оптимізації є актуальною не тільки для Кривбасу, але й для всіх промислових районів відкритого видобутку корисних копалин, в яких на земну поверхню виносяться значні маси твердих розкривних гірських порід. Нами визначені різні літоекотопи та описані рослинні угруповання різної складності на платовидних вершинах, терасах і схилах в залежності від специфіки складаючих їх гірських порід та типологічних особливостей. Рослинні літофільні угруповання відвалів Центрального гірночозбагачувального комбінату у відповідності до стану літоекотопів, включаючи всі типологічні характеристики та геохімічну природу гірських порід, відзначаються значними розбіжностями аналітичних (флористичний і екоморфічний склад, трапляння, ярусність, фізіономічність, ряснота, покриття) та синтетичних (схожість, константність) ознак. Деталізоване дослідження стану рослин і їх угруповань в літоекотопах дозволило переконатися, що їх поширення та розвиток мають чітко виражені субстратні та рельєфно-експозиційні залежності, що можливо використовувати у фітоценотичній меліорації техногенних екотопів. Природне заростання всіх відвалів має розріджений чагарниково-деревний і травянистий характер відповідно до типологічних характеристик і складу порід. З′ясовано, що зміна рослинних угруповань на залишених без впливу людини літоекотопах носить ендоекзогенний характер. рапляння видів, видова та петрофітна ємкість рослинних угруповань, їх індекси петрофітності в літоекотопах відвалів мають розбіжності в залежності від специфіки умов. В цілому таксономічний склад рослинних угруповань відвалів центральної зони Кривбасу визначається 153 видами, які належать до 31 родини, з яких 66 видів є петрофітами, а 18 видів властиві тільки цій зоні.

Ключові слова: літоекотопи, літофільні угруповання, типологія, таксономічний склад

Introduction. In the current period of significant technogenic disturbances of all biological environments, engineering-technological changes in relief, and destruction of soil and vegetation, research aimed at protection of relief, optimization of landscape for human life and work, justification of phytorecultivation measures, deepening of our understanding of ecological phenomena and processes in the current vegetation layer is of particular relevance.

In open-cast mining areas, large areas are occupied by quarrying and dumping sites that impact negatively on the environment. In the Kryvyi Rih iron ore basin, the area occupied by such sites and other technogenically disturbed lands reaches more than 30,000 hectares, so exploratory and applied studies aimed at optimization of these lands is essential for maintaining biological balance and diversity in the steppe zone of Ukraine.

Among the waste dumps of the Mining and Ore Enrichment Combine there are those which are composed of polygenetic overburden rocks and poor ores, the processing and industrial use of which are not organized, slowed down and currently not yet well researched. The natural overgrowth of such dumps and their phytorecultivation are multifactorially complicated.

The plant communities growing on the rock substrates and their fundamental changes (successions) are lithophilic.

The problem of studies of lithophilic plant communities in respect to prediction of their natural development and optimization is relevant not only for the Kryvbas, but also for all industrial areas of open-cast mining, in which considerable masses of solid overburden rocks are brought on the earth's surface.

Vegetation of the Kryvbas quarries and dumps has been studied for quite a long time on the basis of elucidation and consideration of complex ecotopic differentiation of these dumps, typological and systematic approaches, establishment of taxonomic and ecomorphic complexity of the plant communities (Dobrovolsky, Shanda, Gayeva, 1979, Gittins, 1981).

The concept of this vegetation as a complex succession system and isolation of lithophilic, geophilic, psamophilic plant communities and successions has practically not been developed.

The relevance of the work is determined by the urgent need for optimization of the Kryvorizhzhya landscape by phytorecultivation of the dumps, the use of naturally occurring vegetation on the basis of practical fieldsurveys and the expansion of research in the general theory of vegetation to compensate for the negative changes in vegetation of steppezone.

The main purpose of this work was to identify the features of lithophilic plant communities and their successions, which occur on the rock dumps of the Central Mining and Ore Enrichment Combine, Kryvbas.

Material and methods of the survey. The survey coveredthePetrivsky,Bilshovitskiy,Novobilshovitsky, Kominternovsky, Novokominternovsky dumps and waste disposal dumps No. 1 of the Central Mining and Ore Enrichment Combine (Kryvbas Central Zone). The dumps of the Central Mining and Ore Enrichment Combine are made up of different rocks in accordance with the geology of the iron ore deposits in this part of the Kryvbas.

The Petrovsky, Novobilshovitsky, Bilshovitsky, Kominternovsky dumps form a single solid ridge (strand, lane) along the eastern side of the quarry No. 1 with large terrain and substratum differences within each dump, including their rocky and loose rocks. These dumps to the east are bordered by a successive strip of mines and they are located in the area of collapse of their underground workings, which complicate the terrain, leading to funnel-shaped dips on plateau-like peaks and dump slopes, and landslides on the slopes. Within such a continuous heap or strip, we have identified lithoecotopes that have contrasting characteristics in terms of vegetation overgrowth, cover, density, occurrence rate, formation and development of plant communities (Khlyzina, 2008).

Field surveys, geobotanical description of vegetation, and detailed analysis were carried out according to conventional methods, which are outlined in the basic manuals, recommendations and monographs (Korchagin, 1964; Tarasov, 2012).

During the study period, 130 geobotanical descriptions of 100 m^2 plots were made. The 100 m^2 (10 x 10 m) square shaped plots were laid on plateaus and terraces every 100 m. On the slopes, the descriptive plots were oblong (5 x 20 m). We determined occurrence rate, density, plant phytomass, of substratecover.

Total species capacity of plant families (TSF) in lithophilic plant communities was determined by the formula: TSF = -number of species/number of families; total petrophytic capacity of families (PSF) – by the formula PSF = number of petrophytic species/number of families, petrophytic index (PI) of families and plant communities was determined by the formula IP = number of petrophytic species/total number of species.

In our opinion, it is possible to classify the lithoecotopes of quarry and waste dumps according to the leading concepts of O.L. Belgard (Bel'gard, 1950) on the typology of forest and steppe edatopes and the

biogeocenosis detailization scheme of A. P.Travleyev (1973), extending in a certain way the scope of criteria. Among these we distinguished trophicity, moisture capacity, toxicity or vegetative suitability, mechanical composition of substrates, topo- and orographic features of waste dumps, etc., variations and combinations of which allow us to determine the certain types of lithoecotopes and their vegetative suitability.

The terrain of the plateau-like terraces and peaks (planes) may be relatively smooth, flat (a_1), they may also have a large-hilled surface (a_2), or with pronounced micro-terrain of small hillocks (a_3), or wavy (a_4) nature. At the same time, both plateaus and terraces of dumps can be differently oriented : to the south (B_1), to the southeast (B_2), to the southwest (B_3), to the north (B_4), to the northeast (B_5), to the northwest (B_6), to the west (B_7), to the east (B_8), and with the corresponding slopes (c_1, c_2, c_3, c_4, c_5, c_6, c_7, c_8).

Trophicity (d), moisture capacity (e), toxicity (vegetation suitability) (f) of rock substrates that make up rock dumps or parts thereof can be relatively multilevel, such as low, medium, high, i.e. can be characterized by these levels as d_1, d_2, d_3, e_1,e_2,e_3, f_1,f_2,f_3.The dumps or their parts (most often) can be made up of a single type of rock (g_1), or two (g_2) three or more (g_3) types of rock. In size, the rock debris that makes up the dumps can be finely fractional: 1-2 cm (h_1), crushed stone type: 2-5 cm (h_2), middle fragment type: 5-10 cm (h_3), large fragment type: 10-20 cm (h_4), very large fragment type: 20-30 cm (h_5), largest fragment type : 30-50 cm and more (h_6) and differently combined (h_7) for each lithoecotope.

The period of the dumping for the whole dump or its parts is distinguished by the following criteria for litho-ecotopes of dumps of the mining and processing plants: fresh (1-5 years (t_1)), recent (5-10 years (t_2)), medium-old (10-25 years (t_3)), relatively old (25-40 years (t_4)), old (40 years and more (t_5)). On the basis of these criteria it is possible to determine the typological formulas of lithoecotopes on the peaks and terraces, taking into account the compass orientation and the slope exposures. Many such combinations can be uncertain with the complicated combinatorial calculation of their number. With regard to the typology of the slope lithoecotopes, in our opinion, it is still necessary to introduce such a criterion as the slope steepnes: from 3º to 30º (i_1), to 45º (i2), more than 45º (i3).

Results and interpretation. We should emphasize that in our research we focused our attention only on the vegetation developing on rocky dumps or their rocky components (lithoecotopes), i.e. only on lithophilic vegetation.

Along the entire continuous line of dumps at the Petrovskiy mine and at the sludge dumps of the Central Mining and Ore Enrichment Combine (the central zone of Kryvbass) we determined various lithoecotopes and described plant communities of various complexities on plateau-like tops, terraces and slopes. The general cover of lithoecotopes depends on specifics of rocks they are formed of as well as on their typological peculiarities.

Lithophilic plant communities of the dumps at the Central Mining and Ore Enrichment Combine,according to the status of lithoecotopes including all typological characteristics (Belgard, 1950) and geochemical nature of rocks (Paran'ko, Khlyzina, 2005) are characterized through significant differences in their analytic features (floristic and ecomorphic composition, occurrence, layering, physiognomic aspect, abundance, cover) and synthetic features (similarity, constancy).

In lithoecotopes 1, 2, 3, 4 of the upper and middle parts of the northeastern, eastern and southeastern slopes of the Petrovskiy and Bilshovytskiy dumping sites (typological formulas $a_1i_2c_5d_1e_1f_3g_1h_3t_5$, $a_4i_2c_8d_1e_1f_3g_1h_3t_5$, $a_4i_2c_2d_1f_3g_2h_3t_5$, $a_4i_2c_8d_1f_3g_2h_3t_5$) composed of quartz-chlorite-sericite shales and quartz-sericite-biotite shales and unoxidized quartzites of average size ,where continuous movements of slopes are typical, ecological niches during a prolonged period of time are occupied by *Zygopyllum fabago* , which is not a petrophyte, as well as by *Gypsophyla perfoliata* , rarely and separately occupying only the very upper extremities of slopes and by *Crambe tatarica* , which is marked as a petrophyte in the flora of Ukraine. We observed the state of Crambe-Zygophyllum microcomunities with rare distribution in the layer of lithoecotopes during the period 2017-2018. Shale substrates of this type are unfavourable for plants and that is why lithoecotopes located on them are devoid of vegetation during a prolonged period of time, especially when fragments are of a greater size (h_4, h_5, h_6, h_7). This is typical for lower lithoecotopes bordering the mentioned ones. In lithoecotopes which include such or other shales with ore-free quartzites, natural overgrowth is also slowed down and starts in a fragmentary or diffused manner within 20-30 years. Vegetation here is of shrubby-tree-grass type with development of zoochoric and separate anemochorous types of shrubs and trees and anemochorous grasses which is typical for all rocky dumps. It is typical that these can be brought from far away as well as from neighbouring layers of the same dumps covered with soft soil (loess loams, red-brown clays etc.). This soft

soil has much better trophic characteristics and higher suitability for vegetation in comparison with rocks. In case of wind erosion these soft soils are powerful sources of satiation of rock surfaces (especially those composed of small (up to 2 cm) and crushed stone type (2-5 cm) fractions) with the so called fine earth, which fills up substrates of natural rock decay (lithic soil), modifies or partially neutralizes their toxicity, reinforces natural weathering and decay.

The south slope of the Petrovskyi dump is almost completely composed of rocks but at the same time it is differentiated consisting of macroecotopes and microecotopes along its entire length with respective fragments of natural overgrowth (microcomunities and general surface cover of from 8 to 36% according to the L.G. Ramenskiy grid).

On the Petrovskiy dumping site as well as the entire line of dumps bordering the Petrovskiy mine (not far from the quarries) as well as at the sludge dumps of the Central Mining and Ore Enrichment Combine and at dumps of other ore mining and processing plants, on plateau-like tops, terraces and slopes, and in many cases on waterresistant layers covered with rock substrates, fragmentary microcomunities of various forms (insular patchy ones, elongated ones) are formed; these are microcomunities of *Phragmites australis, Calamagrostis epigeios*, sometimes of *Tussilago farfara* with admixtures of *Polygonum persicaria, Tanacetum vulgare* and in rare occasions even with admixtures of *Bidens tripartita*. It should be noted that only on the Petrovskiy dumping site, on the lower parts of the south slope (these parts often consist of large-sized fractions) process farmsteads of resettled families were covered with spoil (these families had cultivated horseradish and hop (either accidentally or intentionally). Such fragmented groups of plants are variously distributed on slopes as well as on surfaces of plateau and terraces with various spatial orientation (often along the entire slope). And this gives an opportunity to predict their hydrochorous origin in cases of water running down the slope.

At the south slope of the Petrovskiy dumping site in lithoecotopes of rocks similar in their composition (quartz - sericite - biotite shales and quartz-chlorite shales and unoxidized quartites) with size of fractions (h_3–h_4), i.e. from 5 to 20 cm we found fragmentary microcomunities of various forms – patchy round ones (3.5 m x 3 m) and elongated ones (1 m x 3-5 m) and broken, sparse strip-like – common reed (*Phragmites australis*). And this fact proved that water resistant layers of various forms were embedded close to the surface. At the same time it was determined that: 1) plants growing in the center of the microcomunity (Table 1) were higher than those growing in the periphery; 2) the plants of the patchy round microcomunities (growing in the center as well as in the periphery) were taller than those of the elongated microcomunities; 3) plants in the broken-rarefied strip-like fragments were smaller than in two previous fragments.

It is natural that under harsh conditions height variability of plants (V) is significantly greater. This fact confirms the difference in humidification of substrate lower layers and indicated manifestation

Table 1. Peculiarities of *Phragmites australis* Growth on the South Slope of the Petrovskiy Dumping Site of the Central Mining and Ore Enrichment Combine

No	Variants of ecological positions of plants	Height of plants		V, %%
		cm	%	
1.	Spotty round microcommunity (3 x 3 m^2) center periphery	 192.36 ± 1.44 163.0 ± 3.34	 100.00 75.49	 9.30 21.03
2.	Long, dense, wide (1m) microcomunity center periphery	 124.32 ± 4.36 92.42 ± 1.37	 64.46 97.82	 16.42 26.41
3.	**Broken-scattered strip-like microcomunity** stippled location	 53.42 ± 4.12	 27.68	 32.13

did we manage to find isolated specimens of *Armoracia rusticana*, *Humulus lupulus* and *Cannabis ruderalis*; and this can be explained by the fact that the process of dumping was going on gradually and in the course of this of batch effect (community effect) in the case of the common reed. At the same time, it is important to note that the batch effect discovered in trees by G.F. Morozov and described by S.I. Chernobryvenko,

V.I. Shanda in cultivated grass plants and by Y.V. Titov in miscellaneous herbs can be also manifested in lithoecotopes. We should denote points not taken into account by previous researchers: the batch effect depends on configuration, diameter or width of the area covered by this or that group of plants.

Envoronment-forming functions of plant communities (groups) are also manifested in differences of plant development in the center and in the periphery of the group (imitation of the so called edge effect in forestry). This is especially important for lithoecotopes in the case of hydrological and thermal extremes and in general it is important for phytoremediation when groups of shrubs are planted or grasses are sown in large fragments for future formation of their optimal density. Really, the central plants of a round-spotty fragment are almost 25% taller than plants in the periphery of this fragment, 33% higher than central plants of an elongated microcomunity; and they are also much taller than dotted-scattered plants of an elongated rarefied spot of plants. A typical point ere is that coefficients of variation in cases of all possible differences of characteristics and polymorphism of populations of wild plants reflect the real picture of increased variability of height in the relatively complex conditions of peripheral and rarefied grass stands growing on rocky shale-quartzite substrate of the south slope of the Petrovskiy dumping site.

Detailed study of the state of plants and their groups in lithoecotopes made it possible to prove that their dissemination and development have clearly expressed substrate and relief-exposure dependencies, which can be used in phytochemical and phytocoenic melioration of these technogenic ecotopes (Malenko, 1999). It should be also noted that sources of dissemination of *Phragmites australis* on the slopes of the Petrovskiy dumping site may include separate centers of the reed along the banks of the Saksagan River (located not far away), near open water pipes and water drains from the ore mining and processing plant, on neighbouring dumps and the plateau-like surface of the same dump. In the case of fine ground (fragmented) relief of the plateau-like top of the dump in the hollows, sheltered areas between piles of rock fragments on a sufficiently solid rolled, pressed surface , nanocomunities and microcomunities of the common reed are formed (their length is 1 meter and more) and on slopes small patchy and elongated communities of various configuration and spatial orientation are formed (especially along the slope) and this fact gives an opportunity to suggest that they are possibly of hydrochorous origin (Diduh, 2012).

By the example of *Phragmites australis* and especially *Melica transsilvanica* we came to the conclusion about the possible spread of their microcommunities as initials especially on slopes on the basis of anemochory and hydrochory. At the same time, the predominant south-east and east winds disseminate communities of *Melica transsilvanica* from east to west or northwest in the majority of cases on slopes of the dumps bordering quarries as well as on the dump No1 of the pre-sludge area. This phenomenon of plant community expansion should be classified as spatial spreading. It may be presented in various types and forms and first of all by means of spacial assimilation. When a plant community present on a rocky slope (regardless of the substrate and size of fragments) is spread from the top downward, this type of spatial spreading is descending or falling; and when spreading takes place from the foot towards the middle, this type of spreading is ascending, with various forms (spray-like, fan-like, tree-like, continuously spotted, torn spotted, comb-like or linear or arc-shaped) on plateau-like tops and terraces as well as on slopes.

In the Melica-Phragmites-Artemisia community of the south slope of the Petrovskiy dumping site (in condition of descending spatial spreading in the complex quartz-chlorite-sericite-biotite-shale lithoecotope with admixtures of unoxidized quartzites of old dumping) (typological formula $a_1i_2c_1d_1e_1f_3g_2h_2$-$_3t_4$) with single representatives of *Populus deltoides*, *Populus nigra* and *Ulmus laevis* , the general level of cover of the slope surface is 28%. The fragmentary elongated location of *Phragmites australis* has a stream-dissected descending nature; *Melica transsilvanica* can be found in relatively dispersed groups, *Artemisia absinthium, Artemisia austriaca, Crambe tataria,* are less dispersed; *Erigeron canadensis, Centaurea diffusa, Linaria genistifolia, Senecio vulgaris, Silene ucrainica* are found in areas of stony substrate.

Natural overgrowth of all dumps includes shrubs, trees (woody plants) and grasses according to typological characteristics and composition of the ground.

In a separated (by means of a downward hollow including large and large-sized fractions and deprived of vegetation) lithoecotope of the south slope of the Petrovskiy dumping site (typological formula $a_4i_2c_1d_1e_1f_2g_2h_3t_4$) on quartz-sericite-biotite shales and ore-free quartzites a Melica-Crambe community has formed, covering up to 26 – 28 % of the substrate. At the same time, *Melica transsilvanica* in the upper and middle part of the slope is disseminated in an insular

way with displacement of fragments across the slope in a westward direction; and *Crambe tatarica* is present as solitary representatives; in addition to that *Erigeron canadensis, Silene ucrainica, Linaria genistifolia* are also present and *Phragmites australis, Centaurea diffusa* are located near the top. The upper part of the slope is better covered with plants, the middle part is less vegetated and the bottom part (consisting of large-sized fractions) is deprived of any vegetation. This scheme is typical for rocks of the entire line (for quarry-bordering dumps, for sludge-dumps of the Central Mining and Ore Enrichment Combine as well as for dumps of the Southern Ore Mining and Processing Plant and Novokryvorizkyi Ore Mining and Processing Plant), where periods of completed dumping equal to 30-50 years do not really influence overgrowth of rocks consisting of big and large-sized fractions.

The Artemisia-Melica community in the upper part of the southern slope of the Petrovskiy dumping site on the mixture of quartz-amphibole-chlorite shales and quartz-chlorite-sercite shales and unoxidized quartzites (lithoecotope typological formula $a_4i_1c_1d_1e_1f_3g_3h_3t_4$) is an illustrative example of descending spatial spreading but it is limited by the zone of large-sized fragments (h_5) and the large lump zone (h_6) from the middle area of the slope. General cover of the substrate is 23%, the maximal density of plants –is 9 specimens per 1 m^2, types of plant location include a demarcated group type and dotted-scattered type with the same composition of microcomunities. The grass stand includes *Artemisia absinthium, Artemisia vulgaris, Achillea submillefolium, Crepis tectorum, Centaurea diffusa, Echium vulgare, Erigeron canadensis, Elaeagnus argentea, Grindelia squarrosa, Gypsophilla perfoliata, Hippophae rhamnoides, Hieracium pilosella, Kochia scoparia, Lactuca tatarica, Melica transsilvanica, Melilotus albus, Poa angustifolia, Populus deltoides, Populus nigra, Rosa dumalis, Senecio jacobaea, Silene ucrainica* and *Ulmus laevis.*

On the plateau-like tops of quarry-bordering dumps of the Central Mining and Ore Enrichment Combine with a typically large-hilled surface (a_2), with various times of dumping (soft spoil and rocks) a very rarefied vegetation is naturally formed (shrubs and trees) as a result of anemochory and zoochory with density from 5 to 25 specimens per 400 m^2 with large distances between them. The main species are *Populus nigra, Ulmus laevis, Rosa dumalis, Elaeagnus argentea, Hippophae rhamnoides, Armeniaca vulgaris*. In addition to this , the same plant species are sometimes artificially replanted as a result of research projects carried out by various institutions (Kryvyi Rih State Pedagogical University) as well as as a result of activities performed by amateur naturalists and phytorecultivation works performed by the Mining and Ore Enrichment Combine or by mines located nearby. In many cases , the lithoecotopes of plateau-like tops of some dumps belonging to the quarry-bordering line are characterized by fine fragment microrelief of hilly type. On the Petrovskiy dumping site in the lithoecotope with its substrate basis formed by quartz-sericite-amphibole shales, chlotite-sericite-biotite shales and unoxidized quartzites consisting of medium sized (h_3) and large (h_4) fragments (typological formula $a_3в_2d_1e_1f_1g_3h_3$-h_4t_5) a Koeleria-Artemisia plant community is in the process of its development with general covering of the substrate surface equal to 28% and with significant differences in density of plants (from 5 to 20 specimens per 1m^2. In nano-cavities (less than 1 meter) and micro cavities (over 1 meter) as well as in cavities between heaps of dumped rocks (as well as outside these cavities) the following plants can be found: *Phragmites australis, Polygonum aviculare, Poa angustifolia, Poa compessa, Anisantra tectorum, Calamagrostis epigeios, Alyssum murale, Barbarea vulgare, Lactuca tatarica, Crepis tectorum,* on heaps the following plants are present: *Berteroa incana, Erigeron canadensis, Artemisia absintium, Artemisia austriaca, Melica transsilvanica, Melilotus albus, Kochia scoparia, Grindelia squarrosa,* some specimens of *Ambrosia artemisifolia, Cyclachaena xanthifolia* were also detected. This indicates that the process of filling these cavities with fine earth from neighbouring hills of the same dump defines the initial stage (weed stage) of covering soft spoil with vegetation on the dumps of the Kryvbass.

In the lithoecotope of the plateau-like top of the Petrovskiy dumping site (typological formula $a_3в_3d_1e_1f_1g_3h_4$-$_5$-$_6t_4$) on a similar shale-quartzite substrate , microrelief is formed not only of big and large fragments (which are heaped) but also of great lumps up to 1.5 meter in diameter and larger. And this creates a more favourable nano- and microclimate in cavities between hillocks where the Melica-Artemisia community is modified by means of admixtures of separate plants, including such species as *Rumex confertus, Tussilago farfara, Tanacetum vulgare*, in the presence of *Melica transsilvanica, Artemisia vulgaris, Artemisia austriaca, Crambe tatarica, Erigeron canadensis, Centaurea diffusa, Atriplex tatarica, Kochia scoparia, Potentilla argentea, Grindelia squarrosa , Polygonum aviculare, Crepis tectorum* and *Asplenium muraria*. In the similar lithoecotope of the Novo-Bilshovytskiy dumping

site (typological formula $a_3в_4d_1e_1f_1g_3h_4$-$_5t_5$) Melica-Artemisia rarefied comunities are formed which provide 32% cover of the substrate, and include such species as *Populus nigra, Pragmites australis* in microcavities and sometimes (in heaps of large lump dumps and between these heaps with diffused uneven grass stand) such species as *Melica transsilvanica, Achillea nobilis, Senecio jacobaea, Poa compressa* and isolated specimens of *Festuca sulcata, Melilotus albus, Consolida arvensis, Bidens tripartita, Plantago media, Erodium cicutarium, Artemisia austriaca, Erigeron canadensis, Centaurea diffusa* are also present. So, in the extreme conditions of small-hilled relief and substrates with fragments of various sizes, lithophilic communities with mixed species of various hygromorphic peculiarities (according to Belgard) are formed as well as species of other ecological valences. This is due to the mixed nature of the composition of the types of rocks and soft spoil these dumps are formed of. This phenomenon is typical for all dumps of the Kryvbass except for several small parts of dumps with oxidized ferruginous quartzites, which are poor ores.

In the lithoecotope of the Bilshovytskiy dumping site (typological formula $a_1i_2c_8d_1e_1$ $f_3g_3h_3$-$_4t_4$) on quartz-chlorite-sercite shales, quartz-sercite-biotite shales and ore-free quartzite substrate in the middle area of the slope there is a Melica community which has a descending elongated fragmentary form with inset fragments of *Crambe tatarica, Gypsophilla perfoliata.* The general cover of the surface is 21%, location of *Melica transsilvanica* is descending, broken linear and diffused (uneven). Linear dotted sections include no more than 4-6 plants per 1 m^2. There are some scattered plants of *Artemisia absinthium, Artemisia austriaca, Diplotaxis muralis, Linaria genistifolia, Erigeron canadensis, Silene ucrainica.* Species composition is poor.

The Koeleria- miscellaneous herbs plant community in the south-western slope of the Bilshovytskiy dumping site on mixed shale-quartzite substrate (typological formula $a_1i_2c_2d_1e_1f_3g_3h_7t_5$) has a broken-fragmentary-patchy horizontal structure with indefinite spatial spreading within the described period. In the area of up to 400 $m^{2,}$ 8 species of shrubs and trees were found, including such species as *Elaeagnus argentea, Populus deltoides, Armeniaca vulgaris, Rosa canina.* The grass stand consists of *Melica transsilvanica, Poa compressa, Artemisia austriaca, Artemisia absinthium, Achillea submillefolium, Grindelia squarrosa, Centaurea diffusa, Stachys recta, Potentilla argentea, Daucus carota, Gypsophilla perfoliata, Anisantha tectorum, Scabiosa ochroleuca, Consolida regalis, Taraxacum officinale, Melilotus albus, Bromopsis inermis, Kochia scoparia,Salvia nemorosa, Barkhausia rhoeadifolia, Euphorbia sequieriana, Linaria genistifolia* and *Salvia nemorosa.*

In the lithoecotope of the eastern slope of the Bilshovytskiy dumping site composed of quartz-cercite-biotite shales and ore-free quartzites (typological formula $a_1i_1c_8d_1e_1f_1$-$_3g_2h_3t_4$), the upper part is occupied by a Melica-miscellaneous herbs community with sparse presence of bushy trees (*Populus deltoides).* The general level of plant cover is 76%, providing diffused relatively even dissemination of a cenopopulation of *Melica transsilvanica* and presence of such weed plants as *Ambrosia artemisifolia, Cyclachaena xanthifolia, Erigeron canadensis, Carduus acanthoides, Lepidium ruderale, Lepidium perfoliatum, Berteroa incana, Diplotaxis muralis, Chenopodium album* and *Atriplex tatarica,* which is an indicator of inclusion of the so called aluminium earth to the stony surface of the slope as the result of water erosion and wind erosion from the surface of this dump and other dumps formed by soft ground (loess soils and clays). In addition to this, great volumes of dust are also produced in the result of explosive technological processes in the quarries. Colonization of this lithoecotope by such plants as *Melica transsilvanica* proves that on shale-poor-ore-quartzite substrates the process of initial overgrowth is proceeding very slowly and penetration of plants is blocked as the result of the extreme conditions of these dumps. *Melica transsilvanica,* as a species has sufficient potential ecological opportunities for holding its positions and expanding its initial centers (fields) on various shale-quartzite substrates. Natural overgrowth of these hard rock substrates is proceeding beyond the stages of weedy short-lived creeping (rhizome) stem grasses as occurs with black earth. Out of 9 species of *Melica* detected in Ukraine, 3 species are evident petrophytes and *Melica monticola Prokud* is able to grow on shaly crushed stone as well as on stony deposits of various rocks , though at the same time it is an endemic in the Crimea. So, the presence of *Melica transsilvanica* on shale-quartzite substrates proves its wide ecological valence. Being non-dense-bushy species *Melica* are able to form dense sods in favourable conditions of various soils but on the hard rocky dumps of ore mining and processing plants, we noticed only dotted and dot-grouped location of *Melica transsilvanica* cenopopulations. In the described plant community with unexpressed spatial spreading, essential plants include such species as *Poa angustifolia, Festuca valesiaca, Euphorbia*

seguieriana, Euphorbia virgultosa, Consolida orientalis, Plantago lanceolata, Medicago romanica, Medicago lupulina, Artemisia absinthium, Artemisia austriaca, Bromopsis inermis, Petrorhagia saxifraga, Asplenium ruta-muraria, Melilotus albus, Scabiosa ochroleuca, Allyssum murale, Consolida regalis, Rumex crispus, Linaria vulgaris, Senecio jacobaea, Diplotaxis muralis, Galium ruthenicum and *Daucus carota.*

On the western slope of the Bilshovytskiy dumping site two lithoecotopes were detected on quartz-cercite-biotite-ore free-quartzite substrate with various peculiarities of relief and fragments. In the upper part in conditions of pectinate spatial spreading with broken fragments and microhollows (typological formula $a_4i_2c_7d_1e_1f_3g_2h_2$-$_3t_3$) a Melica-miscellaneous herbs community was formed covering 35-40% of the substrate and presenting a diffuse-dotted and group location of plants with density of 8-12 specimens per 1 m^2. The grass stand consists of *Melica transsilvanica*, подекуди *Koeleria cristata, Poa compressa, Artemisia austriaca, Artemisia absinthium, Polygonum aviculare, Consolida regalis, Melilotus albus, Anisantha tectorum, Erigeron canadensis, Kochia prostrata, Euphorbia seguieriana, Achillea submillefolium, Cichorium intybus, Lactuca tatarica, Crepis tectorum, Diplotaxis muralis, Berteroa incana, Potentilla argentea, Artemisia vulgaris, Bromus squarrosus, Centaurea diffusa, Gypsophilla perfoliata, Lappula squarrosa, Polygonum aviculare, Linaria genistifolia, Silene ucrainica.*

In the lithoecotope of the plateau-like top of the Bilshovyskiy dumping site (typological formula $a_3в_2d_2e_2f_3g_7h$ t) composed of unoxidized quartzites, biotite-chlorite shales, quartz-cercite-biotite shales with oxidized quartzites with fractions of various sizes from crushed stone fragments (h_2) to large-sized fractions (h_5) over a prolonged period (within 40 years) a Koeleria-miscellaneous herbs community was formed with general surface cover of up to 85% with various density of the grass stand depending on the size of fractions and peculiarities of the pit-and-mound surface. Projective cover was 35-45%, air-dry mass of plants per 1 m^2 was from 250 to 320 g, density was 3-5 species per 1 m^2 with grass stand density of up to 110 plants. The grass stand consists of *Poa angustifolia, Poa compressa, Poa stepposa, Koeleria cristata, Melica transsilvanica, Artemisia absinthium, Artemisia austriaca, Centaurea diffusa, Centaurea orientalis, Anthemis subtinctoria, Echium vulgare, Coronilla varia, Lotus corniculatus, Medicago romanica, Verbascum austriacum, Falcaria vulgaris, Astragalus austriacus, Lappula squarrosa, Inula ensifolia, Picris hieracioides, Seseli campestre, Tripolium vulgare, Achillea submillefolium, Senecio jacobaea, Silene supina, Goniolimon besseranum, Phlomis pungens, Hieracium pilosella, Nepeta parviflora, Teucrium chamaedrys,Cichorium intybus, Crepis tectorum, Ceratocephala festiculata, Scabiosa ochroleuca, Consolida regalis, Euphorbia seguieriana, Galium ruthenicum, Dianthus carbonatus,* also *Erigeron canadensis, Grindelia squarrosa, Melilotus albus, Potentilla argentea, Tanacetum vulgare, Diplotaxis muralis, Berteroa incana, Stachys recta, Polygonum aviculare, Kochia scoparia* and *Gypsophilla perfoliata.* The presence of such pioneer (for crushed stone shale-quartzite substrates) plants as *Erigeron canadensis, Melilotus albus, Polygonum aviculare, Gypsophilla perfoliata, Kochia scoparia, Centaurea diffusa, Melica transsilvanica* testifies the uneven mosaic and slowed process of overgrowth on hard rock dumps. Shrubby and woody plants are represented here by such solitary (on the plateau as well as on terraces and slopes) species as *Populus deltoides, Elaeagnus argentea, Rosa dumalis, Armeniaca vulgaris* and *Crataegus sanguinea.*

On the plateau-like surface of the Kominternivskiy dumping site composed of the same substrates but with greater admixtures of oxidized quartzites and a long period of dumping (up to 80 years) (typological formula $a_1в_2d_3e_3f_1g_3h_1$-$_2t_5$) providing an even and puddled surface, the Koeleria-fescue-miscellaneous herbs community has a greater species diversity and density of plants of up to 350 specimens per 1 m^2, plenitude – up to 37 species per 1 m^2, projective cover up to 90-95%, with-dry phytomass from 1,230 to 1,750 g per 1 m^2. The grass stand includes the following species: *Poa angustifolia, Poa compressa,* Poa *stepposa, Koeleria cristata, Festuca valesiaca,* and sometimes one can find some individual specimens of *Stipa capillata, Stipa lessingiana, Melica transsilvanica,* with scattered growth of *Centaurea orientalis, Dianthus carbonatus, Galium ruthenicum, Lotus corniculatus, Senecio jacobaea, Phlomis pungens, Consolida regalis, Nepeta parviflora, Hieracium pilosella, Cichorium intybus, Teucrium chamaedrys, Silene supina, Scabiosa ochroleuca, Achillea submillefolium, Euphorbia seguieriana, Eryngium campestre, Astragalus austriacus, Falcaria vulgaris, Medicago romanica, Anthemis subtinctoria, Artemisia absinthium, Artemisia austriaca, Asplenium ruta-muraria, Echium vulgare, Grindelia squarrosa, Tripolium vulgare, Inula ensifolia, Lactuca saligna, Lactuca tatarica, Cephalaria uralensis, Crinitaria villosa, Asyneuma canascens, Veronica austriaca,*

Marrubium praecox, Silene latifolia, Herniaria besseri, Erysimum canascens, Carduus acanthoides, Crambe tataria, Potentilla argentea, Diplotaxis muralis, Linaria genistifolia, Plantago lanceolata, Plantago stepposa, Medicago lupulina, Trifolium borysthenicum, Minuartia leiosperma, Petrorhagia saxifraga, Silaum alpestre, Erodium cicutarium, Dodartia orientalis, Ulmus laevis, Armeniaca vulgaris, Verdascum lychnitis, Thymus dimorphus and *Helichrysum arenarium.*

On the Kominternivskiy dumping site the Koeleria-fescue-miscellaneous herbs community is formed on the small fractional substrate of oxidized and unoxidized quartzites (partially quartz-biotite and quartz-amphibole shales) of old dumping (lithoecotope typological formula $a_1в_4c_4d_3e_3f_1g_3h_1t_5$). It is characterized by high density of plants (100 and more specimens per 1 m^2), 98% of substrate cover is represented by rich species diversity including species of feather grass (Stipa) and air dry phytomass of 150-210 g per 1 m^2. The high abundance of the Poaceae family indicates the zonal (typical for steppes) nature of indigenious vegetation restoration in specific conditions of the small-fragment (sometimes consisting of crushed stone) substrate of rocks where oxidized quartzites with small but sufficient trophic characteristics prevail in comparison with other types of rocks with available admixtures of fine grained soil brought here with dust from tillable lands and open surfaces of the entire quarry dump area. Small-fragment and crushed stone substrates are covered with vegetation faster than other substrates especially against the background of sufficient trophic characteristics and water capacity of rocks. This overgrowth takes place with a certain succession of phases and stages; according to our observations it is uneven and due to this fact for a prolonged period of time non-tussock grasses may cohabit in the lithophilic communities with species of the first stages of overgrowth typical for crushed stone substrates including fractions of various sizes; these first-stage species include: *Erigeron canadensis, Polygonum aviculare, Grindelia squarrosa, Senecio jacobaea, Melilotus albus, Melilotus officinalis, Crambe tataria, Berteroa incana, Kochia scoparia, Gypsophilla perfoliata.* In this Koeleria-fescue-miscellaneous herbs community , a significant density is typical for the following species *Poa compressa, Poa angustifolia, Festuca valesiaca, Anisantha tectorum, Koeleria cristata, Stipa capillata, Stipa lessingsana, Agropyron pectinatum, Bromopsis inermis,* and fragmentarily *Melica transsilvanica.* Singular representatives of the following species can be individually found *Cichorium intybus, Achillea submillefolium, Achillea nobilis, Artemisiaabsinthium,Artemisiaaustriaca, Diplotaxis muralis, Stachys recta, Salvia nemorosa, Echium vulgare, Potentilla argentea, Silene ucrainica, Linaria genistifolia, Verbascum lychnitis, Euphorbia seguieriana, Scabiosa ochroleuca, Coronilla varia, Lotus corniculatus, Plantago lanceolata, Medicago romanica, Medicago lupulina, Consolida regalis, Euphorbia virgultosa, Astragalus onobrychis, Silene latifolia, Seseli campestre, Hyssopus officinalis, Verbascum austriacum, Chondrilla juncea, Hieracium echioides, Scorzonera taurica, Rumex crispus, Erysimum diffusum, Linum perenne, Eryngium campestre, Minuartia leiosperma, Petrorhagia saxifraga, Dianthus lanceolatus, Teucrium chamaedrys, Thesium arvense, Holosteum subglutinosum, Silaum alpestre, Ceratocephala testiculata, Consolida paniculata, Reseda lutea, Centaurea diffusa, Centaurea solstitialis, Anthemis subtinctoria, Lycopsis orientalis, Thymus dimorphus, Goniolimon besseranum, Helichrysum arenarium, Phlomis pungens, Nepeta parviflora.* Shrubby and woody species include: *Populus deltoides, Populus nigra, Ulmus caprinifolia, Rosa canina, Elaeagnus argentea, Acer negungo* and *Morus alba.*

All lithophilic communities of plants presented in quarry-bordering dumps are characterized by their high specimen capacity and petrophyte capacity, these capacities and indexes of petrophytic properties are also characteristic of the main families of flowering plants (Table 2).

In general, it should be noted that in the quarry-bordering line of dumps lithophilic plant comunities include 141 species of flowering plants representing 29 plant families including 60 petrophytes (Table 3). Descending rows (spectra) of plant communities are presented as follows: I. According to the number of species, *Asteraceae* (34) – *Poaceae* (15) – *Caryophyllaceae* (10) – *Brassicaceae* (9) – *Fabaceae* (9) – *Lamiaceae* (8) – *Scrophulariacea* (5) – *Apiaceae* (5) – *Rosaceae* (5) – *Chenopodiaceae (4)* – *Ranunculaceae* (4); II. According to the number of petrophytes, *Asteraceae* (11) – *Poaceae* (10) – *Caryophyllaceae* (8) – *Lamiaceae* (6) – *Brassicaceae* (5) – *Fabaceae* (3); III. According to the coefficient of petrophytic properties, (%%): *Caryophyllaceae* (80.00) – *Lamiaceae* (75.00) – *Poaceae* (66.66) – *Brassicaceae* (55.55) – *Asteraceae* (32.35) – *Fabaceae* (33.33).

According to the same scheme (as for frequency of species, taxonomic capacity and petrophytic capacity within families, species, petrophylic indexes) lithophilic communities of plants in the quarry-bordering line as well as in other zones are

Table 2. Petrotrophic Features of Flowering Plant Families of Lithophilic Groups on Quarry-bordering Dumps

No.	Families	The total number of species	Incl. petrophytes.	Index of petrophytic properties, %
1.	Aspleniaceae	1	1	100.00
2.	Campanulaceae	1	1	100.00
3.	Geraniaceae	1	1	100.00
4.	Limoniaceae	1	1	100.00
5.	Resedaceae	1	1	100.00
6.	Rubiaceae	1	1	100.00
7.	Santalaceae	1	1	100.00
8.	Euphorbiaceae	2	1	50.00
9.	Lamiaceae	8	6	75.00
10.	Plantaginaceae	3	2	66.67
11.	Caryophyllaceae	10	8	80.00
12.	Brassicaceae	9	5	55.56
13.	Poaceae	15	10	66.67
14.	Scrophulariaceae	5	1	20.00
15.	Asteraceae	34	11	32.35
16.	Boraginaceae	3	1	33.33
17.	Fabaceae	9	3	33.33
18.	Ulmaceae	2	1	50.00
19.	Apiaceae	5	1	20.00
20.	Dipsacaceae	2	1	50.00
21.	Rosaceae	5	1	20.00
22.	Chenopodiaceae	4	1	25.00
23.	Aceraceae	1	-	0
24.	Elaeagnaceae	2	-	0
25.	Linaceae	1	-	0
26.	Moraceae	1	-	0
27.	Polygonaceae	3	-	0
28.	Ranunculaceae	4	-	0
29.	Salicaceae	2	-	0
Total:		141	60	42.55

distinguished.

Comparison of petrophytic capacities of flowering plant families of lithophilic communities present on the quarry-bordering dumps shows that the highest petrophytic index is typical for the community with the highest species capacity and petrophytic capacity, but this is not a regular pattern and there are some communities in which these indexes are high with low species capacity. The most numerous representatives of all communities include the following species: *Asteraceae, Brassicaceae, Caryophyllaceae, Chenopodiaceae, Euphorbiaceae, Fabaceae, Poaceae, Polygonaceae, Scrophulariaceae.*

The plateau-like top of the first sludge dump with laid rails (for continuous dumping of overburden rocks) and technological excavator and bulldozer works (related to piling rocks, leveling surfaces of the plateau-like tops and terraces) may be viewed as a demonstration and research field for creating a detailed picture of natural overgrowth in various phases and stages of lithophilic successions (Shanda, Voroshylova, 2015). At the same time changes in plant communities on lithoecotopes left without human influence are of endo- and exogenous nature because the excess external pressure overlaps internal coenotic processes. As a result of such integration against the background of this or that substrate, fluctuation as well as successions are naturally realized. In order to illustrate the process of changes typical for plant communities on small-fragment and crushed stone substrates we selected several ecotopes.

On the northwestern terrace of this sludge dumping site in the small-fragmented and crushed stony lithoecotope with sufficient puddled and relatively even surface of the substrate formed of oxidized and unoxidized ferruginous quartzites with admixtures of quartz-sericite-biotite shales (typological formula $a_1в_6c_1d_3e_3f_1g_3h_1$-$_2t_4$), surface cover is 70 – 85% and density of plants is up to 60 specimens per 1 m^2. Here a Koeleria-miscellaneous herbs community has developed. During a certain period of time (1973-1980) this terrace was on the border of the warehouse of ferruginous quartzites. It is significant that on areas of 100 m^2 up to 30 and even more species of the following plants (local spotty sections) can be

found (of course on water retaining lower layers): *Calamagrostis epigeios* (up to 14 specimens per 1 m^2), *Polygonum persicaria, Tussilago farfara, Trifolium repens, Polygonum alpinum,* and in some places small groups of *Phragmites australis* and *Melica transsilvanica.* This community (due to incomplete covering of the substrate surface) is characterized by composition of plants belonging to various phases and stages of natural succession; and so the following species can be found: *Erigeron canadensis, Achillea nobilis, Ambrosia artemisifolia, Grindelia squarrosa, Taraxacum officinale, Centaurea diffusa, Melilotus albus, Polygonum aviculare, Kochia scoparia, Crepis tectorum. Lactuca saligna, Lactuca tatarica, Tragopogon major.* The predominant part of the grass stand is represented by *Poa angustifolia, Poa compressa* and *Festuca valesiana* with high density of the haulm stand (up to 150 specimens per 1 m^2), *Bromopsis inermis, Anisantha tectorum, Lotus ucrainicus, Scabiosa ochroleuca, Medicago romanica, Coronilla varia, Potentilla argentea, Silene ucrainica, Linaria genistifolia, Artemisia absinthium, Artemisia austriaca, Nepeta parviflora, Solidago virgaurea, Goniolimon besseranum, Herniaria besseri, Teucrium chamaedrys, Hieracium echioides* and *Viola ambigua.*

In the lithoecotope of the south-western slope of the same dump composed of sericite-biotite shales and unoxidized quartzites (typological formula $a_1i_2c_1d_1e_1f_3g_2h_4t_4$) a fragmentary Melica-Artemisia community has been formed in conditions of descending spatial spreading ; this community includes intervals between separate fragments of up to 1 meter and larger, grass stand density is not high (from 3 to 5 specimens per 1 m^2), cover of the substrate is 32%, plants grow in intervals between fragments.

Melica transsilvanica plants are located with non-uniform density and location of *Artemisia absinthium* is unevenly dotted and these plants are supplemented with separate plants of *Achillea submillefolium, Crepis tectorum, Erigeron canadensis, Gypsophilla perfoliata, Kochia scoparia, Centaurea diffusa, Senecio jacobaea* and *Grindelia squarrosa.* This fact corresponds to the ecological capacities of lithoecotopes with a similar substrate basis, sizes of fragments and location on the body of the dump.

In the first lithoecotope of the south-western part of the plateau-like top of sludge dump 1 (typological formula $a_1в_3c_3d_2e_2f_2h_2g_3t_4$) composed of ore-free and poor-ore quartzites, quartz-sericite-chlorit-biotite shales with insignificant admixtures of oxidized ferruginous quartzites, shrubby and woody vegetation is represented by separate plants of *Populus deltoides, Elaeagnus argentea, Hippophae rhamnoides.* Overall vegetation cover is 82%, density is 12-32 plants per 1m^2. The grass stand of the Koeleria-miscellaneous herbs community is represented by *Poa angustifolia, Poa compressa, Festuca valesiaca, Melica transsilvanica, Cichorium intubus, Artemisia austriaca, Artemisia absinthium, Koeleria cristata, Anisanta tectorum, Melilotus albus, Lotus corniculatus, Scabiosa ochroleuca, Plantago lanceolata, Centaurea diffusa, Euphorbia seguieriana, Melilotus officinalis, Linaria genistifolia, Daucus carota, Potentilla argentea, Stachys recta, Silaum besseri, Barkhausia rhoeadifolia, Reseda lutea, Dodartia orientalis, Erodium cicutarium, Petrorhagia saxifraga, Polycnemum majus, Seseli campestre, Silene supina, Silene ucrainica, Anthemis subtinctoria, Dianthus pseudoarmeria, Diplotaxis muralis, Lactuca saligna* and *Thesium arvense.*

In the second lithoecotope (typological formula $a_1i_3c_1d_1e_1f_2g_2h_4t_4$) a sparse fragmentary Melica-Crambe comunity was formed (with descending spatial spreading). *Melica transsilvanica, Crambe tataria* are supplemented by separate plants of such species as *Melilotus albus, Erigeron canadensis, Gypsophilla perfoliata, Atriplex tatarica, Senecio jacobaea, Artemisia absinthium, Armeniaca vulgaris, в нижній частині схилу Rumex crispus, Grindelia squarrosa, Lactuca tatarica, Dodartia orientalis, Erodium cicutarium, Eryngium campestre, Diplotaxis muralis, Kochia scoparia, Kochia vulgare, Salsola iberica, Silene latifolia, Centaurea diffusa, Potentilla argentea* and *Silaum alpestre* .

In the lithoecotope of the second terrace of the first sludge dumping site of the Central Mining and Ore Enrichment Combine (typological formula $a_1в_5c_5d_3e_3f_1g_3h_2$-$_3t_4$) a Koeleria-fescue-miscellaneous herbs community has a mosaic structure against the background of local big (20-30) and large lump (30-50) elements of mixed rocks with prevailing poor-ore quartzites and unoxidized quartzites with admixtures of oxidized quartites and quartz-sericite-biotite shales. Density of plants varies from 20-30 to 60-80 specimens, air-dry phytomass is from 192 to 483 g per 1 m^2. Total surface cover is 78%. The grass stand is composed of various ecological groups (in terms of their hygromorphic peculiarities, trophic peculiarities and coenomorphic peculiarities). There are some local small mosaic occurrences of *Melica transsilvanica,* as well as *Calamagrostis epigeios, Phragmites australis, Polygonum alpinum* and *Tussilago farfara,* which is possibly related to the availability of water resistant layers under the

Table 3. Petrophytic Properties of Lithophilic Plant Communities on Sludge Dumps of the Central Mining and Ore Enrichment Combine in Kryvbass

No	Families	The total number of species	Incl. petrophytes	Index of petrophytic properties, %
1.	Aceraceae	1	-	0
2.	Apiaceae	5	1	20.00
3.	Asteraceae	30	8	26.67
4.	Boraginaceae	3	1	33.33
5.	Brassicaceae	5	4	80.00
6.	Caryophyllaceae	11	8	72.73
7.	Chenopodiaceae	4	1	25.00
8.	Dipsacaceae	1	-	0
9.	Euphorbiaceae	2	1	50.00
10.	Elaeagnaceae	2	-	0
11.	Fabaceae	9	2	22.22
12.	Geraniaceae	1	1	100.00
13.	Lamiaceae	5	5	100.00
14.	Limoniaceae	1	1	100.00
15.	Onagraceae	1	1	100.00
16.	Poaceae	9	4	44.44
17.	Plantaginaceae	1	1	100.00
18.	Polygonaceae	5	1	20.00
19.	Ranunculaceae	3	-	0
20.	Resedaceae	1	1	100.00
21.	Rosaceae	5	1	20.00
22.	Salicaceae	2	-	0
23.	Santalaceae	1	1	100.00
24.	Scrophulariacea	5	1	20.00
25.	Ulmaceae	2	1	50.00
26.	Violaceae	1	1	100.00
Total:		116	46	39.65

finely fragmented and crushed stone surface of the lithoecotope substrate as a mixture of rocks. The fund of flowering plants is represented by the following species: *Poa compressa, Poa angustifolia, Festuca valesiaca, Anisantha tectorum, Artemisia absinthium, Artemisia austriaca, Barkhausia rhoeadifolia, Euphorbia seguieriana, Koeleria cristata, Diplotaxis muralis, Centaurea diffusa, Centaurea orientalis, Lactuca saligna, Melilotus albus, Linaria genistifolia, Lotus corniculatus, Petrorhagia saxifraga, Potentilla argentea, Plantago lanceolata, Medicago romanica, Scabiosa ochroleuca, Silaum besseri, Silene supina, Achillea submillefolium, Stachys recta, Berteroa incana, Grindelia squarrosa, Senecio jacobaea, Kochia scoparia, Gypsophilla perfoliata, Crepis tectorum, Cichorium intybus, Astragalus austriacus, Hieracium pilosella, Bidens tripartita, Erigeron canadensis, Polygonum aviculare, Echium vulgare, Consolida regalis, Minuartia leiosperma, Veronica austriaca, Herniaria besseri, Alyssum murale, Erysimum diffusum, Solidago virgaurea, Aster amellus, Taraxacum officinale, Anthemis subtinctoria, Thesium arvense*. Shrubby and woody species include: *Rosa canina, Elaeagnus argentea, Populus deltoides, Populus nigra, Ulmus laevis* and *Armeniaca vulgaris.*

In the lithoecotope of the south slope of the same terrace (typological formula $a_1в_2c_2d_3e_3f_1g_2h_3$-$_4t_4$) the substrate is mainly composed of unoxidized and oxidized quartzites with a smaller admixture of shales. The same Koeleria-fescue-miscellaneous herbs community is characterized by greater cover (85%) of the substrate, greater density of plants (90-120 specimens) and an air-dry phytomass (up to 620 g) per 1m^2. Availability of small fragments of big-fragment substrate reduces the mosaic structure of the community but also defines a combination of plant species at various phases and stages of natural overgrowth which is typical for all lithoecotopes with heterogeneous surface structure (those of terraces as well as those of slopes). The characteristic trees and shrubs includes the following species ; *Rosa canina, Elaeagnus argentea, Populus deltoides, Populus nigra* and *Acer negungo*. Species composition of the grass stand is sufficiently diverse and similar to that of the previous community, excluding such hygromorphic species as *Phragmites australis, Calamagrostis epigeios, Bidens tripartita* and *Tussilago farfara.* Species of the Poaceae family create a relatively even cover of the entire lithoecotope area. This is the case with *Poa compressa, Poa angustifolia, Festuca valesiaca, Koeleria cristata*

and *Anisantha tectorum,* but *Melica transsilvanica* is located in separate fragments with a certain relationship to the eastern and north-eastern winds; the grass stand also includes separate locations of *Medicago romanica, Coronilla varia, Artemisia austriaca, Thymus dimorphus, Helichrysum arenarium, Lotus corniculatus, Xeranthemum annuum, Trifolium borysthenicum* and *Teucrium chamaedrys.* The following species can be relatively sparsely found in the grass stand ; *Artemisia absinthium, Achillea submillefolium, Aster amellus, Centaurea diffusa, Centaurea orientalis, Cichorium intybus, Diplotaxis muralis, Crepis tectorum, Daucus carota, Erigeron canadensis, Gypsophilla perfoliata, Grindelia squarrosa, Kochia scoparia, Lappula squarrosa, Linaria genistifolia, Plantago lanceolata, Polygonum aviculare, Rumex confertus, Verbascum lychnitis, Taraxacum officinale, Carduus acanthoides, Ceratocephala testiculata, Consolida paniculata, Echium vulgare, Scabiosa ochroleuca, Silaum alpestre, Silene latifolia, Chondrilla juncea, Euphorbia virgultosa, Erysimum diffusum, Hieracium echinoides, Dianthus lanceolatus, Melilotus officinalis, Minuartia leiosperma, Lycopsis orientalis, Holosteum subglutinosum, Nepeta parviflora, Phlomis pungens, Scorzonera taurica, Senecio jacobaea, Stachys recta, Silene ucrainica, Seseli campestre, Verbascum austriacum* and *Thesium arvense.* These two lithoecotopes of the first Sludge Dump at the Central Mining and Ore Enrichment Combine are close to the stage of steppification (steppe formation) and natural overgrowth of disturbed grounds.

Within the south-eastern part of the first terrace on the first sludge dumping site (dumped by means of railway transport), where surface leveling and compression was performed during the period of dumping there are sufficiently fresh (1-5 years) and recent (5-10 years) lithoecotopes formed of various types of rocks typical for quarries of the Central Mining and Ore Enrichment Combine. In lithoecotope 1 (typological formula $a_1в_2c_5d_2e_2f_2g_3h_2t_1$), with its substrate basis formed of quartz-biotite shales, biotite-chlorite shales, unoxidized and oxidized quartzites a sparse pioneer Erigeron-Kochia-Polygonum community was formed with general density from 6 to 12 specimens per 1 m^2. The grass stand includes the following species ; *Erigeron canadensis, Kochia scoparia, Polygonum aviculare,* in some places *Gypsophilla perfoliata, Diplotaxis muralis, Centaurea diffusa, Silene ucrainica, Melilotus albus* are found. This poor (in species composition) comunity is a starting (pioneer) one based on slowed colonization of the crushed stone substrate; and when passing to the lithoecotope 2 of older dumping (typological formula $a_1в_2c_5d_2e_2f_2g_3h_3t_2$) density of grass stand *(Erigeron canadensis, Kochia scoparia, Polygonum aviculare, Melilotus albus)* is increased (up to 20 specimens per 1 m^2) creating a continuous carpet covering of the substrate with admixtures of *Silene latifolia, Silene ucrainica, Linaria genistifolia, Achillea submillefolium, Artemisia absinthium, Gypsophilla perfoliata, Diplotaxis muralis, Lactuca saligna, Linaria genistifolia, Melica transsilvanica, Crambe tataria, Grindelia squarrosa, Centaurea diffusa.* Development of *Melilotus albus* is characteristic of rocky dumps and similar lithoeotopes, which was pointed out by V.R.. Williams, who considered this species to be typical in the process of vegetation restoration on crushed stone substrates and determined this developmental phase of the first weed stage as a characteristic one (Melilotus phase). During respective periods of time this was taken into account by I.A. Dobrovolskiy, V.I. Shanda, N.V. Gayeva (Dobrovolsky, Shanda, Gayeva, 1979), who studied overgrowth of substrates composed of various types of rocks. At the same time, it should be noted that in these two lithoecotopes we have a comparative developmental picture of the first stage of natural overgrowth on rocky dumps which was not observed in the previous ecotopes. *Melilotus albus* (as was determined by many authors is characterized by high contents of alkaloid coumarine and that is why its rarefication and change of the species composition of the *Melilotus*-miscellaneous herbs community may have some features of *Melilotus* weariness (similar to *Trifolium* weariness of soils) and the succession has allelopathic causality. This hypothesis has not been sufficiently checked but it is quite probably due to small contents of colloidal compounds in crushed stone substrates.

On the southern slope of the first sludge dumping site where the surface is composed of the mixture (conglomerate) of quartz-sericite-biotite shales, biotite-chlorite shales and poor-ore quartzites including fragments of various sizes (from fine fractions to large-sized fractions) (typological formula $a_1c_1i_2d_1e_1f_3g_3h_7t_3$) an unevenly distributed, sparse, patchy Melica community was formed with density of plants 5-6 plants per 1 m^2 and providing 10-12% cover of the substrate surface in conditions of complete absence of plant mass remnants. This community can be viewed as an example of independent and simple immigration and spreading of *Melica transsilvanica* as a pioneer species and non-dense bushy herb and development of an almost single-species lithophilic community without previous intermediate stages and phases. *Melica transsilvanica* is able to independently take and hold ecological positions in harsh conditions of lowered trophic characteristics, hygrophylous characteristics and thermal extremes (overheating) during the vegetation period. In this

community only separate specimens of *Crambe tataria* were detected.

In the lithoecotope 3 (which is located close to the above-mentioned lithoecotope) against the background of a similar conglomerate of rocks (but with smaller fractions) (typological formula $a_1c_1i_2d_1e_1f_3g_3h_3t_3$) a fragmentary dissected Artemisia-Melica-miscellaneous herbs community was developed with general cover of 26% of the surface (descending spatial spreading). The main species are *Melica transsilvanica, Artemisia absinthium,* also *Erigeron canadensis, Polygonum aviculare, Senecio jacobaea, Achillea submillefolium, Kochia scoparia, Silene ucrainica, Crepis tectorum, Dianthus deltoides, Linaria genistifolia, Berteroa incana, Ambrosia artemisifolia, Atriplex tatarica* and *Grindelia squarrosa.* Presence of these species is conditioned by locally band-like (along the slope) washing of fine grained soil away from the surface of the plateau-like top.

Within the second sludge dumping site there is a hollow up to 60 meters long where lithoecotopes of its eastern and western slopes vary in size of fractions and respective conditions of plant community development.

In the lithoecotope of the eastern slope (its substrate basis includes the same shales and quartzites) (typological formula $a_1c_8i_2d_1e_1f_3g_3h_4t_4$), in the upper part there is a Melica-miscellaneous herbs community with isolated *Ulmus caprinifolia* trees and *Rosa dumalis* shrubs. The grass stand is sparse (5-6 plants per 1 m^2). The main species: *Melica transsilvanica, Artemisia absinthium, Gypsophilla perfoliata, Crambe tataria.*

On the western slope with separate trees of *Populus nigra,* (lithoecotope typological formula $a_1c_7i_3d_2e_2f_2g_2h_3t_4$), the substrate is composed in a similar way but with significant admixtures of oxidized quartzites. A fragmentary- band-like Melica-Koeleria-miscellaneous community has formed with bands in some places reaching the foot of the dump. The following species are present in the grass stand ; *Melica transsilvanica, Poa compressa, Poa angustifolia, Crambe tataria, Erigeron canadensis, Kochia scoparia, Polygonum aviculare, Centaurea diffusa, Crepis tectorum, Senecio jacobaea, Diplotaxis muralis, Silene supina, Linaria genistifolia, Melilotus albus, Lactuca saligna* and *Euphorbia seguieriana.*

On the northeastern slope of the second sludge dump (in the lithoecotope with the technological formula $a_1c_5i_3d_1e_1f_2g_3h_7t_4$) with the substrate basis including quartz-sericite-biotite shales and unoxidized/partially oxidized quartzites a Melica-miscellaneous herbs community (dissected-elongated-patchy) was formed with cover of 25% and density of herbaceous plants from 5 to 20 specimens per 1 m^2 and some separate specimens of *Rosa canina, Populus deltoides, Armeniaca vulgaris.* The grass stand is represented by mixed and isolated groups of *Melica transsilvanica, Phragmites australis, Kochia scoparia, Polygonum aviculare, Centaurea diffusa, Artemisia absinthium, Artemisia austriaca, Erigeron canadensis, Grindelia squarrosa, Atriplex tatarica, Melilotus albus, місцями Achillea nobilis, Diplotaxis muralis, Silene latifolia, Rumex confertus, Senecio jacobaea* and *Crepis tectorum,* while a single specimen of *Oenothera biennis* was registered.

Within the sludge dumping sites of the Central Mining and Ore Enrichment Combine on fresh (up to 5 years) and recent (up to 10 years) flat pressed (by bulldozers and scrapers in the process of moving hard rocks) and relatively even surfaces in conditions of homogeneous substrates (shale-unoxidized-quartzite ones or with admixture of oxidized quartzites or their combinations) uniform Kochia-Erigeron-Polygonum plant communities of carpet type are formed with diffusely uneven spreading and composition of plants belonging to the following cenopopulations: *Kochia scoparia, Erigeron canadensis, Polygonum aviculare* with small admixtures of *Gypsophilla perfoliata, Grindelia squarrosa, Silene ucrainica, Linaria genistifolia,* which are later substituted (within 5-10 years) by Melilotus-Artemisia-Achillea communities i.e. by the Melilotus phase of restoration of the steppe indigeneous vegetation which is typical for hard rocky (crushed stone) substrates in the steppe area with further gradual disappearence of Melilotus from the grass stand and appearence of Koeleria plants and miscellaneous herbs.

Presence of species, species capacity and petrophytic capacity of plant communities, their indexes of petrophytic properties in lithoecotopes of sludge dumps may vary depending on specific conditions.

In the line of sludge dumps (in lithophilic plant communities) 116 species were determined belonging to 26 families including 46 petrophyte species (Table 4). Descending rows (spectra) of plant community families are presented as follows: I. According to the number of species ; *Asteraceae* (30) – *Caryophyllaceae* (11) – *Poaceae* (9) – *Fabaceae* (9) – *Apiaceae* (5) – *Brassicaceae* (5) – *Lamiaceae* (5) –*Polygonaceae* (5) – *Rosaceae* (5) – *Scrophulariacea* (5) – *Chenopodiaceae* (4). II. According to the number of petrophytes ; *Asteraceae* (8) – *Caryophyllaceae* (8) – *Lamiaceae* (5) – *Brassicaceae* (4) – *Poaceae* (4). III. According to the coefficient of petrophytic properties (%%) ; – *Lamiaceae* (100,00) – *Brassicaceae* (80,00) – *Caryophyllaceae* (72,72) – *Poaceae* (44,44) – *Asteraceae* (26,66).

Table 4. Species Capacity and Petrophytic Capacity of Plant Families in the Central Zone

No	Families	The total number of species	Incl. petrophytes	Coefficient of petrophytic properties, %
1.	*Aceraceae*	1	-	0
2.	*Apiaceae*	6	1	16.67
3.	*Aspleniaceae*	1	1	100.00
4.	*Asteraceae*	38	12	31.58
5.	*Boraginaceae*	3	1	33.33
6.	*Brassicaceae*	9	5	55.56
7.	*Campanulaceae*	1	1	100.00
8.	*Caryophyllaceae*	12	9	75.00
9.	*Chenopodiaceae*	6	2	33.33
10.	*Dipsacaceae*	2	1	50.00
11.	*Elaeagnaceae*	2	-	0
12.	*Euphorbiaceae*	2	1	50.00
13.	*Fabaceae*	11	3	27.27
14.	*Geraniaceae*	1	1	100.00
15.	*Lamiaceae*	8	6	75.00
16.	*Limoniaceae*	1	1	100.00
17.	*Linaceae*	1	-	0
18.	*Moraceae*	1	-	0
19.	*Onagraceae*	1	1	100.00
20.	*Plantaginaceae*	3	2	66.67
21.	*Poaceae*	15	10	66.67
22.	*Polygonaceae*	5	1	20.00
23.	*Ranunculaceae*	4	-	0
24.	*Resedaceae*	1	1	100.00
25.	*Rosaceae*	6	1	16.67
26.	*Rubiaceae*	1	1	100.00
27.	*Salicaceae*	2	-	0
28.	*Santalaceae*	1	1	100.00
29.	*Scrophulariaceae*	5	1	20.00
30.	*Ulmaceae*	2	1	50.00
31.	*Violaceae*	1	1	100.00
	Total:	153	66	43.14

Average coefficient of petrophytic properties in plant families is 39.65 %.

Plant communities of sludge dump lithoecotopes are characterized by a greater variability of species capacities and petrophytic capacities and in these lithoecotopes the following families present the greatest species diversity: *Brassicaceae, Caryophyllaceae, Chenopodiaceae, Fabaceae, Poaceae, Polygonaceae* and *Scrophulariaceae.*

So, the species composition of the lithophilic communities present on the sludge dumping sites of the Central Mining and Ore Enrichment Combine

Table 5. Petrophyte Species Typical only for the Central Zone of the Kryvbass

No	Species	Families
1.	*Alyssum murale*	*Brassicaceae*
2.	*Aspleniumruta-muraria*	*Aspleniaceae*
3.	*Asyneuma canescens*	*Campanulaceae*
4.	*Centaurea solstitialis*	*Asteraceae*
5.	*Dianthus carbonatus*	*Caryophyllaceae*
6.	*Dianthus pseudoarmeria*	*Caryophyllaceae*
7.	*Festuca sulcata*	*Poaceae*
8.	*Galium ruthenicum*	*Rubiaceae*
9.	*Goniolimon besseranum*	*Limoniaceae*
10.	*Marrubium praecox*	*Lamiaceae*
11.	*Nepeta parviflora*	*Lamiaceae*
12.	*Phlomis pungens*	*Lamiaceae*
13.	*Poa stepposa*	*Poaceae*
14.	*Polycnemum majus*	*Chenopodiaceae*
15.	*Polygonum alpinum*	*Polygonaceae*
16.	*Scorzonera taurica*	*Asteraceae*
17.	*Silene supina*	*Caryophyllaceae*
18.	*Viola ambigua*	*Violaceae*

demonstrates high substrate dependence and temporal dependence.

In general the taxonomic composition of plant communities on dumps of the Kryvbass central zone includes 153 species belonging to 31 families (Table 4), among them 66 species are petrophytes and 18 species are typical only for this zone (Table 5).

These plant communities are presented in descending order as follows: I. According to the number of species; *Asteraceae* (38) – *Poaceae* (15) – *Caryophyllaceae* (12) – *Fabaceae* (11) – *Brassicaceae* (9) – *Lamiaceae* (8) – *Apiaceae* (6) – *Chenopodiaceae* (6) – *Rosaceae* (6) – *Polygonaceae* (5) – *Scrophulariaceae* (5) – *Plantaginaceae* (3); II. According to the number of petrophytes; *Asteraceae* (12) – *Poaceae* (10) – *Caryophyllaceae* (9) – *Lamiaceae* (6) – *Brassicaceae* (5) – *Fabaceae* (3) – *Plantaginaceae* (2). III. According to the coefficient of petrophytic properties (%%); *Caryophyllaceae* (75.00) – *Lamiaceae* (75.00) – *Poaceae* (66.66) – *Plantaginaceae* (66.66) – *Brassicaceae* (55.55) – *Asteraceae* (31.58) – *Fabaceae* (27.27). Average index of petrophytic properties is 43.14%.

Conclusion. We classified various lithoecotopes and characterized vegetation communities of varying complexity growing on plateau tops, terraces and slopes, depending on specifics of their constituent rocks and typological features. In accordance with the state of the lithoecotopes, including all typological characteristics and the geochemical nature of rocks, plant lithophilic communities growing on the dumps of the Central Mining and Ore Enrichment Combine were characterized by significant differences in analytical (floristic and ecomorphic composition, occurrence, layerage, aspect, abundance, coverage) and synthetic (similarity, constancy) values. A detailed survey of the state of the plants and their communities within the lithoecotopes has allowed us to establish that their distribution and development have clearly expressed dependence on substrate and relief-exposure,which can be used in phytocoenic and phytocenotic melioration of such technogenic ecotopes. Native overgrowth of all dumps has a shrub-tree forest and grassy pattern in accordance with the typological characteristics and rock composition. In general, the taxonomic composition of the plant communities growing on the dumps of the Kryvbas central zone is determined by 153 species belonging to 31 families, of which 66 species are petrophytes, and 18 species are typical only for the zone surveyed.

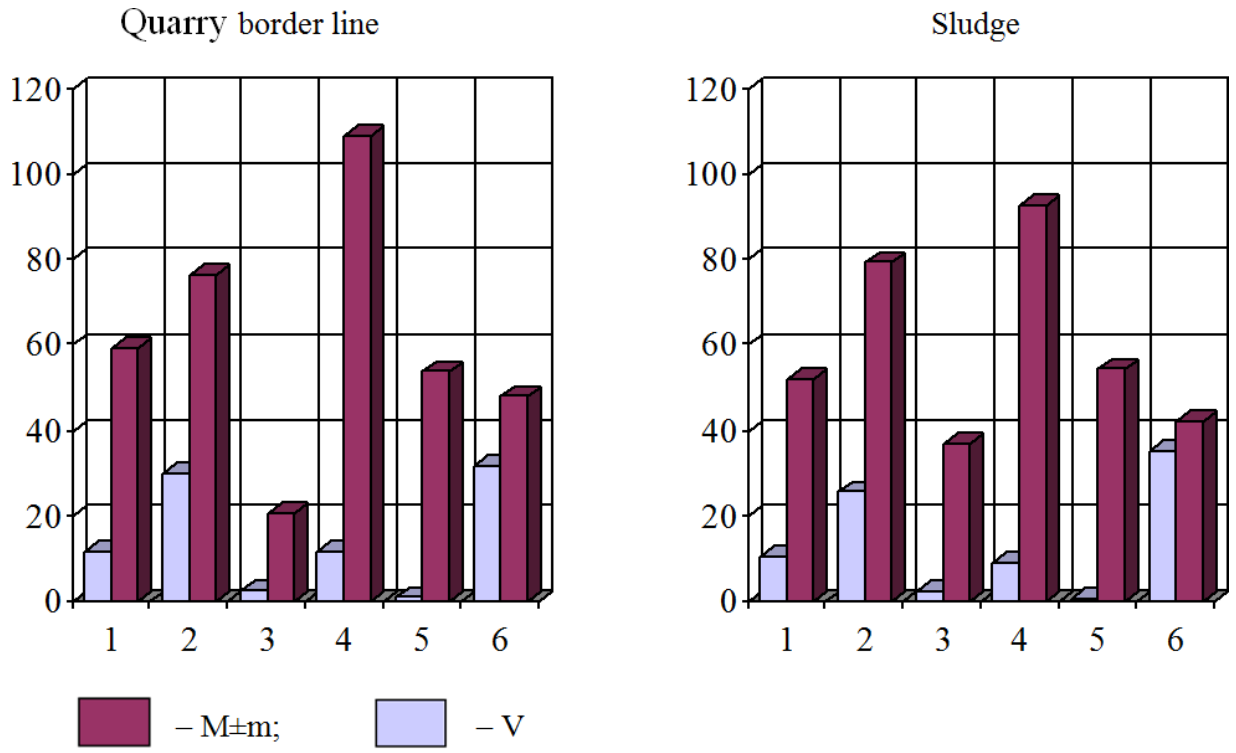

Fig.1. Consolidated indexes of generalized characteristics of lithophilic family communities:

1 – families; 2 – species; 3 – average species capacity of families; 4 – petrophytes; 5 – average petrophytic capacity of families; 6 – index of petrophytic properties of communities

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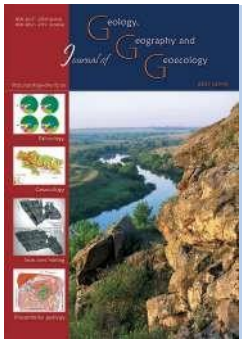

JOURNAL of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(4), 795–803.
doi: 10.15421/111974

Eco-service potential of sustainable development of small towns

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Received: 27.05.2019
Received in revised form: 06.08.2019
Accepted: 18.11.2019

Abstract. The purpose of the study is to determine the ecosystem services potential and capacity for ecological stability of the five nearest small towns to Kyiv by comparative analysis of their territories by the number of ecosystem services provided per unit area and per capita. The researched towns have a similar history of development, but differ in area, number and density of population, industrial development and land use structure. The research is conducted on the basis of public indicators of the master plans of the small towns using the transfer method and relative values. The cost of ecosystem services in the territories of the small towns is calculated according to the categories of the land fund by agricultural land, forest and water. Ecosystem services per 1 ha of each land use category are adjusted for transfer coefficient into USD, taking into account the purchasing power parity factor for Ukraine. The cost of ecosystem services per capita and 1 ha of territory of each town is calculated for the current state of towns and for a 20-year perspective. It was established that the total cost of ecosystem services in Boyarka, Vyshgorod, Bucha and Irpin towns exceeded that of the ecosystem services of Vyshneve by 3.6, 5.8, 10.6 and 25.7 times respectively The cost of ecosystem services per capita in Irpin exceeds by 28.8 times the same indicator of Vyshneve, due to the small number of water bodies, forests and agricultural lands in the territory of the latter town, as well as due to its extremely high level of development. An analysis of the dynamics of the cost of ecosystem services per unit area of the small towns shows that the maximum cost of ecosystem services per 1 hectare of urban territory is borne by Vyshgorod and Irpin, and in the long run – the maximum will be increased by 2.9 and 3.0 times in Vyshgorod and Boyarka respectively. These dynamics are due to the expansion of the urban area. The results of the study indicate the need to adjust the master plans of urban development in terms of expanding the environmental component of Irpin and Bucha.

Keywords: ecosystem services, land use, cost transfer coefficient, eco-balance development.

Екосервісний потенціал сталого розвитку малих міст

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Анотація. Метою дослідження є визначення екосервісного потенціалу та потенційної екологічної стабільності п’яти найближчих до Києва малих міст шляхом порівняльного аналізу їх територій за кількістю екосистемних послуг, що надаються одиницею їх площі та на одного жителя. Досліджувані міста мають подібну історію розвитку, але різняться за площею, кількістю жителів, щільністю населення, промисловим розвитком і структурою землекористування. Дослідження проведене на основі загальнодоступних показників Генеральних планів малих міст з використанням трансферного методу та відносних величин. Вартість екосистемних послуг на території дослідних малих міст розрахована за категоріями земельного фонду сільськогосподарськими угіддями, лісовими масивами і водними поверхнями. Екосистемні послуги на 1 га кожної категорії землекористування скориговані переведенням у долари США з урахуванням коефіцієнту переносу вартості за паритетом купівельної спроможності для України. Вартість екосистемних послуг на одного мешканця і на 1 га міської території кожного міста розрахована для сучасного стану міст і на 20-річну перспективу. Встановлено, що загальна вартість екосистемних послуг міст Боярка, Вишгород, Буча та Ірпінь відповідно у 3,6; 5,8; 10,6 і 25,7 рази перевищує екосистемні послуги міста Вишневе. Вартість екосистемних послуг на одного жителя м. Ірпінь перевищує у 28,8 рази аналогічний показник м. Вишневе, що пояснюється малою кількістю водойм, лісів і сільськогосподарських угідь, а також надзвичайно високим рівнем забудови. Аналіз динаміки вартості екосистемних послуг на одиницю площі малих міст показав, що максимальна вартість екосистемних послуг у розрахунку на 1 га міської території належить Вишгороду та

Ірпеню, а в перспективі – максимально зросте у Вишгороді та Боярці, відповідно у 2,9 і 3 рази. Така динаміка зумовлена розширенням міської території. Результати дослідження свідчать про необхідність коригування генеральних планів міського розвитку в частині розширення екологічної компоненти для міст Ірпінь і Буча.

Ключові слова: екосистемні послуги, землекористування, коефіцієнт переносу вартості, екозбалансованість

Introduction. An important role in the implementation of the New Urban Development Program, adopted at the UN Habitat III Conference in 2016, has been given to ecosystem services (ES), and urban planning has been identified as the main tool for managing the urban environment (Sulkarnaeva, 2017). Ecosystem services contribute to offsetting the negative effects of urban functioning, support environmental safety, sustainable development and human well-being (Xu et al., 2018).

Extension of the built-up area can have irreversible consequences for the environment, biodiversity and ecosystem services (Andrade-Nunez & Aide, 2018). Rapid changes in urban land cover are one of the major environmental issues. Such changes include the transformation of green spaces into an impervious surface and, as a consequence, increases in the temperature of the earth cover (Wu & Zhang, 2018). Quantitative analysis of urban land structure dynamics is important for determining the cost of ecosystem services, which facilitates ecosystem conservation decisions (Lin et al., 2018; Greenhalgh et al., 2017). Quantifying ecosystem services in cities is difficult, but it must be taken into account in their planning (Kim & Coseo, 2018).

Land-use optimization is an effective tool for streamlining its structure to provide the expected ecosystem services, as the reduction of eco-stabilizing lands leads to a loss of green space in the city (Wang et al., 2018). Land use plans are widely used to guide urban development, which can affect the diversity and spatial distribution of urban ecosystem services (Lam & Conway, 2018).

The theoretical underpinnings of urban ecosystem services are less well defined than agricultural or forestry services (Bastian et al., 2012). They are often seen as grey services (not happening) or white cells (undefined, meaning no information is available). However, urban ecosystem services are closely correlated with land use and more related to climate regulation, carbon sequestration and recreation.

Arnold et al. (2018) assessed global and local regulation by urban green space of climate, water cycles, air pollution, food production, recreation, and concluded that the potential provision of regulative ecosystem services is spatially limited by land use types. The cost of ecosystem services related to energy conservation, property value, carbon retention, improved air quality and storm water runoff per street tree has been calculated (Wang et al., 2018). Urban ecosystems are particularly important for the provision of services with a direct impact on health and safety, such as air purification, noise reduction, urban cooling and runoff mitigation (Bolund & Hunhammar, 1999). Which ecosystem services are most relevant in a given city depends on its environmental and socio-economic characteristics (Gómez-Baggethun & Barton, 2013).

Analysis of publications on the assessment of urban ecosystem services revealed that most of the research was conducted in Europe, North America and China. However, few research findings have been incorporated into land use policies (Haase et al., 2014). Analyzing ecosystem service research for 1997-2011, Seppelt et al. (2011) found that 50% of surveys were conducted in six countries (mainly in the US and China), while the cost of all ecosystem services in these countries was only 23.5% of the total (Kasimov D. & Kasimov V., 2015). The vast majority of research has been done in industrialized countries of the Northern Hemisphere, less in developing countries. The interdisciplinary analytical design of urban ecosystem services provides an opportunity to synchronize human impact and sustainability of urban environmental resources.

The first known experience of global ecosystem services assessment was conducted by Costanza et al. (1997) by complex indirect methods. As a result, the global cost of the ES was $33 trillion/year on average. Total global ecosystem services in 2011 were already $125-145 trillion/year, and the loss of environmental services over the period from 1997 to 2011 as a result of land-use change was $4.3-20.2 trillion/year (Costanza et al., 2014). Rosenberg (2014) considers that the easiest way to estimate ecosystem services for a given territory is to determine its share in the total area of the Earth and, in proportion, in the total cost of the ES ($33 trillion).

The assessment of ecosystem services of landscapes is carried out taking into account the area occupied by a certain type of land, as well as changes in the quantitative and qualitative characteristics of individual components. Hossein (2016) has developed a method for economic assessment of urban forests based on the concept of alternative cost of nature use, which reflects the potential return on all possible but not realized options for using the resource. The main

problem of assessming forest ecosystem services is the lack of data available for calculation. In most cases, these are physical rather than economic indicators. Data collection is a very time-consuming and long-term process. But even from insufficient data it is clear that in the long run, the economic effect of forest conservation and restoration, calculated taking into account the smallest ecosystem services, is twice the total value obtained from the sale of timber or/ and the transformation of these lands (Strokov & Poleshkina, 2016).

A method has been proposed for assessing urban cultural ecosystem services by using only two variables: the size of the green zone and the rent for land. In this way, cultural and regulative services are integrated into the common ecosystem services, as urban green areas have almost no provisioning services (Chang et al., 2017). In general, complex cost estimation of ecosystem functions is complicated by their diversity, and the dependence of estimates on the location of the research complicates their distribution to other territories.

Sulkarnaeva (2017) considers the best approach to the assessment of urban ecosystem services, to be that applied in the project "Towards Green Cities: The Values of Urban Biodiversity and Ecosystem Services in China and Germany", which allows one to identify not only the areas with the highest and lowest potential for the production of ecosystem services and areas that need conservation and protection but also identify in the course of the benchmarking the production volumes and needs of ecosystem services and the planning decisions required.

Assessing ecosystem services dynamics in response to land-use change is an effective method of developing land-use management and environmental policies (Xue & Ma, 2018). The importance of carefully designing urban green spaces in urban plans in terms for ecosystem service delivery is emphasized (Derkzen et al., 2015).

Burkhard et al. (2012) developed an evaluation system based on the matrices linking land cover, ecosystem integrity, service supply, demand and budgets. This valuation approach creates relative units of supply and demand for each service. According to Hansen & Pauleit (2014), the methods of analysis need to be adapted to the access of data and the ability to obtain it. Neverov & Andrushko (2016) believe that it is necessary to improve the method of evaluation of ES to adequately reflect their social significance and changes over time. They group all types of land into three categories: natural, natural-anthropogenic (rural regions) and anthropogenic (built-up).

Urban ecosystem services can increase the resilience of a city, which is directly dependent on the quantity, quality and diversity of the green infrastructure that produces them. On a regional scale, ecosystem service delivery is threatened by an increasing anthropogenic load on urban development and, as a consequence, the decline of urban green spaces (Calderón-Contreras & Quiroz-Rosas, 2017). The purpose of assessing urban ecosystem services is to support and enhance the ability of urban ecosystems to provide material services and to further reduce the risks of unstable cities (Tang et al., 2018). Recently, ecosystem services assessment methods, their spatial and temporal nature have been reviewed in 116 publications (Atif et al., 2018).

The purpose of the study is to evaluate and compare the environmental potential of several small towns in Kyiv region at the cost of ecosystem services received in their territories and to provide recommendations on how to improve the most promising plans and eco-balanced development.

Material and methods of research. The research object was five selected small towns of Kyiv region located near the capital and near to each other ,with a population in the range of 10 to 50 thousand inhabitants and with intensive development. Their choice was made on the basis of the availability of up-to-date (newly developed) publicly available master planning materials. This choice is justified by the lack of population censuses, urban green space inventory, availability of data on small urban areas and ease of use (Yukhnovskyi & Zibtseva, 2018).

At present, the legal uncertainty of the mechanisms for the prospective development of small towns and the lack of consideration of their specificities aggravate not only socio-economic but also environmental problems in their territories. The studied towns are located in the immediate area of influence of Kyiv, at a distance of 1.5 km (Vyshneve) to 32 km (Bucha) (Fig. 1).

The towns were surveyed during 2010-2012 and characterized by the highest population growth rates, which amounted 3.73; 3.35; 3.28; 2.1 and 1.1% in Bucha, Irpin, Vyshgorod, Vyshneve and Boyarka , respectively (Bondar, 2014). These towns are characterized by satisfactory (Vyshneve, Boyarka, Vyshgorod) and moderately favourable (Irpin, Bucha) living conditions, different population densities (from 1,050 inhabitants/km^2 in Bucha to 6,604 inhabitants/ km^2 in Vyshneve) and different (from 151.4 in Vyshneve) up to 952.7 (in Bucha) amounts of urban land per capita (Table 1).

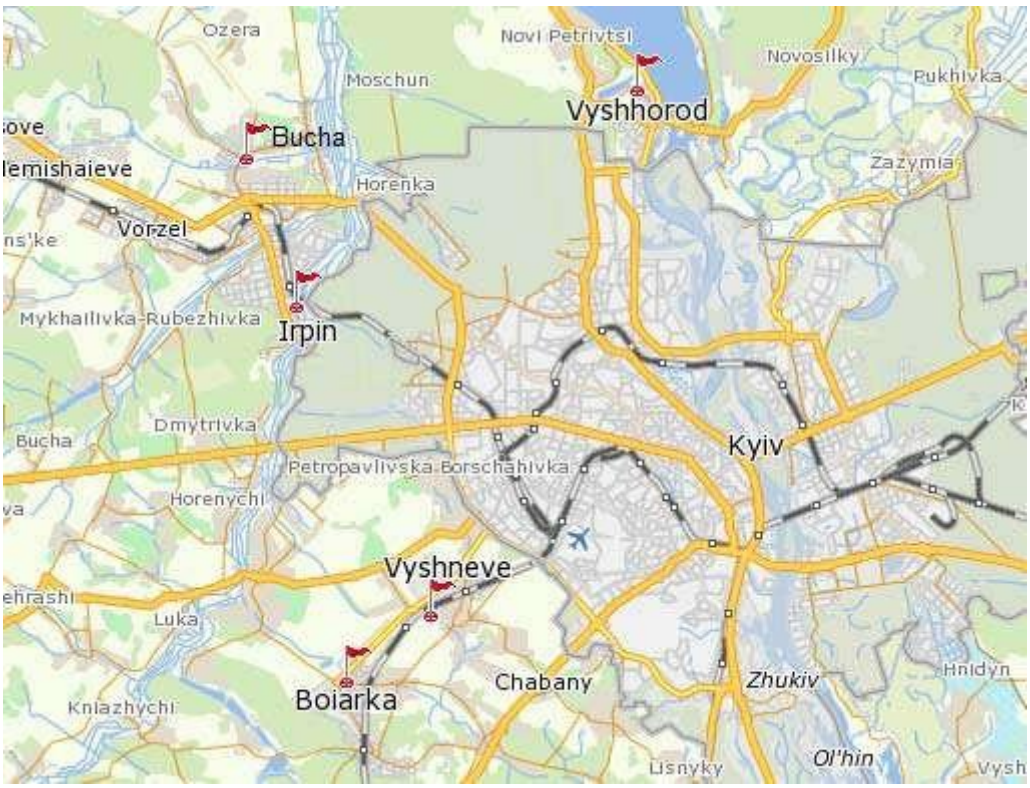

Fig. 1. Location of small towns of Kyiv region relative to Kyiv

Population growth is due to the suburbanization of cities. The socio-demographic situation in the small towns of Kyiv region is correlated with regional and all-Ukrainian tendencies and, despite some exceptions, remains generally difficult. Tomashuk (2014) describes the socio-economic situation of most small towns in Ukraine as a crisis.

The concept of determining of the full cost of urban ecosystem services is currently the most popular. The evaluation of each ecosystem service is carried out by direct and indirect assessment methods. There are four approaches to assessing the economic cost of ecosystem services: the direct market valuation method; indirect market valuation methods; conditional assessment method; group assessment method (Soloviy, 2016).

Indirect market valuation methods include the determination of cost avoidance, alternative cost, factor income and more. These varieties of evaluation are selected based on the specificities and objectives of the study (Groot et al., 2002). Indirect valuation methods include the value transfer (price transfer) method, which is used when information (cost or time) is completely missing to evaluate the service. This method applies the assessment of similar services in other countries, which is adjusted to the conditions of the researched country. The method can be used almost everywhere, where there is no possibility for one's own research.

We have applied this technique using the cost-transfer coefficient defined by the formula (Markandia et al., 2014):

$$V_{tr} = V_1 \quad \frac{GDP_{tr}}{GDP_1}, \qquad (1)$$

where V_{tr} is the value of the service in the target country of study, i.e. Ukraine; GDP_{tr} – gross national product per capita in the country of study; GDP_1 is the

Table 1. Characteristics of small towns of Kyiv region

Town	Area, ha	Population, thousand inhabitants	Living conditions	Population density, inhabitants/km^2	Urban land, m^2/capita	Built up area, m^2/capita	Ecological tax, USD/ha
Vyshneve	704.1	46.5	satisfactory	6,604	151.4	137.4	0.97
Boyarka	1,122	35.5	satisfactory	3,164	316.1	251.5	1.59
Vyshgorod	874.1	27.8	satisfactory	3,180	314.4	179.4	4.40
Irpin	3,705.1	41.5	moderately favourable	1,120	892.8	463.1	6.37
Bucha	2,658.1	27.9	moderately favourable	1,050	952.7	645.1	0.28

gross national product per capita in the country where the data chosen from.

Formula 1 uses gross national income per capita in purchasing power parity in USD for 2017: China - $16,760, Ukraine - $8,900, i.e. the GDP_{tr} / GDP_1/ GDP1 cost transfer ratio is 0.53.

The Cen, et al. (2015) method was used to determine the cost of all ecosystem services provided to local people in the small towns, which takes into account land use types. According to the method, urban land is divided into four categories of land use: urban (built-up), cropland (agricultural), forest and water. We applied the adjusted values of the coefficients for the three land use categories (in RMB and converted to $1 while 1 Yuan costs at $0.15 with Formula 1 adjustment). The calculated ecosystem service cost ratios are presented in Table 2.

Results and their analysis. In towns, the state of the ecosystem is closely linked to the type of land use. Land use is a fundamental variable that affects the social and physical aspects of the environment. Changes in land use and land cover are one of the key factors affecting ecosystem services. Their respective coefficients are used to estimate each type of earth's surface (Rai, 2018). The degree of naturalness of land use types provides a differentiated assessment of urban ecosystem services.

Taking into account the calculated ecosystem service cost ratios (Table 2), the total cost of ecosystem services by land uses for the territories of the five small towns at the current stage and for a 20-year perspective was calculated (Table 3).

Table 4 shows the estimated cost of ecosystem services per capita and per 1 ha of urban area of each

Table 2. Cost coefficients of ecosystem services for different land uses of small towns of Ukraine (by Cen et al., 2015)

Ecosystem services	Land use/cover type categories								
	Cropland			Forest			Water		
	ES, Yuan	ES, USD	Coefficient ES, USD	ES, Yuan	ES, USD	Coefficient ES, USD	ES, Yuan	ES, USD	Coefficient ES, USD
Gas regulation	885.0	132.75	70.36	3,097.0	464.55	246.21	0	0	0
Climate control	1,575.2	236.28	125.23	2,389.1	358.37	189.94	407	61.05	32.36
Water conservation	1,062.1	159.31	84.43	2,831.5	424.73	225.11	18,033.2	2,704.98	1,433.64
Soil conservation	2,584.0	387.60	205.43	3,450.9	517.63	274.34	8.8	1.32	0.70
Loss of health	2,902.7	435.41	230.77	1,159.2	173.88	92.16	16,086.6	2,412.99	1,278.88
Biodiversity conservation	1,256.4	188.46	99.88	2,884.6	432.69	229.32	2,203.3	330.50	175.17
Food	1,770.0	265.50	140.71	88.5	13.27	7.03	88.5	13.27	7.03
Natural materials	177.2	26.58	14.09	2,300.6	345.09	182.90	8.8	1.32	0.70
Recreation and culture	18.6	2.79	1.48	1,132.6	169.89	90.04	3,840.2	576.03	305.29
Total	12,231.2	1,834.68	972.38	19,334	2,900.10	1,537.05	40,676.4	6,101.46	3,233.77

For comparison, the average annual cost of 1 ha of non-urban forest ecosystem services can be $1,093-2,777 (Strokov & Poleshkina, 2016). That is, our rather virtual values are comparable to those of other sources.

The probable differences in the applied absolute values of ecosystem services (in RMB/USD) in our study are offset by the transition in the rating analysis to relative values. The assessment was carried out with the recalculation per 1 ha of urban area and per capita. In the absence of a population census and clear statistics, urban areas and population are dynamically changing in some cities, based on indicators of the current situation at the time of master plans.

In order to better distribute these types of land use, we also included private kitchen gardens and unbuilt on private plots in the category arable land; all categories of planted green perennials were placed in the catogory forest.

town now and for a 20-year perspective, as well as their comparative analysis in relation to Vyshneve the town least provided with ecosystem services .

Data of Table 4 indicate that the total cost of ecosystem services in Boyarka, Vyshgorod, Bucha and Irpin towns is higher by 3.6; 5.8; 10.6 and 25.7 times respectively than the ES of Vyshneve. The land unit of Vyshneve produces 2.3 and 4.9 times less ecosystem services than Boyarka and Irpin, respectively, and the cost of ES per capita of Irpin exceeds by 28.8 times the cost of ES of Vyshneve town. First of all, this is due to the small number of water bodies, forests and farmland, as well as the extremely high level of development of Vyshneve. The penultimate place for the value of ecosystem services provided to the inhabitants belongs to Boyarka, where there are few water bodies and the smallest area of agricultural lands.

In the long run, the total cost of ecosystem services in Vyshneve will increase by 2.4 times,

Table 3. Assessment of ecosystem services of small towns for land use

Towns	Area now, ha			Area in perspective, ha		
	Cropland	Forest	Water	Cropland	Forest	Water
Area of main land uses, ha						
Vyshneve	0	64.8	0.5	0	153.0	2.0
Boyarka	12.3	206.0	10.9	12.3	2,114.3	10.9
Vyshhorod	78.3	267.6	29.5	95.2	2,197.4	1,941.0
Irpin	602.6	1,060.4	120.4	35.6	1,736.7	110.0
Bucha	476.0	303.4	40.1	0	505.8	40.1
Amount per 1 ha	972.38	1,537.05	3,233.77	972.38	1,537.05	3,233.77
Cost of ecosystem services by land use, USD						
Vyshneve	0	99,600.84	1,616.88	0	235,168.65	6,467.54
Boyarka	11,960.27	31,6632.3	35,248.09	11,960.27	3,249,784.81	35,248.09
Vyshhorod	76,137.35	411,314.58	95,396.21	92,570.58	3,377,513.67	6,276,747.5
Irpin	585,956.18	1,629,887.82	389,345.91	34,616.73	2,669,394.73	3,55,714.7
Bucha	462,852.88	466,340.97	129,674.17	0	777,439.89	129,674.18

Table 4. Comparative up-to-date and prospective assessment of ecosystem services of small towns per capita and unit of area

Towns	Current state			20 years perspective		
	Total cost of ES, USD	Per capita	Per 1 ha	Total cost of ES, USD	Per capita	Per 1 ha
Cost of ecosystem services in absolute terms, USD						
Vyshneve	101,217.72	2.18	143.75	241,636.19	3.72	209.93
Boyarka	363,840.66	10.51	324.28	3,296,993.17	54.95	972.85
Vyshhorod	582,848.14	20.97	666.80	9,746,831.75	108.30	1,961.92
Irpin	2,605,189.91	62.77	703.14	3,059,726.16	55.63	825.81
Bucha	1,058,868.02	37.95	398.36	907,114.07	15.12	341.26
Cost of ecosystem services relative to Vyshneve ES						
Vyshneve	1	1	1	1	1	1
Boyarka	3.6	4.8	2.3	13.6	14.8	4.6
Vyshhorod	5.8	9.6	4.6	40.3	29.1	9.3
Irpin	25.7	28.8	4.9	12.7	14.9	3.9
Bucha	10.6	17.4	2.8	3.7	4.1	1.6

which corresponds to an increase in their number per prospective inhabitant by 1.7 times and by 50% per 1 ha. However, Vyshneve will remain in the last place in the eco-balance of the towns of research.

Currently, the correlation between the total cost of ecosystem services and their cost per capita is 0.97, and per hectare – 0.71, and in the future it will be 0.970 and 0.992 respectively. The correlation between the cost of ecosystem services per inhabitant and 1 ha of urban area is currently 0.74, and in the future it will increase to 0.99, which indicates that the territories will be more balanced in the future. The visibility of this positive dynamic of the cost of ecosystem services per capita is illustrated by Fig. 2.

Data of Fig. 2 shows that according to the master plan, the cost of urban ecosystem services per capita is almost unchanged in the future for Vyshneve, significantly increases for Boyarka and Vyshgorod and decreases for Irpin and especially (at times) for Bucha. It indicates an acceptance of not well-considered prospective planning decisions, and significantly reduces their stable development prospects. In terms of prospective planning, Vyshgorod will be the most environmentally friendly and conducive environment among five pilot cities, where the planned triple population growth will be accompanied by a 5.7-fold increase in land use, and changes in land use will be limited by the special status of historic town and the availability of protected urban areas. The second position belongs to Boyarka (given the unplanned population density in Irpin already), where population growth will be doubled with a three times expansion of the urban area. Planned actions for the future development of Bucha (population increase of 2.2 times due to increase in population density and stable area of the city) will lead to a decrease of 4.2 times the cost of ecosystem services per capita.

The dynamics of the cost of ecosystem services per 1 ha of the towns is shown in Fig. 3.

Data from Fig. 3 indicate that the maximum cost of ecosystem services per 1 ha of urban area belongs to Vyshgorod and Irpin, and in the long run – will increase to maximum in Vyshgorod and Boyarka (by 2.9 and 3.0 times respectively). The analysis

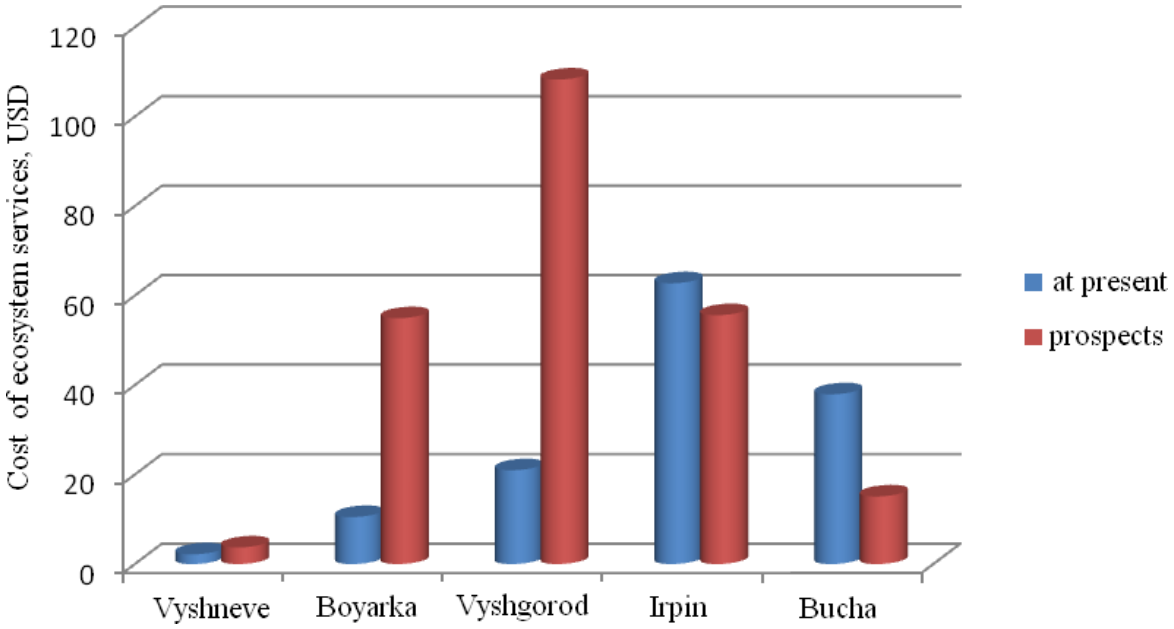

Fig. 2. Dynamics of ecosystem services cost per capita in small towns

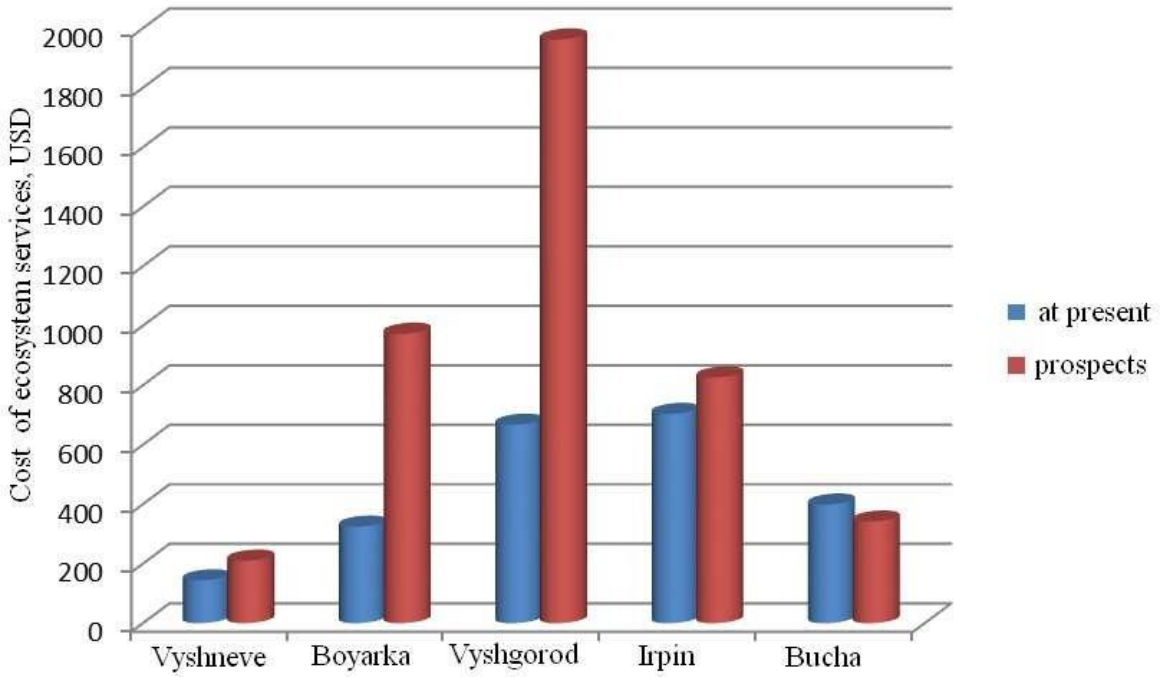

Fig. 3. Dynamics of the cost of ecosystem services per unit area of small towns

shows that such temporal dynamics are caused by the expansion of urban territory. The situation in Vyshneve and Irpin will improve somewhat and in Bucha it will worsen (by 1.2 times).

Conclusions. For the sustainable development of urban ecosystems, it is necessary to take into account their features at the stage of planning of territorial development. Especially important is the design of urban green spaces from the point of view of providing ecosystem services, assessing the current situation and prospects.

Ukraine's plans to implement ecosystem service approaches as standard components of territorial planning are hampered by the difficulty of identifying them. The assessment of ecosystem services by indirect valuation – cost transfer – can serve as a platform for integrating the ecosystem services approach to master planning by transferring into the economic form the degradation process of specific natural-tech urban ecosystems. The application of this method allows one to analyze the directions of development of the territories, to obtain meaningful information on the

dynamics of their ecological balance, useful for solving environmental aspects of urban land use planning and improving its efficiency, to predict possible scenarios and to choose the most constructive solutions from the standpoint of sustainable development.

Urban development and, as a consequence, reductions in forest and arable land, which typically result in urban expansion, will further reduce the total amount of ecosystem services provided by urban green infrastructure, as evidenced by our calculated relative values per capita and per unit area of towns.

The calculated ecosystem potential for the current state of towns and over the next 20 years showed that the total cost of ecosystem services for the towns of Boyarka, Vyshgorod, Bucha and Irpin is 3.6; 5.8; 10.6 and 25.7 times respectively higher than the ecosystem services of Vyshneve. The cost of ecosystem services per capita of Irpin is 28.8 times higher than the similar indicator of Vyshneve, which is explained by the small number of water bodies, forests and agricultural lands, as well as the extremely high level of building in the latter.

It has been established that the maximum cost of ecosystem services per 1 ha of urban area belongs to Vyshgorod and Irpin, and in the long run – will maximize growth in Vyshgorod and Boyarka, respectively by 2.9 and 3 times, which is due to the expansion of the territory mainly due to suburban forests.

The results of the research indicate the need to adjust the master plans for the development of the environmental component for the towns of Irpin and Bucha, and the use of the cost estimation of ecosystem services in urban areas provides meaningful information on the dynamics of eco-balance of urban areas and is useful for addressing environmental aspects of urban planning. The proposed algorithm for calculating the cost of ecosystem services in the development of master plans for towns will help to track future trends and avoid ill-considered decisions on sustainable eco-balanced urban development.

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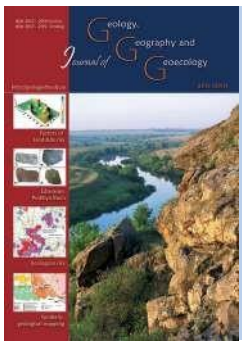

JOURNAL of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(4)
doi: 10.15421/11197401

CONTENTS

JOURNAL OF GEOLOGY, GEOGRAPHY AND GEOECOLOGY

The Journal was founded in 1993 under the title
«Dnipropetrovsk University Bulletin. Series: Geology»
The journal, beginning in June 2018, is published under the title
«Journal of Geology, Geography and Geoecology».

Volume 28 (4)

English

Certificate of state registration of a series of KV № 23167-13007 dated February 26, 2018 in accordance with the order of the Ministry of Education and Science of Ukraine dated 24.05.2018 №527 (Annex 5), a printed (electronic) publication "Journal of Geology, Geography and Geoecology" is included in the List of Scientific Specialized Publications of Ukraine in the Field of Geological Sciences (included in professional editions since 2003).

The international level of the Journal obtained recognition in 2017 when it was included in the Web of Science and over 20 well-known scientific citation databases

Literary editors: Paul W. Bradbeer, Michael O. Tikhomyrov
Text Layout: Volodymyr V. Manyuk, Vadym V. Manyuk
Cover design: Vadym V. Manyuk

Підписано до друку Формат 60х84 $^{1}/_{8}$. Папір друкарський. Друк плоский.
Ум. друк. арк. Тираж 100 пр. Зам. №

РВВ ДНУ, просп. Гагаріна, 72, м. Дніпро, 49010.
ПП «Ліра ЛТД», вул. Наукова, 5, м. Дніпро, 49107.
Свідоцтво про внесення до Державного реєстру
серія ДК №6042, від 26.02.2018 р.