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To cite this article: O Komliev *et al* 2023 *IOP Conf. Ser.: Earth Environ. Sci.* **1254** 012130

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The predictive and search system of amber (PSSA) and sustainable development of mining areas

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Abstract. A new ("amber") branch of the economy is currently developing in Ukraine, which includes the search for, mining and processing of amber. Ukrainian amber is noted for its high quality and is one of the most competitive types of domestic coloured stones on world markets. A significant part of the territory of Ukraine is promising for the discovery of placer deposits of amber, but their industrial development is currently carried out only within the boundaries of "the Pripyat amber-bearing basin" (PAB), which covers the regions of Volyn, Rivne, Zhytomyr, and Kyiv regions. The development of the "amber" industry of Ukraine caused problems of a production, organizational, socio-economic and environmental nature. They significantly influence the socio-economic development of amber mining areas. These are: 1) lack of a national program for the development of the "amber" industry; 2) its insufficient level compared to the real potential; 3) uncontrolled mining of amber; 4) negative impact on the ecology of the natural environment; 5) socio-economic consequences for the population of amber mining areas. "The predictive and search system for amber" (PSSA) allows solving these problems in a complex manner. The PSSA of Ukraine allows systematic research of "the amber-bearing formation" (AF) developed on its territory. PSSA uses scientific ideas about the origin of amber and the main natural factors of its formation, develops methods and a specific research algorithm. The main goal of PSSA is to identify "amber-bearing objects" (AO) in the geological body of the AF, which may contain high concentrations of amber, the so-called "traps".

1. Introduction

In recent decades, the "amber" branch of the economy has been developing in Ukraine, which integrates the search for, mining and processing of amber. Ukrainian amber, thanks to its high quality, is recognized in the world and represents one of the most competitive types of domestic colored stones on the world market. The territory of Ukraine is promising for the discovery of placer deposits of amber, but their industrial development is currently carried out only within the boundaries of "the Pripyat amber-bearing basin" (PAB), which covers the regions of Volyn, Rivne, Zhytomyr, and Kyiv regions.

In a short time, the development of the "amber" industry of Ukraine caused a number of problems of a production, organizational, socio-economic and environmental nature. They

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significantly influence the socio-economic development of amber mining areas and at a certain stage were considered from the standpoint of national security of Ukraine [1, 2]. These problems can be presented as: 1) lack of a national program for the development of the "amber" industry; 2) its insufficient level compared to the real potential; 3) uncontrolled mining of amber; 4) negative impact on the ecology of the natural environment; 5) socio-economic consequences for the population of amber mining areas [3, 4]. A comprehensive solution to these problems is provided by "the predictive and search system of amber" (PSSA) [5–7].

2. Metods and materials

The methodology of general systems theory is used in the PSSA. The partial methods used are geological, geomorphological, paleogeographical, paleogeomorphological, laboratory data on amber, and statistical data on the socio-economic status of amber mining areas. The results presented in tables, graphically, on general and thematic maps of various scales, geological and geomorphological sections were further analyzed.

The article is based on the results of the authors' own research, obtained during the implementation of research work on amber in Ukraine, as well as international projects with the Republic of Belarus ("Development of a geological and genetic model of amber-bearing deposits of Ukraine and Belarus" with the financial support of the State Fund for Financial Development of Ukraine and Belarus) and the Republic of Poland ("Amber ways: deposits formation-mining. Scientific-methodical basis, rational use" and "Amber deposits and characteristics" funded by the EU). Stock materials (Geoinform) and geological expeditions of the Ukrainian Geological Company were also used.

3. Results

Lack of a national program for the development of the "amber" industry. The national program for the development of the amber industry in Ukraine is being formed, but its structure and connections of its components are clearly visible – forecasting, searches, development and exploitation of amber deposits, practical use of amber raw materials, regulatory and legal regulation, informational and educational and museum and educational activities. Currently, the amber industry in Ukraine is being developed by various state and private institutions, organizations, and individuals. The stage of spontaneous, chaotic development of the industry has passed and the primary experience of organized work has been acquired by it. To a large extent, this was facilitated by meetings, conferences, symposia on amber topics held in Ukraine and abroad, in which Ukrainian and foreign experts participated. Thanks to them, the content of the national program for the development of the amber industry in Ukraine was determined: active (anticipatory) conducting of forecasting and search for new amber deposits; the creation of state guarantees within the framework of international agreements between interested countries regarding the origin of trade batches of amber; development of quality certification schemes for Ukrainian raw amber and its adaptation to global schemes; establishment of legal and legislative norms of the optimal mode of extraction and sale of amber under the control of the state; in-depth comprehensive study of medicinal properties of amber, succinic acid, processing products and their introduction into medicine; launch of the "Polissya amber" brand and promotion to the international level. International conferences devoted to the topic of amber also made it possible to establish important contacts between scientists of different countries and in the future to carry out mutually beneficial joint interstate projects [8, 9]. This makes it possible to improve national programs for the development of the industry, in particular, to create the PSSA, which, over time, can be integrated into international ones. The PSSA will allow solving the main strategic task of the amber industry – the opening of new deposits of amber raw materials and the expansion of the market for amber products.

A necessary condition for the development of the amber industry in Ukraine is a clear and reliable legal framework. It is prescribed in the articles of the Constitution of Ukraine, Laws of Ukraine and Resolutions of the Cabinet of Ministers (CM) of Ukraine. According to them, the subsoil is an object of the right and property of the Ukrainian people (Constitution of Ukraine, Article 13). It is owned by the Ukrainian people and some of its representatives. On behalf of the Ukrainian people, the rights of the owner are exercised by state authorities and local self-government bodies within the limits set by the Constitution. On behalf of the Ukrainian people, the rights of the owner are exercised by state authorities and local self-government bodies within the limits set by the Constitution. The general procedure for the regulation of relations in the field of the study, extraction and sale of amber raw materials is carried out in accordance with the Codes of Ukraine – On Subsoil, Land, Forestry, Criminal, the Law of Ukraine "On State Regulation of Mining, Production and Use of Precious Metals and Precious Stones and Control of Operations with Them", by-laws adopted for their implementation. By this law, amber is classified as a precious stone of organogenic origin and a mineral of national importance [10–13].

Legal relations in the amber industry at the state level appeared in Ukraine only with the declaration of independence. In 1993, by Resolution (No. 111 dated February 18, 1993), the State Enterprise "Ukrburshtyn" was established for amber mining and processing. At the legislative level, changes were made to the Law of Ukraine "On entrepreneurship" (December 22, 1995), according to which amber mining is allowed only to state enterprises. After 10 years, thanks to the general development trends of our country, the Law of Ukraine (October 18, 2005) removed restrictions on amber mining only by state enterprises. Thus, the legislation in the amber industry determines that the subsoil and what is in it is the property of the Ukrainian people. Protection of the right to them is regulated by legislative acts of Ukraine.

In general, the legislative basis for the development of the amber industry in Ukraine has been created. Currently, only the issues of its normative and legal regulation are being proved. Complaints about the imperfection of the laws here are only partially justified. Laws must be obeyed by everyone – both those to whom it must be done "on duty" and ordinary representatives of society. Problems in the development of the industry began only after openly criminal elements became interested in amber.

At the same time, it should be noted that for the population of mining areas, "amber" is a profound issue. It is history, traditions, life – the opportunity to get an education, build a house, just live. They may not be at the scientific level, but they protect the ecology of their own home. In our opinion, the concept of "mentality" can be used here. Mentality is a combination of inherited (from past generations) and acquired (in current life) elements. The acquisition of the latter is served by the informational and educational and museum and educational directions of the development of the amber industry. Kindergarten, school, college, gymnasium, school, technical school, institute, university, olympics, newspapers, radio, television, Internet, conferences, exhibitions, expositions in salons and museums, specialized amber museums. As can be seen from the list, these areas can be developed systematically on the basis of existing organizational forms.

The insufficient level of development of the amber industry compared to its potential. In Ukraine, a significant database of lithological-facies, paleontological-stratigraphic, structural-tectonic, paleogeographical, geomorphological, paleogeomorphological studies has been accumulated. It gives grounds to predict that Ukraine has perhaps the largest reserves of raw amber in Europe. Currently, industrial amber mining is carried out within the northwestern part and the western slope of the Ukrainian Shield, where the main amber deposits of the PAB are located. However, the northern, northeastern, and southern slopes of the Ukrainian shield and the adjacent areas of the Black Sea and Dnipro-Donetsk depressions (and in the latter, adjacent to the southwestern spurs of the Voronezh anteclise) are considered promising for the discovery of amber raw material deposits. In these territories, in contrast to the PAB, the Paleogene

lithological-stratigraphic horizons, which are promising for the discovery of new amber deposits, lie deep.

At the same time, the main resource of raw amber in the explored and currently developed deposits of the PAB is running out. The limitation of the raw material base is the main problem of the development of the amber industry in Ukraine. According to experts, its expansion in the PAB can be achieved by: 1) increasing amber production at known deposits 2) opening new deposits. The first way is limited by the natural and geographical conditions of the territory – all known deposits and manifestations of amber are located among valuable forest and land areas, under swamps; where productive horizons are located at a depth of 5-10 m. The amber in them is extremely dispersed. Outdated search data used by mining enterprises do not allow discovering new large deposits of amber. The second way – the discovery of new industrial deposits of amber is strategic and can determine the development of the amber industry in the coming years. The figure 1 shows fragments of some special maps of the PAB territory, which, in combination with other maps and materials, can be used to search for new types of amber deposits.

The figure 2 and figure 3 shows for the Dubivka area of the Volodymyrets group of deposits: maps: the paleorelief of the formation of promising amber-bearing horizons of the mezhyhirskya and obukhiv switas of the Paleogene (eocene-oligocene); the forecast of placer amber deposits.

Uncontrolled mining of amber. Uncontrolled amber mining causes the greatest damage to the state and the local population. Dangerous due to its predatory lack of control and the annual increase in the volume of shadow mining, it began to flourish in the country from the end of the 80s of the last century. This problem became especially relevant in the mid-1990s, when massive systematic illegal mining of amber covered a huge area of Polissya and prospectors began to use complex mining techniques.

The main reasons for the rapid increase in illegal amber mining are: the growth in demand for amber on the domestic and foreign markets; the possibility of mining with inexpensive, efficient equipment, due to the presence of productive layers close to the surface; the low level of employment of the local population in the districts of Rivne (Rokytniv, Zarichnen, Dubrovytskyi, Volodymyretskyi, Sarnenskyi), Zhytomyr (Olevskyi, Ovrutskyi), Volyn (Ratnivskyi, Manevytskyi, Lyubeshivskyi) regions, where the largest illegal amber mining currently takes place; low level of control of the authorities and law enforcement agencies over the activities of illegals; inadequate responsibility for the committed crime.

Currently, amber extraction by illegal miners is carried out by open (excavator-transport) and underground (motor pump) methods. The mined ore is enriched, washed on sieves. The empty rock is washed away, and the amber remains and is selected. The local population uses motorized pumps, with the help of which rocks are washed out from a depth of up to 10 m. This method belongs to complex underground.

Illegal amber miners mine manually and with the help of motor pumps wherever possible – in the forest, in meadows, in swamps and wetlands, on the banks of rivers and lakes, in exploited or abandoned granite quarries, in dumps, in terricones, within the boundaries of irrigation facilities, protected state facilities, under railway tracks, power line towers, in agricultural lands on all elements of the modern topography of the territory.

The level of qualification of illegal miners is also increasing. In the first years of illegal mining, there were mutilations among inexperienced executors, and frequent deaths of young people during the drilling of shafts in loose and waterlogged sands. Now, every year, an increasing number of qualified workers are involved in shadow production, and not only from among local residents, who unite in teams equipped with hand drills, motor pumps and other tunneling equipment.

Illegal extraction of minerals is classified as a crime, the consequences of which are manifested in the ecological, economic, and social spheres. According to estimates, the development of

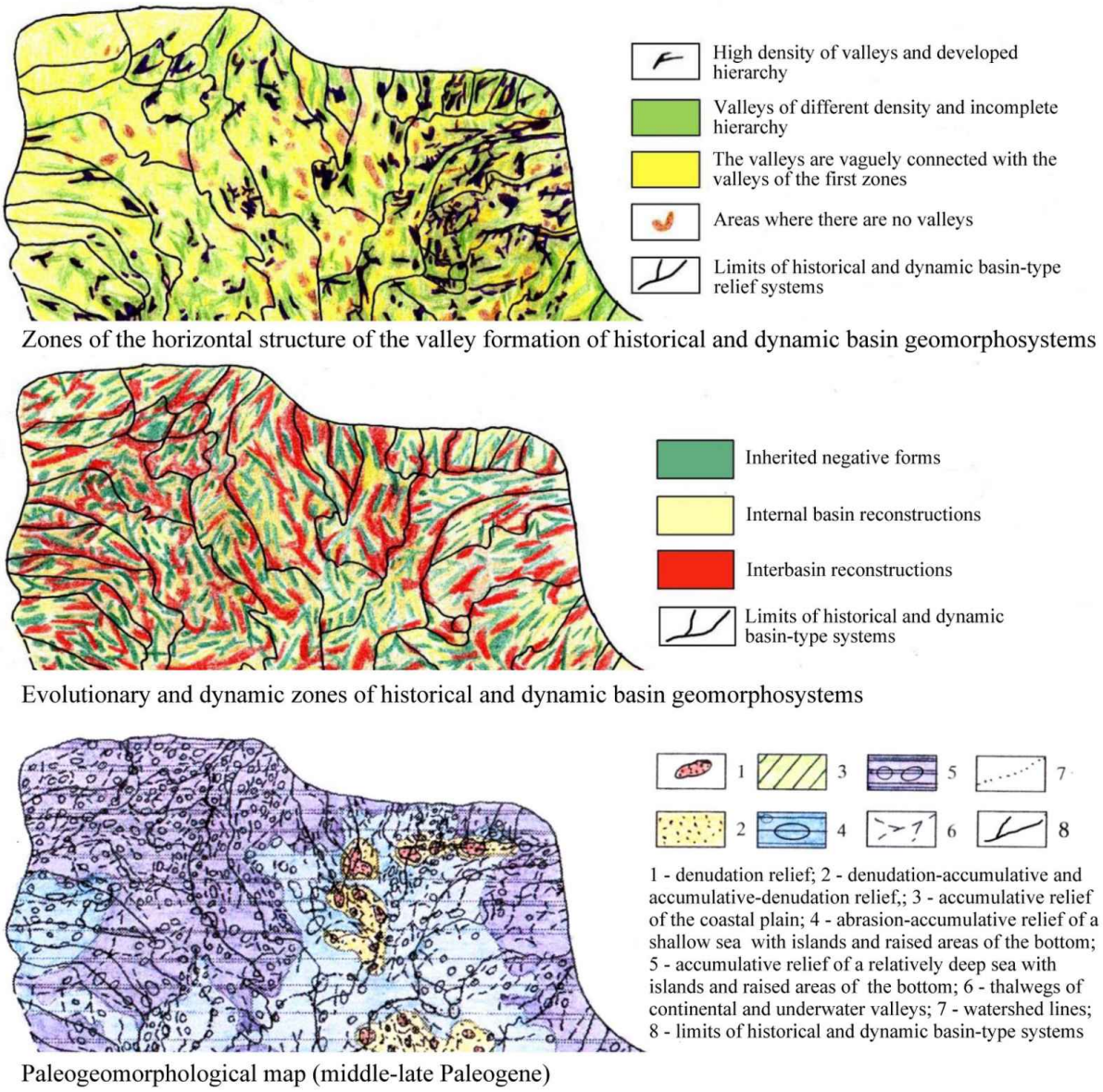

Figure 1. Special maps of the historically-dynamic geomorphosystem territory of the PAB.

amber costs the state UAH 8-10 million per day. According to various estimates, up to 30 tons are exported from the country annually.

To solve this problem, it is necessary to build relations with prospectors. In order to solve the problem of employment, individual prospectors are proposed to be united in prospector artels, for which the possibilities of obtaining permits for simplified subsoil use are opened. But here there is a question regarding the interpretation of the term “seeker”.

In most countries, a prospector is a person who extracts minerals without the use of heavy machinery, exclusively by hand. Therefore, for exploratory mining, it is advisable to transfer small-sized placers that can be developed in an artisanal way. In Polissya, the majority of such placers are located in the Zhytomyr region. It is proposed to introduce the category “local prospector – a citizen of Ukraine”, who is registered and lives in settlements located on amber

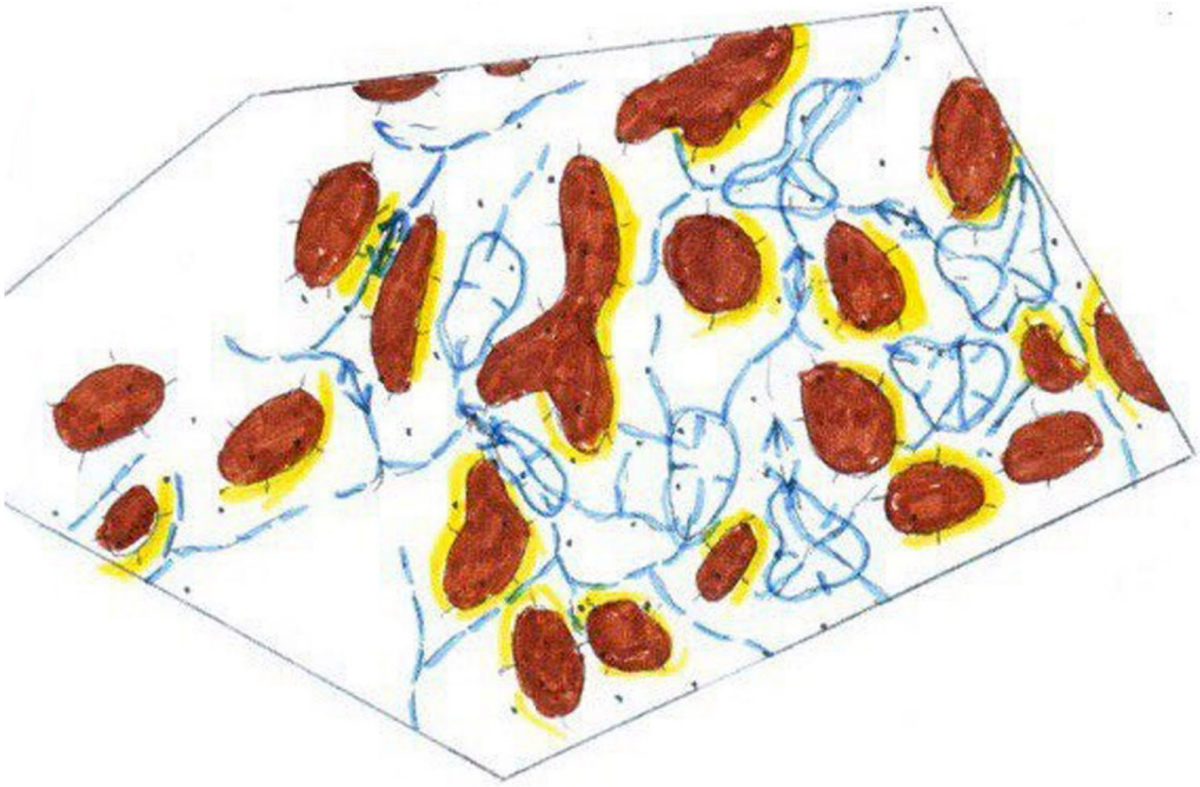

Figure 2. Paleorelief of the formation of promising amber-bearing horizons of the mezhyhirskya and obukhiv switas of the Paleogene (eocene-oligocene) (brown color – denudation relief of islands; yellow color – abrasive-accumulative relief of beaches; shallow sea bottom – thalwegs of underwater valleys, buried areas, directions of movement).

deposits, carries out its extraction and primary sale and compensates for the damage caused to nature as a result of such activities. It is proposed to introduce a special simplified taxation and reporting system for prospectors. In order to solve the issue of sales, it is proposed to create specialized exchanges in mining areas, where it is possible to legally purchase amber raw materials, as well as state points of purchase of mined stone.

The lack of a developed methodology for assessing damages caused by illegal amber mining leads to the state budget not receiving significant funds. The main criteria here are ecology and economy.

Violation of the legislation on subsoil entails responsibility: disciplinary, administrative, civil and criminal.

Negative impact on the ecology of the natural environment. According to the scale of impact on the natural environment of the territory of Polissya, the illegal activity of illegals is equated to the action of spontaneous natural processes. Currently, it is difficult to assess the extent of the damage caused by them. This problem is exacerbated by the fact that uncontrolled amber mining is imposed on the heavily damaged nature of this territory.

Illegal mining (pits-pits, ditches, hand-drilled wells, erosion of the soil with a motor pump) without proper backfilling of the trenches with waste rock disrupts the root system of trees, destroys the shrub and grass undergrowth, and leaves sand mounds and gaping pits filled to the top on the surface of the soil muddy water Problems arise with animals that fall into holes and cannot get out. In the forest, where the diggers have already visited, after a few years all the trees disappear, because the hydrological regime is disturbed by pits and pumps. Unauthorized

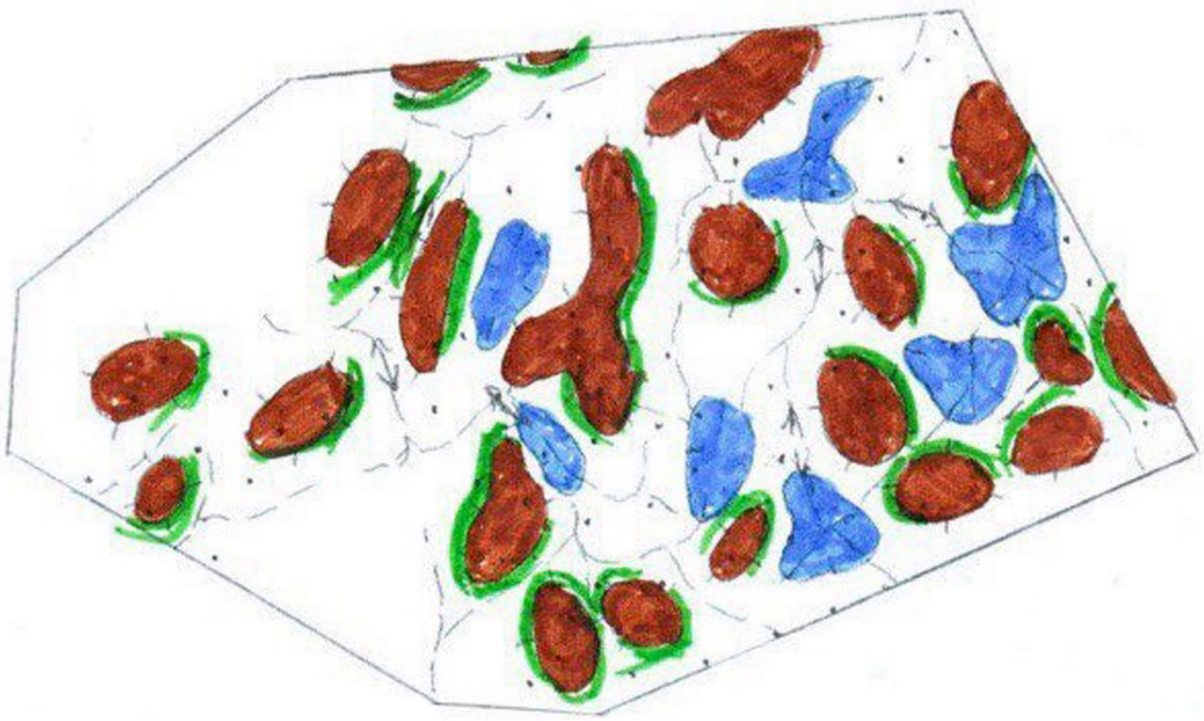

Figure 3. Forecast of placer amber deposits Dubivka area (brown color – low islands – places of wear and tear; green color – bench, beaches – accumulation of large fractions of amber; blue color – buried trap areas – accumulation of large fractions of amber).

mining, which is carried out by hydromechanical methods, devalues productive horizons and deposits lose their industrial value (figure 4).

Very often, amber is mined within the protected natural areas – nature reserves, nature reserves, etc. Violation of the territorial regime makes it impossible for many species of protected animals to exist here.

Illegal mining of amber leads to the destruction of surface (4-5 m) productive horizons. Illegal prospectors choose high-quality and most valuable amber, and the "small stuff" that can be successfully used in many industries remains in the dumps.

Illegal mining of amber in recent years has created another environmental problem – the burning of charcoal. Deliberate arsons are carried out, fallen trees are burned.

Thus, illegal mining of amber affects all components of the natural complex: soils – by removing the fertile layer, disrupting the structure of the soil cover, clogging the land plot, which causes loss of humus, macro- and microelements, destruction of the upper fertile layer, increased wind and water erosion; vegetation – violation of the integrity of the grass cover, illegal destruction of trees, which leads to the violation of the integrity of the grass cover, drying and destruction of trees; animals – by violation of the usual mode of living of animals, the creation of an unusual man-made terrain for them, which leads to the migration of animals to other places, their mutilation, death; water – arbitrary, uncontrolled use of surface and underground water, which leads to a violation of the hydrological regime of the territory, a decrease in the level of groundwater; air – as a result of the burning of fuel and lubricants, the burning of charcoal, the atmosphere is polluted with CO_2, CO, SO_2, NO_2, and hydrocarbons; subsoil – violation of the geological structure of the territory, loss of subsoil, which leads to deformations of the earth's surface, damage to mineral deposits, restriction or complete removal of them from exploitation,

Figure 4. Consequences of illegal amber mining in Zhytomyr region.

impoverishment of subsoil.

Illegal amber mining exacerbated the problem of reclamation of disturbed lands, which is important for the organization of rational amber mining and prevention of the destruction of natural landscapes. This problem should be solved by specialized organizations that have mastered the methodology and have experience in similar work. Reclamation of disturbed lands takes place during 3 stages – preparatory, hydrotechnical, biological. In the preparatory stage, a survey and typification of disturbed lands is carried out and the type of reclamation is chosen. In the hydrotechnical stage, land vacated after mining operations is prepared for their further use. At this stage, the following is carried out: selective removal, storage and preservation of overburden suitable for biological reclamation, including the fertile layer; selective formation of overburden dumps; if necessary, planning and covering the planned surface with a layer of soil; backfilling and planning of deformed surfaces; creation of access roads; drainage and anti-erosion measures. The biological stage of reclamation consists in restoring the fertility of disturbed lands, restoring flora and fauna by agrotechnical and phytoremedial means.

Socio-economic consequences in amber mining areas. Illegal mining of amber within the territory has revealed many shortcomings of modern social life, these are: lack of an effective system of combating illegal mining, use and circulation of amber in Ukraine; the invalidity of some laws regarding the protection of subsoil and the regulatory and legal support of labor activities on the extraction, production and use of amber; low level of environmental education of Ukrainian citizens, primarily young people; social roots of criminal activity (unemployment, etc.).

The results of the work were discussed at scientific and practical conferences in Ukraine and abroad (Poland – Ambermarket, Amberif), scientific seminars at the Polish and Ukrainian

Academies of Sciences.

4. Conclusions

All these problems have a complex nature and cover various aspects of the socio-economic, cultural and political life of the country and can be solved exclusively at the state level. This requires the adoption of a number of state laws and, first of all, the law on preserving the country's national wealth – amber and protecting it from looting. Without the adoption of these laws, the scale of theft will increase, which will lead to the disappearance of the upper productive horizon and the transformation of Polissya into a desert.

The PSSA should solve the mentioned problems of the amber mining areas.

The PSSA of Ukraine allows systematic study and use of AF developed on its territory. The PSSA takes into account scientific ideas about the origin of amber and the main natural factors of its formation, develops methods and a certain research algorithm.

The AF represents a special type of sedimentary geological formations, since their central, formation-forming element (amber) at the beginning of its formation came from the biosphere, and not from the lithosphere (as in most geological formations).

The AF is formed by the processes of tectogenesis, morphogenesis, lithogenesis, oreogenesis of amber, which interact systematically. As a result, tectonic (neotectonic) structures, landforms, deposits, amber deposits are formed. The AF of Ukraine is constantly being studied. In general, its spatio-temporal parameters, structure, trends of transformations of the geological "body" of the AF are understood. Within the boundaries of the PAB, the geological body of the AF is exposed on the surface almost everywhere, intersects with modern (and ancient) "geomorphological formations", which are parts of the historical-dynamic geomorphosystem.

The main goal of the PSSA is to forecast and search for the AOs located in the geological body of the AF. AOs include natural formations or their parts that contain or may contain concentrations of amber. The accumulated experience of amber exploration allows to distinguish stratigraphic, lithological-stratigraphic, lithological, structural-tectonic, paleogeomorphological, geomorphological types of the AOs.

The specific stratigraphic horizons of the Paleogene system (charkiv, mezhihirsky, obukhiv layers) in which primary amber-succinite placers are found belong to the stratigraphic AOs on the territory of Ukraine. This also includes the stratigraphic horizon of the buchac svita of the middle Eocene, the amber-like resins from which, according to many researchers, were the starting point for the formation of the AF of Western and Eastern Europe. AOs of the lithological-stratigraphic type are revealed in the process of detailed study of promising Paleogene horizons. Lithological AOs are "lithological bodies-collectors" that are found in Neogene and Quaternary stratigraphic horizons, in particular cross-cutting "lithological bodies" that cover several stratigraphic horizons. Identification of the structural-tectonic type of AOs requires the use of structural-tectonic models of the tectonosphere for the time of formation of the AF. It will show the tectonic (neotectonic) structures that are dynamically active in the Neogene-Quaternary (neotectonic) time – newly formed or inherited from the morphostructures that formed during the Mesozoic. These structures could influence the processes of lithogenesis and morphogenesis from the time of the accumulation of amber-like resins (middle Eocene), the formation of primary amber-succinite placers (late Eocene-Oligocene), the destruction of primary deposits, redeposition of their derivatives, the emergence of new placer deposits in Neogene and Quaternary horizons. In order to identify paleogeomorphological and geomorphological AOs, it is necessary to have a modern understanding of the "relief" as a "historical-dynamic geomorphosystem" and take into account the peculiarities of its functioning. This approach makes it possible to identify potentially possible relief forms of various stages of the development of the AF on a systematic basis.

The use, as a basic, geomorphosystem factor, allows to search for AOs on a scientific basis,

which is important for geoecology and protection of the natural environment in amber mining areas.

It is important to note that the main goal of organized and illegal amber miners today is the search for AOs of stratigraphic and lithological-stratigraphic types. This is influenced by the underground occurrence of AF, which allows the use of available and cheap technologies for the development of amber and does not require the use of relatively expensive scientific developments.

The PSSA of Ukraine contributes to the strategic development of the amber industry in Ukraine, which consists in a comprehensive approach to solving the scientific and practical tasks of finding and developing amber deposits, socio-economic and environmental problems. The concept of the AF creates scientific and methodical conditions for this.

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