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RESEARCH OF DEPOSITS, THEIR CHARACTERISTICS AND FEATURES OF AMBER OCCURRENCE IN AMBER-BEARING DEPOSITS OF UKRAINE AND THE WORLD

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Abstract

The paper describes the location of amber deposits in different countries of the world with physico-mechanical and chemical properties.

A potential source of amber production can be exhausted deposits with off-balance reserves, which are man-made deposits, but this requires the development of a technological process.

Due to the imperfection of the existing technologies, losses of minerals in targets and dumps exceed 50%.

Existing technologies for extracting amber from sandy and sandy-clay rocks have a high energy intensity of rock destruction, and segregation requires improvement of technology and equipment to increase the efficiency of the final product extraction process and reduce energy, water and air consumption.

The proposed technological schemes do not provide for an ecological component, the possibility of mining waste reclamation, while their man-made nature requires additional research taking into account various mining and geological characteristics and host rocks and the development of recommendations for technology and equipment taking into account the ecological component.

Introduction

Th main task facing the mining industry is to ensure an increase in the production of minerals due to the increase of production in the most efficient open and underground method based on the wide implementation of progressive technology and mining transport equipment.

The current state of development of mining production in the field of mineral development in the Rivne-Volyn region is characterized by the presence of a significant number of industrially significant amber deposits that are developed and those that are not involved in development due to the impossibility of their exploitation by traditional methods, because they are in difficult mining and geological conditions. Exploitation of such deposits by traditional methods is inefficient and costly.

The hydraulic and hydromechanical method of extraction, which is carried out with the help of hydraulic energy, which is used to destroy amber-bearing rocks and deliver amber to the surface, allows efficient development of amber deposits. Identifying the peculiarities of the location of amber deposits, their characteristics in different countries of the world with the indication of physical, mechanical and chemical properties is undeniably relevant.

The purpose of the research is to identify the features of the location of amber deposits, their characteristics in different countries of the world with the indication of physical, mechanical and chemical properties and proposals for improving technologies and equipment to increase the efficiency of the process of extracting the final product and reducing the consumption of energy, water and air.

The subject of research is deposits, their characteristics and features of amber occurrence in amber-bearing deposits of Ukraine and the world.

The object of research is the amber-bearing areas of the Rivne region.

Scientists dealt with the problems of amber mining: Bulat A.F., Nadutyi V.P., Malanchuk Z.R., Lustyuk M.G., Kravets S.V., Kornienko V.Ya., Romanovskyi O.L., Malanchuk E. .Z., Nikitin V.G., Kirikovich V.D., Kononenko E.A., Sierdobolskyi B.N., Hrystiuk A.O., Krynytska M.V. and other.

Large deposits of amber were discovered in the Volyn, Zhytomyr, and Rivne regions. The most explored is the Klesivske deposit, located in the Sarnensky district of the Rivne region. On the territory of Ukraine, amber is found in Volyn, in the basin of the Pripyat River, in the area of Kyiv and in the Carpathians.

In modern economic conditions, the efficiency of hydraulic mining equipment can be increased by substantiating the rational factors affecting the process of hydromechanized mining and improving the existing technological equipment based on the application of the automatic control system for the hydraulic washing process. However, known extraction technologies do not allow to fully extract amber due to the imperfection and lack of effective technology for the complete extraction of amber from amber-containing deposits.

The complexity and large number of possible technological processes of extraction and the specifics of the operating conditions of deposits indicate that for the study and extraction of minerals there is a need to conduct additional studies of equipment complexes as part of hydromonitors. Increasing the efficiency of such complexes by reducing energy costs while increasing the assortment and improving the quality of products requires scientific substantiation of the parameters of the constituent elements of mining complexes of a new technical level.

The conditions of the accumulation of primary amber placers in the amber-bearing areas of the Rivne region are given based on the research materials of M.V. Krynytska, a senior lecturer of the Department of Geology and Hydrogeology of the NUWEE.

1. Historical and geographical characteristics of the location of amber deposits

The ancient Greeks believed that giving amber as a gift means wishing for happiness. The stone gives optimism and self-confidence, helps to choose friends, attracts the object of love, sharpens intuition. In ancient times, it was noticed that amber burns and emits smoke with a pleasant smell. Many people are familiar with the word "frankincense", but few people know that frankincense is precisely the smoke from burning small, worthless amber. It was used in wedding rituals and other solemn occasions. Amber is a fossil fossilized resin of ancient coniferous trees, which has preserved its purity, transparency and bright color in the coastal sand sediments. Amber is called succinite, as the pine, from the resin of which amber was formed, is called "pinus succinifera" in Latin. Baltic succinite is the most common. Close to it is the amber of Ukraine: Rivne, Zhytomyr, and Volyn regions, Kyiv, Kharkiv regions, and the North Sea coast. All other fossil resins found in various deposits are named according to their location - Baikal, Sakhalin, Greenland, British, Mexican, Brazilian, Sicilian, etc. amber. Special names are aikaite, almashite, ambrite, ambrosite, beckerite, birmite, walkhovite, etc. - these are only amber resins. Amber is often called any fossil resin [1-34, 42, 55].

The history of amber fishing in the Baltic goes back several thousand years.

A large amber mining enterprise is located in the Russian Federation in the village of Yantarny, which is located in the Kaliningrad region of Russia. Development of this deposit began in 1872. Baltic amber yields 100-700 tons of raw amber every year.

Amber deposits are located in marine and coastal placers. Amber is washed by sea waves from the clay that is in the bowels of the earth, pieces of amber are thrown ashore. It is a well-known fact that in 1862, two tons of amber were found on the shore near the village of Yantarny after a storm. According to average data, up to 38 tons of amber are produced per year in the Kaliningrad region, but the main extraction of amber is carried out by an industrial method.

The most ancient way of extracting amber is quite simple: pieces of gem thrown out by the sea were collected on the sea coast. Especially a lot of stone was found after sea storms. In the western part of the coast of the Kaliningrad Peninsula, the sea provided approximately 75% of the total amount of amber. According to estimates, sea waves annually wash 36-38 tons of amber from the bottom to the shore.

The first mentions of land extraction of Baltic amber date back to the middle of the 16th century. Pits were dug on the shore until amber and groundwater appeared, the gem floated in the water and was collected by saka.

In the middle of the 18 th century attempts were made to extract amber from coastal ledges. But the tunnels built in the cliffs were unstable and soon filled up with sand deposits that covered the amber-bearing layer.

In 1467, privileges for the free collection and digging of amber were established for the northwestern lands of Poland. In the second half of the 16th century amber was mined by scooping. Stone miners went out to sea in boats and looked for accumulations on the bottom between the stones (in calm water, the gem is clearly visible at a depth of up to 7 m). One of the hunters loosened the soil with a long stick, and the other collected floating amber with a sack. In the areas of the seabed, where there were outcrops of blue earth, extraction was carried out with the help of a kesale - a net attached to a horseshoe-shaped arc. Kesale was installed between two boats, while moving, she furrowed the bottom of the sea with a net, loosened the productive layer and collected stone from the bottom.

Amber was mined underground in Polish Pomerania in the 17th and 18th centuries. The depth of laying tunnels was 1-5 m (some - up to 20 m). Even then, dredges were used when digging tunnels. Later, preference was given to open development. Thus, in 1840, 60 amber mines operated in Kurpy.

In 1871, the first mine with an extensive system of inclined and horizontal workings was laid near the present village of Sinyavino. But she never discovered the amber-rich areas of the blue earth. After seven years, the mine was closed due to its unprofitability. In the first half of the XIX century. amber extraction in this area was carried out with the help of small open pits. The most stone-rich areas of the coast were opened by small quarries that operated throughout the year. Extraction of the gem in this way proved to be successful and continued with interruptions for about 50 years.

The use of earthmoving machines (middle of the 19th century) significantly increased the extraction of amber. At the end of the 19th century such machines were successfully used by a special firm for excavation of the seabed in the Curonian Lagoon. The amber, together with the surrounding rock, was scooped up by nine steam engines and three manual machines, taken to the shore, where it was selected and sorted. The firm also had an amber mine in Palmniken and a diving facility in Schwarzrote. In this way, up to 75 tons of gems were mined per year.

Until the beginning of the XX century. underground development of amber-bearing layers became technically unprofitable. It was continued at the Anna mine, which was closed in 1922 due to difficult mining conditions. But somewhat earlier, in 1912, a deep (up to 50 m) quarry was laid for the open development of the deposit, north of Palmniken (the modern village of Yantarne), 1,5 km east of the sea. The amber-bearing layer lay 7 m below sea level under a layer of covering rocks with a thickness of up to 30 m. Excavation work was carried out with multi-bucket excavators. They scooped up the blue earth and loaded it into the open cars of the electric train, which went along the inclined track to the enrichment factory. Excavated rock was filled in the created space. This method of amber mining existed until 1944. The area of the deposit named

"Prykarierna" was developed for 60 years (until 1972). From 1880 to 1938, 7,734 tons of amber were mined at the deposit. Of the 600 tons of other fossil resin mined in the year before World War I worldwide, 500 tons of amber came from the Baltic States.

The Second World War caused losses to the national economy of the Baltic States. The retreating German troops destroyed the factories, destroyed the machines and pumps, liquidated the water supply and power plant, and flooded the quarry. After the reconstruction in 1948, the quarry yielded the first amber. On the basis of the deposit, a plant was created in the village of Amber, where all work was concentrated - from the extraction of amber to its artistic processing.

After detailed exploration of the Beach area, the plant started its operation. The deposit had productive rocks at a depth of 8-10 m with a high (about 2 kg/m^3) amber content. In 1977, a section of the Primorsky field began to operate with much larger reserves. On it, the layer of blue earth has a thickness of 6-14 m, the gem content is up to 2,5 kg/m^3, and the depth of the blue earth is 40-60 m. Both areas were developed by the open method. The mining process consisted of several operations. Excavated rocks in both quarries are removed with the help of hydraulic monitors and earthmoving machines. Hydromonitors use a powerful stream of water to wash away the covering rocks, turning them into pulp. The dredger drives the pulp through the pipeline into the sea and squeezes the water column of the Baltic in the western direction. This makes it possible to carry out work on areas that were previously under the water column [1,2,13,14,15,25].

In the Rivne region, at the Klesiv deposit, amber-bearing deposits are taken out with an excavator. The extracted rock is delivered to the washing unit located on the industrial site by motor vehicle. First, the rock enters the loader, from which it is fed on a conveyor to a screen equipped with a metal grid with square cells with a diameter of 5 mm. Above the screen at a height of 20 cm from the grid, a system of tubes is installed, into which water is supplied by a pump under pressure. It waters the rock, washes out clay, sand, silicon, fragments of crystalline rocks and amber less than 5 mm in size, taking them to a specially prepared quarry. Pieces of rock and gem 5 mm and larger are sent by conveyor for development. Here, the amber is manually separated from the rock containing it. Since 1980, more than 100 kg of mineral has been mined annually at the deposit, 95% of the mined amber belongs to the jewelry category [30,34,42,45,54].

The most energy-intensive and costly process is the removal of the slag rock, which does not represent much value for the enterprise, but the cost price of amber at the same time increases.

Physical, mechanical and chemical properties of amber.

Amber is a high-molecular compound of organic acids containing an average of 79% carbon; 10,5% hydrogen; 10,5% oxygen. Its formula is $C_{10}H_{16}O$. 100 g of amber contains 81 g of carbon; 7,3 g of hydrogen; 6,34 g of oxygen, little sulfur, nitrogen and minerals. In the process of oxidation (weathering), the content of oxygen in amber increases, and the content of the remaining components decreases. 24 chemical elements (Y, V, Mn, Cu, Ti, Zr, Al, Si, Mg, Ca, Fe, Nb, P, Pb, Zn, Cr, Ba) were detected in amber as impurities (from traces to 3%) , Co, Na, Sr, Sn, Mo, Yb). Of them, 17 were found in the lowland amber of the Klesiv deposit, 12 in the amber of the Beach area of the Primorsky deposit, 11 and 13 in the amber of the Curonian Spit and Prykarpattia, respectively. The smallest amount of chemical elements is contained in transparent amber. This mineral can be white, yellow, greenish, blue, red, but orange and golden-yellow varieties are typical. The mineral is amorphous, soft (hardness 2,2-2,5 on the Mohs scale), viscous, easily ground and polished. Its density: 1,05-1,096 g/cm^3. In terms of classification, this mineral is a representative of the group of combustible minerals - humic coal of the "liptobiolite" class. Chemically, it is a high-molecular compound of organic acids with the approximate formula $C_{10}H_{16}O$, usually with sulfur impurities. Amber softens at a temperature of 150 °C, and melts at more than 300 °C. It burns easily, giving off a resinous smell. The mineral has dielectric and heat-resistant properties, occurs in nature in the form of grains and pieces with a size from 1 to 10-20 cm or more in diameter, but very large pieces are also found - up to 10 kg in weight. The shape of the pieces can be any: drops, icicles, influxes of various irregular shapes, porous plates [13-15, 25, 45, 49-51, 56, 58, 61-67].

The elemental composition of amber from the beach area of the Primorskyi (Southern Baltic) and Klesivske (Ukraine) deposits, manifestations of the Carpathians and Prykarpattia is similar. The average content of the main components (C and H) in them is 80,78% and 10,12%, respectively; 78,05% and 955%; 79,8% and 10,07%; 78,26% and 9,99%.

Ukrainian amber contains up to 3,19% sulfur.

In the scientific literature, the term "Baltic amber" or "succinite" usually refers to resins containing succinic acid. The content of succinic acid in Baltic amber (succinite) ranges from 3 to 8%. Depending on the type of amber, it is distributed differently. Succinic acid is contained in transparent amber from 3,2 to 4,5%, in Bastardo - from 4,0 to 6,2%, in bone amber - from 5,5 to 7,8%, in oxidized crust - 8,2 %. The composition and structure of amber continue to be studied. Its volatile part (about 10% of the mass) has been known for a long time. These are aromatic compounds - terpenes with 10 carbon atoms and sesquiterpenes with 15 carbon atoms in the molecule. As mass spectrometric studies have shown, more than 40 compounds are part of amber. Many of them are not yet known. Pure abietic acid and its isomers were isolated from amber. They make up the part (20-25%) of Baltic amber soluble in organic solvents. Mineral inclusions in amber are represented by iron sulfide - pyrite and bituminous substance. Among the gas inclusions in amber, CO_2 was found; O_2; H_2; Ar; Cr; Xe; Ne, among which nitrogen predominates. A residue of amber, insoluble in any of the known solvents. IR spectrometry data showed that "succinite" contains lactone (ester) groups, that is, it is an ester. In addition, amber constantly contains succinic acid (about 4%) and impurities of salts (mainly succinic) of potassium, calcium, sodium, and iron (up to 1%). Thus, amber consists of three groups of compounds: volatile terpenes and sesquiterpenes; soluble organic acids; of insoluble polyesters of these acids with alcohols formed from the same acids [52, 59-62].

Rivne amber differs in its chemical composition. It is the most saturated with impurities and includes 18 chemical elements. In addition to silicon, magnesium, iron, calcium, which are present in almost all deposits, lead, zirconium and up to 3,19% sulfur are added. The ash content of Klesiv amber is 8,7%. This affects the quality and color of the cured resin. Amber is a mineral of the class of organic compounds, the resin of coniferous trees mainly of the

Paleogene period. Composition of amber: volatile aromatic oil, two soluble resin fractions, succinic acid and 90% of insoluble fractions. Its chemical formula is $C_{25}H_{40}O_4$. Amber is an amorphous polymer, has many colors, gives a specific IR spectrum (within 700-1900 cm^1), which distinguishes amber from other similar resins. Melting point t=365-390°C. The specific gravity is 1000-1100 kg/m^3 (970 kg/m^3 is found in the Baltic region, and 1220 kg/m^3 in the Carpathians). It is well amenable to mechanical processing. It does not dissolve in water (partially in alcohol - 20-25%, ether - 18-23%, chloroform - up to 20%), but it can swell and increase in volume up to 8% with prolonged stay in it. Completely decomposes in hot concentrated nitric acid, can be softened and at t=100°C.

The value of amber depends on the uniqueness of the amber samples and is established collegially by experts.

Geological features of the location of amber deposits

The main types of amber and fossil resin deposits are marine and littoral placers, occurring in sediments ranging from the Lower Cretaceous to the Quaternary. Marine amber deposits are located on the Baltic coast, in Ukraine, Siberia, Mexico (Fig. 1), the Dominican Republic (Figs. 2,3), and Burma. Coastal seas are widely distributed along the shores of modern seas and oceans.

Amber ("Burmite") from Myanmar's Hukawng Valley has been known since at least the 1st century AD. The hill (Noije-bum), which has been known as an amber deposit since 1836, is currently being developed.

Several groups of geologists visited this area with research between 1892 and 1930. All of them believed that the deposit contains tertiary amber rocks. However, recent studies have shown deposits of Cretaceous age. Insects are found in the amber, a famous sample of the ammonite Mortoniceras, which was discovered during the visit of a group of researchers to the deposit.

The amber deposit is located in the Hukawng Basin (Myanmar), which consists mainly of composite sedimentary (volcanic) rocks of the Cretaceous and Cenozoic ages. The deposit contains many fragmentary sedimentary rocks, with thin limestone layers and a layer of carbonaceous material. Sediments are located in a coastal marine area, such as a bay or a river mouth.

Amber is found in the form of pieces, mainly in the form of disk fragments [2].

In Europe, a large deposit of amber is located in the Kaliningrad region of Russia. It has no equal not only in terms of explored reserves, but also in gem concentration (on average 2 kg/m^3). The processing plant, which operates on its base in the village of Amber provides about 90% of the world production of this stone [1-5].

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Fig. 1. Mexican amber weighing 3472 grams **Fig. 2**. Dominican amber deposit

Amber deposits are located at a depth of up to fifty meters, as a rule, they are layers about twelve meters thick. Going far into the sea, this layer is eventually washed away by water, which leads to the emergence of amber on the surface.

In nature, amber is found in the form of amorphous bodies of various shapes and sizes. The weight of amber found in nature can be from a fraction of a gram to several kilograms. And the world's largest "Burmese amber" can be seen in the Natural History Museum in London, weighing 15 kg 250 grams.

Fig. 3. Dominican raw amber

There is amber and an unusual blue color. This very rare and exceptionally beautiful amber is mined in the Dominican Republic, Mexico and Nicaragua. On a light surface, amber casts a soft blue, and on a dark one, it changes its color to rich blue. It has a natural ability to glow in the dark, which is associated with the presence of volcanic ash in it. The difference in the color of tropical amber compared to Baltic amber is explained by the fact that yellow amber was formed from the resin of pine trees, and blue amber - from carob resin.

The Russian Amber Museum, located in the "Don" tower in Kaliningrad, has collected several thousand amber exhibits, including an amber nugget weighing 4 kg 280 g. This is the second largest whole piece of amber found during the entire period of its mining. In the Lithuanian city of Palanga, the Amber Museum is located in the Tyshkevych Palace. The rich collection includes 5 thousand objects occupying 15 rooms. Here you can also see the "Amber Sun" - a nugget weighing 3,5 kg. The most famous amber museum in Central America is the Mexican Museum "Hidden Stone". It contains 10,000 samples of amber with inclusions of algae, shells and even fish.

Small deposits are located on the shores of the Bay of Gdańsk in Poland and on the coast of the North Sea in the Netherlands, Germany and Denmark. The gem content in the Stubbenfelde deposit on Usedom Island is 0,357 kg/m^3. In Poland, amber is mined from coastal deposits along the Gulf of Gdańsk. Significant deposits of Lower Miocene amber are found in Western Pomerania in the Slupsk region.

The depth of the blue earth is greater, the farther from the coast of the Baltic Sea. If in the northwest near the village of Filino the amber-bearing rock is exposed at the base of the coastal ledges, then in the western direction it lies at a depth of 80-100 m from the surface.

The Paleogene layers of the Southern Baltic represent only a part of the huge amber horizon, which is exposed in Belarus (in the Minsk and Grodno regions) and in Ukraine (the Klesiv deposit in the Rivne region). The presence of this horizon was confirmed by drilling operations carried out on the territory of Poland, in particular in Eastern Primorye and the vicinity of Braniev, as well as in Western Pomerania between Slupsk and Koszalin. The German researcher H. Konventz believes that the amber rocks continue in the western direction to the coast of England [45-53].

In Ukraine, amber has been known for a long time. Its first developments are known near Kyiv (Mizhhirya and Vyshhorod region) and in Volyn (near modern Klesiv). In 1870, near Kyiv, 50 pieces of gems of different sizes, weighing a little more than 800 grams, were found in one layer. Amber was washed by the Dnieper and other rivers during the flood, carried away by meltwater and rainwater from streams and ravines. In ancient times, its extraction not only satisfied local demand, but also made it possible to export it to ancient countries along the shores of the Mediterranean Sea and to eastern states. However, near-surface development of small Kyiv deposits, accessible to miners, were gradually developed and forgotten [45-47].

Small deposits of amber have long been known in the western regions of Ukraine on the territory of the present Lviv and Ivano-Frankivsk regions. Red amber was found in the Tertiary deposits of Lviv and its surroundings as early as the middle of the last century. Amber was not only mined along the Dnieper and its tributaries, in Volyn and Transcarpathia, but also processed in these places. Kyiv amber was not inferior in composition and properties to Baltic amber. That is why it was sometimes called Kyiv succinite.

Currently, amber is found in Neogene deposits covering sulfur ores in the Yaziv, Nemyriv, Rozdil and Podorozhnen deposits and in the Rechichan sulfur deposit. There are more than 2,000 gem pieces ranging from a millimeter to 25 cm in size in the Yazivskoye deposit pit.

Amber is colorless, yellow-white, yellow, brown-yellow, light and yellow-brown, transparent, translucent and opaque. A change in the degree of transparency of the stone by section was observed. Transparent amber is concentrated in its middle [45-49].

Geotectonically, the Klesiv amber-bearing zone is located at the junction of the northwestern slope of the Ukrainian Crystalline Massif, the Volyn-Podilsky Plate and the Pripyat Depression and has a two-tiered structure. The morphology of the modern surface of the crystalline base is determined by its structural position on the northwestern slope of the shield.

In the area of project works, the crystalline foundation is covered by Cenozoic and Quaternary sediments and has absolute elevations of 130-170 m above sea level, gradually dipping in the northern and western directions with a slope of 10 m per 1 km. The general tendency to dip is complicated by individual local uplifts of the shield protrusions. The crystalline foundation consists of ultrametamorphic, metasomatic and intrusive formations of the Lower and Middle Proterozoic.

The large-brick nature of the foundation relief is established with the development of oval, isometric, or irregularly shaped projections of Precambrian rocks with an area of 1 to 10 km, separated by relatively narrow (the first hundred of meters) and elongated (the first kilometers) depressions. In the modern relief, they correspond to swampy valley-like areas, the relative excesses of the foundation protrusions above the adjacent depressions are on average 10-12 m. The leveling of the foundation relief takes place due to the accumulation of sedimentary deposits of the Paleogene age in its depressions. An intermittent layer of bluish-gray, sometimes greenish-gray, dense, viscous clay up to 2,5 m long lies on the weathered crust of crystalline rocks. The age of the clay is Lower Oligocene. On clays and in places where they are absent, on the crust of weathering of crystalline rocks, there are two layers of glauconite-quartz sands of Oligocene age of different color shades, which are a productive horizon. The lower layer of amber-bearing rocks is represented by shallow-medium-grained sands of dark gray, sometimes greenish color and medium-grained sands of dark gray color with a bluish-gray tint. The rocks are saturated with water, the thickness of the layer ranges from 1,0 to 6,0 m. In the lower part of the section, thin (2-3 cm) layers of black humus matter are noted.

The upper amber-bearing layer is represented by shallow-medium-grained gray, light-gray sands saturated with water, which contain a significant amount of humic matter unevenly distributed over the layer. In the section, there are thin (1-3 cm) layers of lenticular clays, as well as the remains of plants and roots. The average thickness of the layer is 2,0 m. Oligocene deposits are overlain by a horizon of Quaternary formations, which are represented by light-yellowish-gray, gray, light-gray fine-grained quartz sands of fluvioglacial genesis. The thickness of the layer of Quaternary deposits varies from 1 to 8 m.

The hydrogeological conditions of the Klesiv deposit are relatively simple, the upper groundwater aquifer is developed everywhere, the source of which is atmospheric precipitation. Water-bearing rocks are represented by fine-grained Quaternary sands and fine-medium-grained sands of Oligocene age. The thickness of the horizon reaches 12 m. In the lower part, it is a pressure float. In the greater part of the territory, dark greenish-gray clays of early Oligocene age or structured kaolinized crust of weathering of crystalline rocks are waterproof.

According to Ukrainian geologist V.I. Panchenko [45-49] The Klesiv amber deposit is located in the zone of Proterozoic crystalline rocks of the northwestern part of the Ukrainian shield surrounded by Paleogene sedimentary formations. The placer consists of several areas, two of which are open quarries. The productive horizon of the deposit consists of three sand layers composed of different-grained quartz sands, which are unequally enriched in clay, organic material and amber. The lower layer is sporadically enriched with glauconite, which gives the amber-bearing rock a blue tint. Pieces of amber reach a size of 10 cm. According to V.I. Panchenko and O.S. Tkachuk, the amber content in the deposit is from 15 to 310 g/m^3 and even 1000 g/m^3, the average is 50 g/m^3. The distribution of amber is uneven, the maximum concentration is at the base of the layer. Annual extraction of amber at the Klesiv deposit does not exceed 140 kg (Fig. 4). In a short time, Klesiv amber gained recognition on the domestic and foreign markets.

Fig. 4. Polish amber

Unlike Baltic amber, Klesiv is much further away from the sea. It can be predicted that in Paleogene times there was a sea shore not far from the village. The position of the ancient coastal strip in Volyn is also recorded by other finds of amber in this area. It is known that vertical tectonic movements of the Earth's crust took place on the border of the Eocene and Oligocene, which led to the transgression (advance) and regression (retreat) of the sea. German researcher F.

Kaunhoven found that in the Tertiary period on the territory of the current Kaliningrad Peninsula, the interpenetration of sea and land changed 19 times.

In the post-Oligocene period, amber deposits were exposed to denudation factors, it was carried away by water into new deposits. During the Ice Age in the southern Baltic region, part of the deposits was pushed away from the main deposit by the moving glacier. Glacial waters and moraines carried pieces of rock with amber to different countries of Europe. Outcrops of such rocks coincide with the boundary of glacial deposits, which lie on the border of Tertiary and Quaternary deposits. The discovery of small deposits of amber in Poland and Germany is connected with this process.

Amber-bearing rocks on the underwater slope of the Kaliningrad Peninsula are still exposed to the active action of sea waves. A lot of amber is washed up on beaches on a large part of the southern coast of the Baltic Sea. The researchers claim that amber finds on the territory of Belarus are connected with fluvioglacial, lake-marsh and coastal-sea deposits of the Cenozoic age. According to the combination of paleotectonic, facies-paleogeographical data and the results of testing, two amber-bearing regions have been identified in Belarus - Poliska and Mykashevitsko-Zhytkovyka.

2. Characteristics of amber deposits in Ukraine

According to research data [45-53], three zones and four districts with industrial concentrations of amber were found in the Rivne region. All of them belong to the Pripyat basin of sedimentation, in which large-scale amber placers were formed simultaneously with the accumulation of marine sediments in the Oligocene epoch (about 35 million years ago). The total area of productive amber-bearing horizons in the Rivne region is 3,810 km^2, which is 18% of its territory.

In the Rivne region, two amber deposits have been explored: Klesivske in Sarnenska and Vilne in Dubrovytsa districts, which are currently being developed by the state enterprise "Burshtyn Ukrainy" [45-49].

Further growth of raw amber reserves is possible due to the completion of the stage of prospecting and prospecting and evaluation works at the "Fedorivska" and "Melioratyvna" sites within the Klesiv deposit and the areas of the Volodymyrets amber-bearing zone, where work has been carried out by the "Rivne Geological Expedition of the North-Geological State Enterprise" since 1988.

The largest amber deposits "Klesiv", "Vilne", "Volodymyrets-Skhidny" contain at least several hundred tons of amber raw materials, of which 128 tons of industrial reserves have been explored. Two of them are exploited: Klesivske deposit (site "Pugach") is developed by the state enterprise "Burshtyn" of Ukraine", "Volodymyrets-Skhidny" - LLC "Center "Solar Craft". The official production of amber in 2015 was 4,5 tons.

In the Klesiv deposit, amber is mined using an open pit method (Fig. 5). Amber lies in sandy soil. The depth of occurrence is up to 15 m. There is a granite quarry with a significant supply of water near the deposit. The deposit is located close to roads and the power grid. During the first six months of 2003, 230 kg of mineral was mined at the State Enterprise Amber Mines. And already in 2006, amber extraction is 3,200 kg per year, which was achieved by using the new ESH-5/45 excavator for amber extraction and stable financing from the state budget. At the same time, for 2006, the volumes of works in the quarry are: excavation works - 23,6 t/m^3; mining mass - 17,466 t/m^3; reclamation per month - 0,5 ha. [45-53]

However, due to the lack of funding, as of January 1,2017, the State Enterprise "Ukrburshtyn" practically does not work and is bankrupt.

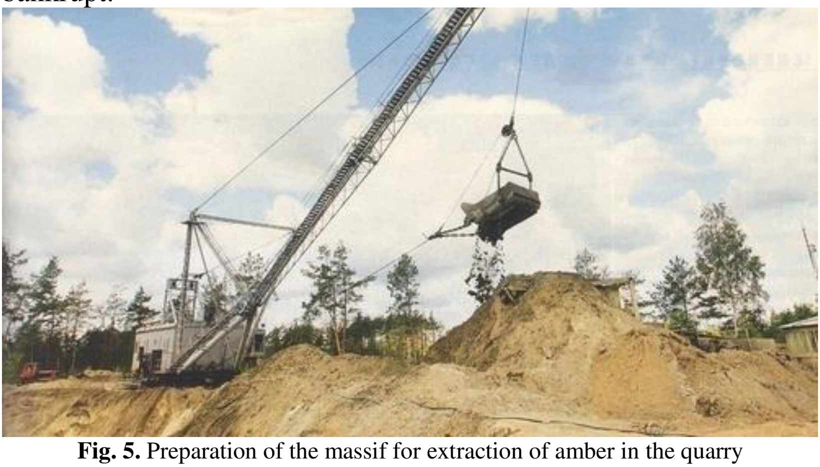

Fig. 5. Preparation of the massif for extraction of amber in the quarry by excavation method

Polish amber differs in its chemical composition. It is the most saturated with impurities and includes 18 chemical elements. In addition to silicon, magnesium, iron, calcium, which are present in almost all deposits, lead, zirconium and up to 3,19% sulfur are added. The ash content of Klesiv amber is 8,7%. This affects the quality and color of the hardened resin [36-41].

Amber is used for the manufacture of jewelry, varnishes, paints, medicinal preparations are made from amber. In 1998, the first Rivne jewelry factory was put into operation, which, in addition to amber jewelry, produces succinic, glutaric acids and volatile aromatic oil, which is used in pharmacy.

Potential reserves of amber in the region are much larger. According to the results of the exploration and evaluation work of the Rivne KGP of the SE "Ukrainian Geological Company", the estimated amber resources in the Dubrovitsa, Sarne, and Volodymyrets districts alone amount to more than 1,400 tons.

The number and total area of the areas for which special permits for geological study, including research and industrial development of subsoil were issued to subsoil users as of the beginning of 2016: state - 3 and 46,5 km^2; private - 2 and 68,4 km^2, respectively. The total area of amber-prospecting sites offered to the Ukrainian Geological Company for geological study is about 800 km^2. Thus, 685 km^2 of amber-bearing areas of the region are not controlled and are objects of unauthorized development.

As of 2009, the total area of areas affected by unauthorized amber mining was 374 ha. Now, according to approximate estimates, it exceeds more than 1,000 ha and is growing, but their accounting and auditing is not carried out.

3. Conditions of accumulation of primary amber deposits in amber-bearing areas of Rivne region

Amber accumulation conditions within the Oligocene sedimentation basin of the Rivne, Volyn, and Zhytomyr regions are determined by the features of the geological structure of the northwestern slope of the shield and the features of the structural and morphological structure of various parts of the Intermountain Sea. This section is provided based on research materials of associate professor M.V. Krynytska, prof. Melnychuk V.G., Nesterovsky V.A.

and studies of the Rivne KGS SE "Ukrainian Geological Company" [45-53, 65].

Primary amber placers of the Klesiv district

The discovery of industrial amber deposits in Ukraine began with the discovery of the Klesiv deposit in 1980, which is still active today. Further prospecting and prospecting and evaluation work within the Klesiv amber-bearing district, which was carried out over the past 30 years, expanded information about its geological structure and the conditions for the formation of primary amber deposits.

The Klesivske deposit is tectonically located within the lowered part of the Osnytskyi block - the Klesiv graben [45-49, 61]. The negative structure is small in size (according to geological surveys - 240 km²), has a shape close to a regular quadrilateral and is limited by faults. It is separated from the shield by Shahynska [45], and to the west it is bordered by Mylyatka by meridional local tectonic zones. Within the limits of this inherited subsidence are mainly all (except for the manifestation near the village of Perebrody in the north of the district and the Tomashgorod manifestation in the east) currently discovered amber manifestations within the Klesiv amber-bearing district.

Productive (intermontane) sediments of the southeastern part of the Klesiv district (Pugach, Rodnikova, Duny sites and the Fedorivka manifestation) fill the depression between the outcrops of Proterozoic crystalline formations and their weathering crusts. The productive deposits of the Klesiv deposit proper lie in a strip from 200 to 700 m wide, which is traced from the southeast to the northwest between the exits to the sub montane surface of the small ledges of the foundation. The length of the amber-enriched strip is more than 2 km. Outcrops of crystalline rocks among intermountain sediments are insignificant in size and in intermountain time represented numerous abrasion islands [45] with an area of about 50%.

In the complete sections of the Cenozoic of the Klesiv deposit, on the Proterozoic crystalline rocks of the Osnytsk complex, their weathered crust or chalk deposits, the Upper Eocene Obukhovian deposits, formed in relatively deep-sea conditions, are located, which are replaced by sands formed in shallow sea conditions up the section.

The amber-bearing stratum productive of industrial contents is a stratum of sands of early and middle Oligocene age [45-47]. The sediments are usually limited to paleo-depressions between the crystalline protrusions of the basement and lie on a thin (up to 15 m) layer of Obukhov sediments, represented by glauconite-quartz sands and clays. The thickness of the Obukhov deposits decreases on paleo highs, where they are represented by clays or clays underlain by layers of sand that are insignificant in thickness. The depressions in the roof of the clayey Obukhov horizon are sometimes filled with fine-grained, clayey sands of a dark green color. Amber-bearing sands are multi-grained, mostly fine-medium-grained, gray, dark gray, greenish-gray in color, sometimes with a content of up to 3-5% flint and fragments of crystalline rocks. Amber fragments of various shapes and sizes, with an oxidation crust up to 1-2 mm. Sizes are mostly 1-2, rarely 5-10 cm. Contents (according to the Zahidkvartssamotsvity VO) range from 1 to 420 g/m³.

The amber-bearing deposits of this amber-bearing region contain a small (mainly 0,5-1%) amount of glauconite. According to the data of Zahidkvartssamotsvity [450-53], the frequency of detection of glauconite in studies of the electromagnetic fraction of samples is 69%, including 50% in the light fraction. The glauconite of the light fraction is mostly rounded and rounded-angular, rarely in the form of intergrowths, which indicates the erosion and over wash of bottom sediments formed in the conditions of the deeper shelf of the Obukhov Sea.

The productive stratum, which is somewhat uniform in lithological characteristics, is divided into two slightly lithologically different parts when studied in detail, taking into account the structural and morphological features of the bottom of the sedimentation basin and the abrasion-accumulative nature of sediment accumulation.

According to the data of Zahidkvartssamotsvity [45-49], the lower part of the horizon (700 m long) of the Velikiy Pugach section of the Klesiv deposit is represented by fine- and medium-grained sand of a predominantly greenish-gray color, with a glauconite content of up to 5%. The thickness varies from 1-2 m to 5-6 m. Among the sand, there are dark gray to black (2-3 cm) patches, enriched with scattered carbonaceous material and, mainly, with amber. Amber is mostly run-in. Pebbles of foundation rocks and black flint (3-5%) are found at the base of the horizon.

The upper part of the horizon is represented by fine- and medium-grained gray sand, with patches of light gray; carbonaceous organic matter is scattered unevenly, there are 1-2 cm thick clay patches and chaotically arranged fragments of charred wood. Power from 0,5 to 1,6 m.

In the northwest of the field, the productive stratum can be traced between two islands composed of foundation rocks and located at a small distance from each other. The Mezhyhirska stratum is limited to the central parts of the paleoduct. The upper part of the stratum, with a thickness of 0,6-1,9 m, is represented by variegated sands of gray, dark gray, and sometimes greenish-gray color. Amber was not detected in this part of the stratum within the investigated section. In most cases, amber is found in the lower part of the stratum, the thickness of which varies from 2,7 to 4,3 m. The lower greenish-gray part is lithologically similar to the upper part, but there are samples enriched with scattered carbonaceous matter and fragments of carbonized wood.

Probably, the bottoms of the productive layer were formed in coastal-marine conditions at the beginning of the intermountain time. Amber resin washed from the stable mainland and the territory of the islands accumulated in the channels between the islands. Within wide channels with a slow hydrodynamic regime (Velikiy Pugach area), amber resin entered the sea basin along with the seasonal removal of terrigenous material from the main shore and islands. The removal of the resin into the open sea was prevented by the differences in the seabed and the ability of amber to sink in desalinated water. The connection with the open sea contributed to the inflow of seawater and the formation of a geochemical environment favorable for the final fossilization of amber. The absence in the sediments of narrow paleochannels of pebbly and crushed stone formations, checkers containing carbonaceous matter indicates an increase in the speed of currents in such channels. Amber in these zones of the shallow sea was eroded when the low-lying terrigenous zones of the islands were flooded.

The upper parts of the productive horizon were probably formed at the end of the intermountain time during the reduction of the area of the islands, the expansion of the straits, and the leveling (reduction of elevation differences) of the seabed in the straits.

Near the slopes of paleo-elevations and on washed-out paleo-elevations, the lithological characteristics of amber-bearing sediments are different - the sands become clayey. The color varies from dark gray to gray and bluish gray. On the section, these deposits occupy a hypsometrically higher position and are separated from the sediments formed in the channels by a layer of dark gray clay, 0,3-0,5 m thick, which in some places within the district increases to 6,0 m.

According to the lithological and paleogeomorphological studies of I.O. Maidanovych [55] clays mark the beginning of the transgression of the Berek Sea, and the bluish-gray sands, in which rolled fragments (1-5 cm) of flint and gray quartz, samples of carbonaceous matter and amber, are also found, belong to its regressive stage.

However, the materials of the exploration and evaluation works of the Rivne KGP of the SE "Ukrainian Geological Company" over the past two decades at the Oleksiivka and Tomashhorod manifestations allowed to investigate in more detail the structural and morphological and clarify the lithologic and facies conditions of the formation of amber deposits within the northwestern edge of the shield.

We attribute the lower part of the productive horizon to the terrigenous deposits of the shallow coastal zone of the Kharkiv Sea, formed at the beginning of its regressive stage (intermountain time). The upper part of the stratum belongs to deposits formed in conditions of a more open sea. The litho-facies section reflects the transition from the sediments formed in the conditions of a sea channel to the sediments of the flooded coastal zone of the islands - the intermontane stratum, represented by dark greenish-gray, fine-medium-grained sand (lower stratum), is replaced by dark gray dense clay, which is higher in section and in the direction of paleo-islands is replaced by bluish-gray, clayey sand. Sediments covered with gray and bluish-gray sand were formed at the same time as the upper layer within the blurred terrigenous zones of paleoislands. The sediments probably acquired a bluish color due to erosion of the weathering crust of crystalline rocks.

At the end of the regressive stage of the intermountain sea (Middle Oligocene), the shield area underwent minor subsidence, and the crystalline abrasion remains within the sea underwent significant destruction. Thus, the sea in the stage of regression transgressed into low-lying insular and coastal areas (beaches, river deltas, coasts of lagoons and bays) and the coastline, accordingly, receded to the east. A new coastal shallow zone was formed, in which the processes of converting fossil resin into amber continued.

This assumption is also confirmed by the fact that for the greenish-gray, dark-gray sands lying hypsometrically below, 1-5 cm thick black carbonaceous matter, which is often associated with increased amber content, is more characteristic, and bluish-gray sands are characterized by the presence carbonaceous matter unevenly scattered throughout the stratum and clay samples. Oblique layering was sometimes noted in the hypsometrically higher sands, which also confirms the gradual migration of the coastline.

According to the data of the Department of Fossil Flora of the Institute of Geological Sciences of the Academy of Sciences of Ukraine [45-49, 64], the age of the sands of the productive layer is Lower-Middle Oligocene.

To the north-east of the Pugach section, in the Duna section, the productive stratum forms a layer to the local depressions of the crystalline basement. Here, an increase in the strength of the underlying clays and an increase in the strength of the most productive stratum is noted.

In terms of litho-facies, the sections of the Klesiv deposit belong to the terrigenous facies of the coastal zone of the shallow shelf, formed within the straits between the islands and near-island beaches, as well as the submerged terrigenous zones of the islands.

On the Fedorivsky manifestation, located to the south of the Klesiv deposit, the productive deposits are represented by fine-medium-grained sands of mainly gray, dark gray color, with glauconite (up to 5%). There are also flints and fragments of crystalline rocks (3-5%) with a size of 0,4-1,5 cm, samples (1-15 cm) of black carbonaceous material with a high content of amber.

Amber pieces (from 0,3 to 5-15 cm) and marked macrofossils - fossilized cones of conifers from the Pinaceae family are found within the manifestation. The thickness of the productive stratum varies from 0,5 to 11 m. It is assumed that the productive deposits were formed during the flooding of the coastal parts by the sea and the mass removal of amber into the sea area. To the southeast of this manifestation, a paleo-depression filled with intermontane sediments "cuts" into the shield. According to Maidanovych I.A. [55] is the Fedorivska river paleovalley, in which gray and dark gray intermontane sediments without amber are common. Deposits of the Fedorivskyi manifestation are classified [55] as shallow-marine lagoon-delta deposits.

Litho-facies sections of the southern part of the amber-bearing area (Oleksiivka manifestation) confirm the conclusion about shoreline migration. The manifestation is adjacent to the edge of the shield and is limited in the east by outcrops of crystalline rocks of the foundation, in the northwest by the modern occurrence of Middle Eocene rocks.

Intermontane deposits, represented by medium-grained sand, with separate grains of glauconite and gravel grains of quartz. Taking into account the structural and morphological position of the bottom of the sedimentation basin, these sediments are classified as marine sediments formed in the zone of mobile shallow water of the wave field of the inner part of the sea (perhaps a large bay), which maintained a connection with the open sea.

Cross-sections of wells and shafts located further east in the lower part of the stratum contain multi-grained, clayey sands with admixtures of quartz gravel grains, glauconite grains, and crushed fragments of crystalline rocks. There are fragments of charred wood 0,5-15 cm in size and clay samples (5-10 cm thick) and lumpy fragments of dark gray plastic clay. Accordingly, the coastal zone was located further east.

With the erosion of the paleo-elevations and the gradual uplift of the territory adjacent to the shield, the coastline gradually moved to the east. The Intermountain Sea initially spread beyond the coastal embankment, into the zone of active wave influence and, further, into the coastal shallow water zone, limited by the main shore. With the active action of the waves, a new beach area was formed. The sea gradually flooded the land, washing loose sediments, soils, vegetation, including resin-producing ones, and amber resins washed from the soil into the sea waters.

To the west of the Oleksiivka occurrence, the Oligocene sediments are washed out, but the spread of Eocene Kyiv deposits and the absence of Obukhov deposits in the northwest, as well as the discovery of grain amber in the extreme western outcrops of the occurrence, suggest that the bottom of the intermountain sea was complicated by an underwater or island bar, which could prevent the transfer of fragmental amber to open sea

According to [45-47] detailed exploration of the Klesiv deposit, amber in all samples is represented mainly by angular, partially rolled fragments, which also indicates the formation of primary amber deposits in the immediate vicinity of the parent deposits of fossil resin by its washing when seawater enters the low shore. The fact of mass transfer of amber resin by water remains questionable. Amber sinks in fresh water and can only be transported in rivers by turbid bottom waters by pumping or dragging.

The distribution of amber-bearing deposits of the Tomashhorod manifestation (eastern part of the district) in the south, east and, partly, in the west is limited by outcrops of crystalline rocks of the foundation. Probably, in the intermountain time, their accumulation took place in the conditions of a bay. Lithologically, the deposits are represented by quartz sands and quartz sands with single grains of dark gray glauconite with a greenish tint, dark green color and dark gray clay siltstones. The sands are multi-grained, mostly coarse-grained.

The quartz grains are well rolled, quartz gravel, some feldspars and small pebbles of crystalline rocks are present. Characteristic tests of dense clays are greenish-gray, dark gray (to black). There are rolled fragments of charred wood and amber.

The extreme northern geological survey wells [21,45], drilled partly on the territory of Belarus, revealed erosion of Oligocene sediments. According to lithological features, deposits productive of amber were found at a considerable depth (12, 20-23 m) in the area of the village. Crossings [21, 46-50]. They are represented by gray, brownish-gray, coarse-grained sand (or medium-grained with layers of coarse-grained), quartz with glauconite and feldspar, with wood fragments and enriched gravel, sandstone pebbles, tuff sandstone, granite in the lower horizons. This manifestation is the extreme northeastern, potentially amber-bearing area, confirmed by finds of fragmentary amber. In tectonic terms, it is timed to the intersection of the local Veliko Lake zone [45-49, 61] with the South Pripyat fault. Probably, due to the action of neotectonic movements, the amber-bearing layer was lowered and covered by a thick layer of deposits of the post-Mezhyhirian period. The lithological features of the sediments allow us to assume that they were formed in the places of accumulative forms (overburdens, bars) of sedentary shallow water in the sublittoral zones and littoral zones of the islands.

Primary amber placers of Dubrovytsa district

The geological study of amber-bearing deposits of the Dubrovytsa amber-bearing district began in 1982-1983, when the Vilne deposit was discovered by the staff of the IGN of Ukraine. Since that time, a large number of wells and pits have been drilled within its borders, but practically no manifestations promising for industrial development, except for the Vilne deposit, have been found. However, a large amount of field material confirmed the complex geological structure of the area and the uneven distribution of intermontane deposits. The southern limit of the distribution of productive deposits is the erosion cut of Paleogene sediments within the Bielsky fault, in the north - the erosion cut of the Pripyat valley and its tributary, in the east - the erosion cut of the Horyn valley, and the western limit is timed to the Manevytskyi-Stolinsky, revealed by geological surveys [46-50] fault

In terms of structure, the Vilne deposit spatially gravitates toward the intersection of the northeast-trending Horyn tectonic zone with the latitudinal Bilsky tectonic fault and is located southwest of the Dubrovytsa ledge (a structural element of the North Ukrainian horst zone), broken by an orthogonal system of tectonic zones into smaller ledges, complicated in turn by by linear, low-amplitude steps of a northeastern trend [46].

The heterogeneity of the tectonic structure and tectonic activity in the pre- and post-Mezhyhirian times actually determined the complex geological structure of the deposit and the amber-bearing area as a whole.

According to the description of the exploration trench of the Southern section of the Vilne deposit [46], the productive intermountain stratum is represented by gray, dark gray to black, fine-medium-grained, quartz, clayey sand. Oblique layering of sands, emphasized by clayey material, and the presence of lenses of dark gray, black, recorded, thinly layered clay, enriched with the remains of partially charred wood, were noted. Findings of fragments and pieces of amber, mostly from 1-2 to 3-5 cm in size, rarely 10-15 cm, are associated with such lenses. Amber is also found in lenses formed by accumulations of wood remains, to which the largest amber contents are attributed, and also in lenticular samples of carbonaceous sand (often with fragments of charred wood). Fragments of branches and trunks, cones and bark are noted among the wood remains, which are sometimes replaced by pyrite or silica. The frequency of detection of glauconite according to the results of studies of electromagnetic fractions of the Vilne deposit is 66% (according to the data of the Zahidkvartssamotsvity).

The territorially remote (2 km) Northern (near the village of Kryvytsia) section of the deposit was formed under similar geological conditions. The thickness of amber-bearing deposits in this area is insignificant - 1-2 m and is represented by fine-, medium-grained, clayey, dark gray, dark greenish-gray sand, with lenses of brown, dark gray, dark greenish-gray clay, with fragments of carbonized wood, with pebbles of quartz, flint. Findings of amber are limited to clay lenses or to finds of wood fragments. According to the conclusions of individual geologists [46-55], the productive stratum of this area is assigned to the redeposited alluvial type based on lithologic-facies features (the presence of stratification, the presence of gray multi-grained sands at the base of the stratum). However, this assumption is not confirmed by structural and morphological studies.

The structural and morphological analysis of the pre-Cenozoic surface and the analysis of the depths and thicknesses of the Eocene (Kyiv and Obukhov) sediments allow us to assume the presence of a significant island located further east (within the Dubrovitsa ledge) and the possibility of resin-producing trees growing on it.

The occurrence of amber-bearing deposits is hypsometrically higher than in the Northern section, the density and variability of dark gray, fine-medium-grained, clayey sands (enriched in plant remains, carbonaceous and clayey samples) in the southern part of the deposit are bluish-gray, dark bluish-gray sands , greenish-gray, fine-medium-grained, clayey, with randomly arranged fragments of amber, indicates the formation of the latter at the base of the bar from the side of the open sea. These deposits are characterized by the absence of carbonaceous material. The hydrodynamic activity of the sea contributed to the increase of the overburden in height with marine sediments and terrigenous material brought from the side of the island. Let us assume that enrichment with terrigenous material also occurred from the side of the archipelago of the islands of the Volodymyrets amber-bearing district.

According to the modern structural and morphological study of the bottom of the seas, the formation of island bars is characterized by being tied to tectonic faults. As noted above, the Horyn tectonic fault runs along the territory of the deposit. In addition, other manifestations of the Volodymyrets amber-bearing district are spatially confined to it.

To the north-east of the Vilne deposit, with amber contents from 0,60 to 242,7 g/m^3 (on average 56,0 g/m^3), fragmental amber was found at the Mochulishche occurrence (in 11 shafts out of 22 passed, contents 1,0 36,5 g/m^3) and at the Khutirskyi exposure (in 17 pits out of 99 passed, contents 2,2-51,6 g/m^3) in dark gray sandy-clay deposits of the Lower Oligocene. The discovered amber is usually flattened, mostly angular, slightly rolled and not rolled, with an oxidation crust up to 1 mm. Timed, in the predominant amount, to tests of clay and carbonaceous matter. These deposits are also classified as those formed under the conditions of accumulation of terrigenous material within the surface and underwater parts of the island bar, which may have continued from the Vilne deposit in the northeast direction.

Similar facies formations were also found in the northeastern part of this amber-bearing area during prospecting works on the Zolote, Yasinets, and Osova manifestations [46]. The sediments are characterized by the absence of a coarse-grained sand component and psephitic particles and are represented mainly by fine-grained sand, rarely medium-grained. Loose sandy rocks lie on deep-water (siltstones, clays, fine-grained silty sands) sediments of the Obukhov regional. These manifestations were found to the northeast of the manifestations described above and presumably continued the ridge of surface paleouplifts with submarine ones under the conditions of increased depths of the open shelf.

By prospecting wells [46-49], drilled 2-3 km north of the Vilne deposit (on the outskirts of the villages of Litvytsia, Tryputnia), Oligocene amber-bearing sediments overlap with Miocene continental sediments and are found at a considerable depth or are completely absent, while marine formations are revealed at their characteristic modern hypsometric levels Upper Eocene. Such features of the geological structure are justified by the different amplitude of adjacent structural blocks and their inheritance in the plate stage of development, as well as neotectonic movements in the post-Mezhyhirian period. According to geological surveys, neotectonic movements are clearly recorded, both on the pre-Quaternary and on the modern surface [46].

In general, the formation of productive sediments in the epicontinental sea is confirmed for the area, and the conditions of accumulation are equated to the conditions of sedimentation within the limits of a shallow marine shelf complicated by islands, bars, and overbanks.

It should be noted that this area underwent neotectonic movements and exaggeration during the ice ages, which led to the disruption of Paleogene sediments and the formation of numerous secondary amber deposits and large-scale halos of mechanical dispersion of grain amber. According to the data of search and search and evaluation works, the frequency of detection of amber grains in sand fractions within individual manifestations of this area varies from 9% to 31% (on average - 13,4%). Amber of psephytic dimensions of the Vilne deposit is confined to the intermountain world of the Oligocene [46].

Amber of psammite dimensions in the Quaternary, Neogene, and Oligocene Paleogene deposits, which lie above the deposits of the intermountain world, was formed as a result of redeposition of primary placers. In addition, this amber-bearing area, as well as the entire research area, is characterized by paleokarst, the formation of which in the post-Mezhyhirian period also contributed to the redistribution of primary amber deposits.

Primary amber placers of the Volodymyretsky district

Discovery of the Volodymyrets Shchydnyi deposit, located east of the village. Volodymyrets in the Rivne region, is the result of exploration and evaluation works carried out by RGE over the past

20 years within the boundaries of the Volodymyrets amber district. In addition to the deposit, promising manifestations of Dubivka, Zhovkini, Volodymyrets and Virka were discovered here.

Deposits of the productive stratum are mostly represented by sand fractions with different-grained material. Silt-sand and clay-sand intermontane formations are also found, mainly in the southern outskirts of the district.

The study of the Volodymyrets Shchydnyi deposit by means of wells, shafts, and an experimental trench made it possible to carry out detailed lithological studies of productive deposits and to analyze changes in their capacities and depths of occurrence.

Within the deposit, the roof of the Eocene era formations lies at hypsometric levels from 158,30 m to 164,70 m [46, 48] and reflects the morphostructure of the bottom of the sedimentation basin of the intermountain time. In general, it is an undulating surface with local depressions and elevations of various configurations and sizes. Fractionally weathered laterally and in sections, the material of the deposits of the Obukhov age (mica silty clays and argillaceous siltstones) indicates the relative deep water of the sedimentation basin and the calm hydrodynamic environment of their formation.

The sediments of the intermountain world, which lie according to the section above, were formed in the conditions of the shallow waters of the regressing epicontinental sea.

The stratum is composed of quartz, glauconite-containing, multi-grained sands, with a predominance of fine-medium-grained sands, containing an admixture of the coarse-grained fraction of the quartz composition, gravel grains and quartz pebbles, as well as pieces of amber. Usually, when amber is detected, a slight increase in the content of coarse-grained quartz grains and charred wood fragments is noted.

4. Definition of concepts of geotechnological methods of mineral extraction

In connection with the development and introduction of geotechnological methods of mineral extraction, there is a need to define new and clarify a number of concepts that are stable in mining science and relate to the subject of research. Formation and implementation of borehole hydraulic testing as a method of geotechnology for prospecting and trial exploitation of deposits was done for the first time by prof. V.Zh. Arensom, M.I. Babichev, E.I. Chernei [7, 51-54].

The existing terminology related to the concept of borehole hydraulic production is not indisputable. For example, B.Zh. Ahrens believes [7] that borehole hydraulic mining (HBM) is a method of underground mining of solid minerals, based on bringing the ore at the place of occurrence into a mobile state by means of hydromechanical influence and releasing it in the form of a hydraulic mixture to the surface. There is no objection to the disclosure of the essence of SGD as a method of underground mining, except for the term "...hydromechanical influence".

In our opinion, it should not be limited to hydromechanical influence, because the goal of geotechnology and its constituent parts of SGS is the influence of working agents on a useful mineral in the process of extraction to transfer it into a mobile state. There are systems that do not have a well (wells) as an element of the system. For example, removable cameras, which are reconnaissance products in the systems of mechano-hydraulic testing (MHO) and mechano-hydraulic production (MHD).

If we mean the entire complex of underground development activities without the presence of workers in the cleaning space under the SGS, such a definition does not reveal the essence of the name.

The method of deposit opening - wells, open and underground mining, as well as a combined option is a clearly expressed feature, which is especially important for the characterization of geotechnological mining methods, both in terms of form and content.

With regard to the mechanism of influence on the mineral, which is a means of transferring it into a mobile state, in our opinion, it is worth following the division into the term–working agent [51-54], which includes solid, liquid, gaseous substances and their combinations, and also mechanical action.

The term "hydro production" is acceptable at this stage, since the specific weight of energy water, which is supplied for destruction, erosion, disintegration, gravity hydraulic transport and other operations in the general energy balance, prevails compared to compressed air, surface-active substances, solid components, etc.

Taking into account the proposed classification feature and the expansion of the concept of a working agent, as a subject of influence on the mineral being developed, it is advisable to highlight the following methods of hydraulic extraction and give them a definition.

Borehole hydraulic production (SGD) is a method based on bringing a mineral at the place of occurrence into a mobile state by exposure to a working agent and releasing the hydraulic mixture to the surface through wells, which are productions of discovery.

Underground hydraulic extraction (UGD) is a method based on bringing a mineral at the place of occurrence into a mobile state by exposure to a working agent and releasing the hydraulic mixture to the surface through underground mining operations.

Combined hydromining (CMH) is a method that includes elements of HMD, underground and open-pit mining methods, based on bringing the mineral to a mobile state at the place of occurrence by the action of a working agent and releasing the hydraulic mixture to the surface through wells or underground mining.

Developing the research of Professor E.I. Cherneya, it is possible to give a new definition to the mechano-hydraulic product.

Mechano-hydraulic production (MHD) is a method based on bringing the mineral at the place of occurrence into a mobile state through the influence of a mechanical executive body and releasing the hydraulic mixture to the surface through vertical mining works that open the deposit.

Unlike wells, open pits are usually rectangular in cross-section.

Field testing is the most important element of exploration, and its results are one of the main components of field evaluation. According to V.M. Crater testing, which reveals the composition and properties of a mineral, is understood in a broad sense as a method that establishes the quality of mineral raw materials. Taking into account the proximity of hydraulic mining and hydraulic testing both in terms of the mechanism of impact on the mineral and in terms of the equipment used, as well as the logical connection between the principles of exploration and testing as a method, Professor E.I. Chernei singled out the following varieties [51-54].

Borehole hydraulic testing (SGO) is a method of implementing the principles of exploration, based on bringing the required volume of the investigated object at the place of occurrence into a mobile state by the influence of a working agent and releasing the hydraulic mixture to the surface through wells for further processing and testing.

Underground hydraulic testing (GWP) is a similar method, but with the release of a hydraulic mixture to the surface through underground workings for subsequent processing and testing.

Combined hydraulic testing (KHO) is a way of implementing the principles of exploration, which includes elements of SGO and PGO. It is also appropriate to highlight the method of hydro-hydraulic testing, as independent due to differences from SGO, PGO and KGO.

Mechanical-hydraulic testing (MHG) is a method of conducting geological exploration, based on bringing the required volume of the investigated object at the place of occurrence into a mobile state by the influence of a mechanical executive body and issuing a hydraulic mixture to the surface through vertical mine workings for further processing and testing.

Testing and development systems are a necessary component of the methods of MGO, SGO, PGO, KGO, MHD, SGD, PGD and KGD and their technologies.

Academician N.V. Melnikov defined the subject of mining as "a system of knowledge about the methods and means of searching, exploration, extraction and beneficiation of minerals." As an integral part of mining and its scientific foundations, this knowledge is subordinated to a single goal - the study of processes, phenomena, forms and their manifestations in nature, connections and regularities at the stages of exploration, trial exploitation and development of deposits.

Borrowing some technical and technological means in the study of the scientific foundations of MGO and MHD, the scientific and practical potential of related knowledge is used much more widely. Effective systems of testing and development of the proposed methods should be those that, due to the combination of qualitative and quantitative components, technical and technological parameters, allow obtaining a concentrate at the place of occurrence, leaving the containing rocks in the subsoil, which will be given later.

The state of study of the problem of amber extraction as a component of geotechnological methods of mineral extraction and their generalized classification

When analyzing and researching the works of scientists, it is known that the SGS method for various minerals is widely implemented in the mining industry of Ukraine, Russia, the USA, Canada, Poland, etc.

Starting from 1965, under the scientific guidance of Professor B.Zh. Apenca conducts scientific research and development work aimed at the implementation of the SGD of phosphorites in the Leningrad Region. In 1975, a semi-industrial site with a monthly productivity of 20,000 tons per unit was put into operation. Despite the well-known advantages of the method, the losses of the mineral in the targets exceed 50%.

At the stage of semi-industrial testing of equipment and development systems, research is being conducted under the leadership of B.S. Kovalenko in the conditions of the Lermontov Mining and Chemical Administration.

Research under the scientific guidance of Prof. D.P. Lobanova.

In some cases, it is technically impractical and economically unprofitable to use hydraulic mining. This primarily refers to the extraction of strong weakly fractured minerals. There are two extraction schemes:

- the rock is separated from the massif followed by the removal of the reflected rock mass by mechanical means and the rock mass is transported through the mine workings with the help of low-pressure (0,20-0,25 MPa) water;
- the rock is separated from the massif by a mechanical executive body with subsequent transportation of the reflected rock mass by hydraulic methods.

As a rule, the basis for using CGD technologies is the results of field exploration. The task is reduced to the clarification of individual mining and technological indicators on the basis of laboratory studies of the physical and mechanical properties of the mineral and overlying rocks. This is a significant drawback.

A fundamentally new approach is necessary - at the stages of exploration using the methods of MGO, SGO, PGO, KGO, move to trial operation, based on the results of which the effectiveness of geotechnological methods can be predicted and their use, in particular, MHD.

Structural elements of the considered methods are testing and development systems. In this regard, the classifications of underground mining methods, underground hydro-mining and gas extraction systems are known, which is the basis for creating a classification of systems.

The most complete information on this issue is given in the works of M.I. Agoshkova, R.V. Imenitova, Y.D. Shevyakova, N.I. Trushkova, E.I. Cherneya, V.P. Prokop'eva, G.A. Tsulukidze, G.N. Popova, Z.R. Malanchuk and others. [51-54].

There is no need to consider in detail the advantages and disadvantages of different classifications, because they are considered quite fully in various scientific works. Each of the developed classifications is based on the identification of contradictions in the existing ones and their resolution at a higher scientific and technical level.

S.M. Shorokhov, considering placer deposits with a small capacity and a positive deposit, considers the classification of academician L.D. Shevyakov most acceptable, and on this basis singles out two systems - columnar and continuous, i.e. systems of group "A" without division into layers.

A leap in the development of the mining industry in the 1970s was the scientific development of geotechnological methods such as borehole and underground hydraulic mining. In a relatively short period of time, these methods have passed all stages of scientific research and industrial development on deposits of various mineral raw materials - amber, diamonds, gold, etc.

N.O. Babichev and E.I. Chernei considered the classification of technological schemes of borehole hydraulic production and the selection of technology parameters and technical means at the design stages.

The classification proposed by Academic M.I. Agoshkov, is universal for ore deposits developed by traditional methods, can and should be the basis for systems of geotechnological methods, which is not disputed by researchers and is accepted as a classification - the standard of systems of MGO, SGO, KGO, PGO, MHD, SGD, PGD and KGD.

In the process of analyzing the methods and methods of amber extraction, the following classification of amber deposit testing and development systems can be proposed.

Testing methods:

1. mechano-hydraulic testing (MHO);
2. borehole hydraulic testing (SGO);
3. underground hydraulic testing (PGO);
4. combined hydraulic pressing (KGO).

Mining methods:

1. mechano-hydraulic mining (MHD);
2. borehole hydraulic production (SGD);
3. underground hydraulic production (PGD);
4. combined hydraulic mining (KHD).

Testing and development systems are the main elements of technology, which is the beginning of the design of geological exploration works and the functional activity of a mining enterprise [51-54].

Conclusion

A potential source of amber production can be exhausted deposits with off-balance reserves, which are man-made deposits, but this requires the development of a technological process.

Due to the imperfection of the existing technologies, losses of minerals in targets and dumps exceed 50%.

Existing technologies for extracting amber from sandy and sandy-clay rocks have a high energy intensity of rock destruction, and segregation requires improvement of technology and equipment to increase the efficiency of the final product extraction process and reduce energy, water and air consumption.

The proposed technological schemes do not provide for an ecological component, the possibility of mining waste reclamation, while their man-made nature requires additional research taking into account various mining and geological characteristics and host rocks and the development of recommendations for technology and equipment taking into account the ecological component.

References

1. **Cruickshank, R. D., & Ko, K.** (2003). Geology of an amber locality in the Hukawng Valley, northern Myanmar. Journal of Asian Earth Sciences, 21(5), 441-455.

2. **Darby R.** Hydrodynamics of slurries and suspensions // Encyclopedia of Liquid Mechanics. Vol.5 / Slurry Flow Technology. Gulf Publishing Company, Houston, Texas. – 2005. - P. 50-91.

3. **Vand V.** Viscosity of soulutions and suspensions / V.Vand. – J. Phys.Coll.Chem, 1948. vol.52. - p. 277-308.

4. **Zenz F.A., Othmer D.F.** Fouidization and fluid-particle systems, Reinhold Publ. Coorp., New York, 1960.

5. **Arens V. Zh**. et al. - M.: Mountain book, 2007. - 295 p

6. **Azbel H.G**. The use of cranes with vibrating feeders for the extraction of metallic sheet metal / H.G. Azbel, Yu.A. Mykhaylov, A.I.Savelev // Installation and special works in construction No. 12, 1990. - P.17-19.

7. **Arens V.Zh.** Well-drilled hydro-mining of solid minerals / V.Zh. Ahrens. - M., Nedra, 1980, - P.93, 100-101.

8. **Baladinsky V.L.** Justification of the shape of the dump of soil-protecting multi-tiered working bodies / **V.L. Baladinskyi, S.V. Kravets, O.L. Romanovskyi** // Mining, construction, road and reclamation machines. Rep. inter. science and technology - K.: Technology. - 1995.- No. 49. - P.37-39.

9. **Bernyk P.S.** Vibrating technological machines with spatial oscillations of working bodies / P.S. Bernyk, L. V. Yaroshenko - Vynnytsia, 1998. - 116 p.

10. **Bondarenko A.O.** Physical study of the jet formation of an underwater blowout of an earth-sucking projectile / Bondarenko A.O./ - Dnipropetrovsk: Scientific Bulletin of NSU. -2009. - #2. – P.79 - 81.

11. **Bulat A.F**. Non-stationary movement of hydromixture during thickening in technological equipment / **A.F. Bulat, A.M. Sokil** // Geotechnical mechanics. - Dnipropetrovsk: IGTM of the National Academy of Sciences. – 2000. - No. 22. - P.3-7.

12. **Bulat A.F.** Ways to increase the profitability of amber mining and processing / **A.F. Bulat, V.P. Nadutyy, Z.R. Malanchuk** // Abstracts of reports of the II international scientific and practical conference "Ukrainian amber world". October 16-17, 2008. - Kyiv, 2008. - P. 36-37.

13. **Bulat A.F.** Substantiations of technological parameters of extraction of amber in Ukraine. / **Bulat A.F., Naduty V.P., Korniyenko V.Ya**. // American Journal of Scientific and Educational Research, 2014, No.2. (5)(July-December). Volume II. “Columbia Press”. New York, 2014. P. 591 -597

14. **Bulat A.F.** Features spread occurrence of amber deposits in the world. / **Bulat A.F., Naduty V.P., Korniyenko V.Ya.** // Oxford Review of Education and Science, №1 (9), January-June 2015. p. 60-65.

15**. Bulat A.F.** Modern technology of extraction of amber from sand deposits. / **Bulat A.F., Naduty V.P., Korniyenko V.Ya**. // Harvard Journal of Fundamental and Applied Studies, 2015, No.1. (7) (January-June). Volume VIII. “Harvard University Press”, 2015. p. 514-519.

16. **Bulat A.F.** The experience of using vibration installations in amber mining technology. / Bulat A.F., Nadutyy V.P., Kornienko V.Ya. // All-Ukrainian Scientific and Technical Journal "Vibration in Engineering and Technologies". Vinnytsia, No. 4(80) 2015, p. 128-131.

17. **Bulat A.F.** The experience of using vibration installations in the technology of amber mining. / **Bulat A.F., Nadutyy V.P., Kornienko V.Ya.** // "Vibrations in engineering and technology". Abstracts of reports: Materials of the XIV international scientific and technical conference, September 21-25, 2015, Dnipropetrovsk", 2015, p. 31-32.

18. **Vakhrushev I.A.** Interpolation formula for calculating the speed of motion of individual gas bubbles in liquids / I.A. Vakhrushev, G.I. Efremov //Chemistry and technology of oils, No. 5, 1970. - P.46-49.

19. **Verstov V.V.** Otechestvennyj vysokoefektivitnyi vibropružatel for carrying out work in soils / V.V. Verstov, E.M. Perley, I.V. Goldenstein // Construction Mechanization, No. 9, 2000. - P.2-5.

20. Vibrational disintegration of solid materials / **V.I. Revnyvtsev, G.A. Denisov, L.P. Zarogatsky, V.Ya. Turkin.** - M.: Nedra, 1992. – 430 p.

21. **Melnychuk V.G., Krynytska M.V.** Amber Polissia. - Rivne: NUVHP, 2018. - 236 p. http://ep3.nuwm.edu.ua/id/eprint/14531

22. **Dudlya M. A**. Technique and technology of drilling hydrogeological wells: [Textbook for students. special from direction 0707 "Geology"] / M. A. Dudlya, I. O. Sadovenko / National Mining University / H.G. Pivnyak (ed.). - D., 2007. - 399 p.

23. **Zhivotovsky L.S.** Technical mechanics of hydraulic mixtures and soil pumps / **L.S. Zhivotovsky, L.A. Smoilovskaia**. - M.: Mashinostroenie, 1986. - 224 p.

24. **Ivanov P.L.** Liquefaction of sand soils / **P.L. Ivanov**.. - M. -L.: Gosudarstvennoe energeticheskoe izd., 1962. -260 p.

25. **Ivanova A.A.** Liquefaction of a loose medium in a viscous liquid caused by vertical vibrations / **A.A. Ivanov, V.G. Kozlov, P. Evesk** // Izvestiya AN. Fluid and gas mechanics. - M., No. 3. 2000. - P.113-122.

26. **Indutny V.A**. Stone colors of Ukraine: amber / **V.A. Indutny** // Geography and the basics of economics in school. - 1999. - No. 8. - P. 26-31.

27. **Kirikovich V.D.** Study of the optimal structure of the working process of amber extraction by hydrofreza / **V.D. Kyrykovich** // Bulletin of the NUVHP. - 2007. - Issue 4 (40). - Part 3. - P. 120 - 125.

28. **Klepach M.I.** Automatic control of the process of well hydro technology/ **M.I. Klepach, E.Z. Malanchuk** // Abstracts of reports of the international industrial conference "Effectiveness of realization of scientific, resource and industrial potential in modern conditions", Slavske, Karpaty, 2007. P.90- 93

29. **Koval P.V.** Hydraulic drive of mining machines: [Textbook for students of special universities. "Mountain machines and complexes"] / P.V. Koval. - M.: Nedra, 1967. - 367 p.

30. **V. Ya. Kornienko.** The method of determining the geometric parameters of the spatial dispersion of vibroemitters of the amber extractor from the deposit with the use of PEOM. - Rivne. -2002. - P. 305-310.

31. **Kornienko V.Ya.** Analysis of modern technologies and the selection of equipment for the extraction of amber from sand deposits with the least technogenic and ecological impact on the environment / V. Ya. Kornienko // Bulletin of the NUVHP, Collection of scientific papers, No. 2 (38). - Rivne. - 2007. - p. 352-358.

32. **Kornienko V.Ya.** Study of the parameters of vibration equipment in the extraction of minerals. / **Kornienko V.Ya.** // Abstracts of reports: Materials of the All-Ukrainian scientific and technical conference "Actual research in construction and agricultural mechanical engineering" dedicated to the 50th anniversary of the department of BSMSGM and O., October 8-10, 2015, Rivne, 2015, p. 2-3.

33. **Kornienko V.Ya.** Study of parameters of hydraulic and hydromechanical methods of amber extraction. / Kornienko V.Ya. // Bulletin of the NUVHP, Coll. scientific works. Vol. 4 (72), Rivne, 2015, p. 235-241.

34. Kornienko V.Ya. Study of segregation in the extraction of amber from deposits. / **Kornienko V.Ya**. // Bulletin of the NUVHP, Coll. scientific works. Vol. 3 (67), Rivne, 2014, p. 120-126.

35. **Kornienko V.Ya**. Prospects and current state of amber mining in Ukraine. / **Kornienko V.Ya.** // Bulletin of the NUVHP, Coll. scientific works. Vol. 3 (67), Rivne, 2014, p. 127-133.

36. **Kornienko V.Ya.** Promising technologies and means for extracting amber from sand deposits. / **Kornienko V.Ya**. // "Materials. Methods. Technologies": Materials of the 13th international conference, February 18-22, 2013, Plavya village, Carpathians, - Kyiv UIC "Science, Technology, Technologies", 2013, p. 156-157.

37. **Kornienko V.Ya.** Development of amber deposits by hydromechanical method. / **Kornienko V.Ya**. // International scientific and technical Internet conference "Innovative development of the mining industry". Section - Open mining of mineral deposits December 14, 2016 Kryvyi Rih, c. 56

38. **Kornienko V.Ya.** Modern technologies of amber extraction from deposits. / **Kornienko V.Ya.** // Bulletin of the NUVHP, Coll. scientific works. Vol. 1 (65), Rivne, 2014, p. 449-457.

39. **Kornienko V.Ya**. Modern technologies of amber extraction from deposits. / **Kornienko V.Ya**. // All-Ukrainian Environmental League. Reclamation of territories disturbed by amber mining. Informational materials to round table on September 4, 2015 Abstracts of reports, Rivne, 2015, p. 13-19.

40. **Kornienko V.Ya**. Highly efficient technology of amber extraction from sand deposits. / Kornienko V.Ya., Malanchuk Z.R., Hryniuk T.Yu., Strykha V.A. // Polyfunctional chemical materials and technologies. A collection of theses. T. 2. / Ed. V.V. Kozika, H.M. Mokrousova. - Tomsk: Izd. TSU House, 2013, p. 45-46.

41. **Kornienko V.Ya.** The technological process of amber extraction using a vibro-hydraulic extractor. / **Kornienko V.Ya., Machuk E.Yu**. // Bulletin of the NUVHP, Coll. scientific works. Vol. 3 (63), Rivne, 2013, p. 412-418.

42. **Kornienko V.Ya**. Improvement of technological equipment for the extraction of amber by hydromechanical method. / **Kornienko V.Ya., Semenyuk V.V.** // Bulletin of the NUVHP, Coll. scientific works. Vol. 1 (73), Rivne, 2016, p. 116-122.

43. **Kostyashova Z.O.** What is amber? / **Z. O. Kostyashova**. - Science and Life, 1999. – 454 p.

44. **S. V. Kravets** Spatial distribution of vibration emitters of amber extractors from sand deposits // **S. V. Kravets, O. L. Romanovskyi, V. Ya. Kornienko** // Mining, construction, road and reclamation machines. Scientific and technical coll. - K.: "Technique" - No. 59. - 2002. - P. 53-56.

45. **Kravtsov M.V**. Influence of shape on the rate of sedimentation of axisymmetric bodies in liquids / **M.V. Kravtsov, V.V. Suvorov, I.V. Fedyukovich** – V. [book: Vodnoe hozjaystvo Belorussii]. Issue 5, 1975. C.130-138.

46. **M. V. Krynytska**. Litho-facies conditions of the accumulation of amber deposits within the northwestern slope of the Ukrainian shield: author's abstract... candidate. geologist. Science, special.: 04.00.21 - lithology / **Krynytska M. V**. – K.: Institute of Geology. Nauk, 2012. - 20 p.

47. **M. V. Krynytska** New research methods for identifying prospective deposits of amber / **M. V. Krynytska** // Bulletin of Taras Shevchenko Kyiv National University. Geology. - 2011. - Issue 55. - pp. 46-48. - Access mode: http://nbuv.gov.ua/UJRN/VKNU_geol_2011_55_16.

48. **Krynytska M.V.** Paleogeographic conditions of amber accumulation at the Volodymyrets-Skhidny deposit / **M.V. Krynytska, V.A. Nesterovskyi**. // Mater. And international science and practice conf. - K., 2008. - pp. 92–94.

49. **Krynytska M.V.** Paleokarst declines as promising traps for amber deposits within the northwestern slope of the Ush / **Krynytska M.V., Nesterovsky V.A.** // Abstracts of reports of the Second International Scientific and Practical Conference "Ukrainian Amber World". - K. 2008. - P. 31.

50. **Krynytska M.V.** Influence of pre-Cenozoic surface behavior and karst processes on the formation of amber deposits of the Rivne Polyssia. / **Krynytska M.V., Nesterovsky V.A.** // Collection of scientific works of the Institute of Geological Sciences of the National Academy of Sciences of Ukraine. Vol. 3. 2010, pp. 271-275

51. **Lustyuk M.G.** Classification of testing and development systems of amber deposits / **M.G. Lustyuk** // Mining, construction, road and reclamation machines. Scientific and technical coll. - K.: "Technology" - No. 69, 2007. - P.34-41.

52. **Lustyuk M.G.** Description of the technological scheme for the development of amber deposits / **M.H. Lustyuk** // Bulletin of the NUVHP, Collection of scientific works, No. 2(34) part 1 - Rivne, 2006. - P.214-220.

53. **Lustyuk M.G.** Physical and technical basis of hydraulic extraction of lumpy materials from placer deposits / **M.G. Lustyuk** - Rivne: Europe. University, 2005. - 234 p.

54. Lyakhov H.M. Waves in soil and porous multicomponent media / **H.M. Lyakhov.** - M., Nauka, 1982. - 288 p.

55. **Maidanovych I.A.** Geology and genesis of amber deposits of Ukrainian Polesia / **I.A. Maidanovych** //AS USSR, Institute of Geol. Nauk / Kyiv: Naukova dumka, 1988. – 81 p.

56. **Malanchuk E. Z.** Modeling of the control system of the process of well hydraulic extraction of minerals by means of visual programming / **Malanchuk E. Z., Hrystiuk A. O.** // Herald of the Kryvyi Rih National University: collection of scientific works. – Kryvyi Rih. - 2016. - No. 41. – pp. 26–32.

57. **Malanchuk E.Z.** Prospects for the introduction of new amber mining technologies in the Rivne region. / Malanchuk E.Z., Kornienko V.Ya., Malanchuk Z.R. // Herald of KNU. Coll. Science Paper No. 41, 2016, p. 74-78.

58. **Malanchuk E.Z.** Classification of technogenic deposits / **E.Z. Malanchuk**. Bulletin of the NUVHP. - Rivne: NUVHP, 2008, No. 3(43). - P.313-320.

59. **Malanchuk E.Z.** Peculiarities of the study of hydraulic parameters of production wells during hydraulic mining / **E.Z. Malanchuk, S.E. Stets** // Contemporary methods and means of non-destructive control and technical diagnostics: materials of the fifteenth anniversary international conference, October 1-5, 2007, Yalta: UIC « Science. Technique. Technology" - 2007. - P.252-255.

60. **Malanchuk E.** Mathematical modeling of hydraulic mining from placer deposits of minerals / **E. Malanchuk, A. Khrystyuk** // Mining of Mineral Deposits. - National mining university. - 2016. - No. 10. - pp. 18–24.

61. **Malanchuk Z.** Modern condition and problems of extraction of amber in Ukraine. / **Malanchuk Z., Korniyenko V.** // Canadian Journal of Science and Education, No. 2 (6), July-December, Volume I. "Toronto Press", 2014. pp. 372-376.

62. **Malanchuk Z.** Modern condition and prospects of extraction of amber in Ukraine. / **Malanchuk Z., Korniyenko V**. // Proceedings of the 1st International Academic Congress "Fundamental and Applied Studies in the Pacific and Atlantic Oceans Countries". (Japan, Tokyo, October 25, 2014). Volume II. "Tokyo University Press", 2014. pp. 318-321.

63. **Malanchuk Z.R.** Hydromining of minerals: [scientific. study guide higher education closed.] / **Z. R. Malanchuk, S. R. Boblyakh, E. Z. Malanchuk**. National University of Water Management and Nature Management. - Rivne: NUVHP, 2009. - 280p.

64. **Malanchuk Z.** Results of experimental studies of amber extraction by hydromechanical method in Ukraine. / **Malanchuk Z., Korniyenko V., Malanchuk Ye., Khrystyuk A.** // Eastern-European Journal of Enterprise Technologies ISSN 1729-3774, Volume 3, No. 10(81), DOI: 10.15587/1729-4061.2016.72404, 2016 with. 24-28.

65. **Malanchuk Z.R. Kornienko V.Ya., Malanchuk E.Z.** The technology of amber extraction has been impr**oved to former equipment. / Malanchuk Z.R. Kornienko V.Ya., Malanchuk E.Z.** // International scientific and technical Internet conference "Innovative development of the mining industry". Section - Mining machines and equipment December 14, 2016 Kryvyi Rih, c. 232.

66. **Malanchuk Z.R.** Methods of establishing rational parameters of erosion of useful minerals and underlying rocks / **Z.R. Malanchuk**. Bulletin of the UGUVHP. Sat. scientific labor - Exactly: UGUVHP. -2002. - #17. - P.356-367.

67. **Malanchuk Z.R.** Scientific foundations of drilling hydrotechnology / **Z.R. Malanchuk**. - Rivne, RGTU, 2002. - 372 p.