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TUFF EXTRACTION TECHNOLOGY IN RIVNE-VOLYN REGION

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Abstract

Interest in volcanic tuffs has grown significantly in the world due to the discovery of zeolite tuff deposits with valuable sorption, cation exchange and other properties. The estimated resources of such zeolite-containing volcanic tuffs in the Rivne-Volyn region are hundreds of millions of tons, they are almost inexhaustible. The analysis of the tuff deposit and the results of geological research, according to Rivne and Kovel exploration expeditions, show that it is impossible to openly develop the deposit, as much of it is under productive privatized agricultural land and lands, and partly under forests belonging to protected area. The impossibility of open development is also due to excessive flooding of the territory and increasing the depth of tuff in the northern regions to 200 meters.

Due to the widespread use of zeolite-smectite tuffs, the issue of using well hydro technology for their production is included in the state program for the development of mineral resources of Rivne region and recorded in it a separate item with some funding.

1. Physical and geographical haracteristics of the area

Administratively, the territory of geological and ecological research is located within the Volyn and Rivne regions of Ukraine (Fig. 1). In terms of physical and geographical zoning, it occupies the north-eastern part of Volyn Polissya in the interfluves of the Stokhid - Styr and Styr - Goryn rivers.

The terrain is mostly slightly undulating, poorly drained, little runoff with some moraine hills and poorly defined valleys of small rivers. The research area is largely swampy (up to 30 %). The main massifs of swamps are in floodplains of the river, on the low-flowing plain, in smaller numbers on watersheds. The maximum absolute mark of the surface is south of the village Kostyukhnivka (tablet M-35-16-G) - *h*. Polish, 206.2 m; minimal - in the floodplain of the Styr River on the northern border of the territory near the village of Cheeks - 154.8 m. The ratio of the highest and lowest points is 51.4

m, the excess of watersheds over the valley of the river Styr, as a rule, are 17-25 m, and reaching maximum values of 40-50 m only in areas of development on the interfluves of the Aeolian and moraine ridges. The relative height of individual hills reaches 23 m; the steepness of the slopes is mostly 15-20 °, rarely up to 30 °. Styr - Horyn is slightly dismembered, relative elevations are not more than 14-18 m, the slopes are gentle.

Of the rivers it is necessary to note the river Styr - the largest water artery of the territory of works, its small tributaries Kormin and Stublu, and also small tributaries of the river Goryn - Virka and Chopelka. All these rivers belong to the basin of the Pripyat River. The largest waterway in the Styr district flows in the western part of the territory in the sub meridian direction. The width of the floodplain is mainly 1.5-2.5 km, the riverbed - 20-50 m, the depth of the river - 0.7-4.5 m, the current speed up to 0.5 m/s. The river travels a lot, has many straits and old houses.

The left tributaries of the Styr River - Okonka, Pishchanka, and Gorbach stand out from the small rivers; right ─ Kormin, Stubla and left tributaries of the Goryn River - Chopelka, Virka, Berezhanka. All of them are canalized, in some areas serve as water intakes of reclamation systems. The hydrogeological regime of the Styr River is characterized by high spring floods and low summer lows, which are disturbed by torrential floods. The average annual amplitude of fluctuations is about 2.2 m, the maximum reached 5.0 m. The intensity of water rise is to some extent regulated by the Khrinniki Reservoir, located in the south of Volyn region and water-regulating facilities of reclamation systems on small rivers. River runoff during the year is uneven and, depending on the water content of the year, is distributed as follows: spring - 51-83 %, summer - 3.8 %, autumn - 5-12 %, winter - 8-29 %.

On the territory of the research there is one large lake - White, with an area of about seven square kilometers and a maximum depth of 48 m.

The climate of the district is temperate-continental, humid, with mild winters, unstable frosts, frequent thaws, mild summers, and long rains in spring and autumn. One of the main factors in the formation of climate is solar radiation. The average annual intake of direct solar radiation is 92.7 kcal/m^2. Annual albedo varies from 70-

75 % in winter to 9-10 % in summer on the water surface. The annual radiation balance is positive and is 34-38 kcal/cm^2. The vast majority of solar radiation (about 89 %) is spent on evaporation. The average annual air temperature is +6.6 °C, the average January temperature is 5.2 °C, the average June temperature is +17 °C. The annual rainfall reaches 700 mm, which creates sufficient, and in some year's even excess moisture. Sometimes the amount of precipitation reaches 900 mm, but it is never less than 400 mm. The average humidity is 70 %. Here the winds of the western direction prevail: in the cold period - southern, south-western, and western; in the warm - northwest. The average annual wind speed is 3.1 m/s, varying from 2.4 m/s in August to 3.8 m/s in March. Strong winds with a speed of more than 15 m/s are infrequent, occurring mainly in the cold season.

Spring begins in the second half of March and lasts 70-80 days. This time is characterized by very intense floods, with heavy flooding of rivers. Summer is always warm, with sufficient humidity, begins in late May, when the average daily temperature exceeds +15 °C. Autumn begins in late September. During this period, the amount of precipitation decreases. Winter comes in late November or early December. It is mild, with gloomy weather, frequent light precipitation in the form of snow and rain, with ice. The greatest snow cover is observed in February, on average 20 cm, in some years it reaches 60-80 cm. In mid-December, swamps freeze, the greatest depth of freezing - 50 cm. The depth of soil freezing averages about 60 cm, but in some years reaches 100-110 cm.

Ice cover on rivers is unstable, during thawing there is an increase in water level, and in some areas and river overflow.

A large area is covered with forests and wetlands. Of the woody vegetation, pine predominates, smaller areas are occupied by mixed deciduous-pine forests, in the south there are oak-hornbeam, and in the north - spruce forests.

The work area is densely populated (about 30 people per km^2), but there are no large settlements. It is possible to note only the regional center of Vladimirets, Varash, villages Rafalivka, Stara Rafalivka, Stary Czartorysk, Tsminy, Romeyki. The main occupation of the population is agriculture and forestry. The largest industrial enterprise is the Rivne Nuclear Power Plant (Rivne NPP). In the city of Vladimirets there are objects of the food industry, in the village of

Rafalivka concentrated woodworking enterprises and railway transport facilities. There are several quarries for basalts and sands.

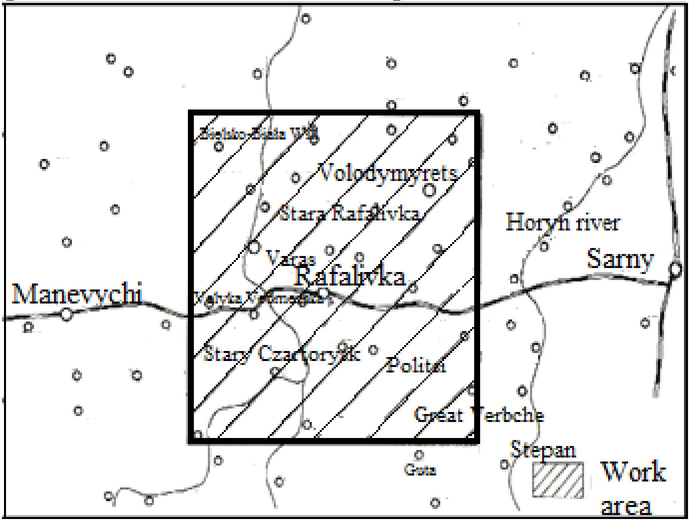

Fig. 1. Overview map of the area of geological and ecological research

Ways of communication are developed satisfactorily. The Kovel-Sarny railway is available, the Volodymyrets-Varash-Rafalivka asphalt roads pass, it is a pass between Kyiv and the Western border. The villages are connected, both with each other and with the district center, and mostly with paved roads, less often with dirt roads.

Characteristics of the relief

The territory of geological and ecological research is located within Volyn Polissya, Polissya lowland of Ukraine [1] and is a denudation-accumulative plain, which belongs to the joint zone of the Pripyat embankment, Volyn-Podolsk plate and the north-western slope of the Ukrainian Shield. Volyn Polissya is located within the morphological structure of the same name, consists of the following morphogenetic sculptures.

I. Volyn water-glacial accumulative gently undulating and gently sloping plain with areas of stone hilly-ridge relief.

II. Sculpture Volyn gentle-hilly hill with smoothed forms of marginal moraines.

III. Turia-Kostopil gently undulating denudation plain.

Volyn water-glacial accumulative flat-wavy and gently-hilly plain, with areas of the main moraine and stone hilly-ridge relief occupies the northern part of the sheets M-35-16-G and M-35-17-B, borders on the south with the Volyn Upland. Its formation is mainly due to the degradation of the Dnieper cover glaciation. The relief is flat and wavy with marks from 155-160 m in the north and up to 170-180 m in the south. The calm nature of the relief is disturbed by the gently undulating and hilly-ridged areas of the rocks formed in the inner zone of the regional glacial complex.

Exceeding the stone forms of the relief over the water-glacial plain from 2-3 to 10-20 m. Lake. It consists of ridge-hilly areas, not connected to each other, based on the raised surface of Paleogene and Cretaceous rocks, preserved from erosion in the form of plinths, covered by low-power marine moraines, dissected by weakly incised river valleys. Depth of vertical dismemberment from 5-10 to 20-30 m. Karst relief forms are widely developed on the hill. Absolute surface marks range from 180-190 to 215 m.

Turiysko-Kostopil gently undulating denudation plain occupies the southern part of the territory and borders on the north with the Volyn Upland. The described morphogenetic sculpture is formed by joint activity of denudation and erosion processes. There, glacial waters have shown accumulative activity, and the deposits formed by them cover more ancient sediments. When studying the geomorphological structure of the work area, an analytical method of mapping was used, a distinctive feature of which is the separate display of genesis and age with the inclusion of units of different taxonomic rank.

The geomorphological characteristics of the territory are based on the principle of selection of genetically homogeneous surfaces, including areas of the territory, both relatively simple genesis and more complex origin, due to the simultaneous action of a complex of different factors. The relief elements characteristic of this region are reflected in the following separate forms of relief.

Denudation relief surfaces

These surfaces are scattered on all morphogenetic sculptures of the work area. The relief of the hills and plains is complicated by karst and karst-suffusion funnels and depressions. Absolute marks of the plain are 160-170 m, height - 175-207 m.

Accumulative relief surfaces

Surfaces formed by swamp and lake-swamp accumulation of the Holocene age are very widespread and form wetlands of different configurations and areas within all morphogenetic sculptures.

The Volyn water-glacial plain is characterized by the largest wetlands, where the largest wetlands are developed, and biogenic accumulation predominates over terrigenous accumulation. The largest wetlands belong to the valleys of the rivers Styr and Stubla, hollows, lakes Bile and Stav.

Within the Turia-Kostolola denudation plain, wetlands are less developed, in the form of small isolated depressions, in interfluves, or in narrow, more deeply incised river valleys, where biogenic accumulation predominates over terrigenous. Within the Volyn Uplands, wetlands are poorly developed, mainly in isolated depressions and floodplains of small rivers. All wetlands of the study area are mostly lowland. The position of their surface below the surrounding area and the curved profile, cause the inflow to the swamp of groundwater, pressure and flood waters. By the nature of microlandscapes swamps are divided into grass, forest and moss. Plant formations are mainly pine-sedge, sedge, alder and reed. Transitional and upland bogs are limited, on the Volyn Upland and the Turia-Kostopil Plain. Their surfaces are flat or weakly concave, fed by groundwater. Plant formations are mainly birch-alder-pine-sphagnum. A large number of wetlands have been drained, which significantly changes the morphological accounting of the characterizing surface.

Surfaces formed by alluvial accumulation

Their formation is associated with the erosion and accumulation of rivers and streams of the Styr and Horyn river basins. The general plan of the hydro grid, due to the relief and geological structure of the territory, belongs to the branched-pinnate type, although the tributaries of the Goryn River often form a lattice-pinnate pattern. River valleys are asymmetric, trough-shaped, box-shaped, tray-shaped, with a flat bottom and gentle or gently concave slopes. Floodplain Holocene and the first floodplain Upper Pleistocene terraces were formed on the area of works by alluvial processes. Floodplain terraces are developed in the valleys of all watercourses that exist in the area of work, and the floodplain terrace was found only in the valley of the Styr River, which can be traced for 52.5 km and is the most pronounced element of the valley. The transverse profile of the floodplain of this river is trough-shaped. Its bottom is flat, or flat-wavy, and the sides of various shapes, from sloping to steep 1-4 m high, and in areas of erosion of the valley and washing away bedrock - up to 6-7 m. In the lower reaches of the river floodplain sides are gentle height not more than 1 m [2-5].

Most of the floodplain terrace of the river is occupied by a flat, swampy, low floodplain, with a large number of old houses and exceeding the water cut from 0.5 to 3 m. among low floodplains, erosive remains. The surface of the high floodplain is gently undulating, often complicated by eolian deposits. Its height above the low floodplain is 0.5-1.5 m.

The width of the floodplain is 1-2 km with narrowing strips up to 0.5-0.7 km and widening up to 2.5 km. Absolute marks of the surface of the floodplain of the Styr River vary from 166.5-170.0 m to 154.0 m, decreasing downstream. The floodplain is embedded in the first floodplain terrace and adjoins the root slopes only at the intersection of the Volyn Upland. The bed of the Styr River is narrow, winding in relation to the floodplain, and it travels poorly in areas. Travels are diverse - segmental, sinusoidal, chest. In areas of modern elevations, the channel forms straightened areas, knee-shaped bends, the coefficient of mandrake is 1.03-1.08. Marks of water cut vary from 165.3 to 153.8 m, the magnitude of the slope of the river Styr is 2.19. The floodplains of the Styr and Horyn tributaries are of the same type, narrow, from 5-10 to 500-700 m, winding, swampy, in the upper and middle parts of the flow they are weakly incised, almost not expressed in relief, covered with peat beyond the floodplains. Lower - well expressed in relief, incised at 1-2 m, trough-shaped, with a flat bottom and gentle slopes. The tributaries of the Goryn River in the area of works (Verka, Smuha, Chopelka, Melnytsia) have 2-3 m inlets, chests, with a flat bottom and steep slopes. The valley of the Stubla River occupies an intermediate position between the Styr River and its tributaries. Its floodplain is wide (1-3 km), clearly defined in plan, trough-shaped, with a flat swampy bottom, low-alluvium (1.0-1.5 m). Terrace accumulative type, has a width on both banks from several meters to 3.5 km. The surface is mostly flat, weakly dissected, and swampy, especially in the rear, often complicated by

Aeolian landforms and eolian-deluvial deposits.

The height of the first floodplain terrace above the water level in the channel is 3-8 m, above the low floodplain 1-5 m, and above the high floodplain 1-3 m Sopachi, as noted above, the rear seams of the floodplain are poorly traced. The rear seams of the floodplain terrace are practically not expressed in the relief. Absolute marks of the terrace surface vary from 154-155 m - in the north, to 165-170 m - in the south.

Surfaces formed by lake-alluvial accumulation

Near the settlements of Bielska Volia, Kolodia, Staryi Pidtsarevychi, Volodymyrets, Berestivka, and Politsi, small river valleys up to 0.5-0.8 km wide with a weak concave swampy bottom, gentle slopes and slow current are noted for lake-alluvial morphogenesis.

Surfaces formed by glacial, water-glacial and lake-glacial accumulation

The formation of these surfaces took place during the activity of the Dnieper cover glaciation and its melt water.

In the proximal zone of the glacial complex, a sandy plain was formed, consisting of water-glacial flat and gently undulating surfaces, separated by depressions, depressions of melting glacial waters and complicated by hilly-ridge relief of rocks, eolian dunes and ridges, and sometimes.

In the periglacial zone a sandy flat-wavy plain was formed, complicated by areas of gently undulating lake-glacial surfaces, eolian forms of relief and karst-small-depressive relief. In the area of the village the smoothed small hills of marginal moraines are noted. The Volyn gentle-hilly hill separates the above-described zones. Its morphological structure was formed by marginal moraines lying on high plinths of Upper Cretaceous and Paleogene rocks, separated by depressions of melting glacial waters, which, inherited by modern drains and wetlands, are often complicated by Aeolian dunes and ridges and karsts. Depth of relief within the Volyn ridge 25-30 m, on zander plains is 5-10 m. Absolute marks of zander plains 157-160 m in the north and up to 165-175 m in the south, and moraine and stone hills from 175 to 206.2 m.

Eolian landforms

Forms formed by wind accumulation are a regional feature of the Polissya relief. Developed in the study area is very wide, but uneven. The largest number of eolian forms is found along river valleys, on the slopes and at the foot of glacial and water-glacial hilly-ridge accumulations.

The described landforms of dunes, ridges, hills of parabolic type are presented. The dunes are oriented naturally and turned with the top of the parabola to the east, and the wings, which are located parallel - to the west. This orientation of the dunes indicates the predominance of westerly winds in their formation.

Dunes often merge to form parallel shaft-like shapes. The strands in the plan are rectilinear in shape, often oriented sublatitudinally, or from northwest to southeast. The slopes of the ridges, in contrast to the dunes, are gentler (steepness from 5 to 10-20 °). The height of dunes and ridges is from 1-3 to 10-12 m, width up to 50-100 m, rarely 200-500 m.

Eolian-deluvial landforms

Scattered eolian, screened water-glacial, alluvial and moraine sands often form areas up to 1-2 km^2, gently undulating and hilly plains, which rise above the adjacent surfaces by 0.5-2.0 m.

They are located at the foot of Aeolian dunes and ridges, fluviocamps, moraine hills, along the brooches of summer terraces and other irregularities.

Glacial landforms

At the boundary of the glacial marginal zone and the per glacial zone is a strip of small smoothed remnants of marginal moraines, expressed in relief in the form of low, various configurations, domed hills with smoothed peaks and gentle slopes. Such forms of relief are often found on sheets M-35-17-B and M-35-29-A.

Water-glacial landforms

Kami formed in the proximal zone of the lattice glacial complex are one of the most characteristic features of glacial morphogenesis.

In modern relief, positive isometric or oval domed and conical slopes are represented. Often kami merge into a single whole, forming linearly elongated, gently hilly kami strands.

The sizes of stones change in wide limits, from 200-500 m, to 1,5-2 km in cross section, and their height over adjoining surfaces makes from 1-2 m to 5-10 m.

Fluvial forms of relief

The relief forms formed by the activity of water flows are represented by erosional ledges, ravines, ravines, and valley-like depressions of the dead hydrogrid.

Erosion ledges are most pronounced in the valley of the Styr and Kormin rivers. Typical floodplain ledges are often slightly curved, 1-5 m high 6 m.

Gorges and ravines in the study area are very rare: on the steep slopes of the Volyn Upland, adjacent to the valley of the Styr River, near the settlements of Babka, Stara Rafalivka, Tsmina, Kozlinichi, Stary Czartoryisk. V-shaped ravines, with steep walls up to 1-2 m deep, can be traced to a distance of not more than 50 m. weakly concave, turfed, flat bottoms.

Proluvial landforms

Relief forms formed by temporary currents are found on the steep slopes of the Volyn Upland, near the settlements of Novaky, Rafalivka, Tsmina, Kozlynychi, and Staryi Czartoryisk. In the upper parts of the slopes, these are narrow, linearly elongated, sometimes branched runoff basins, along which small particles of rocks are transported by temporary currents, forming small removal cones and plumes at the foot.

Karst landforms

Karst in the study area is represented by both deep and surface forms, where marl-chalk rocks are karstic. Deep karst is developed throughout the territory in the form of cavities and cavities, which are filled with sand-clay-carbonate mass. The most complete underground karst has been studied at the karstological site near the Rivne NPP. Surface karst is developed in areas of high-basement Upper Cretaceous rocks, mainly in areas undergoing neotectonic uplift. Surface karst morphology is divided into 2 forms: funnel-shaped and saucer-shaped depressions, in the section of which certain patterns are observed in area.

Karst pits are widespread in the Volyn Upland, especially in the settlements of Novaky, Volodymyrets, Dovhovolya, Lyubakhy, Lozky, Varash, Zhovkin, Velyka Vedmezhka, Stary Czartoryisk, where there are accumulations of karst pits up to 20 or more pieces per 1 km^2. They are much less common in the Turia-Kostopil plain (up to 10 units per 1 km^2) and even less common (up to 5 units per 1 km^2) in the Volyn plain.

Karst pits, in plan, are isometric or oval, and their size varies widely - from a few meters to 110 m in cross section. The walls are steep (up to 40 °C), often steep, turfed. The bottom is swampy or flooded with water. The depth of the visible pit is 1-3 m.

Karst and karst-suffusion saucer-shaped depressions are much larger (up to 300 m in cross section) and small (up to 0.5-1.0 m). The bottom is flat or slightly concave, sometimes swampy or flooded with water. Slopes are gentle (1-3), so their boundaries in relief are weak.

No new forms of karst on the territory of the works have been identified, but the violation of the hydrodynamic regime of groundwater by anthropogenic activity leads to the intensification of karst and suffusion processes. This is especially noticeable in drained areas, where karst-suffusion processes are intensifying. In the area of Rivne NPP after violation of the thermal regime of groundwater, there is an intensification of underground karst.

Lakes

Lakes are common only in the northern part of the territory and in the valleys of the rivers Styr and Stubla. Lakes outside the river valleys, near the settlements of Bilska Volya and Rudka, were formed as a result of glacier flooding of its melt water or filling of thermokarst depressions in the proximal zone of the glacial complex with water. The shape of these lakes is oval or round, the area from several tens of square meters to 80 thousand m^2.

The largest lake Bile is of karst-glacial origin. Only its southeastern part is located on the territory of the works. It arose on the site of a large karst depression formed by the Dnipro Glacier, up to 43 m deep, with high northern and eastern and low wetlands - western and southern shores. Closed reservoirs of summer old women were also found on the first floodplain terrace of the Styr River. They are round in shape, sometimes elongated from 300-500 m to 1-2 km, 50-150 m wide. The depth of the old houses is not great, from 1.0 m to 2-3 m, with low wetlands [6-9].

Denudation ledges

The ledges formed by the predominance of denudation processes over erosive ones were found on sheet M-35-28-B, north of Varash, north-western and south-eastern village of Velyka Vedmezhka, convex and steep (10-40 °).

Man-made landforms

The forms of relief formed by human activity play a significant role on the territory of the works. They are divided into forms related to industrial-residential, agro-industrial, hydro-ameliorative, road construction, as well as mining.

During the industrial and residential construction there were various constructions, embankments and excavations not only within the settlements, but also outside them. Livestock farms, manure dumps, silo pits, etc. are connected with the agro-industrial complex. Numerous embankments and excavations are formed during the construction of highways and railways. During the reclamation construction, drainage systems, reclamation ditches, dams, ponds, and fire reservoirs appeared.

Mining is carried out in almost all settlements. It is mainly artisanal mining of sand and clay, in small quarries, which does not significantly affect the terrain.

Larger quarries, expressed in the scale of the map, are located near the settlements of Volodymyrets, Zhovkiny, Velyka Vedmezhka are sandy and clay quarries measuring about 100×200 and 100×300 m, 2-5 m deep, rarely up to 15 m. Ivanchi are basalt quarries, up to 20 m deep, with heaps in the form of hills, an area of 1-2 hectares and a height of 10-18 m. flat platforms of different heights.

Exploration of the field

Rivne geological expedition in the process of deep geological mapping, search for native copper, diamonds and exploration of basalt raw materials volcanic tuffs in the Rivne region have discovered dozens of wells and several quarries. In the regional plan their petrographic, mineral, chemical composition, parameters of bodies and conditions of occurrence are studied. According to deep mapping data, volcanic tuffs can be traced under Mesozoic-Cenozoic deposits along the western slope of the Ukrainian Crystal Shield in the form of a strip 1-10 km wide at depths of 5 to 200 m (Fig. 2).

Of great interest as a mineral raw material are tuffs along their southeastern border of modern distribution. Here they lie shallow (meters and tens of meters) from the earth's surface and in some places are transformed by hydrochemical processes into zeolite-smectite raw materials, which are suitable for industrial use.

Tuffs lie in horizontal or slightly inclined (at angles of 1-5°) layers, forming thicknesses with a thickness of several meters to 140 meters. Together with basalt flows, they form the so-called trap formation (Volyn volcanic series) of the Lower Vendian.

According to the current stratigraphic scheme in the Volyn-Polissya depression in the section of the Volyn series there are four worlds (from bottom to top) in the section: 1 - Gorbash Gravelite-sandstone with pyroclastic admixtures (up to 30 m), 2 - Zabolotov basalt with layers of tuff (17-125 m), 3 - Babin tuff with separate streams of basalts (100-220 m), 4 - Ratne basalt with layers of lavoclastic breccias, horizons of tuffs, tuff sandstones, tuff argillites and tuff conglomerates (30-190 m). All the above summer-stratigraphic subdivisions are composed of tuff material to a greater or lesser extent, but the most powerful layers of tuff are inherent in the Babin world, which in the context of the Volyn series in the Rivne region is most common.

On the territory of Rivne region tuffs lie under Mesozoic and Cenozoic deposits at depths from 4 to 60 m and stretch in the form of a strip through Volodymyrets, Sarny, Kostopil, Rivne and Goschansky administrative districts. They appear on the day surface only in the basalt quarries Berestovets, Basaltove, Politsi (Ivanchi), and outside the Rivne region, 5 km southeast of Slavuta, Khmelnytsky region in Tashka's career.

Volcanic tuffs of the main (basalt) composition are widespread in Volodymyrets, Sarny, and Kostopil districts. From the latitude of Rivne to the south-east in the context of the Babinka world, in addition to them, there are tuffites and tuff sandstones, which are characterized by impurities of terrigenous material from 10 to 25 %, rounded and semi-rolled forms of fragments of volcanic origin. The ash material here is significantly changed to complete conversion into clay products. According to textural features, among the pyroclastic rocks of the Babinian world in the Rivne region, massive varieties of tuffs, layered, thin- and obliquely layered, with cross-layered and vaguely layered tuffs are distinguished. These textures are due to the intermittency of tuffs of different shades and sizes of fragments. Change of layers and lenses happens sharp or gradual and vague. Sometimes the stratification is due to the oriented arrangement of elongated and flattened fragments. According to the size of the pyroclastic (fragmentary) material - medium- and small-fragmentary (psammitic) and ash fine-fragmented (siltstone) varieties, which form separate layers or often overlap with each other. Among them are sometimes found layers and layers of coarse-grained (psammitic) tuffs.

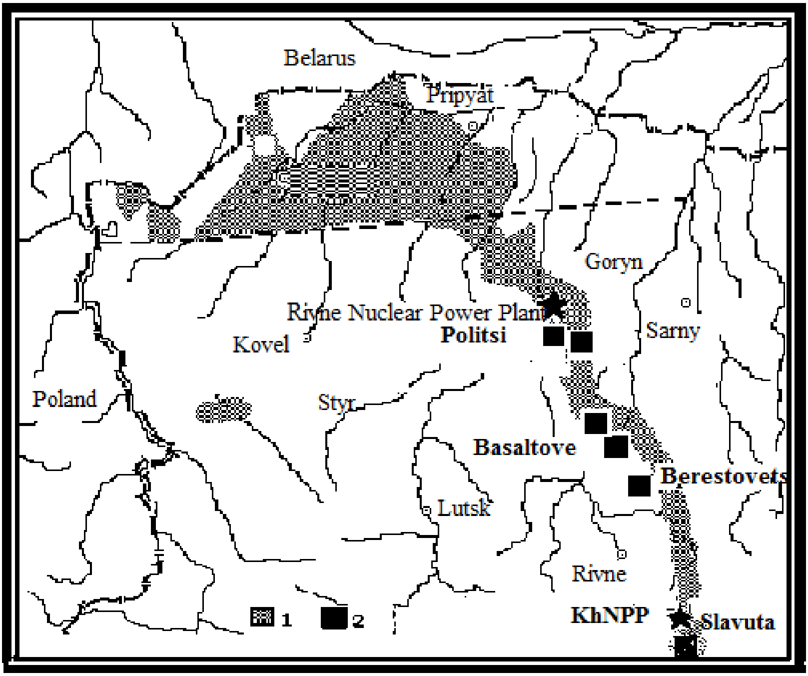

Fig. 2. Tuff outcrops on the pre-Mesozoic-Cenozoic surface (1) and in quarries (2)

Visually, it is greenish gray and chocolate brown, relatively soft rocks with a grainy structure and striped texture. When viewed under a polarizing microscope, they are composed of cemented fragments ranging in size from 0.01 mm to several mm in diameter of bubble slag, various in structure and composition of basalts, volcanic glass, occasionally intrusive types of ladders, and clastogenic minerals: plagioclase, liquid pyroxene quartz and potassium feldspar.

The fragments are bonded with cementing minerals: mainly analzyme, zeolites and smectites, to a lesser extent chlorite, chalcedony and calcite. Dominant in tuffs volcanic glass is largely replaced by smectites - clay minerals of the montmorillonite-saponite group.

Geological characteristics of the deposit and material composition

These tuffs were studied in the most detail 2-3 km southwest of the village Ivanchi, where during the preliminary exploration of basalt raw materials it was drilled by 30 wells [10-13]. Here the following horizons of effusive rocks (bottom up) take part in the structure of the cover: 1 – lavaclastic breccias, 2 - almond-basalts, 3 - massive aphanite and plywood basalts, 4 - almond-stone basalts, 5 - lavoclastic basalts, 5 - lavoclastic breccias, volcanic tuffs composition. Effusive are underlain and covered with summer-wind-clastic, mainly psammitic tuffs and basalts. For direct observation, tuffs are available only on the outskirts of the village Ivanchi, where they form the bottom, as well as the base of the southern and eastern walls of the basalt quarry. In the southern wall and bottom of the quarry tuffs form a continuous horizon with an apparent length of up to 180 m and an open thickness of 0.3-1.7 m, which is sporadically observed within the quarry in an area of about 0.5 km^2, varying from 0.1 to 7 m, and is fixed around the quarry in the wells.

The tufa of the Rafalivsky quarry (near the village of Ivanchi) is represented mainly by medium- and small-fragmented psammitic varieties. They lie under the basalts in a thick (up to 100 m) layer, which after the extraction of basalts is revealed in the bottom and walls of the quarry. In tuffs discovered by wells near the quarry, in the area of the Ivanchi basalt deposit (2 km southwest), a complete mineralogical analysis revealed high levels of zeolites, smectites and ferrous dispersed minerals, which are probably also smectites.

Characteristics of the material composition of tuff raw materials

Freshly mined tuffs are well-cemented, semi-rocky rocks, but with prolonged exposure to moisture, they decompose easily to form a loose mass. After grinding these rocks on a jaw mill, the obtained tuff flour by granulometric composition corresponds to hard sand: contains particles with a size> 2 mm - 25 %; 1-2 mm - 32 %; 0.5-1.0 mm - 9 %; 0.25-0.5 mm - 14 %; 0.1-0.25 mm - 11 %; 0.1 mm – 9 % of the total mass of air-dry material. After grinding in a ball mill, the tuff material contains about 50 % physical sand, 33% dusty fraction and 17 % clay matter, has a plasticity number of 5-7 and according to these parameters corresponds to low-plastic dusty sand. The bulk density of crushed tuff is in the range of $0.96\text{-}1.22 \cdot 10^3$ kg/m^3, and the specific surface area is 120-150 m^2/kg. The total porosity of the dispersed tuff material reaches about 30 %; swelling in water – 36 %, and in the presence of coagulant - 62 %. Water absorption is about 18 % by weight and 33 % by volume.

According to spectral analyzes, the average contents of microelements, including environmentally hazardous ones, in shelf tuffs generally correspond to the Clark values calculated for the main lithosphere rocks and the maximum allowable concentrations (MPC) in soils (Table 1).

Table 1

Average contents of microelements in tuffs of the Rafilovske deposit (42 samples) in $1 \cdot 10^{-4}$%

Elements	P	Pb	Ba	Mo	Sn	Cu	Zn	Ni	Zr	Co	Cr	V	Mn	Ti
Average	670	5	350	0,8	5	103	46	34	140	31	47	116	1240	5480
Clark	1500	6	330	1,5	6	87	105	130	110	48	170	250	1200	8000
GDK	-	30	-	-	-	100	100	100	-	-	100	150	1500	-

Samples of tuffs extracted from other wells near the quarry, according to X-ray diffraction and thermal analyzes (6 determinations) contain on average 65.0 (+16.0; -13.0)% smectites of trioctahedral structure of a number of hectorite-saponite and 28, 17 (+14.83; -14.17)% analcym. Tuffs were taken in samples (37 samples) at the Ivanchi basalt deposit, on average they contain: SiO_2 - 47.2 %; TiO_2 - 1.98 %; Al_2O_3 - 13.9 %; Fe_2O_3 - 11.9 %; FeO - 1.7 %; MnO - 0.17 %; MgO - 7.0 %; CaO - 2.79 %; Na_2O - 4.87 %; K_2O - 1.48 %; P_2O_5 - 0.14 %; SO_3 - 0.03 %; the rest - 6.65 %.

Ivanovo basalt deposit is located in Volodymyrets district of Rivne region and partly in Manevychi district of Volyn region of Ukraine. Geographical coordinates of the field:

26°01'-26°03 '- east longitude

51°12'-51°13 '- north latitude

The area of the field is 6.4 km^2, including the area of preliminary exploration - 1.2 km^2, has no natural boundaries.

According to the physical and geographical zoning, the area of the deposit is located on the Eastern European plain and belongs to the zone of mixed forests, to the subzone of Volyn Polissya [11-13]. Most of the area of the field is covered with forest, which belongs to the second group. The area of the deposit is characterized by accumulative types of relief - alluvial, glacial and water-glacial plains.

The deposit is located on a swampy plain with absolute marks of 168.8-173.8 m, adjacent to the watershed of the rivers Styr and Goryn. The modern surface has a general slope to the north, in the direction of the right tributaries of the Pripyat River. The area is characterized by wide sandy plains formed from sands of glacial origin. Formations of this origin include slopes and shafts, kami, as well as moraine plains. There are also ridges, shafts and slopes, which are unique forms of eolian relief. Forest species do not occupy large areas; they are blurred by water and survived only by individual islands on the sub-highlands. The lowest areas are occupied by swamps, peat deposits and wetlands.

This subzone (Volyn Polissya) has a climate of mixed forest zone, characterized by mild winters with thaws, warm and relatively humid summers, and gloomy rainy autumn with fog. Spring is always cooler than autumn. In winter, the southwest is dominated by relatively warm humid winds, which often come with thaws. In summer, westerly winds prevail. Dates of the first frost: the earliest - 14.09, The late - 07.11, The average - 06.10. Dates of the last frost: the earliest - 04.04, the latest - 27.05, The average - 28.04. Duration without frosty period in days: maximum - 207, minimum - 124, average - 160. Dates of snow cover: the earliest - 02.10, Late - 23.12, Average 17.11. Dates of snow cover rise: the earliest - 17.02., The late - 05.04, The middle - 19.03. The greatest average thickness of snow cover (in February) is 20-30 cm.

Sod-slightly podzolic, sod-medium-podzolic gley soils are located in the area of works. River valleys are characterized by meadow, meadow-swamp soils and peat deposits. The average thickness of peat is 1.5 m.

The main waterway of the district is the river Styr with the right tributaries Karmin and Stubla. Within the described area, the Styr River has a well-developed valley; the width of the river (up to 50 m) allows the passage of small displacement vessels upstream to the village falcon in Rozhysche district of Volyn region.

The nearest settlement is Ivanchi is 2.8 km north of the field, Rafalivka railway station - 10.2 km north-west of it. 2.5 km northeast of the field is the Rafalivka Basalt Quarry, connected by a railway branch to the Rafalivka station. The capacity of the Rafalivka railway station (along the Rafalivka quarry) is up to 100 cars per day. A 10 kV transmission line is connected to the Rafalivsky quarry.

The population of the district is employed mainly in agriculture and forestry, as well as in fireplaces. Agricultural specialization: flax growing, dairy and meat cattle breeding, growing potatoes, grain, hemp and hops.

The set of labor in the area of the field is insignificant; there are no premises for rent. Water supply of the district is carried out at the expense of surface and underground waters (aquifers of quarter deposits).

Physico-mechanical properties of tuffs

Tuffs are characterized by thermal stability, resistance to aggressive environments and ionizing radiation, sufficient mechanical strength, the absence or presence of only trace amounts of toxic compounds, the absence of infection of the mineral by microorganisms.

According to their chemical composition, physical structure and properties, zeolites have much in common with bentonites and other fatty clays, alumina and similar mineral complexes, which determines the biological characteristics, targeted use of these compounds in various sectors of the economy, including livestock. However, the mechanisms of biological action of silicon-aluminum mineral complexes, the features of their use to improve the efficiency of livestock and crop production have not been studied enough. Due to the ability of these minerals at a temperature above 500 °C to emit water and allegedly boil, they were called "zeolites", "boiling stones". With careful heating (up to +300-400 °C) zeolite water can be removed without destroying the crystal lattice. At a temperature of 1000-1200 °C the edges of the zeolite melt quickly, so the water in the inner parts of the mineral cannot come out, resulting in swelling of the zeolite. Partially or completely dehydrated zeolites can reabsorb water and other gaseous and liquid substances. This is one of the main properties of zeolites. Ease of cation exchange is the second important property of zeolites. It occurs without disturbing the crystal structure. The release of water from zeolites in most cases is the reverse process. The temperature of even partial dehydration and possible re-hydration varies greatly from sample to sample.

Table 2

Mineral composition of tuffs near the quarry Shelves (wt. %)

№ well	19	17	8	20	13	14	Average
Depth of selection, m	54,5	58,4	60,0	61,0	62,0	62,0	
Zeolites	39,15	46,23	33,50	45,40	47,51	47,35	43,19
Smectite	23,24	19,12	0,09	18,28	4,8	31,2	16,20
Iron dispersed minerals	36,38	23,71	31,45	36,50	46,03	19,88	32,33
Feldspars	0,92	9,13	13,73	1,6	0,89	found	5,25
Magnetite	0,30	1,49	found	0,22	0,77	1,57	0,87
Martite	0	0	3,52	0	0	0	0,59
Quartz	found	found	found	0	0	found	found
Chlorite	found	found	found	0	found	found	found
Pyroxene	0	0,22	0	0	found	found	0,06
Mud	0	0	17,66	0	0	0	2,94
Sum	99,99	99,90	99,95	102,00	100,00	100,00	100,31

Structural changes in zeolites that occurred during dehydration are studied using X-ray diffraction analysis, differential thermal analysis (DTA), thermogravimetric analysis (TGA), infrared spectroscopy (IR), nuclear magnetic resonance (NMR), mass spectrometry, and mass spectrometers. These structural changes range from the simple thermal expansion found in mordenite and the complex movement of cations, as in shabavit, fozhavit, mazzite, etc., to phase transformations into more dehydrated structures. There are three main models (types) of zeolite dehydration.

Type.1. Rapid dehydration in a relatively narrow temperature range, characterized by one narrow endothermic peak, abrupt weight loss on the TGA curve, marked changes in unit cell parameters and (or) phase transition. This behavior is characteristic of gismondin, natrolite, phillipsite, gmelinite, gaylandite and stilbit.

Type.2. Gradual dehydration in a wide range of temperatures, which consists of successive stages of dehydration, which is manifested in clear DTA and TGA reactions and which is accompanied by a gradual adjustment of the structure. This behavior is characteristic of edigonite, and is also found in lion's disease, gonarditis and lomontitis.

*Type.*3*a*. Multistage dehydration, consisting of the initial main reaction, followed by another, but weaker; thus, this type is a combination of 1 and 2 types. The adaptation of the structure occurs after the main reaction. This behavior is characteristic of Shabazite, Offretite, Erionite, Yugavaralite and Brewsterite.

Type.3*b*. In fact, similar to type 3a behavior when heated, but with the absolute predominance of the first clear endothermic peak and the absence of structural changes (mordenitis) or very minor structural changes (faujasite and clinoptilolite).

The different nature of dehydration when heated corresponds to different forms of water molecules in the structure. In type 1 dehydration, water is a necessary component of the structure, similar to hydrates. Type 2 dehydration is characterized by the presence of water in the appropriate position, but its presence is not required for the stability of the structure; it is held mainly by absorption forces inside the channels and cavities of the frame. The same applies to types 3.

The complexity of this situation is determined by the interaction between large out-of-frame cations, water molecules and aluminosilicate frame. These cations are solvated (surrounded by water molecules) in the hydrated state; during dehydration they behave differently, depending on the degree of polarization and electrostatic energy. In the case of highly polarizing cations, water molecules are divided into a cation-bound hydroxyl and a proton, which is attracted to the oxygen of the framework. Weakly polarizing cations lose the surrounding water and reduce free energy by joining the oxygen of the framework. These two phenomena cause different deformations of the frame, which neutralize the existing electrostatic fields. Dehydrated and partially dehydrated zeolites are in the "activated" state and rehydrate very quickly, absorbing water from the atmosphere when in the air. Sorption properties of zeolites are not limited to water absorption; other molecules, polar and nonpolar (carbohydrates), can penetrate into the structure of zeolites. The "free diameter" of the channels is the main controlling factor for the entry of "external units", but the cations already present in the cavities can also limit the entry of insufficiently polar and active units. Moreover, the temperature affects the sorption properties not only qualitatively but also quantitatively, changing the effective size of the cavities.

High selectivity of adsorption and ion exchange on zeolites can lead to the accumulation of scattered chemical elements in them after the formation of minerals. The results of numerous chemical analyzes of zeolites known from the literature show that they contain almost all known chemical elements, including rare earths.

Due to the unique and diverse physicochemical properties of zeolites and other natural sorbents are beginning to play an increasingly important role in various industries and agriculture of developed countries. Ukraine has recently developed an interesting scientific field for the use of zeolites and other complex inorganic formations that have sorbing properties, as mineral additives in the production of feed and as fillers in premixes for animals.

Discovered more than two hundred years ago, natural zeolite minerals in recent decades have attracted the attention of agricultural scientists and practitioners in many countries. Japanese scientists were the first in the mid-1960s to show the possibility of using cheap zeolite tuff as a feed additive for animals, as well as for manure disposal and application to the soil along with fertilizers. The "zeolite boom" that began later in the 1970s was accompanied by an intensive search for zeolite tuff deposits in all parts of the globe. By the end of the twentieth century, about 1,000 deposits were already known in about 40 countries, including in Japan, USA, Italy, Bulgaria, Hungary, Cuba, China, Poland, Mongolia, Russia, Georgia, and Ukraine. The total explored reserves of zeolite deposits in the world are billions of tons.

According to Japanese researchers, the beneficial effect of zeolite in crop production is positive for 10 years after its introduction into the soil. From an economic point of view, zeolite justifies itself in two or three years, and in four years provides a stable income.

The difficult environmental situation in Ukraine encourages many domestic scientists and practitioners to find effective means by which to increase the efficiency of crop production, as well as at the lowest cost to improve the health of animals and get from them sound and environmentally friendly products. New technologies, materials and means are needed for the general improvement of the ecological situation in the country, reclamation of lands affected by man-made pollution. The place and importance of these natural minerals such as zeolites have not yet been fully studied. In our opinion, it is interesting that in the presence of zeolites under the action of electric discharge from methane biologically active amino acids are formed, which may indicate the important role of alumina in the prebiotic formation of life on Earth. Zeolites have been used as a medicine in ancient Tibetan medicine. It has also long been known that they are well eaten by wild animals, especially in winter and spring, when changing feeds, disorders of the gastrointestinal tract and so on. The use of zeolites in medicine is rediscovered today. The use of zeolites as enterosorbents for the binding and excretion of radionuclides, toxic products of bacterial activity in the intestine, various kinds of intoxication of the body, etc. is promising.

In animal husbandry, zeolites began to be used as feed additives about twenty years ago in order to increase the daily weight gain of animals and poultry, under stress, to reduce the radiological load. Zeolites are especially useful in feeding animals low-quality feed, which usually leads to the development of dyspepsia, food poisoning, dysbacteriosis. A number of publications testify to the positive effect of natural zeolites as adsorbents in the removal (binding) of heavy metals from animals.

Contamination of a large area of land and water bodies of Ukraine with heavy metals and radionuclides creates an unfavorable environmental situation, which is being improved by scientists and practitioners from many sectors of the economy. They offer a large arsenal of drugs and other drugs that cause the excretion or binding of toxic compounds in the body. At the same time, there is an active search for such reagents that could block the negative effects of heavy metals on the approach of the latter to the animal or human body: preventive treatment of water, soil, green fodder, vegetables and more.

Given the fact that large-scale and large-scale areas require preventive treatment, the question of introducing such antitoxicants, which would be easily available in extraction and production, cheap and effective, arises in a timely manner. In this regard, the most promising is the use of natural zeolites.

Calculation of balance reserves of minerals

The calculation of the balance reserves of minerals performed by specialists of the Rivne Geological Party in accordance with the approved regulations and is presented in table 3.

Table 3

Table of calculation of mineral reserves

Category of stocks	№ blocks	Area, m^2	Average power, m	Volume, m^3	Including		Volume, m^3	Volumetric weight, t / m^3	Stocks, t
					Industrial purpose of breeds	%			
1	2	3	4	5	6	7	8	9	10
C_1	1	977862	3,75	3666983	for tufa smectite	100	3666983	2,11	7737334
	2	192928	8,45	1630242	for tufa smectite	100	1630242	2,10	3423508
C_2	4	473376	1,40	662726	for rubble	42,9	284309	2,67	759105
					for tufa smectite	57,1	378417	2,09	790891
					total	100	662726	2,34	1549996
	5	1373933	15,50	21295961	for tufa smectite	100	2129561	2,09	44508558
	6	1625156	6,72	10921048	for tufa smectite	100	10921048	2,09	22824990
	7	1653017	27,42	45325726	for tufa smectite	100	45325726	2,09	94730767

2. Tuff extraction technology

Application of down hole hydraulic production of tuffs

Well hydraulic extraction is a method of underground extraction of solid minerals, based on bringing tuff at the place of occurrence into a mobile state by hydromechanical influence and its release in the form of a hydraulic mixture on the surface. Well hydraulic production - one of the geotechnological methods of production - is the most effective for the development of deposits of loose, weakly cemented tuffs. The extraction of the useful component is carried out through special equipment and well preparation, and the production well is an opening, preparatory and threaded product, from which the purification of tuff is carried out. Methods of destruction of the tuff massif mainly depend on its strength. The separation of loose and weakly cemented permeable tuffs can be carried out by creating a filtration flow with the required value of the hydraulic gradient in the formation. It is most rational to destroy cohesive rocks with a hydro monitor jet of water. Intensification of the destruction process is possible due to vibration, explosion, and chemical or microbiological decomposition of the cementations substance. The destroyed tuff is fed to the suction of the dispensing device either by gravity (with a sufficient inclination of the sole of the chamber), or by pressure flows of water. Dispensing of the hydraulic mixture to the surface is carried out by means of a hydroelectric elevator, airlift, and submerged dredger or by creating back pressure, injection into the water or air deposit. A distinctive feature of down hole equipment is the harsh conditions to the transverse dimensions due to the need to work in the well. Hydraulic unit is a set of down hole hydraulic monitor and dispensing mechanism with a lifting and transport part and installation for transporting pulp from the unit. A production site is a part of the field prepared for operation, ie an area perturbed by production wells and which has access roads and communications for the supply of water, air, electricity to the production units, as well as a pipeline for transporting the hydraulic mixture. The extraction process is controlled from the surface by changing the use and pressure of the working agents, as well as the places of influence of the working agent and the selection of useful components. The choice of parameters of the technological process of down hole hydraulic production is determined by the geotechnological properties of the useful component and the physical - geological situation. Test work on the extraction of deep water-saturated sands, covered with clay rocks, was carried out in 1973 by the Institute of Foundations and Foundations Gersevanova together with the oil and gas management of Nizhnevar - Tovsknafta. The hydroelevator with a diameter of 490 mm was lowered into a well with a diameter of 510 mm at a pressure of 210 m of water developing pump. At a flow rate of 150 m^3/h and a 37 mm nozzle, 40 m^3 of sand per hour was extracted from a depth of 23 m. Thus, the possibility of developing sands and gravel in the harsh conditions of Siberia and solving the important problem of providing building materials for areas of development of new oil and gas fields, where everywhere at a depth of 20-80 m there are sand deposits with a thickness of 5 to 40 m.

Development of deposits by SGV method in Poland.

At the humidified phosphorite deposit in Buzhenin in 1965-1967, seven wells were drilled in 30×30 and 40×40 grids with 16 ”pipes lined up to the tuff layer. Mining was carried out by one airlift. To prevent jamming of the airlift by collapsed large pieces of rock, it was placed in a movable pipe 12 ", which moved in a layer after the suction of the airlift.

When designing these works, it was assumed that if its angle of natural slope is 30 °, the volume of production from one chamber will be about 1000 tons of tuff. However, in practice, production from one chamber did not exceed 100 tons: the main reason - the presence of layers that prevented the approach of tuff to the beginning of the well, and therefore the volume of the chamber did not reach the required size. In addition, there were difficulties such as jamming of the airlift in the well due to the fact that clogged the suction and discharge pipes of the airlift and hydraulic pipes of the surface.

In 1964-1965 in Tarnobrzeg experiments were conducted on the extraction of quartz sands for the glass industry. A layer of sand up to 30-60 m thick lies at a depth of 40 m. The deposit is very moist. Mining was carried out by one airlift without hydromonitor destruction. Four wells were drilled and produced. The maximum production from one chamber was 900 m^3 with a layer thickness of 30 m. During the development of the next chamber, the surface collapsed a crater with a diameter of 14 m and a depth of 8-10 m was formed. After that, the experiments were stopped. The main reason for the negative results was that the development system did not take into account the influence of technology parameters on surface deformation.

Development of dry deposits.

Moscow Geological Survey named after S. Ordzhonikidze conducts research and industrial works on SGV sedimentary deposit, represented by sandy-clay deposits with a thickness of 0.5 to 2.0 m. Overlying rocks - dense tertiary clays, depth of occurrence from 10 to 150 m. For the destruction of tuffs (strength on the scale of M.M. Protodeacon f=1.0-1.5) required a water pressure of 5.6 MPa at a flow rate of 150 m^3/h. At the same time productivity of 30-40 m^3/h on rock weight is reached. Promising method of SGV and for working out of the cassiterite placers buried under the seabed. The complexity of the usual mining of these placers by dredgers is associated with significant losses in the process of gross excavation of placers covered with loose hollow rocks, with long (up to 10 months) winter and sea turbulence.

Employees of the Institute of Physical and Technical Problems of the North of the YaF SB USSR Academy of Sciences proposed to develop these placers by the method of SGV from ice by artificial freezing of sea water and the thickness of the cover rocks. It is proposed to conduct mining without hydromonitor destruction by one hydroelevator. Experience shows that to ensure the profitability of development, it is advisable to use hydromonitoring destruction of tuff and its construction in the suction zone, and for pumping - airlift. Application of the SGV method in the USA.

This method was used in the experimental development of a uranium deposit from a depth of 61-107 m. A hydromonitor with two nozzles was used to destroy the tuff: the water flow through them was 110 m^3/h at a water pressure of 5.6 MPa. In addition, water was fed to the nozzle of the hydroelectric elevator (134 m^3/h) and to the drill bit (27 m^3/h) to destroy large particles of tuff reflected by the hydromonitor. Then the tuff through the lattice enters the suction of the elevator. The average productivity of the hydroelevator is 46 m^3 / h for ore (136 m^3/h for the hydraulic mixture). The concentration of solids in the pulp is 60 % by weight. The level of the pulp in the chamber was maintained so that the jet acted in the air. It was found that with a layer thickness of 1.8 m, the production will be 720 tons of tuff from each meter of the well with a chamber radius of 9.15 m. Based on this development, it is planned to further develop deeper deposits. It is calculated that the joint operation of the elevator with the airlift is possible to extract from a depth of 460 m. In addition, the possibility of pumping air into a sealed chamber to reduce energy consumption for lifting the pulp. It is estimated that, using the hydroelectric elevator together with the airlift and pumping air into the chamber, you can count on successful downhole hydraulic production from a depth of 2290 m. The main characteristics of the field when choosing the parameters of development are the physical and mechanical properties of tuffs and rocks that contain them, the angle of incidence and thickness of the tuff layer, the thickness of the overlying rocks, hydrogeological conditions.

Physics-mechanical properties of tuff determine the most important parameters of SGV: specific consumption and required water pressure for destruction and flushing, parameters of hydrotransportation of rocks, the size of the alluvium map. The same properties largely determine the choice of basic equipment (pumps, hydromonitor, and output mechanism). Finally, the physical and mechanical properties of tuff depend on the loss and consistency during extraction, under-grinding during hydrotransportation, caking and drainage during storage. Physics-mechanical properties of roof rocks determine their resistance to exposure during the extraction of the tuff layer. According to the degree of stability of the roof rock can be divided into unstable (roof rocks collapse after tuff mining), stable (allowing tuff mining in chambers with a bare area up to 100-500 m^2) and monolithic (allowing bare areas up to 500-1000 m^2). The stability of the roof determines the parameters of the development system, the size of the chamber and the order of its extraction. The shape and elements of tuff bodies have a great influence on the effective use of SGV. The contact conditions of the rocks that accommodate them on the roof and sole determine the loss of tuff and methods of delivery (flushing) into the chamber. The thickness of the tuff layer largely determines the amount of production from one chamber and thus the economic efficiency of the method. However, the value of minerals plays an important role here. It may turn out that the high value of tuff allows you to effectively develop low-capacity tuff deposits. Under the conditions of treatment, tuff bodies should be divided into thin (up to 0.8 m), low-power (0.8-2 m), powerful (2-15 m) and very powerful (more than 15 m). At the angle of incidence, the layers are horizontal (0–5 °), sloping (5–15 °), inclined (15–45 °), and steep (more than 45 °). The angle of incidence of the layer determines the method of delivery of the destroyed tuff to the suction of the dispensing mechanism, the greater the angle of incidence of the layer, the better the conditions of delivery to the chamber.

The depth of occurrence determines the design of mining equipment and affects the economic efficiency of the method. As the depth of occurrence increases, the cost of tuff extraction by the SGV method increases slightly. This allows you to effectively work out tuff bodies that lie at great depths or under bodies of water, the development of which in traditional ways is unprofitable or impossible.

Requirements for the quality of tuff, losses and consistency largely determine the parameters of the technology and equipment of SGV. Hydrogeological conditions affect the choice of mining equipment and the scheme of mining the tuff layer. If the water inflow is low, the water can be pumped directly from the chamber and production is carried out in an unflooded bottom. With a large influx of water production can be carried out in a flooded face, but this significantly complicates the processes of destruction and delivery of tuff.

Wetness or complexity of the surface relief above the tuff body affects the design and type of equipment used for mechanization of mining operations, drilling rig, pipe layer and vehicles. The made equipment can be of general industrial purpose, in bog execution or with use of floating means (ship, pontoon, barge).

Determination of design parameters of the airlift

Usually when calculating the airlift are set: hourly productivity Q, the height of the rise Hs static or relative water level in the well h_{st}($\alpha=\dfrac{H}{h_{st}+H}$). Then the purpose of the calculation is to determine the parameters of compressed air and the choice of the compressor, the diameters of the air and slurry pipes, the design parameters of the nozzle. The following calculation procedure is used for this case.

1. Consumption of compressed air

$$V_0=\frac{Q\cdot H\cdot\gamma'_g}{23\cdot 60\eta_{iz}\lg\left(\dfrac{h}{w\cdot 10}+1\right)} \tag{2.1}$$

where γ'_g is the relative density of the hydraulic mixture, kg/m^3: $\gamma'_g=\dfrac{\gamma_v}{\gamma_g}$; γ_v, γ_g - density of water and hydraulic mixture, kg/m^3, respectively; h - dynamic level in the well, m; η_{iz} - isothermal efficiency of the airlift

$$\eta_{iz}=\frac{H\cdot\gamma'_g}{23\cdot q\cdot\lg\cdot\left(\dfrac{h}{w\cdot 10}+1\right)}, \tag{2.2}$$

where q is the specific consumption of compressed air for the rise of 1 m^3 of hydraulic mixture, m^3/m^3.

At Q=50–300 m^3/h and H=80–300 m, the optimal value of ηиз can be taken depending on the values of a

a	0,10-0,15	0,15-0,25	0,25-0,35	0,35-0,50

η_{iz} 0,25 0,32 0,36 0,40

2. Determine the diameter of the air tube, mm

$$d_{air} = \frac{0{,}000125 \cdot \beta \cdot R \cdot T \cdot G^2 \cdot l}{\Delta p p_m}, \tag{2.3}$$

where p_m- the average pressure of compressed air in the pipe, MPa;

Δp- pressure loss, taken 5% of mercury; R is the universal gas constant: R= 29.27 kgm/kg C ° (R=0.0821 l atm/mol, deg); T is the average absolute temperature in this section of the pipe T= t °C+273 °K; l is the length of the air network, m, the length consisting of the actual length plus the length equivalent to the pressure loss on the local supports.

The value of β, which depends on the mass flow rate of compressed air, is determined by the formula

$$\beta = \frac{2{,}86}{G^{0.148}}, \tag{2.4}$$

where G - the amount of compressed air flowing, kg/h; γ - air density, kg/m^3, V - air volume at manometric pressure, $V = \dfrac{V_0}{\rho_m + 1}$; m/hour; V_o - brought to normal conditions air flow, m^3/h (r_0= 0.10393 MPa and T_o=273 K).

Usually at given values of G, r_t, l_n, taking the value of Δp, the diameter of the air tube is determined by known nomograms. You can use the formula to determine the diameter of the air tube< mm.

$$d_{air} = 20\sqrt{V}, \tag{2.5}$$

3. The diameter of the slurry pipe can be determined by the formula of V.G. Geer, sm

$$d_e = \sqrt[2{,}5]{\frac{Q}{k \cdot \alpha}}, \tag{2.6}$$

where $\alpha = \dfrac{h}{H + h}$- the relative coefficient of immersion of the nozzle under the water level; k is a coefficient that depends on the parameters of the airlift.

Within the limits of the change of airlift productivity Q=50-300 m^3/h, lifting height H=100-300 m and at values α=0.20-0.45 the value of k is equal to 0.24, sm.

$$\text{Then } d_e = 1{,}77\left(\frac{Q}{\alpha}\right)^{0{,}4} \tag{2.7}$$

4. Compressed air operating pressureMPa,

$$P_w=0{,}01(h_D+p_1), \tag{2.8}$$

where p_1- air pressure losses in the air tube of the airlift and nozzle; usually take p_1=0.03-0.05 MPa.

5. Starting pressure of compressed air

$$p_{starting}=0{,}01(h_{st}+p_1),\ \text{MPa}. \tag{2.9}$$

6. The compressor pressure is equal to the starting plus losses in the airlift p_1 and on the route p, MPa

$$p_к=p_{starting}+\Sigma p, \tag{2.10}$$

where $\Sigma p=p_1+p_2$.

7. Compressor performance is based on the number of airlift units and gives a margin of 20 % for the unevenness of their work, m^3/ minutes

$$V_к=1{,}2\cdot\Sigma\cdot V_0\ ,\ . \tag{2.11}$$

Stocks of tuff raw materials in the Volyn region allow them to conduct long-term industrial production. First of all, they attract with their availability and wide possibilities for use. The presence of a rich microelement composition allows conducting research on complex industrial processing of tuffs, a deeper study of their properties and on this basis - to improve the technology of extraction and expand the field of use.

The existing experience of using tuffs in agriculture, animal husbandry, construction practically does not provide for deep technological processing of them in order to extract the most valuable components.

Intensive studies of tuff composition over the last decade have shown that its mineral composition requires an integrated approach to processing, as it is a source of valuable raw materials for industry. The presence of native copper, titanium, iron in quantities of industrial interest, requires improvement of mining and processing technology.

The main experience in the extraction of tuff raw materials is focused on the geotechnological method in the form of down hole hydraulic production. In Ukraine, quarry tuff mining is carried out in no more than three quarries with low productivity. However, tuffs associated with the development of basalt quarries are usually dumped, despite their rich micronutrient composition.

In the field of tuff research, the main focus is on down hole hydraulic technology, while it is indisputable that the use of dump tuffs is economically feasible, at the same time insufficiently studied the causes of technological difficulties, the properties of tuffs as a source of rock mass for further processing by existing methods in the mining industry. The issues of selective excavation, softening of tuffs, crushing and separation to the size required for processing are insufficiently studied.

One of the main economic problems that arise in the development of deposits is the choice of the most efficient way to develop them, and is the distribution of capital, which provides maximum mining, reducing construction time and return on investment, as well as minimum cost of minerals. Technical and economic indicators of the used method of development are determined by the initial mining-geological and hydrogeological conditions of the field and the adopted technical and technological decisions. As a rule, as a result of economic calculations, the optimal term of field development, enterprise capacity, current production volume, organization of works, operating costs, etc. are determined. A detailed comparison of different methods is possible only at the stage of technical design, so below we will consider only some aspects of the effectiveness of field development by the method of down hole hydraulic technology.

Significant differences between geotechnological methods and methods of open and underground development, as well as their novelty, determine a certain specificity of the methods of comparative economic evaluation of these methods. In open or underground mining, as a rule, rock mass is obtained, and in geotechnological methods - the finished product. Naturally, a comparison of different types of development technology should be made on the sum of the costs of obtaining the final product, including extraction, enrichment, etc. Therefore, in order to obtain comparative results when considering options, it is necessary to take into account the entire redistribution of tuff to obtain the final product. The efficiency of development is assessed by three main indicators - specific capital investment, cost and productivity. In addition, the evaluation of options should take into account profitability, payback period, construction time, return on investment, annual economic effect, as well as reducing the need for scarce equipment and materials. It is also necessary to take into account social factors - working conditions of workers. In this respect, geotechnological methods are more promising than other methods, because they usually do not require the presence of people in the recesses.

The construction of new mining enterprises operating on the old technology is inefficient, because such enterprises do not provide high economic performance, and the dynamics of their return on investment, as studies have shown in recent years, is clearly unsatisfactory. This is due to the high complexity of mining production and the high share of passive funds of the enterprise (mining, etc.). In general, the extraction of minerals by conventional methods is a very capital-intensive and capital-intensive industry (mainly due to mining). In addition, during the entire period of operation of the mining enterprise it is necessary to regularly (at the expense of capital costs) to prepare more and more new sites for mining. In geotechnological methods, enterprises are characterized by small passive and increased active assets, because geotechnological methods do not require mining (in the usual sense of the word), and the whole production process is reduced to drilling wells, their equipment and preparation for operation. Geotechnical mining technology does not require a huge amount (performed volume) of mining work. Due to this, the complexity of production and capital costs in geotechnological methods are less than in other methods. Thus, the cost of construction of an underground sulfur smelting plant with a capacity of 500 thousand tons/year is 5-10 times less than the cost of construction of the enterprise by conventional technology.

3. Experience in using raw materials

Mineral and petrographic characteristics of tuffs, their mineral composition, and structural features have been studied in sufficient detail, data on geological conditions of occurrence, chemical and mineralogical composition, favorable conditions of occurrence allow considering tuffs as a new type of mineral multipurpose raw materials. At the same time, this raw material, despite the availability of opencast mining, is almost not exploited today, but remains at the bottom of the worked-out areas of basalt quarries and is stored in dumps. As minerals, the volcanic tuffs of the Rivne region have not been sufficiently studied by specialized geological prospecting works and organizations. However, technological experiments and a number of studies of agrochemical, bioactive, environmental and sorbent properties of tuffs have shown their suitability for use in many sectors of the economy, in particular, in animal husbandry, poultry farming, plant growing, medicine, for the manufacture of sorbents for various types of intoxication.

The main areas in which tuffs are already used are as follows: 1). Agriculture - as a mineral fertilizer, preservation of seeds, additives to feed for animals and birds, a stabilizer for plant feeding. 2). Environmental - reclamation of radioactive contamination of soils, underground disposal of toxic substances, wastewater treatment. 3). Construction - production of building materials (bricks, tiles, ceramic tiles), production of cement and expanded clay, pigments for paints and colored concrete. 4). Binding materials - ore pelletizing, fertilizer pelletizing.

An increase in crop yields when using zeolite tuffs has been shown by studies of the National University of Water Management and Environmental Management, the Institute of Forage of the UAAN (Vinnitsa) and the State Control Research Institute of Veterinary Preparations and Feed Additives (Lviv). They developed the technical conditions Technical conditions of Ukraine 46.15.GO-026-2001 for the use of tuffs of the quarries of the Rivne region. The Institute of Epizootology of the UAAS has developed technical conditions for the production of tuff flour from the Polytsi-2 deposit for use in veterinary medicine.

As noted by a number of researchers, in the Rivne region, 1.2 million hectares are exposed to radionuclide contamination as a result of the Chernobyl nuclear power plant accident, including 290 thousand hectares of agricultural land, while the pollution density exceeds the permissible norms by several times. According to the State Department of Ecology and Natural Resources, on the territory of Rivne region, due to the imperfection of the existing systems for the treatment of industrial effluents, gases, and other industrial waste products, man-made anomalies of strontium, lead, arsenic, nitrates, nitrites, organic harmful compounds are formed, usually located in close proximity to settlements and livestock facilities. Their concentrations are from 3-5 to 10 maximum permissible concentrations.

Radionuclides and pollutants migrate by water and air, creating new man-made anomalies in places remote from pollution sources.

The presence of zeolite-smectite tuffs in the Rivne region can radically change the ecological situation and compensate for the lack of many elements in the surrounding space, since tuffs contain many useful micro- and macro elements and can additionally neutralize any harmful organic compounds, thereby improving the region's ecosystem.

The study of the geochemical situation of the Western region of Ukraine, which includes the territory of the Rivne region, showed that the soil and water lacked such biogenic trace elements as zinc, iodine, copper, cobalt, manganese, iron, selenium. This led to the lack of their content in plants, which contributed to their lack in humans and animals. This is especially true due to the lack of hematopoietic microelements in the synthesis of hemoglobin. Therefore, since the zeolite-smectite tuffs of this region contain a sufficient amount of all the listed elements, the area of their use can be significantly expanded. To date, the Rivne Regional State Administration for the past 10 years has been implementing a program for using tuffs to improve the environmental situation, reclamation of lands affected by the Chernobyl disaster in animal husbandry. Within the framework of this program, a team of scientists has developed a method of waste disposal using tuff. The aim was to increase the accumulating capacity of the layer of insulating waste coating with the simultaneous possibility of safe removal of moisture from the array of waste dumps by cleaning the infiltrate containing harmful substances with a layer of tuff. In this case, the deodorization of the environment is carried out. This method has been tested and proposed for widespread use.

The growth of the population in cities and the development of industry are associated with an increase in the amount of household and industrial waste, which, if untimely neutralized, worsen the ecological situation, polluting the air, soil, reservoirs of small, medium and large rivers, groundwater, as well as increasing the area of such territories that are in further cannot be used without special work on their restoration (reclamation). The number of landfills, which are a source of danger to all living things and have exhausted their capabilities, is growing. Landfills overloaded with landfills are a source of infection. In pound waters and bottom sediments near such landfills, the concentration of lead exceeds the norm by 4-36 times, zinc - 2-14 times, copper - 2-8 times, mercury - 950 times, bismuth - 180 times. In addition, a greenhouse effect is created by gases (CH_4, CO_2), which poison the atmosphere and cause spontaneous combustion in hot weather. At the same time, methane causes poisoning and death of vegetation.

The release of methane at landfills of municipal solid waste ranges from 5 to 20 percent of its global emissions and reaches an alarming level. Therefore, there is a need to design waste landfills as engineering and environmental structures in the system of a natural and technogenic complex.

The design method is based on the idea of increasing the sorption capacity of the insulating layer over the landfill of garbage and local pollutants with the simultaneous possibility of protecting the soil, safely removing moisture from the array of solid waste dumps by cleaning the infiltrate that contains harmful substances, and deodorizing the surrounding atmosphere.

The solution to this problem is achieved by implementing a method for storing waste at landfills by layering an insulating material and creating absorber trenches with an insulating material. For these purposes, zeolite tuff is used with high efficiency as a powerful natural sorbent and a by-product of basalt mining.

In addition, zeolite tuff has a high selectivity of absorption and the ability to separate the ions and molecules of different substances by size, and a sufficiently high mechanical and chemical resistance. High porosity, in comparison with quartz sand, provides an increase in the capacity of harmful substances; therefore it has higher ion-exchange selectivity in comparison with a number of chemical elements, the content of which is strictly standardized.

References

1. **Melnichuk V.G.** Mineral resources of the Volyn trap formation. Proceedings of the scientific conference "Natural Resources of Volyn. Results of basic research (1993-2003) ". Scientific Bulletin of Volyn State University. (2004) - №1. - R. 90-92.

2. **Melnichuk V.G., Mateyuk V.V**. Tuffs of Volyn-Podillya as a new type of mineral resources. Problems of rational use, protection and reproduction of natural resource potential of Ukraine. Abstracts of the report of the 2nd All-Ukrainian Scientific and Methodological Conference. - Chernivtsi, (2000). - R. 133-134.

3. **Skakun L., Tkachuk A., Melnychuk V.** Types of zeolite associations in hydrothermal formations of the Volyn series. Mineralogical collection. LNU, (2003) - № 53. Issue 1-2. - R. 4-13.

4. **Melnichuk V.G., Novosad Ya.O**. Basalt tuffs of Volyn-Podillya are a potential object of radioactive waste (RW) disposal. Geological science and education in Ukraine at the turn of the millennium: state, problems, prospects. - Proceedings of the scientific conference dedicated to the 55th anniversary of the Faculty of Geology of Lviv National University. LNU Publishing House. - Lviv, (2000). - R. 141-142.

5. **Malanchuk Z.R.** Scientific bases of well hydraulic technology. Exactly, (2002). - R. 204.

6. **Tsilmag O.** Mineral composition and formation of palagonite aggregates in the Vendian basalts of Volhynia. Mineralogical collection. LNU, (2005).

7. **Cherney E.I., Malanchuk Z.R.** Methods of selection and calculation of hydroelevator lifting of pulp of large hydraulic size. Bulletin of the UGUVHP. Sat scientific tr. - Exactly: UGUVHP, (2002). - Issue. №16. - R. 297-308.

8. **Malanchuk Z.R**. Modeling of hydromechanical processes of hydro-erosion of placer deposits. Sat scientific tr. "Geotechnical Mechanics". - Dnepropetrovsk: IGTM NAS of Ukraine, (2003). - Issue. №34. –R. 164-172.

9. **Malanchuk Z.R**. Methods for establishing rational parameters of erosion of minerals and underlying rocks. Bulletin of the UGUVHP. Sat scientific tr.- Rovno: UGUVHP, (2002). - Issue. №17. - R. 356-367.

10. **Malanchuk Z.R.** Theoretical bases of calculation of pipelines of systems of borehole hydraulic extraction of minerals. Sat scientific tr. "Geotechnical Mechanics". - Dnepropetrovsk: IGTM NAS of Ukraine, (2002). - Issue №36. - R. 218-224.

11. **Malanchuk Z.R.** Clarification of theoretical dependences of calculation of distribution pipelines of systems of a well of hydraulic mining. Sat scientific tr. "Geotechnical Mechanics". Dnepropetrovsk: IGTM NAS of Ukraine, (2002). - Issue №34. - R. 393-401.

12. **Naduty V., Malanchuk Z., Kurilov V.** The development of works on complex recycling of raw materials of basalt open-pit minesfor the removal of aluminum concentrate. 3rd International scientific and technical conference. Innovative development of resource-saving technologies and sustainable use of natural resources. – Petrosani, Romania: UNIVERSITAS Publishing, (2020). – edition 3 / October 26. – P. 94-95.

13. **Malanchuk Z.R.** Resource-saving technologies of raw-material base development in mineral mining and processing. Multi-authored monograph. – Petrosani, Romania: UNIVERSITAS Publishing, (2020). – P. 514.