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GEODYNAMIC PROCESSES IN THE TERRITORY OF THE SVIDOVETS MOUNTAIN MASSIF OF THE UKRAINIAN CARPATHIANS (IN THE ZONE OF THE PLANNED CREATION OF A TOURIST AND RECREATION COMPLEX)

The purpose of the research is a comprehensive analysis of various geodynamic natural processes on the territory of the Svydovets mountain massif of the Ukrainian Carpathians – the zone of the planned creation of a tourist and recreational complex for the development of a program for their further detailed study in the area of the planned activity (PA). The methodology includes a comprehensive analysis of the manifestation and course of dangerous geodynamic processes based on source information and individual studies of the authors. The Svydovets massif is located within the Central Synclinal Zone of the Carpathians, which is composed of Eocene and Oligocene chalk flysch. The highest part of the ridge with the southwestern and southern slopes and peaks Chorna Kleva (1720 m), Ruska (1678 m), Bratkivska (1788 m), Gropa (1759 m) is confined to the territory of the PA. The massif is characterized by a complex division of thrust structural slices of the Porkuletsky, Duklyansky and Chornohirsky nappes (covers). There are very steep north-eastern and gentle south-western slopes. The main forms of relief that characterize relict glacial relief are cirques, glacial valleys, rocky cirque ridges, steep rocky walls of cirques, moraine deposits, etc. On the southern and northern macroslopes of the Bratkivska Range, stone placers have been preserved from the Ice Age. Slope placers on the south-western macroslopes (areas of the Gropa, Ruska and Chorna Kleva mountains) are potentially dangerous for the formation of landslides and screes. Activities on the middle and lower slopes require special attention, where there is a possible negative impact during the construction of roads, felling and transportation of forest. Earthquakes, mudslides, landslides, debris flows, landslides, and avalanches are among the most dangerous processes on the territory of the PA. Earthquakes are of minor magnitude. Landslides and ossips are common on the northern and eastern slopes of the Svydovets massif, including on the watersheds and southwestern slopes of the Bratkivsky ridge. They are confined to slopes of considerable steepness (more than 35°) and occupy a small area. Small landslides with a volume of several tens of cubic meters of rock predominate, and rockfalls with fragments of 1–1.5 m in size. Landslide processes are widespread in the Ukrainian Carpathians, in particular within the PA in the Krosno tectonic subzone, which covers the latitudinal segment of the upper basin of the Chorna Tysza and the Yasinya syncline. Manifestations of avalanche activity on the Svydovets massif occupy one of the first places in the Ukrainian Carpathians along with the Chornohora and Borzhava ridges. The length of avalanches can be more than 1.5 km, and the volumes of avalanches – more than 400.000 m³. The Bratkivsky ridge is a non-avalanche active area, while the northern slope of the Svydovets massif and the Chorna Tysza valley are avalanche- dangerous. Considering that the PA territory covers mainly the southern slope of the Bratkivsky ridge, the avalanche danger is insignificant. Scientific novelty. The manifestation and activity of various dangerous geodynamic processes within the territory of the Svydovets massif – a zone of possible anthropogenic impact on the environment as a result of PA for the development of the ski resort – are analyzed in detail. Practical significance. The results of the research will help to the future developer of the ski tourist and recreational complex to develop a program for further detailed study of dangerous natural phenomena at the planned construction site, and can be partially used in the implementation of the Environmental Impact Assessment Report for PA. They also inform the public about the possible impact of PA on the environment.

Key words: Ukrainian Carpathians; Rakhiv district of Transcarpathia; Svydovets mountain massif; geodynamic processes; “Svydovets” ski resort, anthropogenic impact.

Introduction

Transcarpathia is one of the most promising and attractive regions of Ukraine for the development of the recreational sector. It is known for its favorable climate, picturesque landscapes with the highest mountain peaks of the Ukrainian Carpathians, rich landscape and biological diversity, numerous monuments of history, culture and architecture. It also has a special geographical location in the neighborhood of four European countries that serve as a basis for the implementation of new significant projects for the development of the recreational industry. Therefore, in accordance with the priority tasks of the Program for the Development of Tourism and Resorts in Transcarpathian Region for 2021–2023, the regional authorities have initiated the creation of a

modern recreational and tourist complex “Svydovets” (RTC “Svydovets”) with a network of suspended passenger cable cars, ski slopes, hotel and commercial infrastructure, infrastructure of winter and summer attractions outside the settlements of the village of Yasinya and the village of Chorna Tysa (Yasinya village council) of Rakhiv district and village of Lopukhovo (Ust-Chorna village council) Tyachiv district. Planned activity (PA) by local territorial communities for the long term is considered extremely important according to their development strategy [Nosalyuk S., 2023; Khmelnytska V., 2023; Levkovych A., 2023]. At the same time, some nature protection activists are disseminating information about the impracticality of any economic activity on the Svydovets massif. As an alternative, they propose to create of a protected area here [Kagalo O., Kanarskyi Yu. and others, 2018]. This is not supported by either local territorial communities or forestry hunting enterprises, considering it an intention to hinder their rational use of available natural resources for the development and improvement of life in mountain settlements. Therefore, it is important to provide the scientific community and the general public with objective information about the possible impact of PA on the environment, in particular regarding the possible provocation of geodynamic natural processes during the construction and operation of a ski resort. As part of the preparation of the Environmental Impact Assessment Report (EIAR) of this facility, leading scientists have been carefully studying the potential risks of PA for various components of the environment in recent years. This paper analyzes the manifestation and activity of various dangerous geodynamic processes within the territory of the Svydovets massif which is a zone of possible anthropogenic impact on the environment due to PA. Let us note that the territory of the PA occupies only a small area of the Svydovets mountain massif, where during the construction process and then long-term operation there will be a certain anthropogenic impact.

Methodology and research results

The Svydovets Massif is located within the Central Synclinal Zone of the Carpathians, which is composed of Eocene and Oligocene chalk flysch [Kravchuk Ya., 2008; Tectonic…, 1986, Matskiv B., 2009]. The highest part of the massif with southwestern and southern slopes is confined to the territory of the PA. The ridges of the massif extend from the southeast to the northwest with the peaks of Chorna Kleva (1720 m), Ruska (1678 m), Bratkivska (1788 m), Gropa (1759 m). The south-western slopes are relatively weakly dissected by the watercourses of the Chorna Tysza and the Turbat Stream. The slopes of the Apshinets and Svydovets ridges are a typical Carpathian strike (Kotel, 1771 m; Dogaska, 1762 m; Troyaska, 1702 m). Powerful spurs depart from these ridges in the northern and north-eastern directions, in particular, from the Troyaska Mountains (1702 m) to the Tataruk Mountains (1707 m) at the interfluve of the Turbatsky and Apshynets streams, from Mount Kotel to the Menchul and Tatul valleys at the interfluve of the Apshynets and Stanislav rivers. The structure of these ridges involves deposits of the Lower Cretaceous (sandstones, marls), as well as the Upper Cretaceous and Paleogene. There are no mineral deposits within the territory of the PA, so there will be no negative impact on the geological environment due to their extraction. Many works have been devoted to the geological study of the Svydovets massif. At the beginning of the last century, the most thorough research was carried out by E. Romer [Romer, 1906], who gave a detailed description of glacial cirques and troughs, pointing out the double glaciation of Svydovets, S. Rudnytskyi (1905), H. Teisseyre (1928), B. Swiderski (1932) and others. The modernization of data on geological and geomorphological surveying and the study of geodynamic processes in the Ukrainian Carpathians is covered in many works, in particular on the territory of the PA in the following works: B. Matskiv and other (2009), G. Rudko and Ya. Kravchuk (2002), I. Hofshtein (1962), P. Tsis (1955), S. Shehunova (2022), S. Pop (2019); I. Kalynych, M. Nychvyd et al., (2022), as well as in the works of scientists of the geographical faculties of Taras Shevchenko National University of Kyiv [Oliynyk Y., Zapototsky S. et al., 2016; Kovtonyuk O., 2014; Bortnyk S., Kravchuk I. et al., 2018] and Ivan Franko National University of Lviv [Kravchuk Ya., 1984; Kravchuk Ya., 2008; Shushnyak V., Ivanyk I., 2006; Bilanyuk, V., Tykhanovich I., 2015], who have educational bases on the Svydovets massif or near it, and scientists of the Institute of Geophysics named after S. I. Subbotina of the National Academy of Sciences of Ukraine [Kendzera O., 2005; Maksymchuk B., 2014; Nazarevych A., 2012; Nazarevyc A. et al., 2016; Ignatyshyn V., 2022; Nazarevych et al., 2022], which having here the densest network of seismic and regime geophysical stations in Ukraine.

The Svydovets massif is characterized by a complex division of sliding structural slices of the Porkuletsky, Duklyansky and Chornohirsky nappes. They have very steep north-eastern and gentle south-western slopes. The right tributaries of the Chorna Tysza are laid along the zones of transverse faults. The most intensive folding is characteristic of the Krosno Formation. The folds are located parallel, sometimes backstage-like to each other [Oliynyk, 2016]. The main forms of relief that characterize the relict glacial relief are cairns, glacial valleys (troughs), rocky cairn ridges (karlings), steep rocky rear and side walls of cairns, bars, moraine deposits, and others. On the southern and northern macroslopes of the Bratkivsky ridge (Gorgan mountain massif), rock

outcrops have been preserved from the Ice Age, which is an integral part of their typical landscape. Slope placers on the southwestern macroslopes of the peaks (areas of the Gropa, Ruska and Chorna Kleva mountains) are potentially dangerous for the formation of landslides and scree. Particular attention is required to activities on the middle and lower slopes, where a negative impact is possible, in particular, when laying roads, felling forests, and transporting wood. Within the territory of the PA, the largest valley with a complete complex of terraces is the Chorna Tysza Valley (Fig. 1). Its largest terraced tributary is the Dovzhina River, the basin of which is located almost entirely in the Krosno tectonic zone. The geological structure of the Dovzhina river basin is made up of fine-rhythmic flysch (argillites, siltstones), which contributed to the formation of a low-mountain, highly fragmented relief.

On the territory of the planned activity (PD), the layout location of cable cars of which is shown in Fig. 2, it is planned: the construction of 23 suspended passenger cable cars of various designs with a total length of 53.2 km (from 4-chairlifts to gondola type), with the possibility of receiving winter infrastructure attractions for 22,000 vacationers daily; arrangement of 223.3 km of ski tracks at altitudes from 800 to 1750 m a.s.l. according to the established classifications of difficulty with the possibility of snowmaking; construction of economic and recreational infrastructure with engineering communications on an area of 800 hectares, including the construction of: 60 hotel-type buildings, 390 cottage-type buildings, 120 food establishments, including integrated into 10 multifunctional centers, premises for drive and upper lift stations; commercial services and entertainment establishments; 2 separate bank branches; 3 fitness centers with medical facilities that will provide medical services and organize preventive medical procedures; 5 multi-storey vehicle parking spaces for 6,000 cars, including those integrated into hotel buildings or multifunctional complexes; 28 additional structures for organizing the work of control and rescue teams. The total area of land parcels for the location of the complex is approximately 1430.0 ha. The total length of the planned roads is 89.9 km. The total volume of reservoirs is 1,260,000.0 m³. Water consumption is from 4 to 5.8 thousand m³/day with the corresponding capacity of wastewater treatment systems up to 6 thousand m³/day [Planovana…, 2018].

Due to the anthropogenic impact on the environment during the construction and operation of the TRC "Svydovets", dangerous geodynamic natural processes related to the geological environment may occur on the territory of the PA and the adjacent mountain ranges. Let's consider which of the possible phenomena (earthquakes, slow tectonic movements, volcanism, planar erosion, linear erosion, defluxion, slow solifluction, nival processes, mudflows, devolution, rubble, landslides, snow) should be taken into account by the future resort developer. This will help the developer to plan a program of their further in-depth study, and if necessary, to conduct constant monitoring observations. We will analyze the available data on their manifestation on the territory of the Svydovets massif during the historical period of special monitoring and scientific observations and determine what warnings and mitigation of the level of impact of PA on the environment should be offered to the future developer when creating a ski complex.

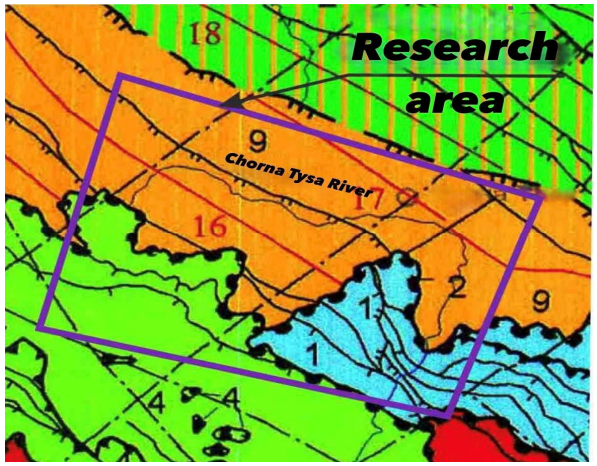

Fig. 1. Tectonic map of the territory of the planned activity [Dosin, 2009].

Seismic hazard. Transcarpathia is one of the most seismically active regions of Ukraine, although, compared to many seismically active regions of the world, its seismic activity is quite weak. The main seismogenic zone of Transcarpathia is the Transcarpathian deep fault, where the largest number of earthquakes occur, including the strongest for the region (up to 7 points on the MSK-64 scale) [Kendzera O., Pronyshyn R., 2005; Maksymchuk B. et al., 2014; Nazarevych L., Nazarevych A., 2012; V. Igatyshyn, 2022; Nazarevych A., Nazarevych L., 2023; Nazarevych et al., 2022]. Among the transverse seismically active structures is the central fault zone of the Transcarpathian mountain trench. From transverse seismically active structures, by the level of seismic activity, the Latorytskyi and Vynogradivskyi (together with the Oashsky meridional) faults, the Tyachiv fault zone (the Tyachiv lineament), as well as the nodes of their intersection with the Transcarpathian deep fault, are distinguished [Maximchuk B. et al., 2014; Nazarevych et al., 2016; Nazarevych et al., 2022]. According to the general seismic zoning maps ZSR-2004-A and ZSR-2004-B [DBN, 2014], the territory of Transcarpathia belongs to the 7-point zone on the MSK-64 scale. Annually, from 2 to 25 earthquakes with K=6÷10 (M=1.1÷3.3) occur here. Average recurrence periods are 5–10 years for events with K=8÷11 (M=2.2÷3.9), 50 years for K=11÷12 (M=3.9÷4.5) and 130 years for maximum energy earthquakes (K>12, M>4.5)) [Kendzera O., Pronyshyn R., 2005; Nazarevych L., Nazarevych A., 2012].

The reasons for the seismic activity of all the Ukrainian Carpathians and the area of the Svydovets

massif, in particular, are the tectonic compression across the Carpathians [Kendzera O., Pronyshyn R., 2005; Nazarevych A., Nazarevych L., 2023; Nazarevych et al., 2022], which leads to the modern activity of thrust processes in the Carpathians and the elevation of the day surface.

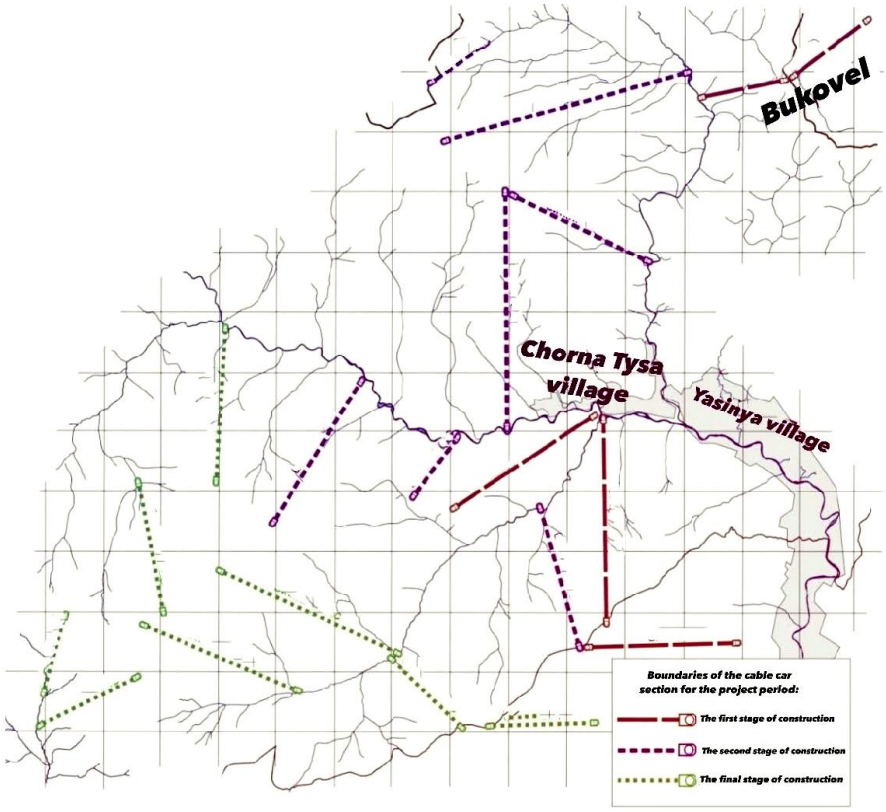

Fig. 2. Scheme of location and order of construction of cable cars [Planned..., 2018].

In the area of the Svydovets massif, such elevations are characterized by the magnitude of 1.5–2 mm/year.

The territory of the PA is located at a distance of up to 20–25 km from the Tyachiv and Transcarpathian faults and belongs to the seismically relatively safer zone (Fig. 3). Local seismicity in the Svydovets region itself is weak (see Fig. 3, inset). During the period of instrumental observations (since 1961), up to 20 earthquakes with magnitudes from 0.8 to 1.6–2.1 (much below the threshold of macroseismic effects) were recorded here. The sources of the nearest historical and modern earthquakes (with a magnitude of up to 3.7–4.3 and shaking intensity I up to 5–7 points on the MSK-64 scale) are localized at a distance of 20–25 km to the south, southwest, west and northwest from this area (Fig. 3), in the districts of Solotvyno – Sighet (I up to 6–7 points), Vilkhivtsi - Neresnytsya (I up to 5–6 points), Uglya (I up to 6–7 points), Dragovo (I up to 5–6 points) and Kolochava (I to 5–6 points), respectively [Nazarevych L., Nazarevych A., 2012; Nazarevych A. et al., 2016]. The sources of local earthquakes in the Svydovets region lie at depths of 3–6 km, 6–10 km, and 10–20 km; near-surface (depth 0–3 km) seismic activity is not traced.

Such characteristics of local seismicity indicate a low probability of these earthquakes exceeding the seismic impacts of the average intensity level on the daytime surface, which is provided for by the general seismic zoning maps for this territory ZSR-2004-A and ZSR-2004-B [DBN, 2014]. Although the features of the interaction of seismic impacts with other factors (topography, geology, hydrogeology, etc.) may require special comprehensive studies, modeling and calculations (in accordance with the requirements of DBN [DBN, 2014]) for specific sites of designed objects, taking into account technogenic loads and parameters of these objects themselves. It is also necessary to take into account the possible impact on this territory and objects of strong earthquakes (with M=5.4÷6.8) from the adjacent territories of Slovakia (seismologically active region of Humenne) and, especially, Romania (seismically active regions of Baia Mare, Satu – Mare, Carey, Oradea, epicentral distances 80–100–120–210 km) ([Nazarevych L., Nazarevych A., 2012; Nazarevych A., Nazarevych L., 2023b et al.], northern and eastern slopes of the Svydovetsky massif, in particular on the watershed and southwestern slopes of the Bratkivsky ridge. They are confined to slopes of significant steepness (more than 35–40°) and occupy a small area (about 2–5 % of slopes). Small earthfalls with a volume of several tens of cubic meters of rock predominate, and rockfalls with debris of 1–1.5 m in size. During

the last decades, avalanche and scree processes have been observed in the Apshynets, Veliky Vedmezhy, and Stanislav basins. In the boundaries adjacent to the PA territory, large areas are occupied by blockfield, especially on the slopes of the Bratkivska ridge. Linearly placed blockfield, which are called stone rivers, move at a speed of mainly 0.2–0.3 m/year. However, with human intervention, their speed can increase to 1.5 m/year or more.

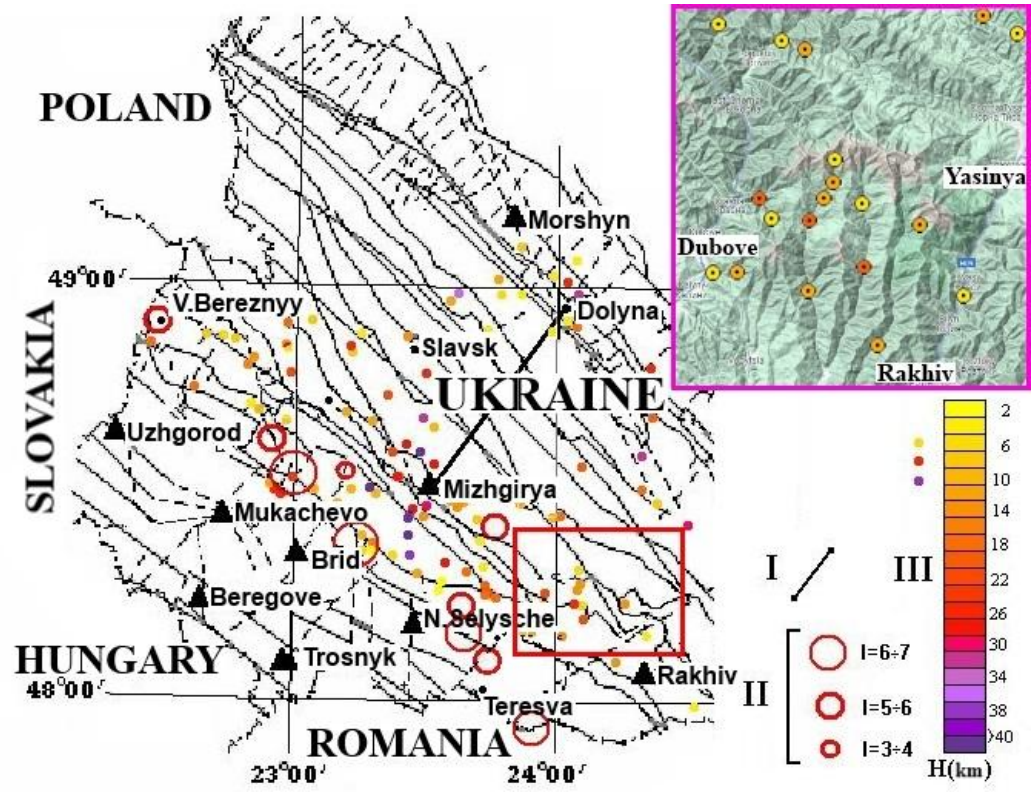

Fig. 3. Seismicity of the Ukrainian Folded Carpathians

Map basis – a generalized map of fault-cover tectonics of the region according to [Tectonical..., 1986], ▲ – main seismic stations, I – seismic geological profile of Mizhhirya – Dolyna; II – epicenters of historical earthquakes with identification of their intensity; III – epicenters of instrumentally registered earthquakes (for the period since 1961) and their depth scale, the studied area of Svydovets is marked with a red rectangle) [Nazarevych L., Nazarevych A., 2012; Nazarevych et al., 2016; Nazarevych et al., 2022] and the study area of Svydovets (on the inset, for the period from 1961, with additions according to [Nazarevych A., Nazarevych L., 2023a], (Google Maps map base with relief).

Respectively the **avalanche danger** and manifestation of avalanche activity, the Svydovets massif occupies one of the first places in the Ukrainian Carpathians, along with the Chornohora and Borzhava massifs [Kovtonyuk O., Tsvelykh E., 2014; Bilanyuk V., Tikhanovich I., 2015; Ozymko A., 2020]. It should be noted that snowslide here are confined to the terrain of the erosive ancient glacial subalpine highlands (Fig. 4).

Earthfalls and screes are common on the Most avalanches caused by snowfall, which are recorded in the study area of the Pozhezhevskaya snow avalanche station, are localized in complex areas of the walls of cirque glacier. Zones of snow accumulation and transit are very steep (30–45°) and steep (15–30°) "ribbed" slopes of the upper parts of the rearmost walls of the cirque of various exposures in hard flysch with alpine-meadow- brownified rocky ground in a complex with outcrops of the rocky material [Oliynyk, 2016; Ozymko A., 2020]. The length of avalanches can be more than 1.5 km, and the volumes of avalanches – more than 400,000 m³. The Bratkivsky ridge is a non-avalanche-active area, while the northern slope of the Svydovets massif and the Chorna Tysza valley are avalanche-prone [Kovtonyuk O., Tsvelykh E., 2014]. Considering that the territory of the TRC "Svydovets" mainly covers the southern slope of the Bratkivsky ridge, the avalanche danger within the PA is insignificant (Fig. 4). Three types of snowfields predominate on the Svydovets ridges: cornice, slope and linear fault trace rift. The cornices are located just below the edge of the top surfaces of the Svydovets and Apshynets ridges. They are formed as a result of snow transport perpendicular to the axes of the ridges (southwest-northeast).

These snowfields are located on the ledges of solid rock. The snow depth in July is 1.0–1.5 m, sometimes the snow is preserved until the next winter.

Slope snowfields mostly melt by early July and never remain until the following winter. Solifluction flows and mud streams originate on the periphery of these snowdrifts. If the thickness of loose waterlogged sediments exceeds 40–50 cm, then nival blowing hole are formed. Nival processes are associated with the influence of snowfields on their foot and the surrounding area by increasing daily temperature fluctuations near 0° and at the same time moistening rocks with melted snow water. Nival processes are associated with the formation of slope blowing hole, kars, and cirques.

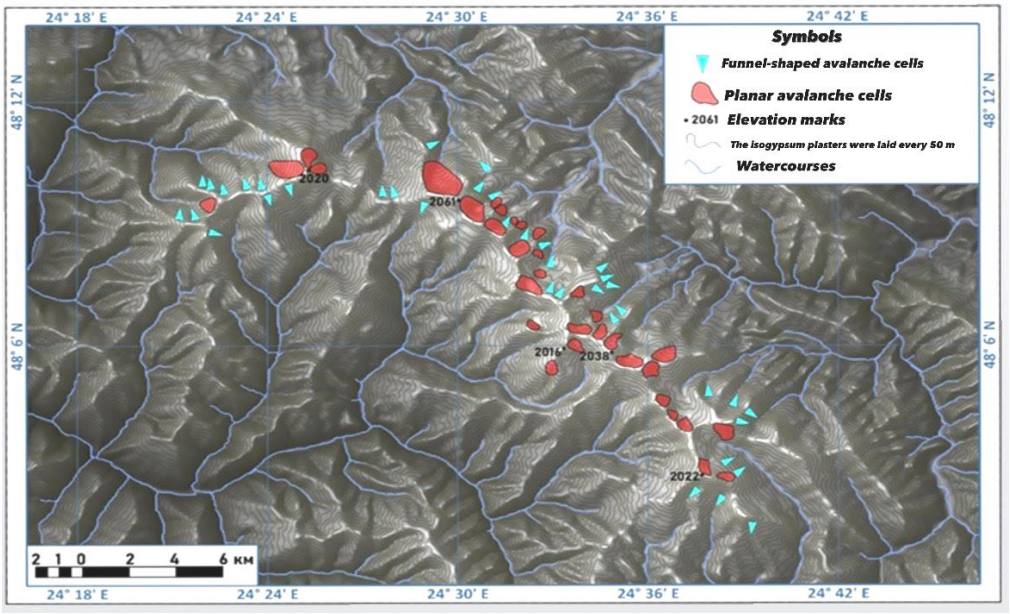

Fig. 4. Updated map of avalanche centers of the Svydovets and Chornohora massifs [Ozymko, 2020].

Landslide processes are widespread in the Ukrainian Carpathians [Shekhunova C., Syumar N. et al., 2022; Kalynych I., Nychvyd M. et al., 2022], in particular in the Krosno tectonic zone (Fig. 5). The Turkiv subzone of the Krosno zone is located within the PA, which covers the latitudinal segment of the upper Chorna Tysza basin and the Yasinya syncline. The structure of their territories is characterized by fissures and groundwater seeps. The age of the ancient landslides reaches 4–10 thousand years, the bodies of the landslides rest on the 10–12-meter terrace of Chorna Tysza. Landslide processes continue in the present [Shehunova C., Syumar N. et al., 2022; Kalynych I., Nychvyd M. et al., 2022]. Landslides are confined to tectonic contacts (the confluence of the Zhigalivskyi and Dyurdenkov streams), or where the mudstones of the Menilite Formation are underlain by dense sandstones of the Dovzhansk Formation. In addition to typical landslides, there are mudslides, which develop mainly on the surface of dense waterproof rocks. Mudflow processes involve sandy-clay and clayey deluvial or defluxation deposits of insignificant thickness (from 0.3–0.5 to 1.5–2 m).

Solifluction is a slow viscoplastic flow of waterlogged soil masses along slopes under the influence of alternating freezing-thawing and gravity forces, which manifests itself in the summit parts of the Svydovets, Apshynets, Urdu-Flavantucha Ridges. The slow movement of rocks on the slopes in the form of floating soil (defluxion), containing varying amounts of detrital material or without it, is most common in the upper part of the Chorna Tysza basin. Despite the insignificant quantitative indicators of the defluxation process, which takes place in large areas, their role in relief formation is quite significant. The vegetation cover does not create barriers to the mass movement of debris, since the displacement occurs below the layer strengthened by tree roots. **Mudslides** (up to 50 % mud and stone material) and **mud floods** (mud and stone material less than 50 %) occur on the northern and northeastern slopes of Svydovets and the southern and southwestern slopes of Bratkivska Mountain (Fig. 6). Within the PA, mudflow-prone areas were found in the upper left-bank valleys of the Chorna Tysza (Velykyi and Maly Vedmezhy, Seredniy and Pletsky, and others) and right-bank (Apsynets, Stanislav, and Svydovets basins, and others [Rudko H., Kravchuk Ya., 2002; Kravchuk Ya., 2008].

In the valleys of many of the Chorna Tysza valleys there are relict forms of the relief of ancient mudflows, for example, in the valleys of the Velykyy and Malyy Vedmezhytskyi, mostly water-stone and mud-stone low-power mudflows predominate. Scientists of the Ivan Franko Lviv National University discovered more than 100 mudflows on the territory of the Svydovetsky massif. In particular, within the studied area, the upper sources of the Chorna Tysza, the left-bank (Velykyi and Maly Vedmezhy, Serednii and Pletskyi, and others) and right-bank (Apsynets, Stanislav, and Svydovets basins, and others) reaches

of the Chorna Tysza are classified as mudslide hazardous [Rudko G., Kravchuk Ya. , 2002].

Planar (accumulative) washout of varying intensity is spread over most of the territory of the PA. Deluvial-deflection slopes are common in the upper part of the Svydovetsky massif, and deluvial-slide slopes dominate in the Yasinya syncline. **Linear erosion** is observed on all morphological levels and is most active in the lower level with absolute heights of 500–900 m. The destruction of the surfaces of narrow low terraces occurs on the narrow V-shaped valleys of the Tysza and its tributaries. More intense erosion and destruction of banks occur during spring floods and summer and autumn floods. We can observe the activation of these processes during years of excess moisture. Their negative impact on the Svydovets massif has increased in recent years due to widespread jeeping and motocross racing here, reaching alarming proportions even in the protected area of glacial lakes. At all height levels, there are **bright erosions**. Above the upper border of the forest, after heavy rains, numerous furrows 1.0–2.0 m wide and 0.2–1.0 m deep are formed on the forest floor. They later grow into ravines. Such erosion is characteristic of the slopes of the Svydovets, Apshynets, and Urdu-Flavantuch Ridges. Slope ravines predominate with an incision depth of 2.0–3.0 m. In the Chorna Tysza valley and most of its tributaries, V-shaped sections of the channel deepen in the upper parts. In the middle and lower parts of the slopes, river valleys acquire the trapezoidal shape. Lateral erosion dominates here, which is several orders of magnitude higher than deep erosion [Kravchuk Ya., 1984, Kravchuk Ya. 2008].

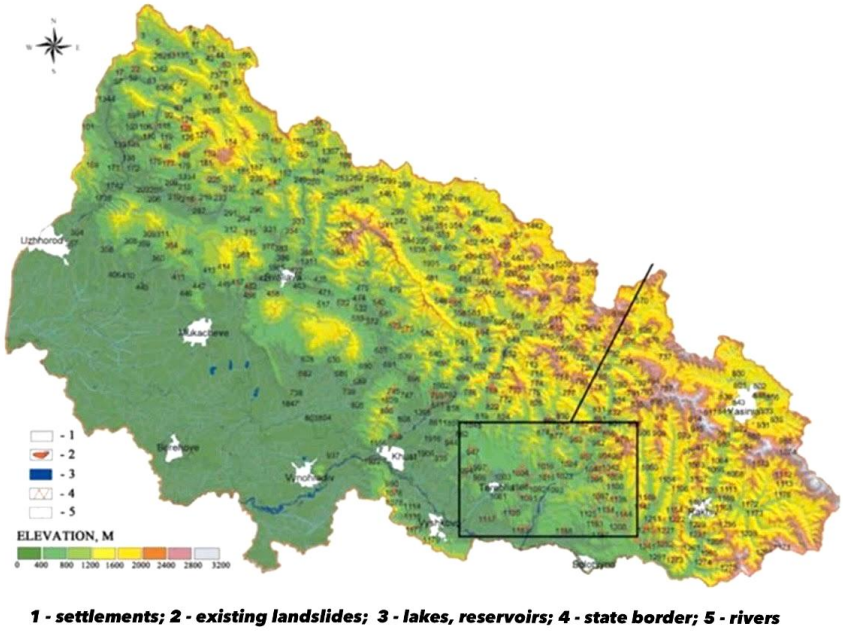

Fig. 5. Map of the distribution of landslides in the Transcarpathian region [Shehunova et al., 2022].

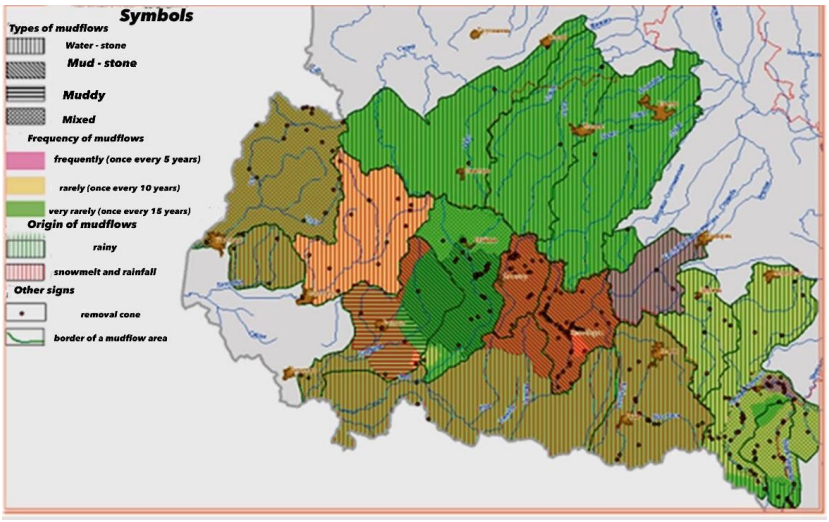

Fig. 6. Distribution of mudflows, their types, frequency of occurrence and location on the territory of Zakarpattia region [Elektronny…, 2014].

Conclusions

The planned activity, which is concentrated in the lowland zone and does not affect the landscape and biological diversity of the upper reaches of the Svydovets massif, will to a certain extent affect the geological environment and, in general, all natural processes occurring in the developed territory. However, the level of possible anthropogenic impact from the planned activity (PA) will be within the acceptable limits on the small areas of Svydovets, which will be directly occupied by economic development. The Svydovets massif, as a unique integrated natural complex and the objects of the nature reserve fund available here from the PA, will not be significantly negatively affected, which would make it impossible to implement the creation of the TRC "Svydovets". This complex is strategically important for the socio-economic development of the mountain communities of Transcarpathia in the long term. The impact of construction will be somewhat more significant than during the operation of the resort, in particular, during the construction of new sections of roads, construction of various complex facilities, water supply and drainage, the arrangement of ski lifts and ski slopes, etc. However, the impact from the construction will be short-term and within the limits of environmental standards. Compliance with construction and sanitary standards at all stages of the complex's creation will minimize the anthropogenic impact on the geological environment and other components of the environment, and will prevent the provocation of dangerous natural processes. Among the dangerous geodynamic natural phenomena, the prevention of which should be paid special attention must be paid during the construction and operation of the ski complex, include: landslide processes, the formation of mudflows in the floodplains of the Chorna Tysza tides and in the glacial crusts, the descent of snow avalanches. We recommend taking preventive and protective measures to prevent and limit destabilizing factors that can activate dangerous natural processes (do not cut the slopes of steep mountains, do not use groundwater, create accumulative reservoirs in the upper reaches of rivers for economic water supply and at the same time regulate surface runoff during floods , to create a reserve of glacial lakes, etc.), including not directly related to the impact on the geological environment of the PA (in particular, the prohibition of jeeping and motocross on the Svydovets massif, increasing the ecological culture of recreationists and tourists, increasing the afforestation of the territory, developing and modernizing the management of farming on the polonyna, streamlining the channels of watercourses and adjacent territories to glacial lakes, creation of a nature protection unit in the structure of the TRC "Svydovets").

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ГЕОДИНАМІЧНІ ПРОЦЕСИ НА ТЕРИТОРІЇ ГІРСЬКОГО МАСИВУ СВИДОВЦЯ УКРАЇНСЬКИХ КАРПАТ (В ЗОНІ ПЛАНОВАНОГО СТВОРЕННЯ ТУРИСТИЧНО-РЕКРЕАЦІЙНОГО КОМПЛЕКСУ)

Мета досліджень – комплексний аналіз різних геодинамічних природних процесів на території гірського масиву Свидовця Українських Карпат – зоні планованого створення туристично-рекреаційного комплексу для розроблення програми подальшого детального їх вивчення на ділянці планованої діяльності (ПД). Методика передбачає комплексний аналіз прояву та перебігу небезпечних геодинамічних процесів за джерельною інформацією та окремими дослідженнями авторів. Свидовецький масив розташований у межах Центральної синклінальної зони Карпат, складеної флішем крейди еоцену та олігоцену. До території ПД приурочена найвища частина хребта з південно-західними і південними схилами та вершинами Чорна Клева (1720 м), Руська (1678 м), Братківська (1788 м), Гропа (1759 м). Масив характеризується складним членуванням насувних структурних скиб Поркулецького, Дуклянського та Чорногірського покривів. Тут дуже круті північно-східні та пологі південно-західні схили. Головними формами рельєфу, які характеризують реліктовий льодовиковий рельєф, є кари, льодовикові долини, скелясті карові гребні, круті скелясті стінки карів, моренні відклади та інше. На південних і північних макросхилах хребта Братківська з льодовикового періоду збереглися кам'яні розсипи. Схилові розсипи на південно-західних макросхилах (ділянки гір Гропа, Руська і Чорна Клева) є потенційно небезпечними для утворення обвалів і осипів. Особливої уваги потребує діяльність на середніх і нижніх схилах, де можливий негативний вплив під час прокладання доріг, вирубування і транспортування лісу. На території ПД до *найнебезпечніших процесів належать* землетруси, селі, обвали, осипища, зсуви, лавини. Землетруси проявляються незначної сили. Обвали й осипища поширені на північних і східних схилах Свидовецького масиву, зокрема на вододілі і південно-західних схилах хребта Братківський. Вони приурочені до схилів значної крутості (більше ніж 35°) і займають незначну площу. Переважають невеликі обвали об'ємом кілька десятків кубометрів гірської породи, каменепади із уламками 1–1,5 м. Зсувні процеси поширені в Українських Карпатах, зокрема в межах ПД у тектонічній підзоні Кросно, яка охоплює широтний відрізок верхнього басейну Чорної Тиси та Ясінську улоговину. Прояви лавинної активності на масиві Свидовця займають одне з перших місць в Українських Карпатах поряд з хребтами Чорногори та Боржави. Довжина пробігу лавин може становити понад 1,5 км, а об'єми лавин – понад 400000 м³. Братківський хребет є нелавиноактивною територією, тоді як лавинонебезпечними є північний схил масиву Свидовець і долина Чорної Тиси. Враховуючи, що територія ПД охоплює в основному південний схил Братківського хребта, то лавинна небезпека є незначною. Наукова новизна. Детально проаналізовано прояв та активність різних небезпечних геодинамічних процесів у межах території масиву Свдовця – зони можливого антропогенного впливу на довкілля внаслідок ПД щодо сторення гірськолижного курорту. Практична значущість. Результати досліджень допоможуть майбутньому забудовнику гірськолижного туристично-рекреаційного комплексу розробити програму подальшого детального вивчення небезпечних природних явищ на ділянці планованого будівництва, а частково можуть бути використані для Звіту з оцінки впливу ПД на довкілля. Вони також інформуватимуть громадськість про можлиий вплив ПД на довкілля.

Ключові слова: Українські Карпати; гірський масив Свидовець; геодинамічні процеси; гірськолижний комплекс "Свидовець", антропогенний вплив.

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