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Geological and geomorphological objects of the Ukrainian Carpathians' Beskid Mountains and their tourist attractiveness

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Abstract. The article explores the geological and geomorphological objects of the Beskydy Ukrainian Carpathians for the further creation of geo-tourist routes. Geo-tourist areas combining several geological and geomorphological objects and establishments of tourist infrastructure are highlighted. Among those objects are Urytskyi, Yamelnytskyi, Skolivskyi, Syniovydnenskyi, Kliuch-Kamianka, Bubnyskyi. Geo-attractions of each area are described in detail: the morphological features of the objects, the structure of rocks composing them, the nature of the rocky surface, as well as the historical and cultural events associated with the objects. The estimation of the tourist attractiveness of geological and geomorphological objects within Beskid region of Ukrainian Carpathians is performed. For this purpose, an assessment methodology has been developed. The methodology is based on the following indicators: the number of geological and geomorphological objects, maximum heights, picturesque, spectacular (objects as an overview of the terrain), accessibility, scientific, cognitive, historical and cultural value, tourist infrastructure, popularity (the number of web pages that highlight search results). The attractive geo-objects' attendance of each district by tourists has been taken into account. It is established that the geological and geomorphological objects of the Urytskyi tourist area of Beskyds are of a greatest attractiveness for the geo-tourism's development (the general indicator of attractiveness is 8.4 points). It has a high historical and cultural value and the highest attendance. The second one is the Bubnyskyi geo-tourist area (7.2 points), where the largest amount of the highest and most spectacular rocks is located. In the third area of a great attractiveness for the development of geo-tourism is Kliuch-Kamianka (6.9 points), within which there is the larger number of various objects than in other regions and the highest online popularity and attendance. The attractiveness of the Skolivskyi geo-tourist district is estimated at 6.6 points. It has seven geo-attractions and is best equipped by the facilities of tourist infrastructure. The attractiveness of the Syniovydnenskyi geo-tourist area's objects is 5.6 points. There are eight geo-attractions here, including outcrops of high scientific and cognitive value. The attractiveness of the Yamelnytskyi region is 4.0 points. There are many different morphological types of rocks here, but the tourist infrastructure is poorly developed. On the basis of the performed estimation of attractiveness, new geo-tourist hiking, bus and motor-cycle routes, including the described geological and geomorphological attractions of the above-mentioned geo-cultural regions of the Beskids, were proposed.

Key words: geological and geomorphological objects, geo-tourism, geo-attraction, tourist attractiveness, Ukrainian Carpathians' Beskid Mountains.

Геолого-геоморфологічні об'єкти Бескидів Українських Карпат та їхня туристична привабливість

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Анотація. У статті досліджено геологічні та геоморфологічні об'єкти Бескидів Українських Карпат з метою організації геотуристичних маршрутів. Виділено геотуристичні райони, які об'єднують кілька геолого-геоморфологічних об'єктів та заклади туристичної інфраструктури. Зокрема, Урицький, Ямельницький, Сколівський, Синьовидненський, Ключа – Кам'янки, Бубнівський. Детально описано геоатракції кожного з цих районів: морфологічні особливості, склад та структуру порід, якими складені об'єкти, присутність знаків на поверхні порід, а також зазначено історико-культурні події, пов'язані з об'єктом. Виконано оцінку туристичної привабливості геолого-геоморфологічних об'єктів. Для цього розроблено методику оцінки, яка

базувалась на таких показниках: кількість геолого-геоморфологічних об'єктів, максимальні висоти, мальовничість, видимість (об'єкти як оглядова точка місцевості), доступність, науково-пізнавальна та історико-культурна цінність, туристична інфраструктура, популярність і відвідуваність туристами. Встановлено, що найбільшу привабливість для розвитку геотуризму у Бескидах мають геолого-геоморфологічні об'єкти Урицького туристичного району, який має також високу історичну-культурну цінність та високу відвідуваність. Друге місце належить Бубніському геотуристичному району, де знаходиться найбільша кількість найвищих і наймальовничіших скель. Район Ключа-Кам'янки на третьому місці, в межах якого спостерігається найбільша кількість різновидів об'єктів, найвища інтернет-популярність і відвідуваність. Привабливість Сколівського геотуристичного району вище середньої. Він налічує сім геоатракцій і найкраші забезпечений закладами туристичної інфраструктури. Привабливість об'єктів Синьовидненського геотуристичного району невисока. Тут налічується вісім геоатракцій, серед яких є відслонення, які мають високу науково-пізнавальну цінність. Привабливість Ямельницького району низька, оскільки він маловідомий, тут слабко розвинена туристична інфраструктура, проте багато морфологічних типів скель. На основі виконаної оцінки привабливості, запропоновано нові геотуристичні пішохідні, автобусні і мотовеломаршрути, які включають описані геолого-геоморфологічні атракції у виділеніх геотуристичних районах Бескидів.

Ключові слова: геолого-геоморфологічні об'єкти, геотуризм, геоатракції, туристична привабливість, Бескиди Українських Карпат.

Introduction. Year by year tourists are becoming more interested in geological and geomorphological sites as an alternative to historical and cultural memorials. Geo-tourism is evolving as a kind of travel connected with sightseeing and investigation of inanimate objects – (Chen, 2015; Cutler, 2010; Dowling, 2011; Hose, 2005; Khomenko, 2018; Newsome, 2005; Ollier, 2012). The main attractions for tourists on these trips are interesting geological and geomorphological sites in combination with the surrounding terrain, reflecting the history of nature and society in a particular area named geosites. The term “geosite” was formed in 1995 as a result of the collaboration of the European Association for the Conservation of Geological Heritage (proGEO) with the International Union of Geological Sciences (IUGS) and UNESCO (Migoń, 2017; Necheş, 2016; Reynard, 2004). In Europe, geosites are being protected; they are included in the system of geoparks, which have been integrated into the Global Network since 2004. Since 2015 to achieve significant progress, environmental education and sustainable local development, they have come under the auspices of UNESCO (Gordon, 2005; Ramsay, 2017). The term “geomorphosites” was introduced (Carton, 2005; Coratza, 2005; Reynard, 2009a) to focus on the conservation of geomorphological sites of ecological, aesthetic, cultural and economic value.

The peculiarities of geoparks’ creation and the geo-tourist objects were studied in the works of G. Denysyk, Yu.Zinko, V. Manyuk, O. Shevchuk (Denysyk, 2014; Kravchuk 2012; Manyuk, 2007; Manyuk, 2016; Shevchuk, 2011; Zinko, 2008) etc. However, there are still many geosites requiring detailed investigation and integration into geo-tourist routes.

Ukrainian Carpathians are distinguished by the richness and variety of geological and geomorphological sites (about one hundred ones). This provides the basis for laying out diversified geo-tourist routes

for acquaintance with geological, geomorphological, hydrological and complex attractions. One of them is the geo-tourist route “Geo-Carpathians”, grounded within the framework of the “International Program of Cross-Border Cooperation Poland - Belarus – Ukraine” and within which scientists I. Bubniak, A. Soliecki and Y. Zinko identified a number of geosites (Bubnjak, 2013; Bubnjak, 2014). One- and two-day tours to the Carpathians, developed by tourism firms, including visits to such geo-attractions as outcrops, rocks, caves, waterfalls, are popular among tourists. However, detailed studies of geological-geomorphological formations in Beskydy as the region with the various geo-attractions, good transport accessibility and developed tourist infrastructure remain relevant. Within this region, we have identified geo-tourist areas, thoroughly researched the morphological indicators of geological-geomorphological sites in them, assessed their tourist attractiveness, and proposed new tourist routes.

According to O. Muzychko-Kozlovska, “Tourist-attractive territory is a locality that has the potential of tourist resources, modern well-developed material and technical tourism base and accessible and sufficient for the tourist information about this locality, which would meet the needs of tourists and ensure the achievement of maximum social and economic effect of tourism industry development within it” (Muzychko-Kozlovska, 2000). In assessing the tourist attractiveness of the territory, the requests, the reasons, the tastes and the degree of the different potential tourists’ needs satisfaction are taken into account. When selecting indicators for assessment, the functional purpose and importance of each factor, as well as its importance in the overall evaluation should be taken into account. Several types of assessment of natural tourist resources have been developed, in particular: medical and biological (influence of natural factors on the human body); technological (according

to the functional suitability of resources for a certain type of tourism and recreational activity); psychological and aesthetic (emotional impact of the natural landscape on the person) (Fomenko, 2001). Some scientists understand the attractiveness of the territory as a positive image of the region and take into account the following indicators: natural and climatic conditions for recreation and recovery; social stability and security; transport accessibility; economic attractiveness; the spiritual appeal of religious pilgrimage centers; attraction of historical monuments; cultural and educational appeal (Omush, 2001; Pereira, 2010; Pralong, 2005). Some foreign researchers, considering the tourist attractiveness of tourist areas, take into account the following indicators: external and internal flows, the number of nights spent in local accommodation facilities and the average length of visitors' staying (Bujdosó, 2015). UNWTO assesses the tourist attractiveness of a territory on the basis of statistics on tourist flows, tourist expenditures and tourism profits.

The purpose of our research is to evaluate the attractiveness of geological and geomorphological sites in the selected geo-tourist areas of the Ukrainian Carpathians Beskids for geo-tourist trips.

Materials and methods of research. Data on geological and geomorphological attractions have been collected through our own field research over several years. Various geo-tourist objects of the Ukrainian Carpathians Beskids were studied: outcrops, rocks, waterfalls, caves. A number of research methods were applied. Among them are morphological, lithogenetic, structural and geomorphological methods, as well as the method of point tourist attractiveness evaluation, statistical method, complex approach and systematic analysis. Morphological methods are used to determine the morphometric indicators of objects: the height of the rocks, waterfalls ledges, rock outcrops etc. Lithogenetic methods have been used in investigation the peculiarities of the rocks' composition and structure, their influence on the formation of typical objects' morphological features. Structural and geomorphological methods have been used to analyze the tectonic fracture of rocks and their influence on the rocks morphology and weathering.

To assess the attractiveness of geo-tourist sites different methods of foreign and domestic scientists were analyzed (Kubalíková, 2013; Rocha, 2014; Reynard, 2009b; Rybár P, 2010; Serrano, 2005; Štrba, 2014). Foreign publications on the assessment of the basic and additional values of geographic heritage much attention paid to the use of quantitative approach (point, percentage). An example of such approach is the technique of Geosite Assessment Model

(GAM) developed and tested by a number of scientists (Vujičić, 2011; Tomić, 2014). This technique consists in a point assessing of geosites (from 0 to 1) considering two criteria: basic (scientific, aesthetic and protective) and additional (functional, tourist) values.

Other assessment criteria, including criteria of internal value, criteria of potential usage and potential threat, and criteria of environmental protection, underpin the methodology of the Spanish geomorphologists V.M. Bruschi and A. Cendrero, which, in addition to the potential assessment, contained the ways of results verifying (Cendrero, 1999; Bruschi, 2005, 2009). These techniques were used by Yu. Zinko and M. Ivanyk to evaluate the geo-tourist and geo-conservation potential of the Dniester Canyon travertine rocks (Zinko, 2016).

We evaluated the tourist attractiveness of geological and geomorphological sites in the selected Beskids geo-tourist areas, taking into account most of the described methods criteria. Our research presents two aspects. One of them consist in an assessment of the existing geological and geomorphological sites attractiveness to which the tourist flows are directed. The other one is the evaluation of the area attractiveness as a tourist center. Ten indicators have been identified and criteria for their evaluation have been developed (table 1).

1. The indicator "Number of geological and geomorphological sites" reflects the number of different formations: geological (outcrops), geomorphological (rocks, peaks, caves), hydrological (lakes), complex (waterfalls) in the geo-tourist areas we have selected. We took into account both formations of different types (geological, geomorphological) and the similar (only geomorphological) ones. One deflection, a group of rocks, a single standing high rock (more than 12 m), a waterfall, and a mountain top were considered as a separate element of the population.
2. The maximum height of objects was determined by measuring with metering tapes, according to GPS data, by climbers, and sometimes by literary sources containing geodetic measurements.
3. "The picturesqueness (aesthetics, landscape) of the object" indicator (Grodzynska, 2014; Klapchuk, 2013). Our studies have taken into account the visual image of an object, its beauty, aesthetic perception, variety, contrast. We appreciated the aesthetics of space with this object.
4. The "Visibility (object as a point of view)" indicator reveals the ability to view the landscape

Table 1. Indicators of tourist attractiveness of the geological and geomorphological sites of the Ukrainian Carpathians Beskids

No	Indicators	Evaluation criteria	Points
1.	Number of geological and geomorphological sites	- large: 11 or more, - average: 6-10 objects, - small: 1-5 objects;	0.8–1 0.4–0.7 0–0.3
2.	The maximum height of objects in a group	- large: 20 m and above, - average: 10–20 m, - small: up to 10 m high;	0.8–1 0.4–0.7 0–0.3
3.	The picturesqueness (aesthetics, landscape) of the object	- high, - average, - low;	0.8–1 0.4–0.7 0–0.3
4.	Visibility (object as a point of view)	- the landscape is traced, - the landscape is closed;	0.6–1 0–0.5
5.	Accessibility (the difficulty of overcoming a route to an object)	- good, - bad;	0.6–1 0–0.5
6.	The scientific value of the object	- significant, - insignificant;	0.6–1 0–0.5
7.	The historical and cultural value of the object	- has value, - does not have;	0.6–1 0–0.5
8.	Tourist infrastructure of the area	- well developed, - average, - poorly developed;	0.8–1 0.4–0.7 0–0.3
9.	Popularity (number of internet search results)	- high (over 100,000 search results), - average (2–100 thousand), - low (less than 2 thousand);	0.8–1 0.4–0.7 0–0.3
10.	Attendance	- high (more than 700 people in one day), - average (100 to 700 people), - low (less than 100 people).	0.8–1 0.4–0.7 0–0.3

from the height of the object, the openness or closeness of the terrain for observation.

5. The “Accessibility (difficulty of overcoming a route to an object)” indicator shows the complexity of the transportation or pedestrian overcoming of the route to the object, the closeness of the object to the solid roads.
6. In determining the “Scientific and cognitive value” indicator, we took into account the multifaceted presentation of the territory’s tectonic regime, the history of relief development, sedimentation or lithological features, the ways of its shape evolution.
7. The historical and cultural value of the object was determined by its role in the history and culture of the region, by information about the historical events associated with this geological/geomorphological object.
8. The tourist infrastructure was evaluated by the number of hospitality establishments in the selected geo-tourist areas.
9. The popularity was determined by the number of web pages that covered the search results for the name of a particular attraction on the Google search engine.
10. Attendance was ascertained according to the

Tustan Historical and Cultural Reserve (for the Urytskyi geo-tourist area) and the Skole Beskydy National Park (for the Kliuch-Kamianka geo-tourist area), by the number of residents in accommodation establishments on the selected day off (for Skolivskyi and Synovydnyenskyi geo-tourist area), own field observations and student studies (Bubnyskyi, Yamelnytskyi geo-tourist area). We took into account averages of a few warm weekends of spring-summer-autumn seasons.

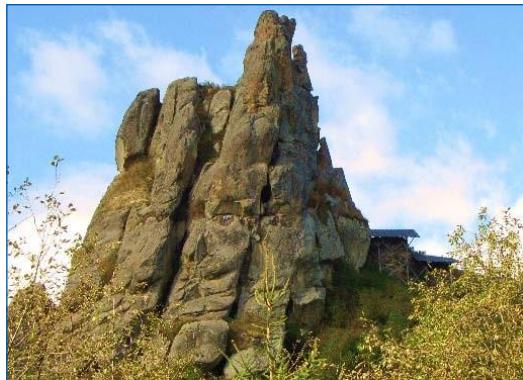
Research results. To evaluate the tourist attractions within the Beskyd region, we have identified geo-tourist areas with several geological and geomorphological sites and nearby tourist facilities. These are Urytskyi, Yamelnytskyi, Skolivskyi, Synovydnyenskyi, Kliuch-Kamianka, Bubnyskyi geo-tourist areas.

The main attraction of the *Urytskyi geo-tourist area* is the rocky outliers including three groups of rocks: Kamin (Stone) or the Tustanskyi Kamin (Tustan Stone), Hostryi Kamin (Sharp Stone), the Zholob (Gutter) and the single rocks Mala (Small) Skelia, Gulka, Krest (Cross) and Bezymianna (Nameless) (Fig. 1a). The most well-known is Tustanskyi Kamin, on which there was Detinets (ancient city-fort) of medieval fortress Tustan (IX–XVI centuries). According

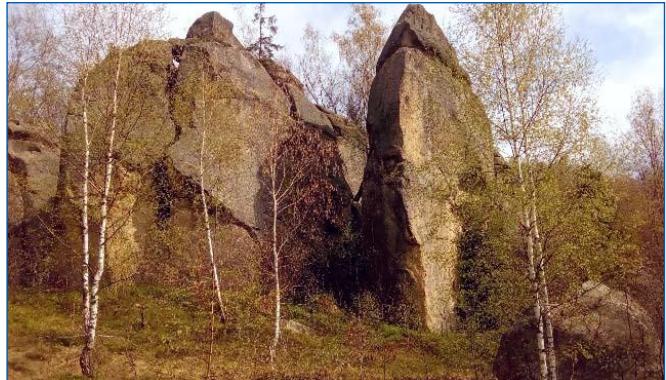
to the scheme of M. Rozko, who carried out detailed measurements and reconstruction of this fortress at the end of the twentieth century, this rock rises above the adjacent valley up to 37 m (Rozko, 1996). The rock is

mines the attractiveness of Uritski rocks for tourists.

Yamelnytskyi geo-tourist area is still poorly known among ordinary tourists. It is best known for rock climbers. The complex consists of five groups



a



b

Fig. 1. The top of the Tustanskyi Kamin rock of in Urytskyi (a) and the wall rocks-outliers in the Yamelnytskyi geo-tourist area (b)

formed by thick sandstone appearing on the upper surface in the form of the layer triangles. The thinner and longer north-eastern part of the layer is called Velyke Krylo (The Big Wing). The layer from the southwest is more powerful, up to 50 m thick, with the highest peak, and is called the Small Wing. There is a 25 m wide decrease between the Small and the Big Wings, where the Tustan Fortress was located, and the tops of the layer triangle served as its supports. The rock is surrounded by valleys on three sides, and is a dominant element of the area terrain. This rock is the most massive in the rock cluster of Urytskyi massif due to a wide wall-like base. The rocks are composed of sandstones of the Yamna's suite of the Paleocene of the Lower Paleogene age (56–66 million years) (Bayrak, 2011). They are gray, of a small and medium-grained structure, pierced with numerous lithological, tectonic and gravitational cracks. They have undergone significant anthropogenic interventions, such as carved long channels, rounded grooves and various signs on the surface, which was studied by I. Vagilevych more than 100 years ago. The grottoes, small caves also diversify the view of this massive rock. The tour lasts about 1.5 hours. Massive rock with six sharp peaks is called the Hostryi Kamin; it is up to 25 m high, located on the edge of the ridge. The other rocks of the Urytska group are not so massive. In morphology, they resemble pillars that hang above the tree crowns. There are also small objects of interest, such as the Zhertovnyk (Altar), a stone reminiscent the sacrifice table. On the western slope of the Tustanskyi Kamin is the Sviate Jerelo (Holy Spring). The unique history, the richness of surface geological and archeological signs, heterogeneous morphological structure deter-

of sandstone rocks and many single rocks – tower-shaped, pillars and cube-shaped cliffs (Mazurski, 1972; Alexandrowicz, 2008). They are formed from sandstones of the Yamna's suite. The most interesting groups are in the northern, northwestern and southeastern boundary of a village Yamelnytsia (Fig. 1b). By morphology, these are the wall-shaped rocks with flat tops that often have small cliffs, which is why these two-topped rocks are known locally as the Shy-yata. The rock walls here are not solid, but are broken by transverse cracks into high cliffs, which are connected to each other at the base. In the northern and northwestern groups the rock tops are accessible, with panoramic views of the surrounding mountain ranges and the height of the rocks is reaching 32 m. In the northwestern group, the rock wall forms a gorge, narrowing to the base of the mountain. A massive rock wall and individual rocks are located on the ridge edge of the southeastern group; their peaks accessible only with climbing equipment. They reach a height of 20 m; the view from the ridge edge is enclosed by a dense forest. The rock wall in this cluster has two through cracks, wide enough to enter and inspect its vaults from the inside and exit to the opposite side of the entrance. There are various traces of the organisms' activity during sedimentation processes on the surface of the rocks. The rocks are attractive for their massiveness, because the length of many rock walls reaches 50 m (southeast) and 100 m (north and northwest). They deeply impress travelers, exceeding their expectations.

Skolivskyi geo-tourist area. It includes the range of Parashka Mountain, the Skolivska Lowland and the Pavliv Stream valley with the adjacent Lopata

(Shovel) Peak. The Parashka Range rises above the surrounding valleys to an elevation of 1268 m and has dominant heights on the left bank of the Opir River. The slopes are steeper in the lower, longitudinal parts, in the upper ones they are sloping. Nearby the highest peak of the Parashka Mountain stand out three smaller, also conical tops: Tymkiv Verkh (1227 m), Zelena (Green) (1217 m), Obroslyi Verkh (1177 m); Korchanka (1178 m) is in a little distance as well. From the northeast side of the ridge, in the valley of the Velyka Richka (Big river) stream, 4 km from the village of Korchyn is the small waterfall Gurkal, which sprays from a ledge of three meters high, formed by massive sandstone. The absolute height of the waterfall is 570 m. In the valley of the Mala Ricka (Little River) stream, 2.5 km from the village of Korchyn the 10 meters high sandstone cliff called Turkish stone Korchinskyi is located. Rock blocks of up to 8 m and sandstone debris are also observed in the area. The Parashka Ridge is available for simple one- and two-day hikes. Its tourist attraction is clarified by the fact that the forestless tops are occupied by the subalpine meadows with the views on the Komarnytskyi ridge and the hills of the Precarpathian highlands in the north, the Kliuch mountain range and the Arshytsia ridge in the southeast, the Vododilno-Verkhovynskyi ridges of Carpathian Mountains in the south and southwest. The proximity of the settlements from which the tourist routes begin is also attractive. They are town of Skole, villages of Korchyn, Korostiv, Krushelnytsia.

the Pavliv Stream. The famous pedestrian route to Lopata Mountain (1210 m) lies through the valley. The second section of rocks is located between the town of Skole and the village of Korostiv, in the tract of Sviatoslav, where in a construction quarry a bundle of 18 m high-grade flysch formations has been uncovered. The nature and dynamics of sediment formation in the ancient Carpathians deep sea can be traced by the interlayer textures of the rocks' stratum, and the circumstances of sediment accumulation, paleoclimatic conditions can be outlined by the surface textures.

Syniovydnytskyi geo-tourist area is characterized by the number of attractive objects for geo-tourism, such as rock outcrops, rocks, modern riverbeds processes and forms. In tectonic aspect at the local level here can be distinguished the Verkhniosyniovydnynska Lowland and the Pobukska Anticline, which limits the Lowland from the east and forms a meridional low ridge. Exactly with this anticlinal are related rocks outputs of different lithological composition and age. In the northern part of the ridge, on the slope of the western exposition at an altitude of 390 m there are sandstone outcrops of the Eocene Vyhodsko's suite (average Paleogene, 34-56 million years). They are yellowish-gray in color, of horizontal occurrence, massive at the top, and thinly layered at the bottom. Sandstone outcrops are fractured by vertical and horizontal cracks into massive rectangular sections. The height of outcrops is 7 m. Two km to the south there are the rocks outcrops that form the basis of



a



b

Fig. 2. Outcrops of flisch rocks “Skolivska Skelia” (a) and forms of cellular weathering on the rocks near Sokolovets Mountain (b)

Skolivska Rock is one of an interesting geo-tourist site in the Skolivska Lowland. It consists of the outcrops of the Paleogene flysch of the Bystrytska's suite on the right bank of the Opir River (Fig. 2a), and Carpathian flint on the left one, at the bottom of the river. The height of the outcrops is 7.5 m. Springs of ferrous and hydrogen sulfide water (the spring Verkhnie (Upper)) are beaten in the valley of

the Pobukska Anticline. It is an interlayer of black mudstone with thin sandstone layers and siltstones of the Oligocene Menilite's suite. Horizontally wavy texture of the entire thickness is clearly visible. There is a black mudstone scale basin in the lower part. This outcrop was extracted in the twentieth century as an oil shale deposit. Its height is about 25 m. It is located on the right bank of the Opir River, and on

the left, on the floodplain of the river, between the river pebbles can be seen the exits of the Carpathian flint (hornfels). Their layers up to 0.5 m thick lie at an angle to the surface of the floodplain and have whitish and black colors. The flints mark the sole of the Nyzhniomenilite's suite.

The rocks in the Syniovydnenskyi geo-tourist area are low and therefore poorly known. There are several groups of rocks far apart from each other. The first group is located in front of the village of Verkhnie Syniovydne, on the east wing of the Pobuk anticlinal fold. They were named Kniazhi (Prince) Rocks near the village of Tyshivnytsia as they are closest to this village. These are three rocks: Knyazha (Prince), Yaroslavna and Khanska (Khan), which rise to the height of 15-18 m above the Stryi River. According morphology these rocks resemble pyramids, located at the base of the ridge. The peaks are accessible, with a view of the Stryi River valley, the Komarnytskyi ridge, the confluence of the rivers Stryi and Opir. They have a story related to the battle of the Russian prince with the Tatars.

Other rocks clusters are located on the southern slopes of Komarnytskyi ridge, which extends from the village of Nyzhnie Syniovydne to the village of Yamelnytsia. Many rocks are observed near Sokolovets Mountain, where there are three groups of them - southeast, northwest and northeast (Bayrak, 2012). They form the walls at different absolute heights. Their length is up to 100 m. The rocks 12–23 m high do not rise above the forest cover, and, therefore, they are not very attractive to tourists, since the overview of them is insignificant. Only from one point of the southeast group of rocks the Syniovydne hollow and the ridge of the Pobukska Anticline are visible. One edge of the rock bursts down to the beams where they form upright walls. Tops are available. On the surface of some rocks there are unique forms of cellular weathering, which are the largest of all the Beskid rocks forms (Fig. 2 b). Another group of rocks on Komarnytskyi Ridge is located near the village of Pozhernytsia. These rocks are also hidden in the forest, low, so poorly known among tourists. Predominant Tower-shaped and cube-shaped rocks are prevailed.

An interesting geomorphological object in the Syniovydnenskyi tourist area is the riverbeds of Stryi and Opir and the place of confluence of the rivers. From the bridges across these rivers the nature of riverbeds processes can be observed, especially, the intense lateral erosion with coastal destruction; the deep erosion manifested in the formation of funnels, molds and rolling; bifurcation, bedding and their causes; the nature of sediment formation and the

accumulation of material in the form of riverbed alluvium on the sides, islands and reaches, its size and the nature of the occurrence. More active, with interesting fluvial forms, is the riverbed of the Opir River.

Kliuch-Kamianka geo-tourist area. All the geological and geomorphological sites of the area are connected with the massive sandstone outcrops of the Yamna's suite; they reach the largest width here - 2.2 km, compared to other areas where their width is 200-700 m. The most popular natural site is the waterfall on Kamianka River. It is located on a steep turn of the river bed, 6.5 m high and thus slightly higher than the Gorkalo waterfall near Korchyn. It is more powerful, has three streams and several times wider. Waterfall streams beat sandstone cliffs jutting out from under the water and this fact grounds the total beauty of the waterfall. 500 m above it, on a river section of 250 m in length, there is a cascade of small waterfalls-rapids up to 2 m in height, and the vertical ten-meter wall of massive sandstone outcrops near them gave the name to this section – Kamianka River Gorge.

The unique attraction of the area is the deep precipices formed by the steep walls of the sandstone outcrops, located on the outskirts of the Kliuch Range. Tourists named them "canyons". One of these "canyons" is located to the west and the other to the southeast of the main peak of Kliuch Mountain (929.7 m). These precipitates are of complex tectonic-gravity and tectonic-erosion origin. The primary was the splitting of sandstone into blocks as a result of the tectonic activities in the Carpathians, and the second was the widening of cracks by gravitational subsidence and deepening by erosion processes. The morphometric parameters of the precipices are different. Thus, in the western part the length is 10 m, the depth is 5 m, the width is 2.5 m, and in the southeast - the length is 100 m, the depth is 25 m, the width is 5 m. The surface of the walls is flat, without any signs or indentations. The access to the surface of the sandstones, which are strongly divided by the cracks into separate parts, is connected with the entrances to the vertical caves, formed by the expansion of the sandstone cracks (Fig. 3 a). These caves are the largest among the sandstone caves in Ukraine. They are not well explored, reach a considerable depth (up to 50 m), without equipment descent in them is dangerous. On the Kliuch Range are the large scattering of small sandstone cliffs and rocks-outliers. Despite the fact that thousands of tourists come to the waterfall, there are almost no guided tours to the nearby rocks, which are within hour's reach, the path to them is practically unknown. The reason may be that the



Fig. 3. Entrance to one of the vertical sandstone caves on Kliuch Mountain (a) and Bukovetski skladky outcrops (b)

rocks are low; the surrounding area is not visible from them. However, they are unique, have exceptional morphological outlines. Their largest group is located west of Kliuch Mountain. Remarkable single rocks are located here: unique the Sokil (Falcon) 6 m high and the Arka (Arch) (3 m), the rock-cracks with blocks of settling, the cube-shaped rocks and the accumulation of erosion-denudation rocks-outliers. The various forms of rocks can be explained by the heterogeneous structure of the sandstones the rocks are composed from, and by the uneven weathering of their fine-, medium- and large-grained layers. Clusters of rocks contain from 3-4 to 10 units. The largest cluster the tourists used to name the Easter Island or the Ihroteka. These rocks are the highest, 8 m high. They are located in a semicircle, with a deep niche in the center, and exit to the opposite side of the cluster. In general, the rocks are spread over an area of about 0.4 km². On the lower slopes of the southern exposition a hydrological site – Zhuravlyne (Cranes) or Mertve (Dead) Lake – is located; it is surrounded by steep slopes of the mountain, which gives it a special attractiveness.

Bubnyskyi geo-tourist area has a great variety of geo-tourist sites. Here are the highest in the Beskids Dovbush rocks, a unique outcrop of flysch rocks “Bukovetski skladky (folds)” and the cascade of waterfalls on the Sukil River. There are rocks of various morphological types: tower-shaped, spire-shaped, cube-shaped rocks, plateau-like clusters of rocks and rocky valley (Mazurski, 1972; Alexandrowicz, 2008). Such diversity is associated with the selective erosion of rocks along cracks in different directions, weathering and turning Yamna’s sandstone surface of heterogeneous structure by wind, rain, and snow. The height of the tallest Bronenosets (Battleship) rock is over 35 m, and it is shaped like a sail. On the tower-shaped Bezimenna (Nameless) Rock, there is a round cuboid cliff, resembling the head on the

shoulders of the giant. Another spire-shaped rock is named “Tiulpan (Tulip) by a peak similar to this flower. The plateau-like cluster of the rocks known as Main Massif is strongly dismembered by longitudinal tectonic cracks into columnar poles that cause the ribbed surface of the massif. Man-made caves are carved into it and there are narrow aisles that a person can enter. The peak is accessible, offering views of the Kliuch Mountain, the Parashka Mountain and the Bezimenna Rock, the Bronenosets rising above the forest cover, and the rocky valley. In total, there are a dozen single high rocks (20–35 m), a dozen small rocks (6–15 m) and rock scattering (Sluckij, 1984). The rocky valley at the top enters the main massif, where it has a gorge-like shape, and below the stream there are separated rocky cliffs, the height of which gradually decreases, passing into scattering of stones. On the surface of the rocks, in shaded spaces, there are areas with small forms of cellular weathering. Rocks are used for rock climbing, which is very popular here for beginners as well as for staggers.

The Bukovetski skladky outcrops is located 4.3 km southwest of the turn from the main road to Bubnytski Rocks, upstream of the Sukil River. They are presented by the flysch of the Late Cretaceous Stryi’s suite (Fig. 3 b). These are the original anticlinal and synclinal folds of the flysch rocks that are torn apart by the outcrops. Up to eight anticlinal folds are disclosed. The height of the exposure is 10 m. Both coarse- and medium-layered strata and thin strata are observed; they indicate the tectonic regime of the territory unevenness during sedimentation. The outcrops illustrate the folded structure of the Carpathian mountain system, formed as a result of tectonic crags caused the rocks to deform into folds. At a distance of 300 m from these outcrops, upstream of the Sukil River, an interesting incision of flysch rocks underlying monoclinic at an angle of 30° can be observed. Below the thicker one there is the

flexure revealed by the river. The height of exposure is 2 m.

Another geo-tourist site of the area is the cascade of waterfalls (rapids) and the scattering of rocks near the village of Kozakivka on the Sukil River. The height of the rapids is up to 2 m. Each side of the riverbed has the largest sandstone block of 3 m high. Rounded recesses called glitomorphosis can be found on the surface of the sandstone. The Sukel River valley is widening in this place, the slopes become flat, there are deep springs in the river, so this area has become a tourist destination.

Beskids of the Ukrainian Carpathians is a region where the tourism infrastructure is unevenly developed. In one place there are a large number of different type's establishments: tourist bases, hotel and restaurant complexes, estates and cottages of green tourism. Most accommodation facilities are located in the town of Skole. Private estates and tourist bases operate in the villages of V. Syniovydne, Dubyna, Korostiv, Korchyn. Other places close to geo-attractions have poorly developed tourism infrastructure. These are Urych, Yamelnytsia, Krushelnytsia, N. Syniovydne, Mezhybrody, Trukhaniv.

Based on the conducted studies, the attractiveness of the selected geo-tourist areas of the Beskids was evaluated (Table 2). The closer the indicator to 10 points is, the higher is the area's attractiveness.

The most attractive for the development of geo-tourism in Beskydy is the *Urytskyi geo-tourist area*, which has an overall attractiveness of 8.4 points. There are rock groups, individual rocks, and springs in its territory. Two rocks are over 20 m high, with a view of the surrounding countryside, the rest ones are smaller. The rocks are complex-shaped, with sharp, peaks surrounded by forest, and towered above the valley creating a highly aesthetic landscape. They are

located close to paved roads, so are well accessible. The scientific and cognitive value of them is determined by the fact that the shape and micro relief of the rock formations' surface reflect their evolution (destruction) under the influence of various types of weathering. They are of high historical and cultural value, since here in IX-XVI there was an ancient Russian fortress Tustan. The tourist infrastructure is poorly developed, with only three lodging estates, but the neighboring resort village of Skhidnytsia provides the accommodation and meals' needs of tourists. Souvenirs and local products are usually sold around the rocks, as well as seasonal food stocks are available. The area is very popular among various tourist groups. Sites are well known to Internet users, and they generate more than 160.000 search results. Attendance, according to the Tustan Historical and Cultural Reserve, averages from 332 to 1085 people per day during the high and medium seasons (not including the number of visitors during the festival).

Bubnyskyi geo-tourist area has a high level of attractiveness (7.2 points). There are the largest amounts of rocks here, some of them have the highest altitude and picturesqueness among all the Beskid rocks. The rocks of the area offer beautiful views of the surrounding countryside. The geological outcrops of the Bukovetski skladky, which illustrates the folded structure of the Carpathians, is of scientific and cognitive value. The Bubnyski rocks are of historical and cultural value due to the movement of the Dovbush opryshkas (mountain outlaws). All objects are away from paved roads. There is practically no tourist infrastructure, the area is of second-rate popularity (the number of search results is more than 9 thousand). Attendance was higher in the last seven to ten years (more than 1 thousand people), and since 2016 the number has fallen to an average of 300

Table 2. Assessment of geo-tourist areas' attractiveness of Beskids (in points)

The name of the area	Number of geo-attractions	Maximal heights	Picturesqueness of objects	Visibility from the object	Object accessibility	Scientific and educational value	Historical and cultural value	Tourist infrastructure	Popularity	Attendance	The overall
Urytskyi	0.6	0.9	1	0.8	1	0.9	1	0.4	0.8	1	8.4
Bubnyskyi	1	1	0.9	0.6	0.4	0.9	0.7	0.3	0.7	0.7	7.2
Kliuch-Kamianka	1	0.3	0.9	0	0.7	0.6	0.7	0.7	1	1	6.9
Skolivskyi	0.4	0.7	0.7	1	0.6	0.2	0.4	1	0.8	0.8	6.6
Syniovydnenskyi	0.5	0.8	0.6	0.5	0.7	0.6	0.1	0.9	0.3	0.6	5.6
Yamelnytskyi	1	0.8	0.6	0.3	0.3	0.3	0	0	0.6	0.1	4.0

people at the weekend during medium season and 500-700 people during high season.

Kliuch-Kamianka geo-tourist area is also quite attractive to tourists with a total potential of 6.9 points. There is the largest number of sites of different type: rocks, gorges, caves, waterfall, and lake. Geological and geomorphological sites have small, with closed views on landscapes. The facilities are accessible to people of average physical condition, with the exception of the waterfall, which is located near the paved road and is accessible to persons in any physical form. The valleys formed as a result of tectonic rock splits and the development of erosion and gravitational processes along them are of scientific and cognitive value. The rocks with unique shapes, the waterfall on the Kamianka River and the Zhuravlyne Lake, are of great landscape value and particular beauty. Kliuch Mountain is of historical and cultural significance because it is related to the activities of Sich Riflemen, as evidenced by the established monument in their honor. The tourist infrastructure is represented by a camp site by the village of Dubyna, four private peasant estates, as well as trade booths and food establishments. The area is known by tourists, the number of search results for the word combination "Kliuch Mountain" is 6.8 million, while for the "waterfall on the river Kamianka" is about 50 thousand. Thus, according to the Skole Beskydy NPP, for Kamianka waterfall, in particular, it ranges from 343 to 1236 people for one day off during the warm season.

The attractiveness of *Skolivskyi geo-tourism* area is estimated at 6.6 points. There are seven geo-attractions in the area: two peaks, on which tourists ascend, a small waterfall, a rocky cliff, two outcrops, springs. To compare the results with other objects, the maximum heights of the rocks were and the heights of the peaks were not taken into account. The Parashkivskyi Range is characterized by high picturesqueness; it opens panoramas over all geographical directions, what is greatly exiting for tourists. Other attractions have the mediocre aesthetic qualities. The objects are accessible for motorcycle and pedestrian trips; one should get there by ground roads and trails, except for the sites in Skole itself. The events on Mountain Lopata, where in July 1944 the Ukrainian Insurgent Army' soldiers fought with the German-Hungarian troops, have historical and cultural significance. Other values are not directly related to geo-tourist sites: they are Skolivschyna Historical and Local History Museum in Skole and a wooden church built in 1597; near the village of Korchyn Ukrainian Insurgent Army' shelters are known. The tourist infrastructure is well

developed: in the town of Skole, the villages of Korchyn and Korostiv there are farmhouses and cottages of rural tourism, catering and entertainment facilities, and in Skole there is a campsite "Hutsulshchyna" (more than 45 in total). The number of Internet search results is also high – more than 400 thousand for the word combination "Mountain Lopata" and 140 thousand for the word "Parashka". Other properties in the area are less well known online. Attendance statistics only indirectly indicate the attractiveness of the area, as it takes into account the number of visitors to accommodation facilities in Skole and Korostiv, with more than 730 people on an average day off. However, there are still amateur groups of tourists who climb Parashka Mountain or Lopata Mountain and are hypothetically taken into account in these statistics.

According to our research, the *Syniovydnenskyi geo-tourist area* is moderately attractive (5.6 points). There are eight geo-attractions (five rock clusters, two outcrops, a river mouth). Rocks and outcrops are average in height, the aesthetics of the space with these objects are lower than in the neighboring areas. You can climb the rocks and the ridge where the outcrops are. An overview of the landscapes is available from the peak of the Tyshivnytsa ridge and rocks, overlooking the Verkhniosyniovydnenksa valley, the Komarnytskyi ridge, the Parashka Mountain, and the Stryi valley. Access to geo-attractions is different: three of them are in close proximity to the paved road (Tyshivnytsya rocks, sandstone outcrops, river confluence), the others need to be accessed by ground roads and trails. The outcrops is of a scientific and cognitive value as they reveal the geological structure of the Carpathians; the largest in the Beskids form of rock surface cellular weathering near Sokolivets Mountain is of a great interest as well. Geo-attractions don't have any historical or cultural values, except an eighteenth-century wooden church in the village of Verkhnie Syniovydne is with its own history. The tourist infrastructure is well developed: at the foot of the Komarnytskyi ridge, on the way to the rocks of Sokolovets Mountain and Pozhernytsia Mountain there is a complex of tourist departmental and private bases; at the outcrops of the menilite shales is a geological research and educational station of the Lviv Ivan Franko National University partly accepting tourists; five rural estates and a hotel and restaurant complex in the village of Verkhnie Syniovydne. The area is popular among tourists for one-day amateur trips and as a transit area for more famous geo-attractions. The number of Internet searches results of separate objects is up to 2 thousand. Attendance can also be determined indirectly, by the number of nights

spent in accommodation establishments. It is 100-300 people in the warm season.

Yamelnytskyi geo-tourist area received 4.0 points for its attractiveness. There are many similar geo-tourist sites here like individual rocks and rock clusters more than 20 m high. Some rock peaks are accessible; they open views to unknown surrounding peaks. Rocks clusters in the north of the Jamelnytsia village form picturesque landscapes on the backdrop of wooded ridges, but most of the rocks are closed off from an observer with a forest cover. The rocks are away from the hard-paved roads, scattered on the terrain, so their accessibility is low. The fracture of rocks composed of cliffs and various sedimentary marks on the sandstone surface, is of scientific and cognitive value. The historical and cultural value is evident in the construction of the structures near the rocks of the cover of the UPA soldiers, a wooden church in the village of Yamelnytsia in 1829. Historical and cultural value lies in the presence of UPA soldiers shelters near the rocks, and a wooden church in the village of Yamelnytsia built in 1829. The tourism infrastructure is underdeveloped and only the Gotar campsite is located at the entrance to the village. The number of search results on the Internet system exceeds 20.000. The largest rocks are known for climbers, who organize groups of up to two dozen people here on certain weekends.

In above mentioned geo-tourist areas tourist companies, departments of local state administrations, local forestry propose routes of various kinds, duration and complexity including the described geo-attractions (Fig. 4).

The hiking routes are as follows: 1) village of Korchyn - Gurkalo waterfall - Parashka Mountain - town of Skole; 2) Bubnyski Rocks - village of Trukhaniv (and vice versa - village of Trukhaniv - Bubnyski Rocks); 3) Bubnyski Rocks - Kamianka Waterfall (Kamianka Waterfall - Bubnyski Rocks); 4) village of Trukhaniv - a monument to Sich Riflemen on Kliuch Mountain - Kamianka Waterfall; 5) the town of Skole - Lopata Mountain - the town of Skole.

Popular bus routes: 1) city of Lviv – town of Stryi - Rozgirche rock and cave complex; 2) city of Lviv – town of Truskavets - Urytski rocks; 3) town of Truskavets - Kamianka Falls - town of Skole.

Motor and cycle routes: 1) town of Skole - Kamianka Falls - Bubnyski rocks - village of Trukhaniv - village of N. Siniovydne; 2) town of Skole - Kliuch Mountain - Bubnyski Rocks - town of Bolekhiv - town of Stryi; 3) village of N. Siniovydne - Urytski rocks; 4) Parashka Mountain - Urytski rocks.

Ecological and educational trails: Buchyna, Lopata, Waterfall (Turystychni...).

The geo-geomorphological attractions described in geo-tourist areas of Beskids may be sites of interest in the proposed tourist routes.

Suggested hiking routes (see Figure 4):

- 1) Yamelnytski Rocks – Komarnytskyi Range, rocks under the Pozhernytsia Mountain and Sokolivets Mountain – geological research and educational station village of V. Syniovydne (outcrops of oil shale) (3 days);
- 2) Rozgirche rock and cave complex – Tyshivnytsia Rocks – Bubnyski Rocks – Bukovetski Skladky – Sukil Waterfall (3 days);
- 3) Rozgirche rock and cave complex – Komarnytskyi Range, rocks under the Sokolivets Mountain – Tyshivnytsia Rocks (1 day);
- 4) Kamianka Waterfall – Kamianka River Gorge – Gorge (Canyon) on Kliuch Range – Pasky, Ark and Sokil Rocks on Kliuch Range – Zhuravlyne Lake (6 hours);
- 5) sandstone outcrops by village of V. Syniovydne – Gorge (Canyon) on Kliuch Range – a monument to Sich Riflemen on Kliuch Mountain – village of Trukhaniv – Tyshivnytsia Rocks (2 days);
- 6) waterfall and gorge on Kamianka River – Gorge (Canyon) on Kliuch Range – a monument to Sich Riflemen on Kliuch Mountain – village of Trukhaniv – Tyshivnytsia Rocks (2 days);
- 7) town of Skole – the Pavliv stream valley with ferrous and sulfur springs – Lopata Mountain – village of Kozakivka – rapids and waterfall on Sukil River – Bukovetski Skladky – Bubnyski Rocks (3 days);
- 8) town of Skole – the Pavliv stream valley with ferrous and sulfur springs – Lopata Mountain – outcrops (quarry) of flysch rocks by village of Korostiv – Parashka Mountain – town of Skole (1 day);
- 9) Parashka Mountain – Gurkalo waterfall – Turkish Stone Korchynskyi (1 day);
- 10) didactic trail in Skole Beskydy National Park (1 day).

Suggested bus routes:

- 1) Yamelnytsia (Bychkov tract, 17th century Orthodox church with ancient cemetery) – Urych – Skhidnytsia (mineral water springs such as Naftusia, Borjomi) (1–2 days);
- 2) city of Lviv – Bubnyski Rocks – Bukovetski Skladky – rapids and waterfall on Sukil River – town of Morshyn (2 days);

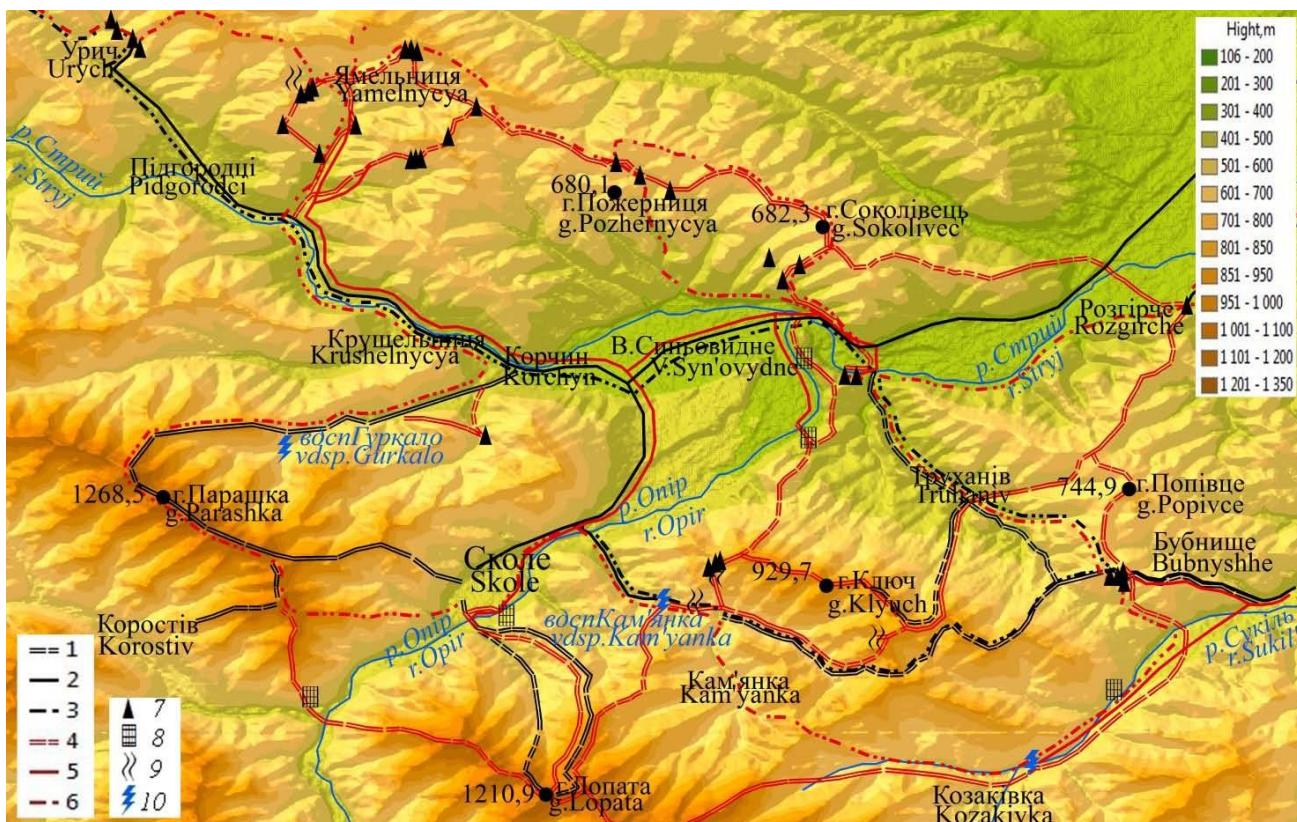


Fig. 4. Geological-geomorphological sites and geo-tourist routes of the Ukrainian Carpathians' Beskids.

Legend. Valid tourist routes: 1 - pedestrian, 2 - bus, 3 - bicycle; Suggested tourist routes: 4 - pedestrian, 5 - bus, 6 - motor-bike. 7 - rocks, 8 - outcrops, 9 - gorges, 10 - waterfalls.

- 3) city of Lviv – Tyshivnytsia Rocks – sandstone outcrops and oil shale by village of V. Syniovydne – Yamelnytski Rocks (Bychkov tract) – town of Skole (riverbed processes on the Opir River and Skolivska Rock) (2 days).

Suggested motorcycle and bicycle routes:

- 1) town of Truskavets – Urytski rocks – Yamelnytski Rocks – waterfall in the village of Korchyn – Parashka Mountain – relay on the nameless top – town of Skole (2 days);
- 2) town of Skole – Kamianka Falls – village of Kozakivka, rapids and waterfall on Sukil River – Bukovetski Skladky – Bubnyski Rocks – village of Trukhaniv – Tyshivnytsia Rocks – village of V. Syniovydne (2 days);
- 3) town of Stryj – Rozgirche rock and cave complex – Tyshivnytsia Rocks – village of Trukhaniv – Bubnyski Rocks (1–2 days);
- 4) village of V. Syniovydne – rocks under the Sokolivets Mountain – rocks under the Pozhernytsia Mountain – Yamelnytski Rocks (Matkhov, Danylov, Bychkov tracts) – Urytski rocks – town of Skhidnytsia – town of Truskavets or Yamelnytski Rocks – village of Oriw – town of Truskavets (2 days).

Duration of trip and load on routes are individually designated according to the age, physical conditions, technical ability and wishes of the tourists.

Conclusions. In recent years, the interest of national and foreign tourists to the inanimate nature sites has increased. The Ukrainian Carpathians Beskids accounts a large number of such objects: rocks, outcrops, caves, waterfalls. Most of them have scientific, educational, historical, cultural, landscape, and aesthetic value, so they are promising for geo-tourist trips.

An assessment of the geological and geomorphological sites' attractiveness of the selected tourist areas showed that the higher scores belong to the areas with the high morphological diverse of the objects, with significant morphometric indicators, high landscape value, geological representativeness of the Carpathian structure, with different sedimentation and solar signs on the rock surface. The popularity of the objects in the search results is high, but the tourist infrastructure of the areas is underdeveloped. The attendance of the particular areas is low owing to poor road conditions. A number of hiking trails are laid out in the area researched, but they do not fully cover the area's geo-tourist attractions. That is why we have proposed new pedestrian, auto, motorcycle

and bicycle routes, which will help to increase the Beskids' traffic, promote the development of tourist infrastructure and increase the image of geo-tourism.

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