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Rocky forms in the Yamna Sandstone (Skyba Nappe, Outer Carpathians, Ukraine)

Formy skałkowe z piaskowca jamneńskiego (płaszczowina skibowa, Karpaty Zewnętrzne, Ukraina)

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Abstract: *Interesting objects – the rocky forms and waterfall thresholds, built of Yamna Sandstone occur in the vicinity of Skole town. Beside the esthetic positive aspects related the morphological variety of the rocky forms and occurrence of the diversified weathering structures, the objects have a substantial cognitive value encompassing the lithology and sedimentological processes of the thick-bedded turbidites. The sandstone rocky forms usually occur in the groups distributed on slopes and forming so-called rocky towns. Their number and distribution allow observation of the changing structural and textural features both lateral and vertical within the 100-m thick composed profiles. The excellent degree of rocks outcropping, variety of structural and textural features and spectrum of possible observations indicates the high geotouristic potential of the investigated objects.*

Key words: *sandstone rocky forms, tors, Eastern Outer Carpathians, Yamna Sandstone, Skyba Nappe, thick-bedded sandstone complex, geotourism*

Treść: *W okolicy miasta Skole, w obrębie wychodni piaskowca jamneńskiego występują interesujące obiekty geoturystyczne, do których należą piaskowcowe formy skałkowe i progi wodospadowe. Oprócz wysokich walorów estetycznych, związanych z urozmaiceniem morfologicznym terenu i różnorodnością poszczególnych skałek oraz struktur wietrzeniowych, obiekty te mają istotną wartość poznawczą w zakresie wykształcenia litologicznego oraz procesów sedymentacyjnych gruboławicowych turbidytów. Skałki piaskowcowe zwykle występują w grupach rozmieszczonych na stokach, tworząc miasta skalne. Taka liczebność oraz położenie daje możliwości obserwacji zmienności cech tekstualnych i strukturalnych, zarówno lateralnie, jak i wertykalnie, w obrębie ponad stumetrowych złożonych profili. Znakomity stopień odsłonięcia oraz różnorodność form strukturalnych i tekstualnych oraz spektrum możliwych obserwacji wskazuje na wysoki potencjał geoturystyczny.*

Słowa kluczowe: *piaskowcowe formy skałkowe, wschodnie Karpaty Zewnętrzne, piaskowiec jamneński, płaszczowina skibowa (skolska), kompleks piaskowców gruboławicowych, geoturystyka*

Introduction

The sandstone rocky forms (tors) constitute one of the main geomorphological objects categories, which activate interest among tourists. Their high esthetic positive aspects and individual morphological diversification represent attributes influencing their attractiveness. They enhance attractiveness of landscape, constitute nature phenomena on local and regional scale and, represent advantageous substantial cognitive value that influence their high geotouristic potential.

The Outer Carpathians lithological inventory includes above all the turbiditic deposits displaying diversified bedding. The larger rocky forms originated within the sequences built of thick- and very thick-bedded sandstones. Their occurrence is known from the various tectonic-facies units of the Outer Carpathians (e.g. Vyalov, 1961, Guidebook, 1977; Alexandrowicz, 1970, 1978, 1977, 2006, 2008; Alexandrowicz & Poprawa, 2000; Bąk *et al*., 2006; Bezvynniy *et al*., 2006; Słomka *et al*., 2013, Stadnik & Waśkowska, 2015; Strzeboński, 2009 and references therein). The diversity and number of the rocky objects is relatively high but they are irregularly distributed. They are mainly small objects, singular or a few in the group. In turn, the occurrence of the large sandstone rocky forms group, so-called "rocky towns" is rather rare. The best known groups are Ciężkowice Rocky Town, Prządki near Krosno and Devil Rocks in Bukowiec. All above mentioned groups of tors are built of the Ciężkowice Sandstone (Ciężkowice Formation) of the Silesian Nappe. Further eastward, within the Ukrainian territory, similar objects originate in the Yamna and Vyhoda formations, belonging to the Skyba Nappe (Skole Nappe in Polish nomenclature) and Boryslav-Pokuttia Nappe (Bezvynniy *et al*., 2006; Bubniak & Solecki, 2013). In Pokuttia-Bukovyna Beskydy the Pysanyi Kamin located on the water dividing ridge at the altitude of 1000 m a.s.l. in vicinity of Bukovets town is known (Wdowiarz, 1947), while in Skolivski Beskydy the Bubnyshche and Urych Rocks representing "rocky towns" and a waterfall on the Kamianka River belong to the best known sandstone objects (Fig. 1, 2). Their popularity is primarily caused by the accessibility for tourists and the ancient history associated with them. These sites are under legal protection being the parts of the nature reserves: Kamianka Waterfall and Urych Rocks are located in the National Park "Skolivski Beskydy", Bubnyshche Rocks – in the Polianytskyi Regional Landscape Park. In Skolivski Beskydy, there are also several attractive, but less accessible rocky areas: Kniazhi Skeli nearby Tyshivnytsia, rocky complex in Yamelnytsia, tors in vicinity of Korchyn, the cave monastery near Rozhirche, and the ridge of Kliuch Mountain.

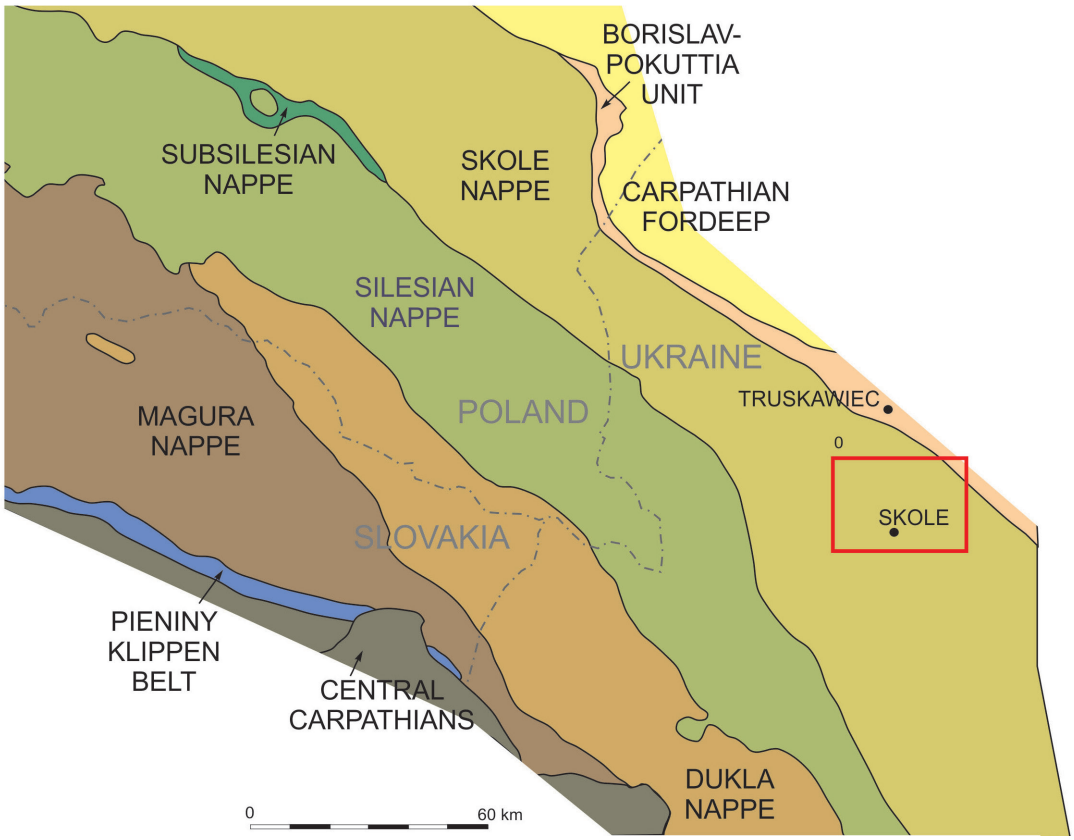

Fig. 1. Location of the study area on the general geological sketch-map in the Polish-Ukrainian border zone (map after Jankowski *et al*., 2004, modified)

The turning attention to these rocky objects and estimation of the selected sandstone rocky form groups constitutes the main goals of this paper.

Study area

The groups of sandstone rocky forms are located in the part of Eastern Beskydy that is called the Skolivski Beskydy. They are located in the basins of Stryi and Opir rivers within Lviv and partly Ivano-Frankivsk regions. Skole, the city that gave the name to these mountains, is located approximately in their center (Fig. 1, 2). The relief of Skolivski Beskydy reflects the sliced structure of the Skyba Nappe composed of Cretaceous–Paleogene flysch sediments, which consists of a range of ridges, following the general Carpathian strike, with gentle southwestern and steep northeastern slopes. Usually the ranges have wide gentle ridges, the tops are rounded and the slopes are flat and gentle. The highest top is Mount Mahura (1362,7 m a.s.l.), the other tops are: Parashka (1268,5 m a.s.l.), Vysokyi Verkh (1242,0 m a.s.l.), Vidnoha (1132,0 m a.s.l.) etc.

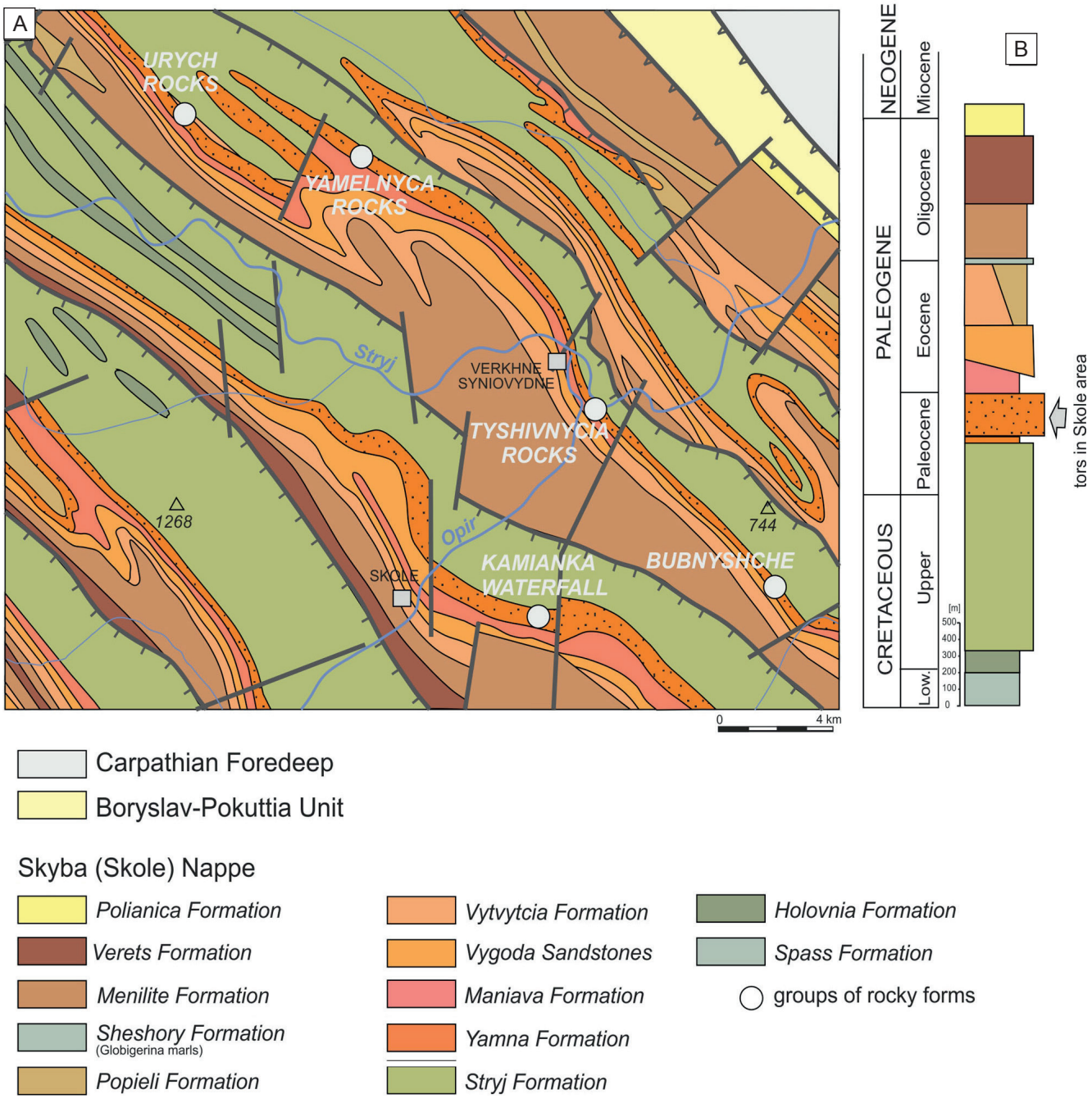

Fig. 2. Geological map of the study area (A) with position the sandy rocky forms on the lithological log (B) (map after Jankowski *et al.*, 2004, modified)

Outline of geology

The sandy rocky forms within the Skolivski Beskydy are located in the Eastern Outer Carpathians which were built from the deep marine sediments deposited from Jurassic up to Miocene times within Tethys Ocean (e.g. Golonka *et al*., 2013; Picha & Golonka, 2006; Słomka *et al*., 2013; Senkovskyi et al., 2018 and references therein). This mountain range is a result of Alpine orogeny movements, which took place during Miocene times. The Tethys Ocean sediments were folded, uplifted and arranged in the imbricated thrusts (nappes) that constitute the main Eastern Outer Carpathian structural units. The Skyba Nappe (Skole Nappe in Poland) belongs to these units (Fig. 1). It stretches from vicinity of Tarnów in Poland through Ukraine to Romania, were it is distinguished as Tarcau Nappe (Hnylko, 2017; Nakapelyukh *et al*., 2018; Matenco *et al*., 2010; Picha & Golonka, 2006, and references therein). The Skyba Nappe constitutes the most external Carpathian unit and represents the near-coast sedimentary area. It display characteristic imbricated structure, and is built of several thrust-sheets ("skybas") thrust over each other. This structure is reflected in the unit's name. The sandstone rocky forms are located in the rocks belonging to the Skyba Nappe in the Skole town area (Fig. 2). The groups of rocky forms belonging to the Urych, Yamelnytsia, Tyshivnytsia and Bubnyshche objects are located in the outermost part of the Oriv Skyba while the Kamianka waterfall belong to the next, so called the Skole Skyba (Fig. 2).

The continuous sequence from the Lower Cretaceous up to Lower Miocene deposits occurs in the Skyba Nappe lithological profile (Fig. 2). The Yamna Formation is distinguished in the Middle–Upper Paleocene interval (Vyalov *et al*., 1988) and is composed by Yaremche Beds and Yamna Sandstone. The Middle Paleocene Yaremche Beds are built by the variegated shales and have variable thickness from 10 m up to 70 m. Yamna Sandstones were distinguished by Paul & Tietze (1877). The thick-bedded and very thick-bedded complexes of sandstones are typical for them (Paul & Tietze, 1877). The sandstone complexes are made up of the fine- up to coarse-grained sandstones, gravelites, conglomeratic sandstones and fine conglomerates (Vyalov, 1961; Vyalov *et al*., 1988). Gravelits are mainly composed of rounded quartz grains and fragments of metamorphic rocks, while sandstones are made up by grains of quartz, feldspars, zirconium, ore minerals, and fragments of metamorphic rocks (Senkovskyi *et al.*, 2018). Sandy concretions especially well separated as a result of weathering sometimes occur in Yamna Sandstone (Gavryshkiv & Zhuvasv, 2009). The layers reach up to 5 m in thickness, while the thin interbeddings of thin- and medium bedded turbidites or shales, playing secondary role, are observed locally (Wdowiarz, 1947). The total thickness of the Yamna Sandstone is estimated as 70–80 m up to 340–360 m (Vyalov *et al*., 1988). The *locus typicus* for the Yamna Sandstone is located along the Prut River near both Yamna village and Yaremche town of the Ivano-Frankivsk region (Paul and Tietze 1877, Vyalov *et al*., 1988). The Paleocene age was indicated by micropaleontological dating and superposition above – and underlying strata (Vyalov *et al*., 1988 and references therein). The age younger than Danian (Mid–Late Paleocene) was estimated by Myatlyuk (1970 and references therein). The Yamna Formation is overlying the Cretaceous–Lower Paleocene Stryi Formation consisting of medium- and thick bedded sandy-shaly turbidities. The variegated shales with thin-bedded turbidites of the Maniava Formation (Lower Eocene) are higher up the Yamna Formation (Vyalov *et al*., 1981, 1988 and references therein).

Rocky forms' geotouristic objects

Numerous surface outcrops of Yamna Sandstone are located in the vicinity of Skole town in Ukraine (Fig. 2). These outcrops are diversified according to geomorphological forms. The sandstone rocky forms developed in the outcrop areas while waterfall thresholds developed in some streams. They constitute on one hand characteristic landscape element of this part of the Carpathians and on other hand the precious geotouristic objects, which values were already noticed. The Bubnyshche, Kamianka Waterfall and Urych Rocks (known as the Tustan Fortress) belong to the objects that enjoy the largest interest and are properly developed according to the touristic usefulness.

Bubnyshche, known as Dovbush Rocks or Bubnyshche Fortress is the area, were the gathering of diversified rocky forms occur. They maximal height exceeds 45 m (the Battleship Rock). They cover around 0,34 km^2 area on the top of the southern slope of the Sokolova Mount (685,0 m a.s.l.). This is the watershed range between the Opir and Sukil rivers. The biggest objects and/or their internal elements have individual names (Fig. 3) mostly referring to general shape of rocky forms or to caves occurring within them. All names were given by rock climbers, who commonly use these forms to practice sports.

In Bubnyshche, isolated rocky forms as well as large rocky groups occur. They display strongly diversified morphology and dimensions being developed within the individual chunky cores. The relatively consistent rocky complex, over 40 m high, known as the Main Massif constitutes the largest Bubnyshche object. It is located on the eastern side of the area and contains a few large sandstone groups of rocky forms (Fig. 3) separated by narrow passageways, originated as a result of tectonic joint fissures. On the southern side, the Main Massif has an arrangement of a horseshoe open southward and surrounding the so-called plaza, the hollow filled with residual sand. This place was inhabited by humans, who adapted their dwellings to the tors morphology (Fig. 4). The ramps, stairs, utility rooms and their elements, sculptured in sandstone, are remnants of these dwellings left over to present-day (Fig. 3, no 1, 3-u 6). They are placed at the outer walls on the plaza side as well inside, along the natural passageways separating rocky objects. Some of rocky

stairs (Fig. 3, no 6) constitute actually part of the touristic infrastructure leading to the top parts of the Main Massif and allowing arrival to the attractive viewpoint (Fig. 5).

Moving gradually westward from the Main Massif, one can observe a change in the rocky forms structure. This change is expressed in decrease of their dimensions, their heights is reaching only a few meters, as well as in disappearance of tors group. The rocky groups changes into singular isolated forms and the objects are gradually segmented (Fig. 3, 6).

This place has an ancient history, coming back to the Middle Ages and even to the Palaeolithic, which is not surprising since deep gorges and innermost caves hiding between the stone giants attracted people long ago giving them reliable protection from natural disasters and different attackers. For many centuries, the stones were not only a shelter for every day existence, but also served to sacral and defence purposes (Kugutiak, 2015). One of the names – Dovbush Rocks – is named after Ukrainian Robin Hood-type avenger Oleksa Dovbush. According to the legend, somewhere between the tors, Dovbush gold had been hidden. However, most likely he has never been there.

The rocky complex have been studied more than 150 years not only by geologists, but also by historians, ethnographers and archaeologists, which described the general features of sandstones, their shape, spreading and distribution (Kugutiak, 2015 and references therein). This place is so fascinating that the famous Ukrainian poet Ivan Franko in 1881 devoted a poetry "Bubnyshche" (in Ukr. *Бубнище*) to it.

The **Urych** Rocks (Fig. 2) is another geotouristic place not far from Skole town. A few sandstone rocky forms group constitute characteristic elements of landscape (Fig. 7). They are built of the Yamna Sandstone. The largest rocky object is located in the southern part of the Urych Rocks in the zone of forks of Tserkivnyi and Husiachyi streams. This zone is relatively dry indicating good dewatering of the area (Fig. 7). The main objects known as the Stone consist of a few isolated rocky forms and groups.

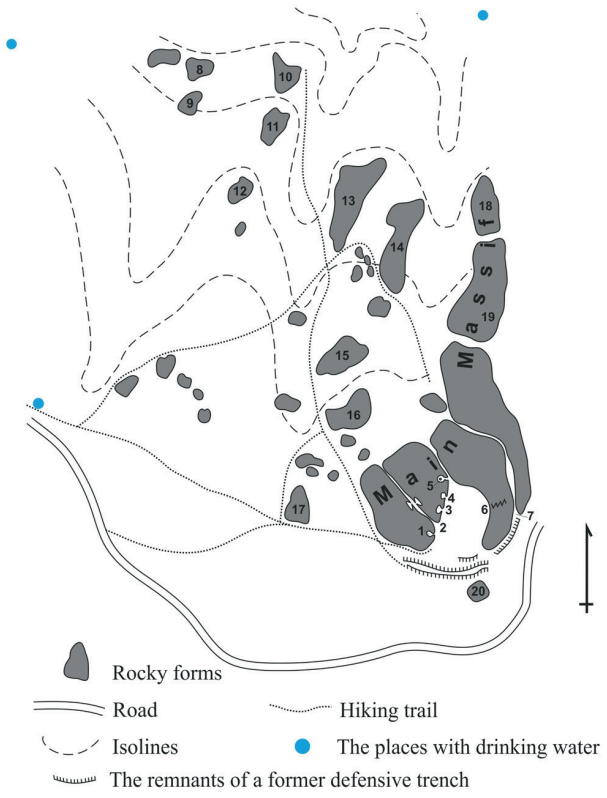

Fig. 3. Distribution of the main sandy rocky forms within Bubnyshche (after scheme from the site of Lviv Climber Club "Extreme" and of Bubniak & Solecki, 2013, modified). Approximate height is given according to climbers): 1 – Large Cave, 2 – Gorge, 3 – Stables Cave, 4 – Little Cave, 5 – Well, 6 – stairs, 7 – entrance to "Purgatory", 8 – Small Austrian (in Ukrainian Mala Avstriyka; high ≈ 9 m), 9 – Big Austrian (in Ukr. Velyka Avstriyka; h ≈ 24 m), 10 – Rustle Man (in Ukr. Shurshunchyk; h ≈ 22 m), 11 – Doll (in Ukr. Lial'ka; h ≈ 18 m), 12 – the Rolling Roll Bun (in Ukr. Kolobok; h ≈ 9 m), 13 – Battleship (in Urk. Bronenosets; h ≈ 45 m), 14 – Nameless (in Ukr. Bezimenna; h ≈ 22 m), 15 – Witch (in Ukr. Vid'ma; h ≈ 40 m), 16 – Tulip (in Ukr. Tul'pan; h ≈ 20 m), 17 – Stand-alone (in Ukr. Odynets; h ≈ 30 m), 18 – Alaska (in Ukr. the same name, h ≈ 22 m), 19 – Horse (in Ukr. Kin'; h ≈ 40 m), 20 – Scorer (in Ukr. Holets; h ≈ 22 m)

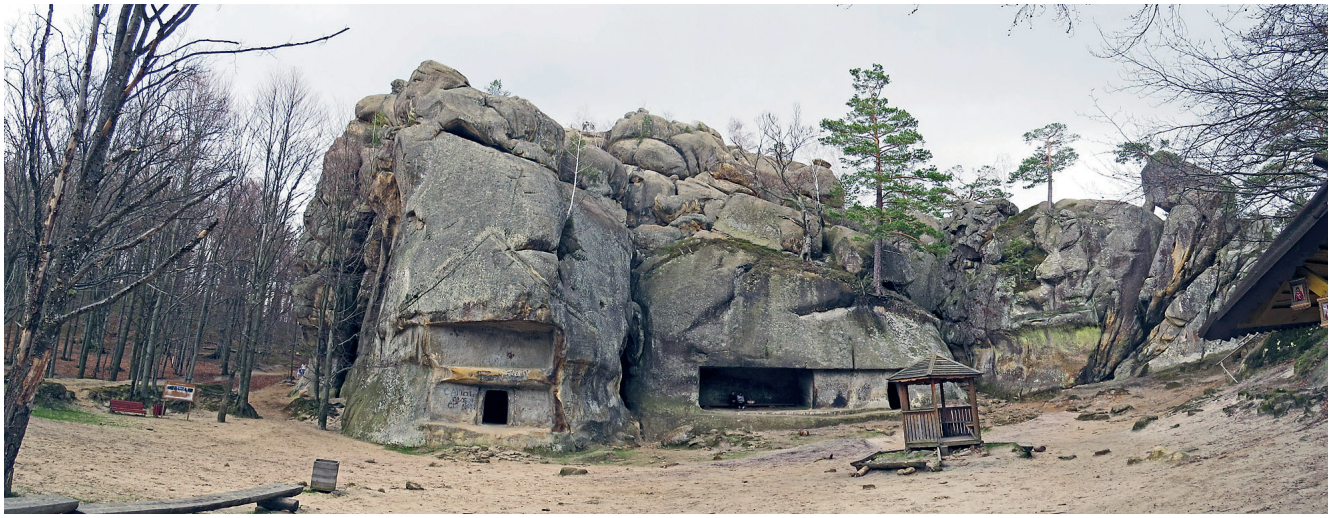

Fig. 4. The Main Massif group of tors in Bubnyshche (western wall), photo S. Bakayeva

Fig. 5. The Main Massif group of tors in Bubnyshche (southern wall), photo A. Waśkowska

Fig. 6. Isolated tour in the western part of the Bubnyshche, photo A. Waśkowska

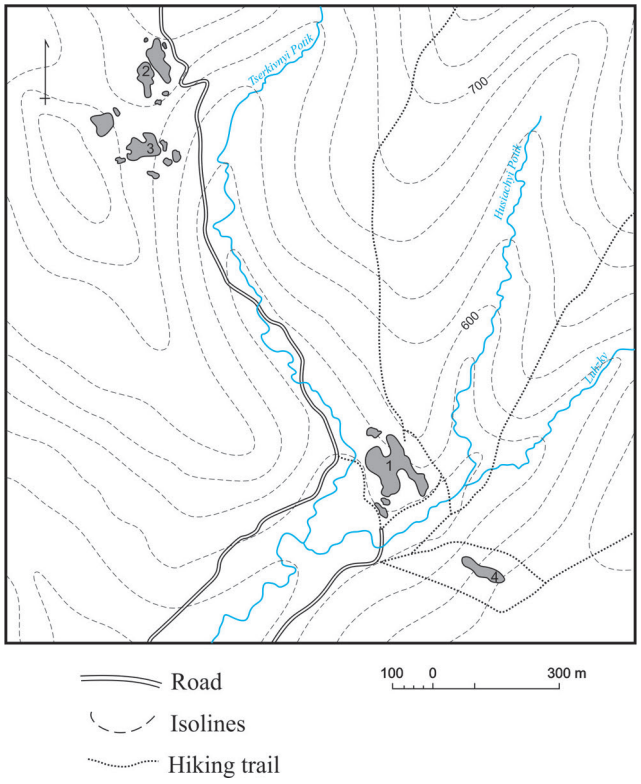

Fig. 7. Distribution of the main sandy rocky forms within the Urych Rocks (after Rozhko, 1996): 1 – The Stone (in Ukr. Kamin' ≈ 87 m); 2 – The Sharp Stone (in Ukr. Hostryi Kamin'); 3 – The Small Rock (in Ukr. Mala Skelia); 4 – Manger (in Ukr. Zholob)

Within these groups, the outcrop creates the rocky culmination of the hila (the Stone) (Fig. 8). That is the lower part (580–600 m a.s.l.) of the southwestern slope of the Dyv Mountain (847 m a.s.l.). This place has a special character, because the Tystan Fortress was constructed here in IX century. This fortress was used until XVI century (Rozhko, 1996). It had shape of highland castle situated here, because such a location allowed defense, observation of the surrounding area as well as good life conditions. Habitable buildings and outhouses were fitting the morphology that was only slightly modified. Actually, the newly developed trail is leading tourists into the top parts of this rocky group, where the broad panorama of the surrounding area is visible. The Stone is surrounded by lesser tors on the slopes of the watershed ridge. These tors represent mainly rocky walls, pulpits and towers according to Alexandrowicz (1978) classification (Fig. 9). Some tors are exposed in open area on the southern side of the hill, the others are located in the forest on the northern and eastern side.

The other rocky objects are located about 1,5 km north of the main object, on the other side of Tserkivnyi Stream. The groups of bigger and smaller sandstone tors are known as the Sharp Stone and the Small Rock. Some of them have individual names. The rocky outcrop known as Zholob (Manger in English) is located on the opposite slope southeast of the main object, on the other side of Husiachyi Stream Fig. 7, 10.

Besides the rocky forms, the spectacular outcrops of the Yamna Sandstone are situated within the waterfalls. The **Kamianka** Waterfall belongs to most popular objects of this type (Fig. 2). It is the biggest form located in the valley of Kamianka Stream, right tributary of the Opir River. The erosion-resistant rocky threshold developed in the upper part of the very thick sandstone layer (Fig. 11). It is around 7 m high and consists of one cascade divided by a tors protrusion into two streams. The waterfall threshold is established on the dipping, very thick layer of Yamna Sandstone. The significant eversion basin developed below the threshold, further downstream the creek is flowing in the narrow gorge-type rocky valley. Upstream from Kamianka Waterfall, other bigger or smaller waterfall thresholds and rapids are located. The largest known as Verkhniokamianskyi is located about 500 m upstream. Near to it there is a sign indicated the direction to the other hydrological object – a Zhuravlyne (Cranberry in English) or Dead Lake. The lake is located at an altitude of 622 m a.s.l. and is about 50 m in longest. The water is dark and very cold, and due to the high saturation of hydrogen sulfide it does not contain higher living organisms, that are why the lake is called dead. From the lake flows a stream that falls into the Kamianka River. The area around the lake is marshy and the banks are covered with moss. Around the lake grow spruce-fir forest and different valuable and rare plants. Cranberry – the another reason of the lake name – also is common here. Surround the lake occur small tors and conglomerates of Yamna Formation (Vashchenko *et al*., 2017).

Fig. 8. The Urych Rocks tours belonging to the Tustan Fortress, photo A. Waśkowska

There are some water sources around the waterfall; one of them is a source of hydrogen sulphide mineral water. These sources are confined to the contact between massive sandstones of Yamna Formation and laying below sandy-clayey flysch (with the predominance of the clay fraction) of Stryi Formation (Vashchenko *et al*., 2017).

Fig. 9. The tour on the southern site from the Rock object (the Urych Rocks), photo A. Waśkowska

Fig. 10. The Zholob sandy rocky forms – the view from the top part of the Main Rock (the Urych Rocks), photo A. Waśkowska

Nearby **Tyshivnytsia** above the Stryi River Kniazhi Skeli (Sovereign Rocks in English) of Yamna Sandstone are rising (Fig. 12, 13). The river waters formed grottoes at the foot of the tors, which can be reached only in the driest summer when the water level is the lowest. The altitude of tors is 400 m a.s.l. There are three cliffs: Kniazha – the highest (42 m), Yaroslavna – slightly lower, and Khanska – the lowest. The name of the Kniazhi Cliffs is related with the legend of the battle of the prince's army with the Tatars, which happened here.

Fig. 11. Kamianka Waterfall, photo A. Waśkowska

Fig. 12. Kniazhi Skeli nearby Tyshivnycia, photo S. Bakayeva

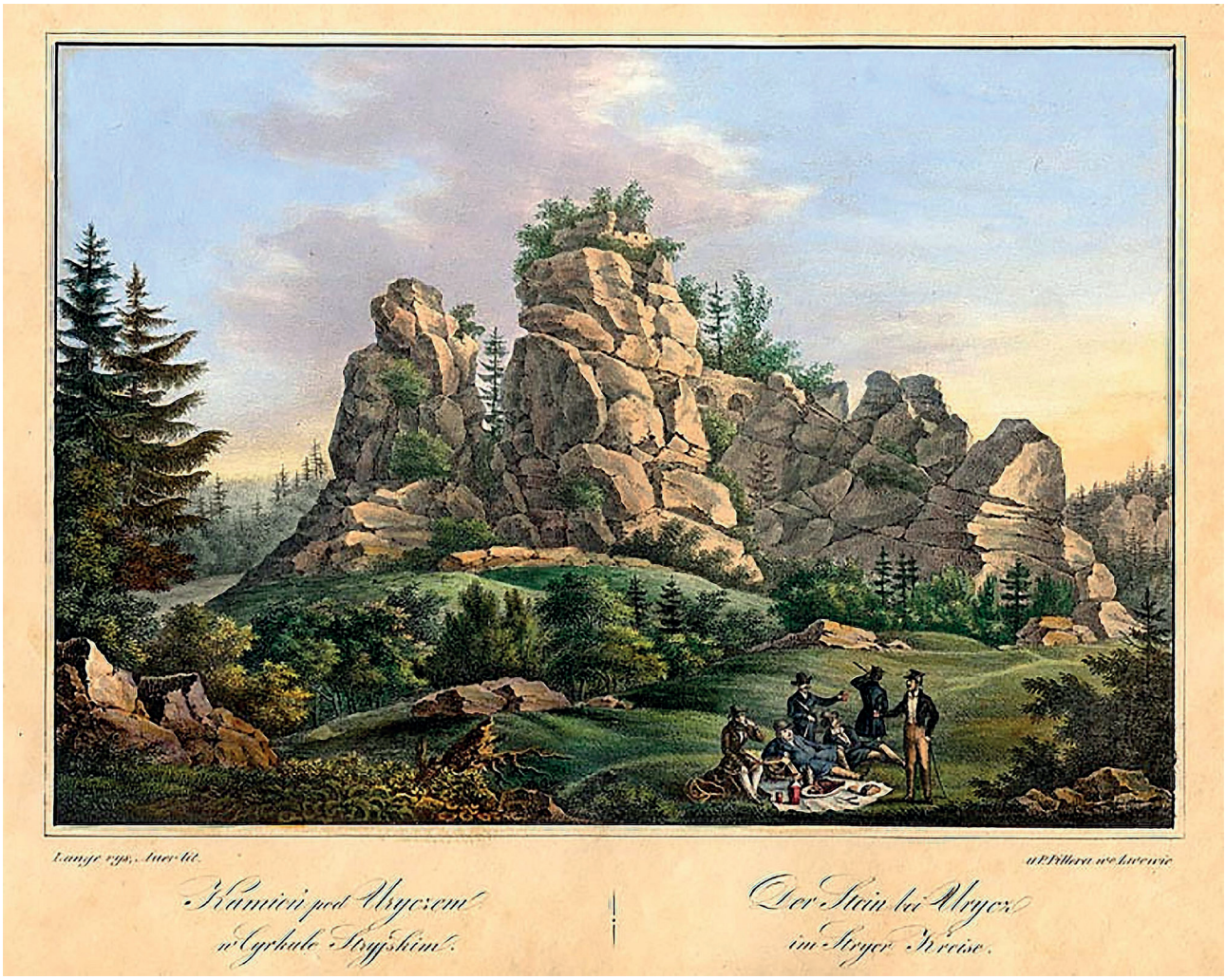

Fig. 13. The Stone with remnants of the construction on the upper part and the southern defensive wall with elastic arches. Engraving of 19 century (after Rozhko, 2016)

The Yamna Sandstone within the rocky forms

Lithological features

The Yamna Sandstone builds the rocky objects. The porous sandstone in thick and very thick (up to 5m) layers dominates within these tors. The sandstone bedding is not uniform and their thicknesses vary (Fig. 9, 10, 14, 15); the medium- and sporadically thin-bedded layers occur among the thick layers. The upper surfaces of layers display erosional character. The layers are mainly massive with weakly or well pronounced grain gradation. The amalgamations are common, they are enhanced by weathering structures (Fig. 14, 15). The described above lithology is common, however the entire sandstone profile is not monotonous, and the facies differences were observed. Beside massive ones, also laminated layers were observed (Fig. 15). The large-scale cross-bedding with sets up 150 cm as well as parallel wavy and flat lamination occur within sandstone layers. The presence of the latter is reflected in the rocky forms relief. Zones with dense parallel layering are less competent comparing with massive ones, the passageways in rocky forms developed within these zones. The fine- and medium-grained sandstones are common. Locally, conglomeratic sandstones with chaotic ore linear arranged grains occur in the lower parts of layers. They gradually pass into finer-grained sandstones (Fig. 16). The amount and degree of scattering of conglomeratic grains vary. Sporadically not so coarse-grained conglomerates occur in these rocks (Fig. 16). They constitute in-fillings of stripes (pinching-out laminas within conglomeratic sandstones or of lower parts of erosional channels). Medium- or well-rounded quartz constitutes main component of conglomeratic grains. The conglomeratic zones are quite porous and less competent for erosion. Sporadically, the coarser, less rounded material is present in the in-fillings of erosional channels.

Fig. 14. Amalgamations within the sandstones (Bubnyshche), photo S. Bakayeva

Fig. 15. Sedimentary structures – bedding and laminations. A–C – thick- and very thick bedding, bedded layers; C – amalgamations; D, E – horizontal flat lamination; G – wavy lamination; F, H, I – cross-bedded lamination. Photos A–D, F–I: Bubnyshche, Photo E: Kamianka waterfall. Photo A. Waśkowska & S. Bakayeva

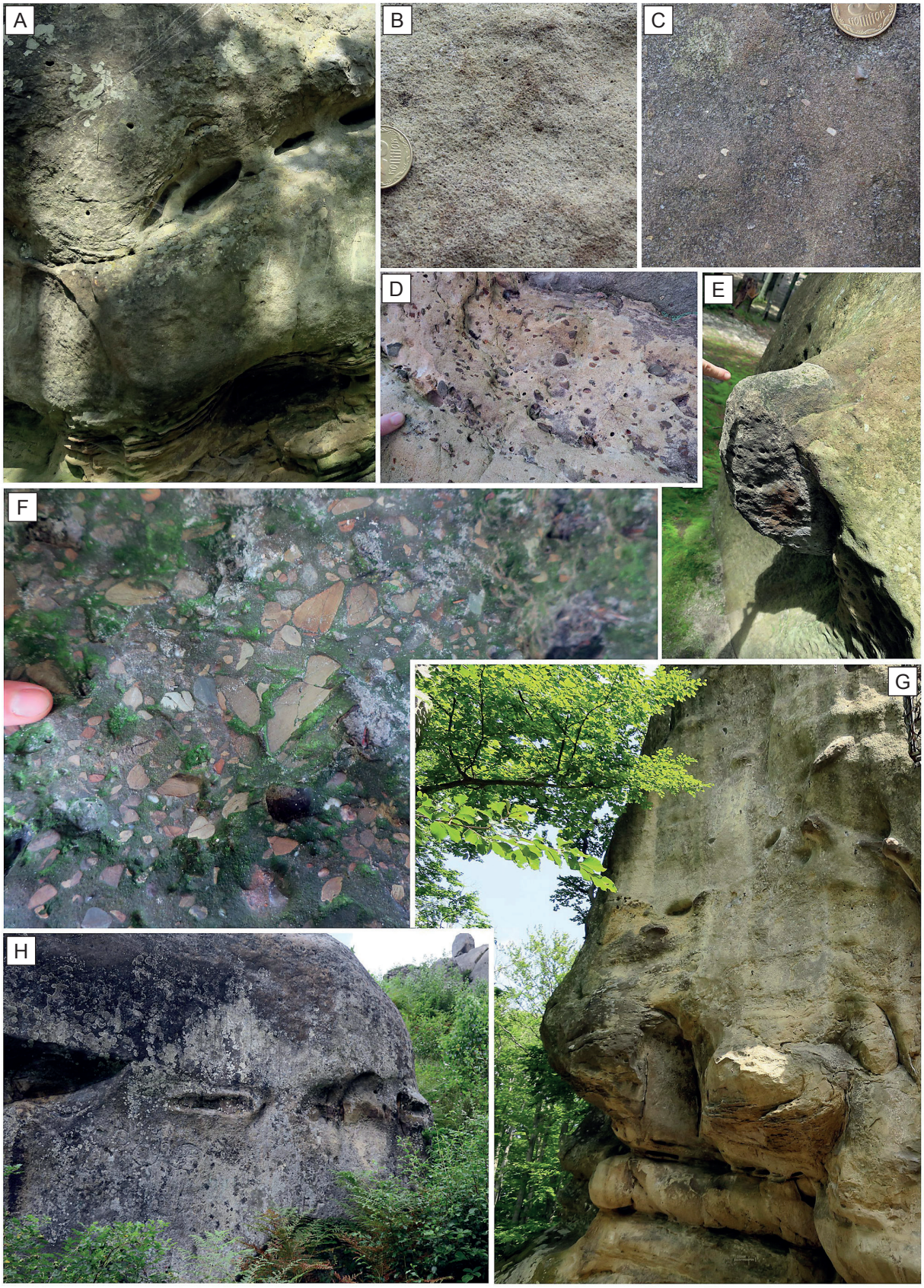

Fig. 16. Sedimentary structures. A – convolutions; B–D – conglomeratic sandstone; F – conglomerate; E – exotic boulder within sandstone; G – layers of sandstone concretions; H – underwater slide deposits. Photos A–C, E–G: Bubnyshche, Photos D, H: Urych Rocks. Photo A. Waśkowska

Fig. 17. Negative relief along the interbeddings (Bubnyshche). Photo A. Waśkowska

Grains of feldspars, metamorphic green and red shales, limestones, quartzite sandstones occur also, beside quartz, in these rocks. The examples of conglomeratic development occur in Bubnyshche. The dispersion of conglomeratic grain sizes is quite significant. The diameter of the coarsest grains reaches 50 cm. The clasts of sandstone redeposited from shallower zones of sea basins belong to these pebbles. They occur in the disturbed zone, typical for submarine slumps (Fig. 16). The grains are linearly arranged along their longer axis. The singular, chaotically displaced grains are less frequent (Fig. 16). They are well or poorly rounded. Some grains display sharp outlines contrasting with the surrounded matrix, other have indistinct, obliterate borders, indication different degree of blocks' diagenesis. The load casts were observed in the lower parts of layers.

Weathering structures

The rocky forms originated as a result of weathering processes in terrestrial conditions that existed since uplift of orogene that is since Miocene. The sedimentary and tectonic structures played an important role during these processes, influencing the final shape of the Yamna Sandstones' rocky forms. Blocks' disintegration took place along the structural surfaces. The vertical axes of the rocky objects are concordant with joint fractures, while the horizontal ones are compatible with sedimentary structures (Fig. 9, 10, 12, 14). Both joint fractures and sedimentary planes like bedding, amalgamation or horizontal lamination constitute primary water migration paths. They were widened along these paths and commonly display concave relief (Fig. 17, 18). The other features, like size and differences in grains' dimensions influenced individual erosional competence that in turn resulted in differentiated relief of individual rocky forms. The rock surfaces are rugged. Caverns of various sizes occur on these surfaces. They originated as a result of granular disintegration; the boulders and clasts were detached from matrix. The exfoliation structure, occurring commonly below overhang rocks, is results of peeling and detachment of near-surface parts of the rock (Fig. 18). Limonitic coatings partially cover some surfaces. They constitute a natural impregnant consolidating outer parts of sandstone rocks (Fig. 18). The iron oxides and hydroxides**,** precipitated from solutions, are commonly present, providing rocks coloring. The rocks surfaces display characteristic orange-brown color.

The Yamna Sandstone rocky forms are characterized by occurrence of numerous internal and surface mesoforms. Besides edge roundness and polished surfaces, the arcade and honey-comb structures are common (Fig. 19). They represent different phases of rocky forms' development. The honey-comb structures occur on the vertical or overhang rocks surfaces. The cells sizes exceed 20 cm. The cells are commonly chaotically arranged; sometimes the regular, linear arrangement, indicating the layers strike, is present. The arcade structures (Fig. 19) originate at horizontal surfaces and are linked to weakly permeable zones. They usually develop in near-bottom, less frequently in near-top parts of layer, along the interlayered shielding grouts. The presence of the arcade structures is visible as drainage holes on rock surfaces, while inside the rocks is marked by the presence of internal passageways, in which water is flowing. The size of individual cells varies between 1 mm and over 10 cm. In Urych Rocks, in objects located north of castle rock, vertical gutters are present. They originated as a result of flowing waters (Fig. 18). The similar drainage gutters are present in the Rocky Town, in the Main Massif's hinterland. They have significantly larger dimensions cutting the vertical surface of high tors from their tops, reaching over 20 m in length (Fig. 18).

The detached fragments of sandstone layers form block colluvium of various thickness. They are characteristic for slopes above deposit cumulating troughs and holes. The residual sands cover the troughs basement.

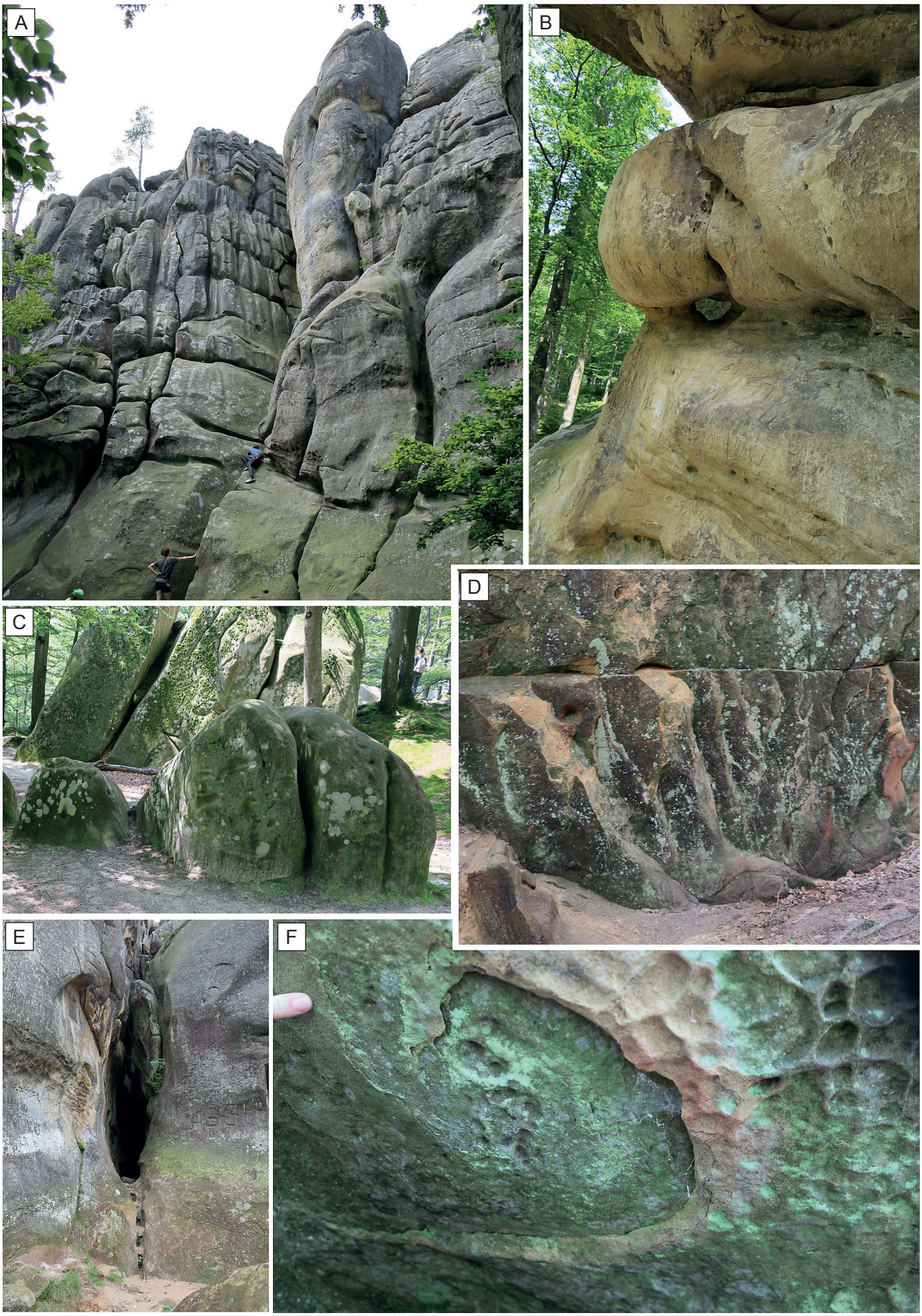

Fig. 18. Weathering structures (Bubnyshche). A – flow gutters; B, C – edge roundness of tors surfaces; D – arcade structure with marked water paths; E – erosional enlargements of joint structures; F – exfoliation. Photo A. Waśkowska

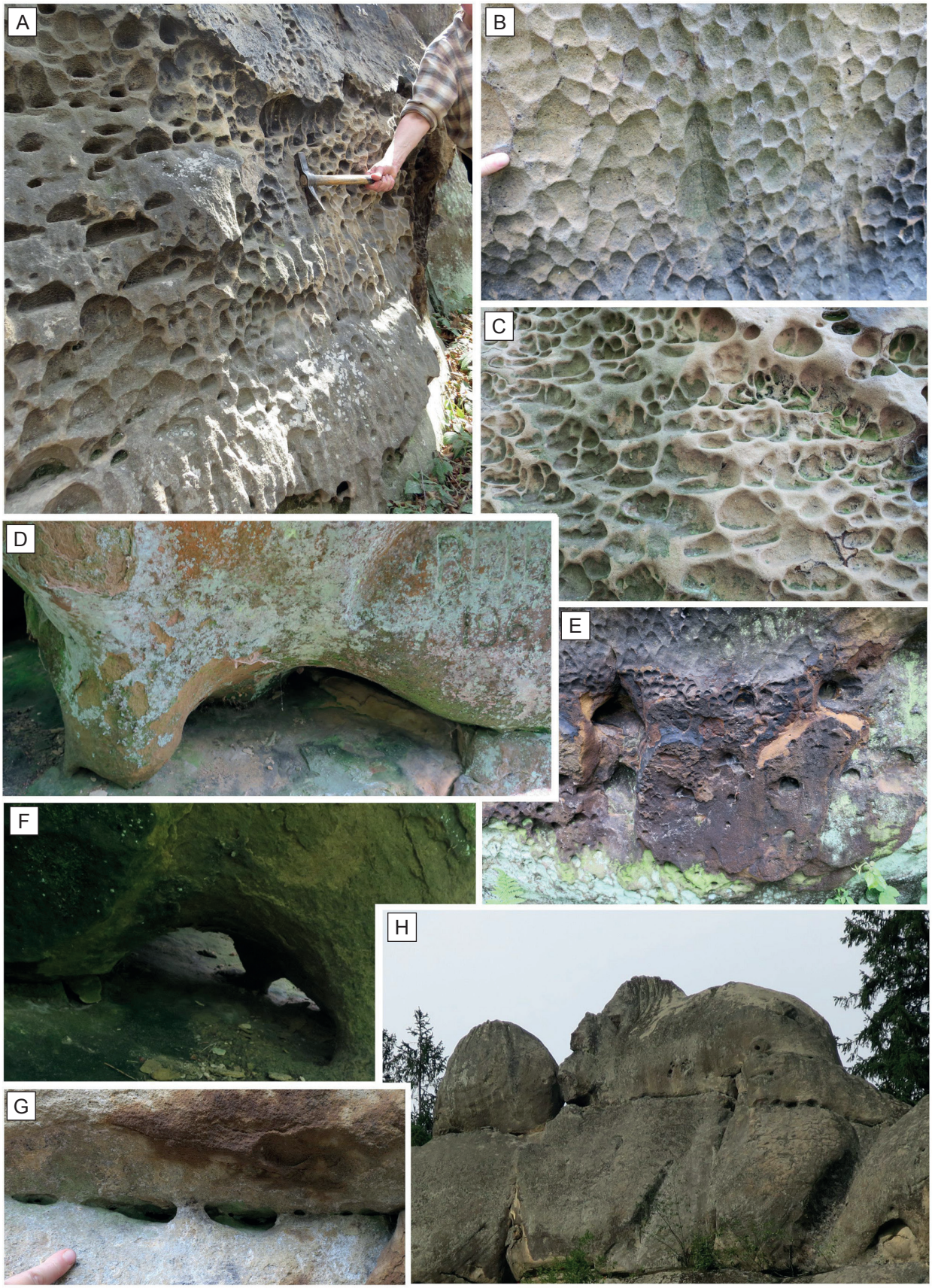

Fig. 19. Weathering structures. A–C – cell structure; D, F, G – arcade structure; E – limonitic crust; H – weathering shape resembling dionosaur with the ball in the hifhest part of the tor. Photos A–G: Bubnyshche, Photo H: Urych Rocks. Photo A. Waśkowska & S. Bakayeva

Discussion

The sandstone rocky forms in the vicinity of Skole town constitute a unique complex of objects in the Eastern Outer Carpathians. This nature' uniqueness was expressed by the fact that they were included into Ukrainian regulations, which preserves and protect natural heritage.

The landscape's values and associated anthropogenic cultural objects decided about high touristic potential. These landscape's values resulted directly from interesting outcropping forms, waterfall thresholds and sandstone tors. Especially tors grouped in complexes display varied morphology, changing from one individual object to the other as well as presence of weathering structures. The popularity of sandstone objects reflects actual infrastructural development, which follows touristic traffic concentrating in this area. Generally, all described above objects are equipped in touristic infrastructure and touristic products. These products include souvenirs made individually and dedicated to the particular place. The abiotic nature objects are main destinations of touristic traffic, therefore the present paper arranged observations concerning the sandstones building these objects, especially their structural-textural features. The Yamna Sandstone is similar at a glance, but detailed observations allow to distinguish dynamic changes within profile of the rocky forms. Besides typical thick-bedded massive sandstones, the whole spectrum of the other various sedimentary structures is present, providing view on dynamically changing sedimentary processes that took place during deposition of these sandstones. The individual rocky objects display different height reaching 50 m. It allows observation of really long segments of lithological profile. Expressivity and accuracy of observation of lithological development decrease toward top parts of tors. The tors are located in different hypsometric positions on the hills slopes allowing construction of so-called composite profiles reaching 100 m in length. The advantage of this approach is that it allows not only observation of the vertical lithological profiles but also lateral tracking of change within layers on several tens of meters distances. It allows also view of sedimentary structures across layers in three crossing each other vertical or almost vertical sections.

Conclusion

The peculiar concentration of unique geotouristic objects is located in Eastern Outer Carpathians in the vicinity of Skole town. The outcrops of Yamna Sandstone (Paleocene) of the Skyba Nappe create waterfall steps or sandstone rocky forms (tors) locally gathered in groups making so-called stone towns. These tors are distributed on different altitude levels and have significant heights allowing observation of long segments of profile san registration of weathering and sedimentary structures. The wide spectrum of observation, variety of lithological development as well as worth attention unique landscape values makes the highly rated geotouristic potential.

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