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Not simply volcanoes – the geoheritage of the Cretaceous system in the Land of the Extinct Volcanoes Geopark, West Sudetes (SW Poland)

Nie tylko wulkany – dziedzictwo okresu kredowego w Geoparku Kraina Wygasłych Wulkanów, Sudety Zachodnie (SW Polska)

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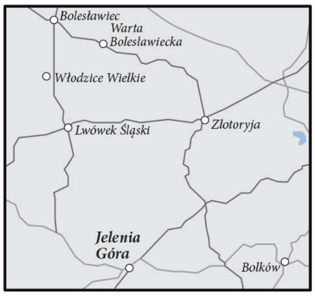

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Abstract: *Volcanic geoheritage is emphasized as the main asset and distinctive characteristic of the Land of Extinct Volcanoes Geopark in the West Sudetes (SW Poland). However, the geoheritage values of the region are not limited to the legacy of ancient volcanism but include various other elements. This paper explores the contribution of geosites that expose sedimentary rocks of Cretaceous age and landforms developed upon these rocks. Six localities from the Geopark area, included in the comprehensive regional inventory of geosites, are presented. They represent natural and man-made sandstone outcrops and show, among others, lithological variations, small- and large-scale post-sedimentary deformation structures, landforms arising from differential weathering (rock shelters, honeycombs), boulder fields and a sandstone xenolith in volcanic rocks. Next, five localities from outside the Geopark, but still within the Pogórze Kaczawskie region, are described. Qualitative and quantitative evaluation of both groups is attempted, and the results show that, in general, geosites within the Geopark rank higher. However at least two from the other group also have significant geotourist potential. Finally, a brief comparative analysis with other parts of the Sudetes, where Cretaceous sedimentary rocks occur, is offered.*

Keywords: *geoheritage, geosite, Cretaceous, sandstone, geopark, Sudetes*

Treść: *Dawny wulkanizm jest podkreślany jako główny walor i wyróżniająca cecha Geoparku Kraina Wygasłych Wulkanów w Sudetach Zachodnich, jednak dziedzictwo Ziemi w regionie nie ogranicza się do reliktów aktywności wulkanicznej i zawiera różne inne elementy. W tym artykule są zaprezentowane miejsca (geostanowiska), w których można oglądać naturalne i sztuczne odsłonięcia skał osadowych wieku kredowego i formy rzeźby zbudowane z tych skał. Sześć z nich jest zlokalizowanych na obszarze Geoparku i zostały one uwzględnione w regionalnej inwentaryzacji obiektów dziedzictwa Ziemi. Zagadnienia, które można omówić na przykładzie tych miejsc, obejmują między innymi zróżnicowanie litologiczne, post-sedymentacyjne struktury deformacyjne w małej i dużej skali, formy będące efektem zróżnicowanego wietrzenia (schroniska podskalne, „plastry miodu"), pokrywy blokowe i ksenolit piaskowca w skałach wulkanicznych. W dalszej części opisano pięć stanowisk spoza Geoparku, z pozostałej części regionu Pogórza Kaczawskiego. Rezultaty jakościowej i ilościowej oceny stanowisk z obu grup pokazują, że obiekty położone w Geoparku mają większą wartość, ale przynajmniej dwa z drugiej grupy mają istotny potencjał geoturystyczny. W części końcowej zostało przedstawione krótkie porównanie z innymi fragmentami Sudetów, gdzie występują skały wieku kredowego.*

Słowa kluczowe: *dziedzictwo Ziemi, geostanowisko, kreda, piaskowiec, geopark, Sudety*

Introduction

Among various rock complexes exposed in Central Europe, the Upper Cretaceous sedimentary succession of marine origin is known to host some of the most spectacular landscapes and landforms that occur in this part of the world. These have developed upon typically weakly deformed clastic rocks, which include quartz, arkosic and calcareous sandstones, mudstones, marls and claystones. The most distinctive sceneries are associated with quartz sandstones, ranging in age from Cenomanian to Coniacian and lying horizontally over long distances or tilted to form monoclinal structures. These eye-catching landscapes include dissected tablelands, plateaus and mesas, cuesta ridges and deep canyons, whereas characteristic medium-size and minor landforms are rock labyrinths and towers, hoodoo rocks, and the outstanding variety of small-scale weathering features on the rock surfaces (Hettner, 1903; Vítek, 1979; Adamovič *et al.*, 2006, 2010; Migoń *et al.*, 2017, 2019). In numerous places, especially in north Bohemia (Czechia), Cretaceous strata are pierced by younger volcanic structures, mostly Oligocene to Miocene in age (Janoška, 2013). These, however, have been considerably degraded since their time of activity, and many remain as exposed former volcanic conduits – necks. Today, these necks provide an impressive scenic contrast to dissected or planated sedimentary tablelands (Rapprich *et al.*, 2007; Cílek, 2010; Wenger *et al.*, 2017). Linkages between Cretaceous sediments and younger volcanics are not merely due to juxtaposition. Instructive evidence of thermal changes in sandstones and mudstones, induced by the injection of hot magma, is provided by numerous outcrops scattered across the region. It ranges from the transformation of mudstone into much harder porcellanite, to the development of columnar jointing in sandstones (e.g., Dutý kámen near Cvikov, north Bohemia, or Orgel in Zittauer Gebirge, Germany). More far-field effects are recorded by the widespread occurrence of ironstones (local ferruginization due to iron precipitation from hydrothermal fluids), which, due to their hardness project from and above softer sandstone surfaces, often in the form of very complicated spatial patterns (Vařilová, 2007; Adamovič, 2016).

Thus, over most of north Bohemia and adjacent parts of Germany and Poland interesting geosites associated with Cretaceous sedimentary rocks and Oligocene-Miocene volcanics occur side by side. In Czechia, both themes are explored in existing geoparks such as the Bohemian Paradise UNESCO Global Geopark (Adamovič *et al.*, 2006; Rapprich *et al.*, 2007, 2017) or the Ralsko National Geopark (*Narodní geopark Ralsko...*, 2018). In Poland, co-existence of these rock systems typifies the NW part of the Sudetes, which includes regions of Pogórze Kaczawskie (Kaczawskie Foothills or Hilly Land) and Pogórze Izerskie (Izerskie Foothills or Hilly Land) (Fig. 1). In parts of the former, the Land of Extinct Volcanoes (LEV) Geopark was recently formally created as a bottom-up initiative, and, soon after, an application for the status of UNESCO Global Geopark was submitted (Pijet-Migoń & Migoń, 2019; Słomski *et al.*, 2019). Although the emphasis is clearly on the evidence of ancient volcanic activity, which was not limited to the Cenozoic, but involved several phases of Palaeozoic volcanism as well, more than 100 potential geosites identified within the Geopark area cover the entire spectrum of geoheritage, from rock records to the use of stone resources. Among these, a few show rocks of Cretaceous age and landforms developed upon these rocks. However, the LEV Geopark does not cover the entire Pogórze Kaczawskie region, whose westernmost part is not included. Nonetheless, the Cretaceous succession extends to the west and then, beyond the Bóbr River valley to the Pogórze Izerskie region (Fig. 1).

This paper aims to explore the geoheritage related to the Cretaceous system, both within the LEV Geopark and its vicinity, in the following way. After a brief presentation of the study area, six geosites in the LEV Geopark are characterized in terms of their scientific content and accessibility. Then, the presentation is extended to the part of Pogórze Kaczawskie outside the Geopark and five localities of interest are shown, following the same template. An attempt to evaluate their values and attractiveness makes up the next part of the paper. Finally, the characteristics of geosites from the Pogórze Kaczawskie are discussed in relation to other parts of the Polish Sudetes, where the Cretaceous system is exposed, with particular focus on the adjacent Pogórze Izerskie region.

The geology of the Cretaceous system in the Land of Extinct Volcanoes Geopark

Sedimentary rocks of Cretaceous age occur in the north-western, least elevated part of the Pogórze Kaczawskie region (Fig. 1), although their outcrops are concealed by younger Cenozoic deposits over most of the area. They are exposed mainly in the vicinity of the town of Złotoryja, within the water-divide area between the drainage basins of Bóbr and Skora rivers, and close to the Bóbr River valley. Chronologically, they cover the Cenomanian – Santonian interval of the Late Cretaceous, which is some 15 million years long. Cretaceous rocks are exclusively marine in origin and interpreted as sediments of a shallow epicontinental sea, representing a variety of facies, from nearshore coarse sandstones and locally sandy conglomerates to deeper-water calcareous sandstones, mudstones and claystones (Milewicz, 1997; Leszczyński, 2018; Leszczyński & Nemec, 2020). Coarse- and fine-grained sediments alternate in the litostratigraphic profile, so that coarse-grained sandstone series occur repeatedly within the Cenomanian, Turonian and Coniacian succession. Basal Cenomanian sandstones are typified by very high percentage of quartz and can be considered as quartz arenites. Their thickness in the eastern part of the area of occurrence reaches 135 m.

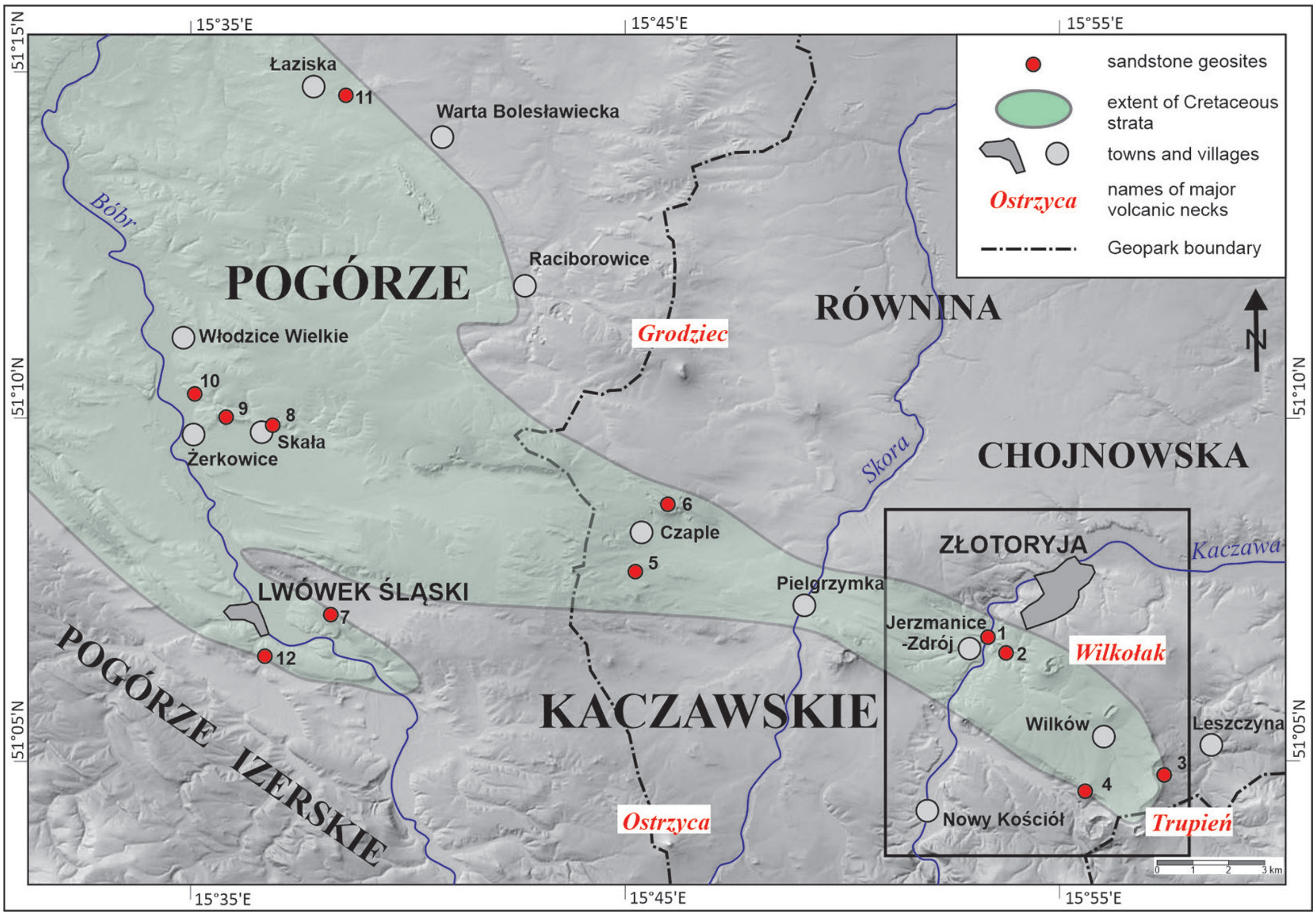

Fig. 1. Study area. Numbering of sites of interest: 1 – Krucze Skały; 2 – Drążnica Valley; 3 – Mount Prusicka – Mount Średnia; 4 – Mount Diablak; 5 – Cygańskie Skałki; 6 – Mount Kopka; 7 – Skałka; 8 – Skała; 9 – Wieżyca; 10 – Huzarski Skok; 11 – Pokutujące Skałki; 12 – Lwóweckie Skały. Black rectangle indicates the extent of 3D model shown on Fig. 2. Source of shaded relief image: geoportal.gov.pl.

Likewise, Turonian sandstones are predominantly coarse and quartz-rich (quartz arenites), up to 90 m thick. Both sandstone series are thickly bedded and regularly jointed. Coniacian sandstones have finer grain, but are still thickly bedded and attain total thickness around 90 m (Milewicz, 1997). Regular jointing and moderate strength contribute to the value of Cretaceous sandstones as building stones, taken advantage of since medieval times. Consequently, quarrying became a widespread industry, and although many quarries are now abandoned, several are still working, exploiting Coniacian sandstones.

The Cretaceous succession is the youngest one within the North-Sudetic Synclinorium, which is a large tectonic unit of regional extent, with the history of sedimentary infilling going back to the latest stages of the Variscan orogeny (see review in: Żelaźniewicz & Aleksandrowski, 2008). The contemporary boundaries of the synclinorium are marked by prominent WNW-ESE-trending fault lines. Further faults of this strike make boundaries of secondary tectonic units within the synclinorium. Synclinal troughs (half-grabens) are of particular interest (Oberc, 1972; Milewicz, 1997), within which Cretaceous strata have been tilted to form monoclinal structures, with the dip of strata typically from 10° to 20°. They provide structural foundations for cuesta landscapes, which have developed in various places of the area presented in this paper. Local brittle structures (joints) were analysed by Solecki (1994, 2011), who recognized two main joint systems: 55°/325° and 25°/295°, with the additional presence of 0°/90° in the westernmost part of the study area. These joints are nearly vertical and control outlines of both natural outcrops and quarry walls.

Geomorphological background and context

The geomorphological landscape of the northern part of the Pogórze Kaczawskie region is generally subdued, with altitudes barely exceeding 400 m a.s.l. and local relief up to 100–150 m, but considerably less in many places. This is apparently because of limited uplift in the late Cenozoic (in contrast to the more southerly parts of the West Sudetes), predominantly moderate to low strength of rock complexes (Adam, 2004; Placek, 2011) and probable impact of the Scandinavian ice sheet in the Middle Pleistocene, which transgressed over the area to reach its maximum extent a few tens of kilometres further south (Jahn, 1960; Badura & Przybylski, 1998). Therefore, the sedimentary terrain in the central and western part of the region lacks prominent elevations, except exposed volcanic conduits of Oligocene/Miocene age – the necks (Fig. 1). However, within this principally low-relief topography, more distinctive landforms do occur, with many associated with outcrops of Late Cretaceous strata, mainly sandstones. Most evident are cuesta ridges, with steep fronts discordant to the dip of bedding planes and low-angle backslopes generally following the dip. The best example is provided by the cuesta, supported by Cenomanian sandstones, located east of the Kaczawa River and south of Złotoryja (Fig. 2). It is ca. 100 m high and follows WNW–ESE direction, turning to N–S in the easternmost part. Several basalt bodies occur within the cuesta front. Less evident and lower are cuestas located to the east of the Bóbr valley (although they become more distinctive beyond the valley, further to the west) (Maciejak & Migoń, 1990). The water gap of the Kaczawa River to the south of Złotoryja is a regionally important feature, probably finally shaped in the Middle Pleistocene, during the decay of the Scandinavian ice sheet (Michniewicz, 1998). The river cuts first through the Cretaceous strata of various resistance and then, after passing the village of Jerzmanice-Zdrój, into the Złotoryja Horst, built of Lower Palaeozoic basement rocks. The total length of the water gap is more than 6 km, and its depth reaches 100 m. In several places, steep valley sides truncating Cretaceous strata were found to be convenient places to start quarrying, and several abandoned sandstone quarries occur within the eastern (right) valley shoulder. However, locally natural outcrops occur as well, as either isolated towers and spurs or more continuous cliff lines. Most sites of geotourist interest described below are located within cuesta faces and in the proximity of main river valleys, so that their connection with increasing local relief is evident.

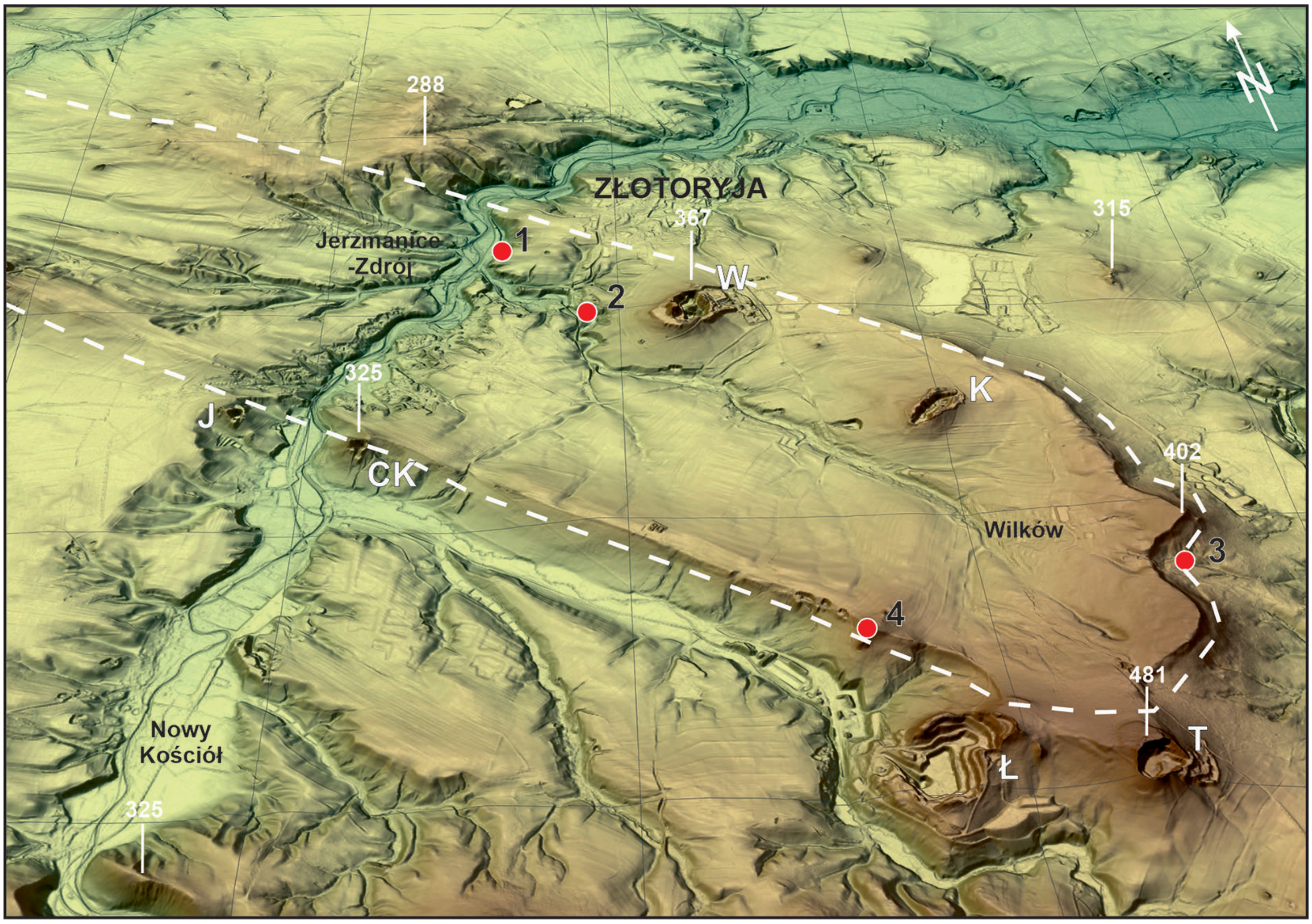

Fig. 2. Three-dimensional model of relief in the vicinity of Złotoryja, including the easternmost extent of Cretaceous strata (within the broken white line) and the water gap of the Kaczawa River (view to the north). Note straight course of the Cretaceous cuesta in the south and sinuous course in the east, as well as numerous basalt quarries within volcanic necks (J – Jeziorna; CK – Czerwony Kamień; Ł – Łysanka; T – Trupień; K – Kozia; W – Wilkołak). No. 1–4 refer to geosites indicated on Fig. 1: 1 – Krucze Skały; 2 – Drążnica Valley; 3 – Mount Prusicka – Mount Średnia; 4 – Mount Diablak. Altitudes of selected elevations are provided. Digital elevation data provided by Główny Urząd Geodezji i Kartografii.

The Land of Extinct Volcanoes Geopark

Despite multifaceted geological record and landform inventory, long explored by geoscientists, the region of Pogórze Kaczawskie had not been a popular tourist destination until the early 1990s. However, its volcanic legacy and associated tourism potential became gradually appreciated and the basaltic cone of Mt. Ostrzyca especially became a regional landmark, often called "Silesian Fuji-yama". The first attempts to link tourism with local geology, focused on the volcanic past, date back to the 1980s, when a 85 km long hiking Trail of Extinct Volcanoes was waymarked. In 1992, the Chełmy Landscape Park was established in the eastern part, with implications for both conservation and environmental education. Although biodiversity was of primary focus, geo-education was not ignored and several local educational trails were set up, to explain aspects of geology, landform evolution and mining history. Within the geoheritage itself, the range of themes brought to public attention steadily expanded, with emphasis on the exploitation of geological resources such as gold, copper and iron ores, as well as building stones. However, within the geological and landform records, volcanism remained as a potential core value for further tourism development, including geotourism.

Efforts to promote the geoheritage and geotourism intensified in the 2000s. In 2005, the Local Action Group (LAG) "Kaczawa Partnership" was created, with the main goal to stimulate and support regional development by means of tourism that would use local resources. Geological history and ancient volcanism were chosen as unique selling points of the region, and the phrase "Land of Extinct Volcanoes" was selected as an official brand name for territorial marketing (Pijet-Migoń, 2016). Since the onset of the activity, LAG has focused on regional education in the field of natural heritage, offered to tourists and local population from all ages. Outputs, not limited to the activity of LAG, but also involving other stakeholders, included publications exploring regional geoheritage, educational trails, study visits, international exchanges and different events (Pijet-Migoń & Migoń, 2019). The most ambitious infrastructural project was the establishment of a geo-educational centre in the village of Dobków, opened in 2015. Considering the general awareness of regional geoheritage, it has become clear that ancient volcanism is but only one facet of the complex history, and other themes are also worth exploring and promoting, both in the field of geology and geomorphology (Solecki, 2008; Różycka, 2014; Migoń & Pijet-Migoń, 2016; Muszer & Muszer, 2017). Consequently, the number of localities explained in the field gradually increased, and these included several places where sedimentary rocks of the Cretaceous system are exposed.

In October 2017, at the meeting of local leaders and mayors of municipalities – members of the LAG "Kaczawa Partnership", a letter of intent was signed to establish the Land of Extinct Volcanoes Geopark and to apply for the status of a UNESCO Global Geopark. As part of preparatory process, comprehensive inventory and evaluation of potential geosites was carried out in 2018–2019, resulting in documentation of more than 130 localities. Bilingual descriptions of these localities are freely available on the website (www1), whereas those considered most representative and visually attractive are also presented in more popular ways. In 2019, an official dossier was submitted to the UNESCO Headquarters and the LEV Geopark is awaiting evaluation (Słomski *et al*., 2019).

Geographically, the boundaries of the area covered by LEV Geopark coincide with the boundaries of the municipalities. Since the municipalities of Lwówek Śląski and Warta Bolesławiecka are not part of the LAG "Kaczawa Partnership" (Fig. 1), their territories could not have been included into the Geopark.

Geosites associated with the Cretaceous system within the Geopark

Krucze Skały

The series of natural and man-made outcrops of Turonian sandstones on the east side of the Kaczawa River valley in the village of Jerzmanice-Zdrój (Fig. 1, 2; no. 1) is arguably the most impressive geosite in the Land of Extinct Volcanoes Geopark, which exposes the Cretaceous system. It is more than 300 m long and comprises three parts. The southern one is a well-exposed, abandoned quarry that consists of two faces perpendicular to each other, 80 and 35 m long respectively. They reach 25 m high (Fig. 3). Further to the north, the outcrops are natural and occur as rock cliffs at two major levels, at the base of the slope and in the upper section. They are separated by a narrow rock bench, from which an isolated, heavily weathered tower-like crag rises, ca. 3 m high. Further outcrops occur along two minor ravines incised into the valley's side. The third part consists of irregular rock cliffs of NW–SE extension, which, in contrast to the more southerly parts, where sandstone beds are nearly horizontal, expose a steep dip of sandstone beds to the south (Fig. 4). This structural deformation is causally related to the proximity of the reverse Jerzmanice Fault, along which sandstone beds were dragged and locally overturned. At the same time, the fault marks the northernmost limit of Cretaceous outcrops in this part of Pogórze Kaczawskie. Among minor features of interest are various surface weathering phenomena, including honeycombs and arcades.

The locality is also of cultural and historical interest, although details of quarrying history do not seem to be well documented. The quarry was probably in operation until the second half of the 19th century, but recreational facilities were built later on, after a small spa was opened next to the site in 1881 (Staffa *et al*., 2002). The path connecting the quarry floor and the upper rim, as well as natural sandstone cliffs nearby, probably dates from that period.

Fig. 3. The former quarry at Krucze Skały exposes thick beds of Turonian sandstone, cross-cut by regular orthogonal joiting. Photo P. Migoń

Fig. 4. Upturned sandstone beds to the north of Krucze Skały, due to dragging along a reverse Jerzmanice Fault. Photo P. Migoń

The well below the cliffs may be of similar date. Due to the proximity of spa buildings and railway station, this local sandstone scenery was a popular recreational spot among health resort patients and other visitors. Nowadays, after many decades of neglect, the site is again a local geotourist attraction, presented in information panels and web-based materials (www1). However, the northern part, with deformed Cretaceous beds, is poorly known and hardly visited, although access from the parking lot near the defunct railway station is easy.

Drążnica Valley

In the lower reach of the Drążnica Valley, east of and close to the village of Jerzmanice-Zdrój and the Krucze Skały geosite (Fig. 1, 2; no. 2), Cretaceous beds are discontinuously exposed within the steep valley side over a distance of ca. 300 m. They are mostly sandstones, but a 1 m thick interlayer of sandy conglomerate is present, determining local morphology. Rock cliffs formed in the clastic succession of Turonian age are up to 5 m high, cut by a regular network of discontinuities (bedding planes, vertical joints). Geomorphic features of primary interest at this locality are due to selective weathering and erosion of the conglomeratic layer, which have produced non-karstic rock shelters and stepped rock slope profiles. Wilcza Jama (Wolf's Cavern) is a rock shelter that has developed at the crossing of the conglomerate layer and a prominent vertical discontinuity. Processes involved in the origin of the shelter include the enhanced weathering of conglomerate, resulting from its higher porosity and less dense packing favouring freeze-thaw weathering, and piping, through which removal of sand grains and matrix by fracture-guided groundwater flow occurs. In this way, the shelter has expanded both horizontally and vertically, the latter into the overlying sandstone (Fig. 5). The triangular entrance is located on a rock bench, and the shelter continues into the rock face for 7 m. It is possible that it was enlarged anthropogenically. Some 100 m upstream, a simple horizontal rock shelter of Niedźwiedzia Jama (Bear's Cavern) is located. It is about 12 m long and reaches 3 m deep, with gradually decreasing height into the rock mass (Fig. 6). Lithological control on its occurrence and shape is exerted by the same, less resistant conglomeratic interlayer. Next to Niedźwiedzia Jama, an episodic creek contributed to the origin of a peculiar rock step in the tributary ravine that dissects the valley side. The step is ca. 2 m high, flanked by 2–3 m high sandstone cliffs on both sides, and overlooks a distinct, circular pothole. The pothole itself is partly filled with sand and organic debris. In winter time, groundwater emerging from rock fissures and bedding surfaces creates picturesque icefalls. Given that the surface flow is episodic and of very low volume, it is likely that the landform is largely relict and originated in different environmental conditions, when the creek had higher discharge and flowed permanently, or at least periodically.

Fig. 5. Wilcza Jama (Wolf's Cavern) rock shelter in the Drążnica Valley. Photo P. Migoń

Fig. 6. Niedźwiedzia Jama (Bear's Cavern) overhang in the Drążnica Valley. Photo P. Migoń

The site is generally easily accessible and access is not restricted. It is located about 100–250 m to the east from the main road connecting the towns of Złotoryja and Świerzawa. However, the path itself is narrow and partly degraded, creating difficulties in wet conditions. Therefore, the waymarked hiking trail was recently relocated to the former access ramp to the basalt quarry at Mount Wilkołak, which goes above the valley shoulder, leaving the path to the rock shelters unmarked. No educational infrastructure exists at the site(s), except a panel at the parking place by the road that introduces the shelters in a general way. However, a more detailed description may be found at the Geopark website (www2). Literature about the locality is limited to simple inventories within regional cave registers (Kowalski K., 1954; Pulina, 1996) and poorly accessible, local popular science accounts (Maciejak & Maciejak, 1991). Faint remnants of industrial facilities connected with basalt exploitation on Mount Wilkołak (access ramp, ruined buildings) can be seen above the parking place, but they are not explained.

Mount Prusicka – Mount Średnia

This is not a classical geosite, understood as one clearly defined locality, but a wider area located ca. 2 km to the east of the village of Wilków (Fig. 1, 2; no. 3), that is distinctive by the presence of impressive boulder fields (Fig. 7). Both elevations are local highs within the cuesta-type escarpment that marks the south-eastern limit of an area built by Cretaceous rocks in the region (Fig. 2). The southerly Mount Średnia rises to 427 m a.s.l., Mount Prusicka to the north is 402 m a.s.l., whereas the height of the escarpment is ca. 100 m. Cretaceous (Cenomanian) quartz sandstones form the cap of the escarpment, only a few tens of metres thick, whereas most of the escarpment slope truncates older sedimentary rocks of Early Triassic age. Although the uppermost part of the escarpment lacks natural rock cliffs, the boulder fields are extensive and mantle the upper and middle slopes over an area nearly 2 km long and up to 350 m wide. Duszyński *et al*. (2017) provided a comprehensive characteristics of the locality and highlighted various specific features which can be observed and examined within the boulder fields. They include:

- evident association of boulder accumulation with the projecting spurs of the escarpments, whereas boulders are almost lacking in the intervening amphitheatre;
- large size of some boulders, as much as 8 m long and 3 m high;
- piling up of boulders in specific places;
- localized examples of cavernous weathering;
- fairly common ferruginization and silification phenomena.

Fig. 7. Boulder-covered slopes of Mount Prusicka. Note the absence of sandstone cliffs in the upper slope. Photo P. Migoń

The latter, post-sedimentary changes in the rock mass are likely linked with the mid-Cenozoic volcanism that occurred in the close vicinity and tectonic deformations during the Alpine compression and late Cenozoic extension (Solecki, 1994, 2011).

There are no formal restrictions to visit the boulder fields and access is technically easy. The escarpment face is crossed by two waymarked hiking trails, starting in the village of Wilków – one to the open-air smelter museum in Leszczyna and another to the village of Kondratów. Some blocks can be seen from the former, otherwise self-guided exploration of the forest is required. No other elements of tourist infrastructure exist, and on-site educational facilities are lacking. However, the site is presented on the web site of the Geopark (www3).

Mount Diablak

Mount Diablak (390 m) near the village of Wilków (Fig. 1, 2; no. 4) is primarily a volcanic geosite that exposes a series of crags built of columnar basalt, which intruded in the form of a narrow vertical vein into Triassic and Cretaceous sandstones. However, a minor abandoned quarry in the lowermost part of the outcrop shows a rare example of large sandstone xenolith, 1.5 m long, with well-developed small-scale columnar jointing (Fig. 8). Individual columns are 2–3 cm wide. Due to the soft nature of the sandstones, these columns easily disintegrate into small pieces, and the locality is vulnerable to degradation. The site is located 1.5 km in the southerly direction from the centre of the village of Wilków. There are no formal restrictions to access, but the locality is not signposted and away from waymarked trails. Other tourist infrastructure is lacking too. However, the locality is elaborately described in web-available materials about the Land of Extinct Volcanoes Geopark (www1).

Fig. 8. Xenolith of Cretaceous sandstone in basalt at Mount Diablak. Photo P. Migoń

Cygańskie Skały

A small and rather inconspicuous outcrop of Middle Turonian quartz sandstones is located ca. 0.5 km from the village of Czaple (Fig. 1, no. 5). However, it is the only one in this part of the region and, therefore, is present in the collective memory of local people as a site of some significance. The crag is ca. 20 m long and up to 2.5 m high, with a rounded outline, due to ongoing weathering, mainly granular disintegration (Fig. 9). Joint-aligned fissures cut the crag in a few places. Minor features of interest include small-scale cross-bedding structures, examples of irregular and rather shallow cavernous weathering and secondary silification phenomena, related to tectonic deformations (cataclasis) and rock-mass displacements (Solecki, 1994) and/or precipitation from hydrothermal fluids as documented elsewhere in the region. Access to the crag is signposted from the nearby local road, but no other elements of tourist infrastructure are present. The site is described in web-available materials about the Land of Extinct Volcanoes Geopark (www1) and in Kowalski A. (n.d.).

Mount Kopka

The elevation of Mount Kopka (343 m) in the north-central part of the region (Fig. 1, no. 6) is built of quartz sandstones of Coniacian age, which were long valued as building stone material and quarried here since at least the 18th century, but probably for much longer. Several working and abandoned quarries are incised into slopes of the hill, the latter in variable state of preservation. The best preserved old quarry is located immediately below the summit and occupies approximately 150 × 80 m (Fig. 10). The height of vertical quarry walls locally exceeds 20 m, allowing for tracing various structural features of the sandstone series, such as northerly dip of 10–14°, thick bedding up to 4 m and regular jointing pattern, with two vertical sets trending NE–SW and NW–SE (Kowalski A., n.d.). Closer inspection of abandoned sandstone blocks and slabs may reveal various trace fossils and casts of molluscs (Chrząstek & Wypych, 2018), as well as ripples and slickensides, the latter related to the proximity of the Jerzmanice Fault. A picturesque double stone bridge at the entrance to one disused quarry, dated back to the late 19th century, is a local landmark and an example of industrial heritage.

A geotourist trail "Walk on the Cretaceous sea floor" (Kowalski A., n.d.) has been prepared by the local self-government organization. It begins in the centre of the village of Czaple, at the open-air display of various types of sandstone called the Stone Square, and leads to Mt. Kopka. Five educational panels are placed on the way to the main quarry, providing information about the geology and palaeogeography of the area in the latest Mesozoic.

Fig. 9. Minor sandstone crag of Cygańskie Skały, with incipient cavernous weathering and visible cross-bedding structures. Photo P. Migoń

Fig. 10. One of abandoned sandstone quarries on Mount Kopka. Note thick bedding and fairly regular jointing pattern. Photo P. Migoń

The trail and the open-air exhibition are parts of a bigger tourist product, aimed at promoting the village under the slogan "Czaple – the village of sand and stone". The quarries of Mount Kopka are described in web-available materials about the Land of Extinct Volcanoes Geopark (www1), and a printed guidebook is available (Kowalski A., n.d.).

Potential geosites in the Pogórze Kaczawskie region, outside the Geopark

Skałka

The low ridge of Skałka (299 m) extends to the east of the town of Lwówek Śląski, parallel to the Bóbr River valley (Fig. 1, no. 7). Its most elevated part is built of quartz sandstones of Turonian age, whereas a regionally important strike-slip fault line runs WNE–ESE along the northern footslope (Milewicz, 1959). The fault juxtaposes two rock complexes of different ages, Cretaceous sandstones in the south and Triassic sandstones in the north. The fault zone itself is not exposed, but the rock outcrops along the crest show various deformation structures genetically linked with the activity of the fault. The most evident are smooth, steeply inclined slickensides, which may also show steps and striations (Fig. 11). Evidence of silica re-precipitation in the form of thin intersecting deformation bands, often following bedding structures, is also common. Sandstone crags are present on both sides of the crest and locally reach 8 m high. Rock cliffs occur side by side with boulder piles, producing rather chaotic rock morphology, with large voids and deep overhangs. A small fissure cave of Zimna Dziura (Cold Hollow), of the total length of 8.5 m, is located to the south of the ridge axis.

The locality is easy to reach, following the blue-marked hiking trail leading from Lwówek Śląski to the village of Bielanka. However, the site itself is not developed in terms of interpretation facilities such as informational panels, although the surrounding area is also interesting from historical and archaeological point of view. Faint remnants of a Lusatian culture hillfort may be recognized near the top of Skałka ridge and various traces of gold prospecting in medieval times occur in the vicinity (Staffa *et al*., 2002). A historical monument worthy of attention is an impressive sandstone-cut block with a relief of a cross on both sides, located by the hiking trail. According to local beliefs, it is an unfinished penance cross.

Fig. 11. Slickensides and deformation bands highlighted by the presence of silica in sandstones at Mount Skałka provide evidence of post-sedimentary tectonic deformations in the vicinity of a regionally important fault. Photo P. Migoń

Skała

The old park grounds in the village of Skała (Fig. 1, no. 8), developed around a ruined palace, comprise several outcrops of quartz sandstones of Coniacian age. They occur within the moderately steep face of a cuesta of W–E extension, which owes its occurrence to higher resistance of these sandstones if compared with the underlying calcareous sandstones and marls. The outcrops take various shapes, from free-standing towers 5 m high, projecting from the cuesta face, through complex cliffs a few metres high, moulded into spurs and pillars, to simple rock steps, artificially enhanced during the development of a romantic park. In addition, several old exploitation places are present, whereas working quarries are located nearby, on the cuesta top surface. Some natural outcrops show various effects of selective rock weathering, including honeycombs, small tafoni up 0.5 m wide, ferruginous and biochemical surface crusts; cross-bedding is also frequently observed (Fig. 12).

The locality is also of considerable cultural value, although the 18/19th century old palace itself, once famous beyond the region for its picturesque location at the cuesta rim and richly decorated interiors (Staffa *et al.*, 2002), remains in ruins and is currently not accessible. Service buildings nearby are in better conditions, but they do not perform any tourist function. Access to the park grounds and its forested surroundings is however without any restrictions. Two informational panels erected near two opposite entrances to the park discuss the history of the palace and the park, but no explanation of local geoheritage is provided.

Wieżyca

One kilometre to the west of the ruined palace in Skała, an impressive sandstone tower known as Wieżyca (or Skałka, also Skałka z Medalionem) rises from the front scarp of the Coniacian sandstone cuesta (Fig. 1, no. 9). It is 14 m high on the downslope side and has a rectangular outline, with generally vertical walls, which expose a variety of sedimentary structures: large-scale cross-stratifications in the lower part, ripple cross-laminations and plane-parallel stratifications in the upper part, interpreted to indicate tidal bars (sand ridges) (Leszczyński & Nemec, 2020). These discontinuities, in turn, influence the process of surface weathering that produced various small-scale cavernous features and narrow ledges (Fig. 13). A natural gap separates the tower from the rock spur on the upslope side, itself bounded by minor cliffs 4–6 m high. Given its height, Wieżyca is a unique landform in the region, as tower-like sandstone crags elsewhere (Krucze Skały, Skała) do not

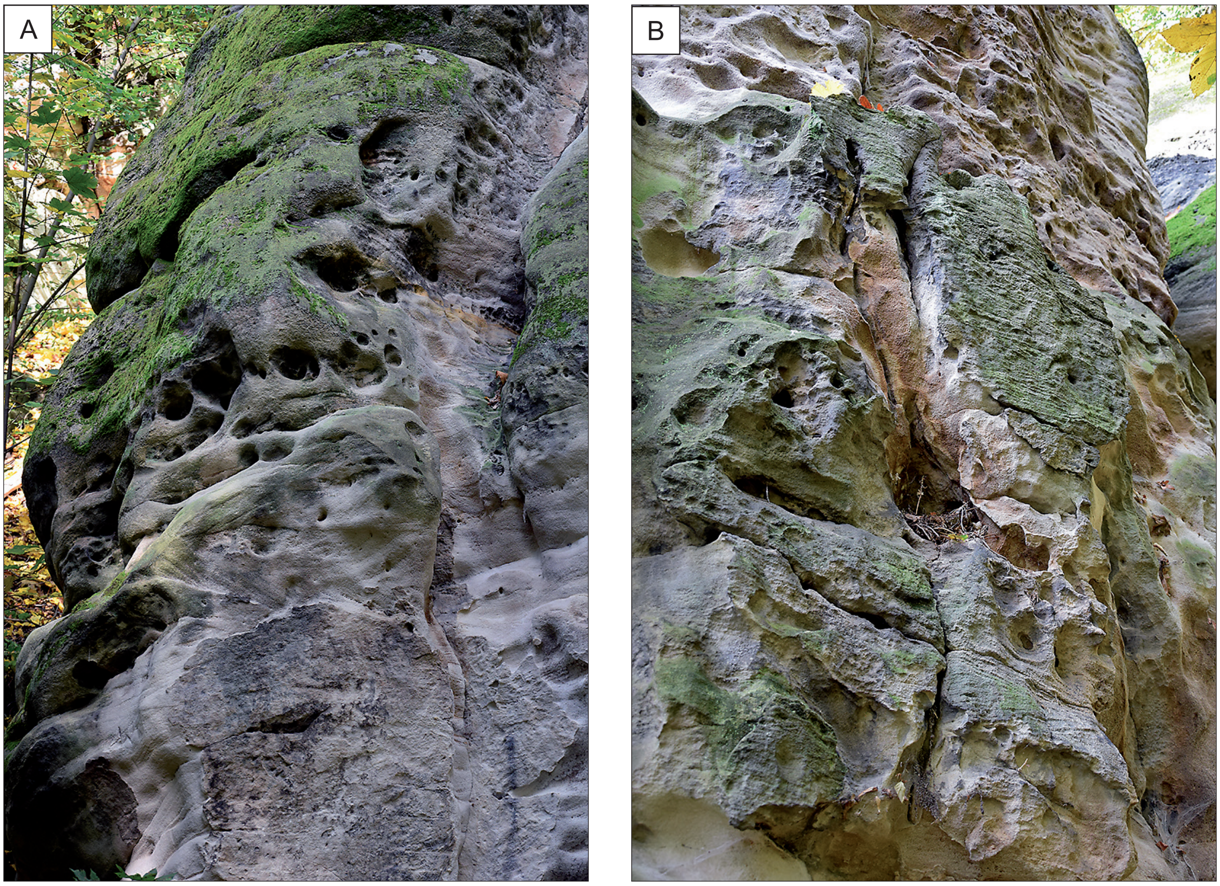

Fig. 12. Selective weathering of sandstone outcrops at Skała: A – cavernous weathering; B – ferruginous and biochemical crusts, arcades and cavernous weathering. Photos P. Migoń

exceed 5 m high. It is also an important geological locality, since unrestricted access allows one to examine a large section of the vertical sedimentary succession, otherwise exposed in working quarries (Leszczyński & Nemec, 2020) and therefore, essentially off limits for an individual geotourist.

The sandstone rock formation of Wieżyca has been considered as a tourist attraction since the 19th century and was visited by tourists and guests from the palace in Skała. In 1897, a medallion with the image of German Emperor Wilhelm II was attached to the rock surface, and a footbridge connecting the rim of the cuesta and the top platform of the tower was erected (Staffa *et al*., 2002). The construction enabled easy access to the viewing point. Nowadays, the footbridge does not exist any longer and only some remnants of the construction are visible. The top of the tower is accessible to climbers only. The medallion apparently disappeared in the 1980s, whereas at the beginning of the 21st century a new one, with an emblem of the town of Lwówek Śląski, was placed in the same spot. Since 1988 Wieżyca has been protected as a nature monument. The site is easily accessible, along a green-marked hiking trail from Skała or the village of Żerkowice in the Bóbr valley.

Fig. 13. Solitary sandstone rock tower of Wieżyca near Skała. Photo P. Migoń

Huzarski Skok

Sandstone bedrock of Coniacian age is exposed within a discontinuous cliff line that overlooks the valley floor of the Bóbr River, ca. 6 km to the north from the town of Lwówek Śląski (Fig. 1, no. 10). The cliffs continue for about 250 m in the east–west direction, rising to 6–8 m high (Fig. 14). The ground plan of the cliff line shows clear adjustment to the presence of two vertical joint sets, and rock spurs alternate with regolith-covered amphitheatres along the outcrop. Within the rock spurs, several small caverns were documented, developed along jointed zones through combined weathering, piping and surface wash. The longest one (Jaskinia Pandurów) is 13 m in total, whereas two have more than one entrance (Pulina, 1996). Prior to the mid-20th century, the cliffs were rising directly above one of the channels of the Bóbr River. Subsequent river regulations involved straightening of the main channel, and the branch was abandoned. Today, it is completely dry and visible only as a shallow sinuous terrain depression.

The site is located next to the district road no. 297, between the villages of Żerkowice and Włodzice Wielkie, and can be reached by the green-marked hiking trail. The name of the place "Huzarski Skok" (Husarensprung in German, Hussar Jump in English) is connected with the local historical legend and goes back to the time of the Battle of the Kaczawa (Katzbach) River during Napoleonic Wars in 1813. According to the legend, a French cavalry soldier jumped from the cliff face into the river and survived unscathed (Staffa *et al.*, 2002). Caverns are mentioned in tourist blogs and web-based materials, but the site itself is not developed at all. During the peak vegetation season, it becomes poorly visible and difficult to explore.

Pokutujące Skałki

The name (Penitent Rocks) is given to a group of abandoned quarries located to the east from the village of Łaziska, within a low terrain swell at the northern boundary of Pogórze Kaczawskie region (Fig. 1, no. 11). Coarse quartz sandstone of Cenomanian age was subject to commercial exploitation, and the entire quarried terrain is ca. 400 × 150 m, with numerous separate working areas. They are all considerably overgrown, and in some of them bedrock outcrops are no longer visible, whereas in other places quarry walls up to 8 m high occur, possibly indicating time elapsed since the closure of a quarry, or local differences in rock strength. The exposed sandstones are massive and thickly bedded, with multidirectional discontinuities and notable vertical zones of rock fracturing (Fig. 15).

Fig. 14. Sandstone cliffs, cavernous weathering and entrances to fissure caves at Huzarski Skok locality. Photo P. Migoń

Fig. 15. Vertical disintegrated zone exposed in the former quarry at Pokutujące Skałki locality. Photo E. Pijet-Migoń

The old quarries are easy to reach from Łaziska along a field access road, but currently they are not signposted. Nor does on-site information exist about the quarries themselves. A few years ago, some sections of the quarry walls were cleared of vegetation and developed for rock climbers.

Geosite evaluation

Literature abounds in proposals how to evaluate geosites in terms of their values and attractiveness for visitors (e.g., Pereira *et al.*, 2007; Reynard *et al.*, 2007; Kubaliková, 2013; Brilha, 2016). Here, we attempt to use the scheme developed by Różycka & Migoń (2018) to evaluate geosites presented above. The choice is dictated by two reasons. First, the scheme was originally applied in the Pogórze Kaczawskie region, which is also the study area here, although assessment was then limited to volcanic geosites. The results may thus be partially comparable. Second, the proposed approach considers both non-weighted evaluation, in which each evaluation criterion is given identical importance (weight) while calculating the total score, as well as customer-oriented evaluations, in which certain assumptions are made regarding criteria that matter most for specific groups of visitors. However, the original approach has been slightly modified in this study.

The evaluation scheme consists of six criteria and the range of possible scores in each is from 0 to 3 (Table 1). Thus, a total of 18 points is the theoretical maximum score in non-weighted evaluation. In the next step, three customer-oriented evaluations are performed, for 'geo-experts', 'interested visitors' and 'unaware visitors'. In each, two criteria are assumed to be more important than the others, and the respective scores from the non-weighted evaluation are multiplied by the factor of two, whereas others remain unchanged. Doubling the scores applies as follows:

- for 'geo-experts' – scientific value and state of preservation,
- for 'interested visitors' – educational value and additional value,
- for 'unaware visitors' – aesthetic value and accessibility.

In the original proposal by Różycka & Migoń (2018), multiplication by 1.5 was applied, whereas partial scores in two criteria considered least important were multiplied by 0.5.

Table 2 shows numerical results of evaluations, whereas Table 3 presents respective rankings of geosites. The following observations emerge. First, Krucze Skały is an evident leader in each ranking, with the difference in score in respect to position no. 2 between 3 and 5 points. Thus, this is the geosite for everyone and visitors with different backgrounds and expectations should have a positive experience. The position of Krucze Skały is consistently followed by Wieżyca, whereas rock outcrops and non-karstic shelters in the Drążnica Valley occupy position no. 3 in three out of four rankings. Shifts between positions are generally minor. Block fields at Mount Prusicka – Mount Średnia scored at no. 5 for geo-experts, but only no. 7–9 for interested visitors and no. 8–10 for unaware ones. This shift down in the score is a result of little if any additional aesthetic values of the site and its relatively remote location. Diablak with its sandstone xenolith changes position from no. 3–4 for geo-experts to no. 6 for unaware visitors. The most evident shift up is experienced by sandstone landforms around the village of Skała (position no. 6–7 for geo-experts and no. 2–3 for interested visitors). This is due to the proximity of historical monuments and educational opportunities. Overall, geosites located within the boundaries of LEV Geopark perform better, although the position of Kopka is below one suggested by intuitive assessment. The locality has been recently developed for tourists, and a special educational trail is available, increasing educational opportunities. This is reflected by the moderately high position no. 5–6 in ranking for interested visitors. The low score, especially for unaware visitors (no. 8–10), is due to the lack of aesthetic values (degraded quarrying grounds) and time-consuming access.

Table 1. Criteria of evaluation of geosites, after Różycka & Migoń (2018)

Criterion	Characteristics	Score
Scientific value	distinctive in the region and scientifically well recognized distinctive in the region and mentioned in literature typical in the region and described in literature typical in the region, no specific features	3 2 1 0
Educational value	at least one geoscience topic can be presented as an outstanding example more than one geoscience topic can be presented, including at least one being a good example one geoscience topic can be presented as a good example very limited geo-educational use	3 2 1 0
Additional value	significant object of cultural heritage or outstanding biological values (nature reserve) moderately important object of cultural heritage or presence of valuable biotic elements historical element of local importance and/or viewpoint no significant biological, cultural or historical elements	3 2 1 0
Aesthetic value	outstanding element of regional landscape and easy to appreciate in full size distinctive element of regional landscape and easy to appreciate or outstanding element but with restricted visibility typical element of regional landscape no specific aesthetic features	3 2 1 0
Accessibility	site can be reached in more/less than 15 minutes from a parking lot access to the site poorly/clearly marked access to the object itself restricted / object fully accessible	0/1 0/1 0/1
State of preservation	no signs of degradation, well-exposed slightly damaged, partially overgrown damaged, markedly overgrown, but main geological and geomorphological features still visible devastated, entirely overgrown, main geological and geomorphological features poorly exposed	3 2 1 0

Table 2. Results of quantitative evaluation of geosites

Geosite	Criteria						Score			
	scientific value	educa-tional value	addi-tional value	aesthetic value	accessi-bility	state of preser-vation	non-weighted	geo-expert	inter-ested visitor	unaware visitor
Within Geopark										
Krucze Skały	3	3	1	2	3	2	14	19	18	19
Drążnica Valley	2	1	0	2	2	2	9	13	10	13
Mount Prusicka	3	1	0	0	1	2	7	12	8	8
Mount Diablak	2	2	1	1	1	2	9	13	12	11
Cygańskie Skały	1	0	0	1	3	2	7	10	7	11
Mount Kopka	2	2	1	0	1	1	7	10	10	8
Outside Geopark										
Skałka	1	1	1	1	1	1	6	8	8	8
Wieżyca	2	1	1	2	2	3	11	16	13	15
Skała	1	2	2	1	2	1	9	11	13	12
Huzarski Skok	2	1	0	0	2	2	7	11	8	9
Pokutujące Skałki	0	1	0	0	1	1	3	4	4	4

Table 3. Ranking of geosites according to different weightings of evaluation criteria

Position	Evaluation			
	non-weighted	**geo-expert**	**interested visitor**	**unaware visitor**
1	Krucze Skały	Krucze Skały	Krucze Skały	Krucze Skały
2	Wieżyca	Wieżyca	Skała	Wieżyca
3	Mount Diablak	Mount Diablak	Wieżyca	Drążnica Valley
4	Drążnica Valley	Drążnica Valley	Mount Diablak	Skała
5	Skała	Mount Prusicka	Drążnica Valley	Cygańskie Skały
6	Cygańskie Skały	Huzarski Skok	Mount Kopka	Mount Diablak
7	Huzarski Skok	Skała	Huzarski Skok	Huzarski Skok
8	Mount Kopka	Cygańskie Skały	Mount Prusicka	Mount Kopka
9	Mount Prusicka	Mount Kopka	Skałka	Mount Prusicka
10	Skałka	Skałka	Cygańskie Skały	Skałka
11	Pokutujące Skałki	Pokutujące Skałki	Pokutujące Skałki	Pokutujące Skałki

Despite the popularity of the numerical evaluation of geosites, this approach does not give clear information about the value of individual localities. Therefore, a qualitative summary is also provided, which lists principal features to note at each site (Table 4). It shows that some localities represent significant values for both geology and geomorphology, and may have additional values related to the human use of geological resources.

Table 4. Summary of features of geoscience interest at Cretaceous sandstone-related geosites in the Pogórze Kaczawskie region. The use of bold indicates particularly high value. Note that sandstone is exposed at each locality and hence, lithology is not specifically listed

Geosite	Geology	Geomorphology	Use of resources
Within Geopark			
Krucze Skały	**jointing** **near-fault deformation**	rock cliffs and towers surface weathering joint-aligned ravines	**quarrying** (abandoned) water intake adjustment to tourist use
Drążnica Valley	lithological differentiation permeability differences	rock cliffs **non-karstic rock shelters** relict fluvial landforms	–
Mount Prusicka	silicification ferruginization	**block fields** surface weathering	–
Mount Diablak	**xenolith in basalt**	–	–
Cygańskie Skały	silicification cross-bedding	minor crag	–
Mount Kopka	**jointing** bedding fossils	anthropic landforms	quarrying (abandoned and ongoing)
Outside Geopark			
Skałka	**silicification** near-fault deformation **slickensides**	rock cliffs and crags fissure cave	–
Wieżyca	cross-bedding	**rock tower** surface weathering	–
Skała	–	rock cliffs and spurs minor rock towers **surface weathering**	incorporation into landscape park outcrop re-shaping
Huzarski Skok	jointing	rock cliffs **non-karstic rock shelters**	–
Pokutujące Skałki	fractured zones	anthropic landforms	quarrying

Others act as windows into interesting geological structures, but are not associated with any spectacular landforms, whereas at further localities, geomorphological features deserve primary attention.

A final point to observe is that the level of appreciation of a geosite will be likely influenced by the visibility of the respective structures and landforms, which in turn is strongly season-dependent. Growth of vegetation in the warm seasons may render some geosites virtually inaccessible and severely reduce the opportunities to see them in full-size, as already observed for several volcanic geosites in the region (Różycka & Migoń, 2014). Experience from sandstone geosites is similar, and the visual value of abandoned quarries in particular suffers from the presence of vegetation which is too dense. Minor crags and cliffs are also hardly visible. Periodical selective removal of vegetation is therefore recommended, especially at the Skała locality (Fig. 1; no. 8), where it should become part of management plan for the landscape park that surrounds the ruined palace.

Comparison with other sandstone terrains in the Polish part of the Sudetes

The occurrence of Cretaceous sedimentary rocks is not restricted to the Pogórze Kaczawskie region. Comparable rock outcrops and sceneries can be found elsewhere in the Sudetes. The Bóbr valley marks a conventional western boundary of Pogórze Kaczawskie, but Cretaceous strata continue further to the west in the vicinity of the town of Lwówek Śląski (Fig. 1). At the southern outskirts of the town, an impressive series of natural sandstone cliffs is exposed in the front slope of a cuesta supported by Cenomanian sandstones. It is known as Lwóweckie Skały (Crags of Lwówek) or, more romantically, Szwajcaria Lwówecka (Lwówek Switzerland) (Fig. 1, no. 12). The cliff line is nearly 200 m long and locally up to 15 m high, exposing underlying Triassic sandstones at the base. Apart from the cliffs themselves, the locality shows various weathering and gravity-driven phenomena (Placek, 2008) and is arguably the best medium-scale example of denudational sandstone landforms in the entire Polish West Sudetes. Sandstone cuestas extend further northwest for another 10 km or so, with minor crags dotting cuesta faces and numerous quarries, now mostly abandoned (Maciejak & Migoń, 1990). Quarrying has a long history around Lwówek Śląski, but this component of local heritage is yet to be explored in the geotourism context.

Further to the south along the Bóbr valley, an isolated outlier of Cretaceous terrain occurs in a downfaulted position in the vicinity of the town of Wleń, known as the Wleń Graben (Gorczyca-Skała, 1977; Kowalski A., 2020). Its geotouristic significance has not yet been comprehensively investigated, although several localities of interest are known from the area, such as block field on Mount Gniazdo (Migoń & Łętkowska, 2016), landslide-related features in the Bóbr valley (Kowalski A., 2017) and the residual hill of Mount Stromiec in inverted position, with abandoned quarries and fissure caves.

Far more widespread, diverse and impressive are the localities in the central part of the Sudetes, in the Intra-Sudetic Synclinorium, whose axial part is filled by the Cretaceous succession up to 400 m thick and spanning the Cenomanian – Upper Turonian/Lower Coniacian interval (Tásler, 1979; Wojewoda, 1997). They cluster in the Stołowe Mountains tableland, its NW extension in the Czech Republic – the Broumov Highland, and in the Zawory escarpment and Krzeszów Basin in the northwest, and include spectacular examples of rock cities, tabular hills (mesas), canyons, cliff lines and hoodoo rocks. Their presentation, however, is beyond the scope and limits of this paper (but see Pulinowa, 2006; Wojewoda, 2011; Duszyński *et al*., 2015; Vítek, 2016 for partial coverage). Whereas it is true that most geosites presented from the Pogórze Kaczawskie region have their analogues in the Central Sudetes, the distance between these regions is 50–80 km, precluding any direct competition. Moreover, Cretaceous sandstone-related geosites in the Pogórze Kaczawskie region are important components of regional geodiversity that covers a much longer and varied rock record, than a group of sites disassociated from other values of the area.

Conclusions

Cretaceous sandstone-related geosites in the Pogórze Kaczawskie region, although not too numerous, add to the considerable geodiversity of the area and are important components of regional geoheritage, even if none of the features exposed at these geosites can be considered really unique in the wider context of the Sudetes. They illustrate a wide range of geological and geomorphological themes, providing insights into sedimentary environments in the Late Cretaceous, various post-sedimentary deformations related to faulting and volcanism, and lithology- and structure-controlled landform evolution, spanning the last 100 million years of Earth history. Moreover, they inform about past use of stone resources and early attempts to use them as sites of tourist interest. In addition, examination of freely available terrain models, using sources such as geoportal.gov.pl, allows one to follow relationships between rocks and landforms at the regional scale (e.g., Fig. 2), beyond the information potential of singular geosites. The sites presented in this paper are complementary to one another and do not duplicate each other's values.

Geosites located in the eastern part of the region, within the Land of Extinct Volcanoes Geopark, are better developed to serve geotourism. Information panels have been erected at some of them, at Mount Kopka an educational trail was set up, and each locality is comprehensively presented on the Geopark website. Sites in the westernmost part of the region, beyond the Geopark boundaries, lack interpretative facilities, but their close proximity to one another offers various options to develop a local tourist product. Given that the most impressive outcrop of Cretaceous sandstones, Lwóweckie Skały in the town of Lwówek Śląski, is in the close vicinity, an attractive 'sandstone trail' can be easily designed in this part of the West Sudetes.

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