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Selected geosites of the Cracow Upland

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A b s t r a c t . The Cracow Upland encloses the Variscan bedrock covered with the Epivariscan Platform forming the Cracow-Silesian Monocline, composed of the sequence of Permian-Cretaceous deposits. Upper Jurassic limestones are the main formation shaping the landscape of this region rich in rocky valleys, tors and karst forms. Landscape parks extending over the considerable part of the mentioned area enclose numerous nature reserves and monuments. The presented European network of geosites consists of the Ojców National Park and 11 small areas or individual localities. This list comprises 7 objects just protected while the remaining ones are documented and proposed for conservation.

Key words: geoconservation, network of European geosites, Cracow Uplan.

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S t r e s z c z e n i e. Wyżyna Krakowska zajmuje część monokliny śląsko-krakowskiej, obejmującej utwory permo-mezozoiczne oraz występujące w ich podłożu skały dewonu i karbonu. Wapienie górnej jury są główną formacją geologiczną decydującą o cechach rzeźby wyżyny, takich jak: skaliste doliny, skałki wierzchowinowe i formy krasowe. Znaczna część obszaru jest objęta ochroną w Zespole Jurajskich Parków Krajobrazowych, znajdują się tu także liczne rezerwaty i pomniki przyrody. Proponowaną sieć europejskich stanowisk reprezentuje Ojcowski Park Narodowy oraz 11 mniejszych obszarów i pojedynczych obiektów. Siedem z nich jest już objętych ochroną, a pozostałe są proponowane do objęcia ochroną.

Słowa kluczowe: geoochrona, sieć europejskich geostanowisk, Wyżna Krakowska.

The Cracow Upland and the adjacent part of the Silesian Upland extend over the Cracow-Silesian Monocline. This geological region encloses Permian, Triassic, Jurassic and Upper Cretaceous deposits dipping gently to north-east. The Palaeozoic bedrock crops out along the south-western margin of the monocline and continues as the large geological structure — the Upper Silesian Basin, covered only with Tertiary and Quaternary sediments.

Early Palaeozoic formations are developed as terrigenous deposits of Cambrian and Ordovician limestones as well as shales and sandstones of Silurian age. The Devonian begins with quartzitic sandstones alternated with red shales, passing upward into dolomites and limestones with fossils. The fauna of brachiopods and conodonts evidences particular biostratigraphic units of the Middle and Upper Devonian. Lower Carboniferous deposits are represented by limestones with fossils (brachiopoda, foraminifera) and sedimentary structures indicating a shallow-marine environment. The occurrence of intraformational conglomerates is noteworthy. Grey shales with thin intercalations of marls, organodetritic limestones and sandstones with fauna typical of the Upper Visenian terminate the sequence of marine sediments. The coal-bearing formations of Namurian–Westfalian age extend in the Upper Silesian Basin.

The described formations are folded, form Variscan structures spreading from north-west to south-east as the Cracow-Silesian Branch of Variscides. They are known from several boreholes and crop out in a few places. Traces of magmatism were noted as well.

Permian-Mesozoic deposits cover discordantly the bedrock. Lower Permian conglomerates and shales as well as volcanic rocks are developed locally. Limestones and dolomites representing the Lower and Middle Triassic extend in the south-western part of the region in question. Middle Jurassic sediments begin with sand, sandy limestones and marls abounding in fossils. They gradually pass into Upper Jurassic marls and limestones forming the main part of the Cracow Upland. Upper Cretaceous transgressive sediments occur in the eastern and southern periphery of the described area.

The system of troughs and horsts connected with Fore-Carpathian Depression is developed in the southern part of the upland. Troughs are filled with Miocene clays rich in microfos-

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sils. Quaternary cover is discontinuous. It encloses boulder clays, loess, calcareous tufa and travertines as well as fluvial sediments.

The large planation surface of the Palaeogene age spreads over the elevated part of the upland. It is locally crowned with several limestone tors. Deep valleys with rocky slopes and karst forms are typical features of the landscape. Rocky hills formed of Jurassic limestones rise over flat areas in the southern part of the mentioned region as typical elements of the structural relief.

Geoconservation network

Geological formations and relief of the Cracow Upland deserve conservation as values particularly important from scientific, didactic and touristic point of view. A few geologists, geomorphologists and naturalists point to necessity of protecting beautifull and differentiated landscape, unique forms of the relief and representative geological outcrops (Sawicki, 1914). The first well documented proposal for the creating a nature reserve in the Prądnik river valley was presented in 1924 (Richter & Szafer, 1924; Smoleński, 1924). Many caves from the Ojców area, explored by archaeologists were just known at that time, 12 of them were included into legal protection (Kowalski, 1951). Another interesting element of the landscape — the Vistula river gate in Tyniec was granted the status of a nature monument in 1937.

After the Second Word War the geological conservation network was created. It encloses the Ojców National Park, 3 geological nature reserves, 11 landscape parks and other reserves important for earth sciences, 107 nature monuments (99 limestone tors, 4 springs, 3 caves, 1 eratic boulder) and 7 documentary sites (Z. Alexandrowicz *et al.*, 1992). Numerous geological and geomorphological localities are protected in valleys crossing the Ojców Plateau and the Tenczynek Range as well as in abandoned quarries (Gradziński & Gradziński, 1994). The most valuable part of these objects is situated inside landscape parks belonging to the Complex of Jura Landscape Parks. The mentioned network needs suplements. Selected outcrops of geological formations representing the whole stratigraphic succession of the upland, sites of deposits rich in fossils and particularly interesting elements of the relief have been documented recently and will be proposed for protecting.

Draft candidate list of geosites

Geological formations and structures as well as geomorphology of the Cracow Upland have been studied in details for about 100 years. The following main research fields can be pointed out as most important ones:

- stratigraphy and lithology of particular geological formations cropping out to the surface (deposits of the Middle and Upper Devonian, Lower Carboniferous, Lower Permian, Lower and Middle Triassic, Middle and Upper Jurassic, Upper Cretaceous and Miocene);
- the fossil fauna of marine deposits with special regard to the Late Palaeozoic, Jurassic and Cretaceous;
- petrography and geological setting of Lower Permian volcanic rocks;
- tectonic elements of the upland connected with Variscan and Alpine orogenic periods;
- lithology and stratigraphy of Quaternary deposits in relation to climatic changes, flora and fauna as well as environmental evolution during the last hundred thousand years;
- the relief and morphogenesis with a special regard to relations between tectonic structures (horsts & troughs) and landforms, planation surfaces and hardrocks, karst phenomena and processes as well as elements of fluvial morphology.

Results of detail geological research and mapping published a hundred years ago by Zaręczny (1894) are the base for knowledge of geology of the region in question. They have been revised by several authors (Siedlecki, 1951, 1952, 1954; Dżułyński, 1952, 1953; Bukowy, 1956; S. W. Alexandrowicz, 1960, 1997a; Gradziński, 1962, 1972; Bogacz, 1967, 1980; Gilewska, 1972).

The draft candidate list of geosites comprises both areas and objects already protected such as a national park, nature reserves, monuments and documentary sites as well as objects documented and proposed for the legal conservation (Fig. 1). A number of them are situated in six landscape parks enclosing a considerable part of the Cracow Upland. Many interesting outcrops and landforms have been evaluated and after selection the most important ones should be pointed out for the proposed list of European geosites.

1. The Carmelite Quarry in Dębnik (435 m a.s.l.; 50°09'50"N/19°40'30"E).

Main features: the sequence of Upper Givetian and lowermost Frasnian limestones (the Dębnik Marble).

It is a large abandoned quarry (about 2 ha, up to 15 m high) with a water body in the bottom (Fig. 2). Dark-grey and black bituminous limestones called locally "Dębnik Marble" dip to WNW forming a 35 m long profile (Siedlecki, 1954). They are distinctly bedded and poorly fossiliferous. In the eastern part of the outcrop a few layers of limestones yield stromatoporoids, corals and brachiopods indicating the Upper Givetian age. They pass upward into bedded limestones with brachiopods and conodonts, typical of the Lower Frasnian (Baliński, 1979).

The Dębnik Marble was used as a decorative stone in sacral and monumental building for a long time. The site comprises the Middle–Upper Devonian boundary documented with fossils. It is an exceptional locality in Central Europe. It will be proposed for protection as a documentary site.

2. The outcrop Czerwona Ścianka (Red Wall) in Czerna (345 m a.s.l.; 50°10'02"N/19°37'34"E).

Main features: Visean detritical and organodetritical limestones, rich in macro- and microfauna, typical shallow-marine deposits.

The outcrop, 200 m long, is situated at the left bank of the Czernka stream valley. The sequence of Visean deposits dipping 130°/40°SW is composed of reddish-grey limestones and malry limestones with numerous brachiopods (a.e. *Gigantoproductus giganteus*), grey organodetritical limestones, intrafor-

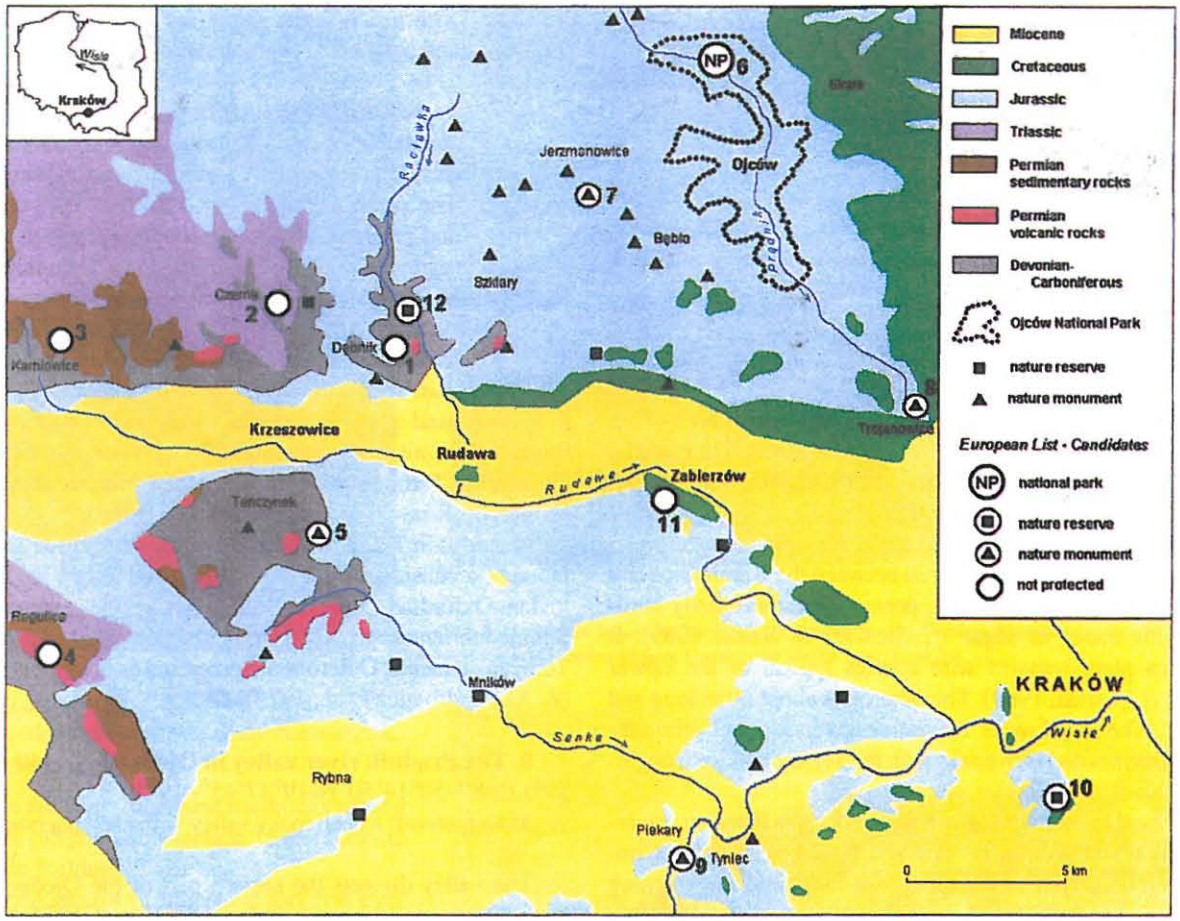

Fig. 1. Distribution of geosites in relation to geology of the Cracow Upland (after Gradziński, 1972 — simplified)

Fig. 2. The Carmelite Quarry in Dębnik, Middle/Upper Devonian limestones (the Dębnik Marble). Photos 2 and 4–6 by Z. Alexandrowicz

mational conglomerates and dark-grey bituminous limestones. The whole thickness of these deposits is about 30 m. Several microfacies characterized by microfossils (calcisphaera, foraminifera, ostracoda) and remains of echinodermata, brachiopoda and bryozoa were distinguished (S. W. Alexandrowicz & Siedlecka, 1964). The rich fauna of Foraminifera encloses about 50 taxa (S.W. Alexandrowicz & Mamet, 1973), and indicates the Upper Visean age.

The locality presents the standard sequence of youngest part of Lower Carboniferous limestones of southern Poland, abounding in fossils and typical of shalow-marine environment. It is a very important geotop for the Late Visean calcareous deposits in Central Europe.

The outcrop is proposed for protection as a documentary site.

3. Outcrops in Karniowice (385 m a.s.l.; 50°09'48"N/19°31'26"E).

Main features: the profile of Lower Permian continental deposits: conglomerates (fanglomerates) and the fossil-bearing travertine.

Lower Permian conglomerates occur on the left side of the Karniowice stream valley (Fig. 3). The main outcrop is up to 20 m high and about 80 m long. Sandstones and arcoses of the Westfalian age, belonging to to coal-bearing formation of the Upper Silesian Basin are visible at the bottom. The conglomerate described as the Myślachowice Conglomerate is composed mainly of pebbles of Devonian limestones and dolomites, Lower Carboniferous limestones and

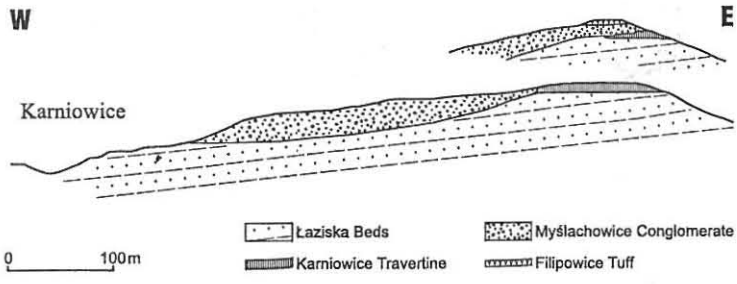

Fig. 3. Geological cross-section of the hill between Karniowice and Filipowice, Upper Carboniferous and Lower Permian deposits (after Siedlecki, 1951 — simplified)

volcanic rocks (porphyr) with a rich matrix. Pebbles are 2–7 cm in diameter but few of them reach more than 20 cm. The material was deposited after a short transport (Siedlecki, 1951, 1954; Siedlecka, 1964; Gradziński, 1972).

The Permian travertine crops out in a few places in the upper part of the slope and at the flat hill between the Karniowice and Filipowice valleys. It is white, porous limestone partly laminated with traces of algae (Ćwiżewicz & Szulc, 1989). It comprises plant remains with species typical of the Lower Permian (Lipiarski, 1969). The outcrop is about 60 m long and 4 m high. The Karniowice Travertine covers Upper Carboniferous sandstones and is overlain with the Myślachowice Conglomarate (Siedlecki, 1951).

The locality encloses two sites: the Lower Permian travertine — one and only in Europe and the Myślachowice Conglomerate as a typical postorogenic fanglomerate reaching the thickness up to 300 m, deposited just after Variscan tectonic movements.

4. Outcops in Regulice (290 m a.s.l.; 50°04'28"N/ 19°31'55"E).

Main features: melaphyres of Lower Permian, two lava flows separated by a volcanic breccia.

Lower Permian melaphyres crop out in a few abandoned quarries on the eastern slope of the hill in Regulice. Melaphyre rests on a thin bed of Myślachowice Conglomerate (Lower Permian) underlain with Upper Carboniferous sandstones (Siedlecki, 1951, 1952). Two lava flows separated by the melaphyre breccia were distinguished and dated by a palaeomagnetic method (Birkenmajer & Nairn, 1964). Massive, vertically jointed melaphyre passing upward into vesicular and amygdaloidal melaphyre occur in a small quarry (50 m long, 12 m high), situated in the lower part of the slope. It represents the first lava flow. The volcanic breccia covering this flow is well exposed in the upper quarry. The melaphyre representing the second lava flow is also visible here.

Melaphyres from Regulice represent the post-Variscan volcanic activity, typical of the eastern margin of the Upper Silesian Basin.

Two described outcrops will be proposed for protection as documentary sites.

5. Outcrops in Tenczynek (330 m a.s.l.; 50°06'43"N/ 19°39'02"E).

Main features: a sequence of Callovian–Oxfordian deposits with a rich fauna important from the stratigraphic and palaeobiogeographic point of view.

Middle/Upper Jurassic deposits rich in fossils are accessible in two small outcrops (abandoned quarries) situated about 2 km to the east of Tenczynek. The sequence begins with sand, locally cemented and passing upward into sandy limestones abounding in brachiopods, ammonites and belemnites. The next layer is developed as nodular limonithic limestone crowned with stromatolit. The fauna indicates the Callovian age. Deposits of the lowermost Oxfordian are represented by marls passing into marly limestones and platy limestones. Very rich assemblages of fossils (ammonites, sponges, foraminifers) occur in this part of the profile. The described sequence reaches the thickness of about 5 m (Różycki, 1953; Szulczewski, 1968).

Outcrops in Tenczynek are of particular interest. The fossil fauna of a considerable stratigraphic value indicating the Callovian–Oxfordian boundary comprises species typical of the Submediterranean province with influences of both Boreal and Tethyan elements. Outcrops are protected as documentary sites (Z. Alexandrowicz *et al.*, 1975).

6. The Prądnik river valley in Ojców (300–440 m a.s.l.; 50°11'08"–50°14'50"N/19°47'45"–19°50'35"E).

Main features: a deep rocky valley with karst phenomena.

The valley dissects the eastern part of the Ojców Plateau forming a deep and narrow rocky gorge (Drzał, 1954; Małecki, 1977). It is surrounded by many rocky walls and tors raising up to 100 m above the valley bottom. Rocky scenery is formed of Upper Jurassic massive limestones concerning fossils such as ammonites, brachiopods and sponges. System of joints is well developed. Particular segments of the valley and its tributaries follow the main directions of fissures (Z. Alexandrowicz & S. W. Alexandrowicz, 1977). Karst phenomena represented by enlarged fissures, microrelief and many caves are important morphogenetic factors. About 200 caves are known here, tourists are allowed to visit a few of them (Gradziński, 1977). Fragments of rocky terraces are marked on both banks of the valley. The outcrop of Holocene travertine and calcareous tufa abounding in shells of molluscs is situated on the right bank of the Sąspówka stream, the main tributary of the Prądnik river. The Holocene terrace with the sequence of peaty loam, calcareous sediments and muds fill the bottom of the valley (S. W. Alexandrowicz, 1997b). The area in question is rich in springs draining the deep groundwater level (S. W. Alexandrowicz & Wilk, 1962).

The Prądnik river valley is the longest and deepest one in the Cracow Upland. It has a typical karst landscape with beautiful scenery (Fig. 4). Historical monuments (two medieval castles) and archaeological sites are aditional values of this area.

The most interesting part of the valley is protected in the Ojców National Park (1,890 ha). It was used as a health resort and now it is a tourist, scientific and educational centre.

7. Limestone tors in Jerzmanowice (500 m a.s.l.; 50°11'28"N/ 19°46'45"E).

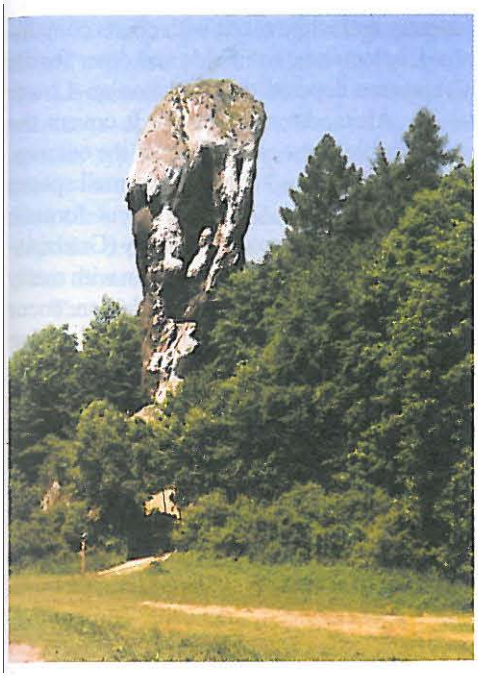

Fig. 4. Oxfordian limestone rock (25 m high) — Maczuga Herkulesa (Hercules Club) in the Ojców National Park

Fig. 5. Oxfordian limestone hardrocks raising above the Tertiary planation surface in Jerzmanowice — Complex of Jura Landscape Parks near Kraków

Fig. 6. Old abandoned quarry in Trojanowice, Upper Jurassic limestones, Turonian sandy limestones and loess

Main features: limestone hardrocks raising above the old planation surface, Upper Jurassic carbonate buildups.

Several groups of limestone tors rise over the Tertiary planation surface, forming the top of the Ojców Plateau. The most interesting of them occur in Jerzmanowice. They enclose 33 rocky forms: tors, groups of tors and rocky hills formed of Upper Jurassic massive limestones (Oxfordian). Their heights are 3–30 m, in most cases about 10 m. According to results of detail microfacial analyses these are mainly carbonate cyanobacterial-sponge buildups (Matyszkiewicz, 1989, 1997; Matyszkiewicz & Felisiak, 1992; Matyszkiewicz & Krajewski, 1996). As more resistant to erosion and denudation in relation to the surrounding bedded limestones they tower over the whole landscape. Numerous tors are divided with gaping joint fissures. Karst phenomena represented by microrelief covering the surface of rocks and by several caves are typical features of this area. Traces of Palaeolithic cultures have been found in archaeological excavations. One of them was distinguished as the Jerzmanowice Culture (Kozłowski, 1966). Changes of the environment of this completely deforested area are evidenced by assemblages of shadow-loving snails found in fossil rendsina soil dated at 1500 years BP (S. W. Alexandrowicz, 1997b).

Limestone tors on the large planation surface are the typical features of the landscape of the Cracow Upland. A similar landscape and Jurassic massive limestones of the same origin occur in Southern Germany in Lochen Area (Swabian Alb) (Matyszkiewicz, 1997).

The group of limestone tors in Jerzmanowice are found in the landscape park (Fig. 5). Particular tors are protected as nature monuments in this area. A few touristic paths pass across.

8. Outcrops in Trojanowice (253 m a.s.l.; 50°08'20"N/ 19°54'12"E).

Main features: a sequence of fossil-bearing Turonian deposits, twó Upper Cretaceous abrasion platforms, Late Vistulian loess with a rich mollusc fauna.

Two small abandoned quarries are situated on the left bank of the Prądnik river valley close to each other (Bukowy, 1956). Upper Jurassic (Oxfordian) massive limestones and a sequence of Turonian calcareous deposit occur in the southern outcrop (70 m long, 7 m high). Lower Turonian sandy limestones with brachiopods and bivalves rest on the abrasion surface. Another such a surface is developed at the top of these limestones. It is covered with conglomerates, nodular limestones and platy limestones abounding in echinoids (Lower/Upper Turonian). Similar succession crops out in the second abandoned quarry (Fig. 6). The fault passes parallel to the wall of this exposure. Mollusc-bearing loess filling the Pleistocene (Vistulian) dry valley is well visible in the northern part of the site (S. W. Alexandrowicz, 1995).

The sequence of Turonian deposits, most representative of the Cracow Upland, is presented in both the mentioned sites. The considerable facial differentiation, small thickness, stratigraphic gaps and abrasion surfaces are features typical of this sequence.

The first referred site is protected while the other one is proposed for conservation.

9. The Tyniec Gate (215 m a.s.l.; 50°00'52"N/19°47'40"E).

Main features: the gap of the Vistula river, rocky hills, two facies of Oxfordian limestones, archaeological/historical monuments.

The Tyniec Gate is the most narrow part of the Vistula river valley. The gap is 2 km long and about 400 m wide. It is surrounded with rocky hills rising 30–130 m above the valley bottom. Five interesting sites of Jurassic limestones (Oxfordian) occur along the gate. On the left bank of the river, massive limestones passing laterally into bedded limestones with cherts crop out in the abandoned quarry in Piekary (S. W. Alexandrowicz, 1960, 1997a; Matyszkiewicz, 1989). The limestone tor, Okrążek, situated 300 m to the south is formed of massive limestones covered with loess. It is a famous archeological site (Palaeolithic) explored both in loess and in sediments filling a small cave (Madeyska *et al.*, 1994). The next rocky hill is a geological and historical site. It encloses the outcrop of Jurassic massive limestones, a small cave and traces of the medieval fortification at the top. The picturesque limestone tor, crowned with the Benedictine Abbey dated from Middle Ages, is situated on the right bank of the river. Huge blocks of limestones accumulated at the foot of the rocky wall derive from the rock-fall connected with the earthquake in 1786 AD (S. W. Alexandrowicz, 1956). Bedded limestones with numerous cherts are accessible in the big quarry on the western slope of the Grodzisko Hill (S. W. Alexandrowicz, 1960).

The gap passes along the tectonic depression filled with Miocene clays. It is surrounded with horsts forming particular rocky hills. The Tyniec Gate is a unique type of the gap, developed by selective erosion which exposed old elements of the structural relief (S. W. Alexandrowicz, 1955). Numerous outcrops of Jurassic limestones presenting the relation between two main facies of shallow-marine Oxfordian deposits are of special scientific interest. The rocky landscape of the gap and archaeological/historical monuments are additional values of the Tyniec Gate.

The described area is included in the Bielany–Tyniec Landscape Park. Individual localities are preserved or proposed for protection as nature monuments or documentary sites.

10. The old quarry Bonarka in Cracow (240 m a.s.l.; 50°01'42"N/19°57'44"E).

Main features: abrasion surface developed on Upper Jurassic limestones covered with Upper Cretaceous marls.

Upper Jurassic bedded limestones with cherts and a scarce fauna of ammonites, brachiopods and sponges crop out in the bottom of the quarry. An abrasion surface connected with the Upper Cretaceous transgression cuts the top of these limestones. It is very well developed and slopes down toward the south-east. A sequence of green-grey and white marls with cherts containing numerous sponges, belemnites, echinoids and other fossils represents Upper Cretaceous deposits of the Santonian–Lower Campanian age (S. W. Alexandrowicz, 1968). It covers the abrasion surface and is visible in the eastern part of the outcrop. A rare mineral chatchettine ($C_{38}H_{78}$) locally fills small spaces within marls (Morozewicz, 1909). A few faults cut Jurassic limestones forming steps at the bottom of the quarry (Gradziński, 1961, 1972). Traces of Miocene caliche, overlain with marly clays rich in microfauna indicating the Lower Badenian, occur in the south-eastern part of this locality. The abrasion surface dislocated by Miocene faults is the exceptional value of the referred site.

The quarry is arranged as a didactic locality and has an educational trail. It is protected as the nature reserve.

11. Abandoned quarry in Zabierzów (270 m a.s.l.; 50°06'52"N/19°47'35"E).

Main features: facial differentiation of Upper Jurassic limestones, a sequence of Upper Cretaceous deposits, Tertiary tectonic structures.

Two facies of Upper Oxfordian limestones crop out in the quarry (Matyszkiewicz & Felisiak, 1992). Massive limestones representing the blue-green algae-spongy reef facies occur in the upper level of the quarry while bedded limestones surrounding them are visible in the lower level. The top of Jurassic limestones is truncated by the Upper Cretaceous abrasion surface. Sandy limestones of Turonian lie on it (S. W. Alexandrowicz, 1954). They are divided in two parts with the diastem marked by stromatolite (Golonka & Rajchel, 1972). Santonian–Lower Campanian marls with fossils supplement the described sequence (S. W. Alexandrowicz, 1968). Karst forms developed inside Jurassic limestones are filled with Tertiary clays and sand. The system of faults bordering the Krzeszowice Graben is clearly visible in this site.

The quarry in Zabierzów is of special interest as the large outcrop of Jurassic and Cretaceous deposits typical of the Cracow Upland, presenting the structure of the margin zone of the Carpathian Trough.

The referred locality has been documented in details and proposed for protection. It is well adopted to didactic. The scientific trail joining the quarry and other geological sites (limestone tors, springs, river gape) has been traced in this area within the Tenczynek Landscape Park (Z. Alexandrowicz & S. W. Alexandrowicz, 1996; Z. Alexandrowicz *et al.*, 1997).

12. Outcrop in the Racławka stream valley (300 m a.s.l.; 50°10'02"N/19°41'15"E).

Main features: a sequence of dated, mollusc-bearing Holocene calcareous deposits.

The Racławka stream valley in its middle reach deeply dissects Lower Carboniferous limestones. Holocene travertine and calcareous tufa locally form the terrace up to 10 m high. The main outcrop situated on the left bank of the stream encloses two types of calcareous deposits: the bioherm forming a barrier and tufa composed of fine- and coarce-grained material with intercalations of limestone gravel, organic mud and fossil soil

(Fig. 7). Radiocarbon dating indicates, that the mentioned sediments accumulated during the interval of 10–1.5 thousand years BP. Very rich assemblages of molluscs occur in calcareous tufa. They contain species typical of particular climatic phases of the Holocene and reflect the human impact during the Late Holocene (S. W. Alexandrowicz, 1983). Calcareous deposits became eroded at the Early Medieval and the 10 m terrace originated.

The refered outcrop is the representative site of Holocene tufa and travertines of Poland documenting changes of the environment during the last ten thousand years. It is also one of the most interesting sites of this type in Europe. The outcrop is situated in the nature reserve Racławka Valley.

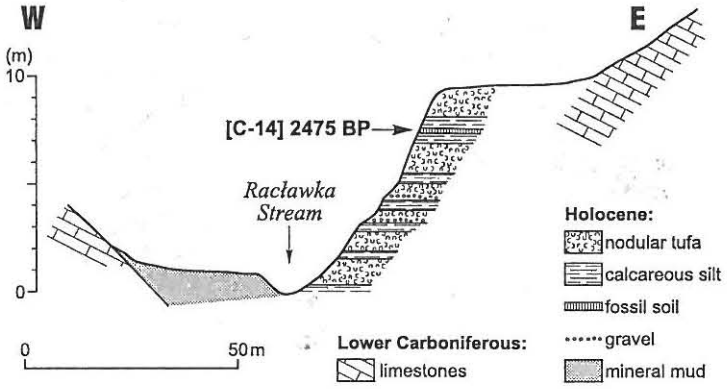

Fig. 7. Outcrop of Holocene travertines in the Racławka stream valley

Conclusions

Geological formations of the Cracow Upland belong to Variscan structures bordering the Upper Silesian Basin, the Cracow–Silesian Monocline and the northern margin of the Fore-Carpathian Depression. The structural relief reflecting both the Tertiary planation surface and elements of disjunctive alpine tectonic are the main features of the landscape. The area is very attractive for tourists and important for earth sciences education and scientific research. It is situated quite close to Cracow, a famous academic, didactic and cultural centre.

The protected areas/sites are of special interest for nature sciences. The existing conservation network encloses a considerable part of formations, structures and landforms representative for the geological history and environmental changes. Geosites just protected and proposed for conservation reflect the geodiversity. A part of them has been selected as candidates to the European list. They are both outcrops of most representative geological formations and landforms characterizing the morphogenesis of the upland. The list comprises 7 areas/sites protected as one national park, 2 nature reserves and 4 individual localities as well as 5 outcrops proposed to conservation.

The local and regional networks will be supplemented according to results of new investigations. Sites and landforms situated inside landscape parks and outside them documented now include: Late Palaeozoic dolomites and limestones (Middle Devonian, Lower Carboniferous), Middle Triassic limestones and dolomites, Middle/Upper Jurassic fossiliferous deposits, Miocene deposits rich in microfauna, selected types of Quaternary sediments (boulder clays, less, calcareous tufa and travertines) and elements of structural relief (a.e. tectonic edges). The most valuable and accessible sites after the selection will be proposed as new candidates to the European list.

References

ALEXANDROWICZ S. 1954 — Turon południowej części Wyżyny Krakowskiej. *Acta Geol. Pol.*, 4: 361–390.

ALEXANDROWICZ S. 1955 — Uwagi o genezie przełomu Wisły pod Tyńcem. *Biul. Inst. Geol.*, 97: 271–295.

ALEXANDROWICZ S. 1956 — Stary obryw skalny w Tyńcu koło Krakowa. *Biul. Inst. Geol.*, 108: 5–16.

ALEXANDROWICZ S.W. 1960 — Budowa geologiczna okolic Tyńca. *Biul. Inst. Geol.*, 152: 5–93.

ALEXANDROWICZ S.W. 1968 — Transgresywne osady santonu w okolicach Krakowa. *Zesz. Nauk. AGH, Geologia*, 11: 45–59.

ALEXANDROWICZ S.W. 1983 — Malacofauna of Holocene calcareous sediments of the Cracow Upland. *Acta Geol. Pol.*, 33: 117–158.

ALEXANDROWICZ S.W. 1995 — Malacofauna of the Vistulian Loess in the Cracow Region (S Poland). *Ann. UMCS*, B-50: 1–28.

ALEXANDROWICZ S.W. 1997a — Waloryzacja i projekt ochrony skałek jurajskich w Piekarach koło Tyńca. *Kwart. AGH, Geologia*, 23: 141–163.

ALEXANDROWICZ S.W. 1997b — Malacofauna of Holocene sediments of the Prądnik and Rudawa River Valleys (Southern Poland). *Fol. Quaternaria*, 68: 133–188.

ALEXANDROWICZ S.W., MAMET B.L. 1973 — Microfacies du Carbonifere infernieur du Dome de Dębnik (Pologne Meridionale). *Revista Espagn. Micropal.*, 5: 447–466.

ALEXANDROWICZ S.W., SIEDLECKA A. 1964 — Charakterystyka litologiczna wapieni wizeńskich z Czernej koło Krzeszowic. *Rocz. Pol. Tow. Geol.*, 34: 395–423.

ALEXANDROWICZ S.W., WILK Z. 1962 — Budowa geologiczna i źródła doliny Prądnika w Ojcowskim Parku Narodowym. *Ochr. Przyr.*, 28: 187–210.

ALEXANDROWICZ Z., ALEXANDROWICZ S.W. 1977 — Zarys budowy geologicznej. In: Przyroda Ojcowskiego Parku Narodowego. *Stud. Naturae*, B-28: 33–49.

ALEXANDROWICZ Z., ALEXANDROWICZ S.W. 1996 — Waloryzacja geologiczna i malakologiczna rezerwatu Skała Kmity na Wyżynie Krakowskiej. *Ochr. Przyr.*, 52: 95–110.

ALEXANDROWICZ Z., DRZAŁ M., KOZŁOWSKI S. 1975 — Katalog rezerwatów i pomników przyrody nieożywionej w Polsce. *Stud. Naturae*, B-26: 1–298.

ALEXANDROWICZ Z., FELISIAK I., MUSIELEWICZ-JASIŃSKA Z. 1997 — Geologiczna ścieżka dydaktyczna w okolicy Zabierzowa. *Chrońmy Przyr. Ojcz.*, 53 (4): 102–116.

ALEXANDROWICZ Z., KUĆMIERZ A., URBAN J., OTĘSKA-BUDZYN J. 1992 — Waloryzacja przyrody nieożywionej obszarów i obiektów chronionych w Polsce. Państw. Inst. Geol.

BALIŃSKI A. 1979 — Brachiopods and Conodonts from the Frasnian of the Dębnik Antycline, Southern Poland. *Palaeont. Pol.*, 39: 4–95.

BIRKENMAJER K., NAIRN A.E.M. 1964 — Palaeomagnetic studies of Polish rocks. I. The Permian igneous rocks of the Kraków district and some results from the Holy Cross Mountains. *Rocz. Pol. Tow. Geol.*, 34: 225–244.

BOGACZ K. 1967 — Budowa geologiczna północnego obrzeżenia rowu krzeszowickiego. *Pr. Geol. Komis. Nauk. Geol.* PAN Oddz. w Krakowie, 41: 5–89.

BOGACZ K. 1980 — Budowa geologiczna paleozoiku dębnickiego. *Rocz. Pol. Tow. Geol.*, 50: 183–208.

BUKOWY S. 1956 — Geologia obszaru pomiędzy Krakowem a Korzkwią. *Biul. Inst. Geol.*, 108: 17–82.

ĆWIŻEWICZ M. & SZULC J. 1989 — Warunki klimatyczne środowiska sedymentacji martwicy karniowickiej. *Prz. Geol.*, 37: 180–187.

DRZAŁ M. 1954 — Morfologia dorzecza Prądnika. *Ochr. Przyr.*, 22: 42–66.

DŻUŁYŃSKI S. 1952 — Powstanie wapieni skalistych jury krakowskiej. *Rocz. Pol. Tow. Geol.*, 21: 125–180.

DŻUŁYŃSKI S. 1953 — Tektonika południowej części Wyżyny Krakowskiej. *Acta Geol. Pol.*, 3: 325–440.

GILEWSKA S. 1972 — Wyżyny Śląsko-Małopolskie. In: Geomorfologia Polski, 1: 232–339. PWN. Warszawa.

GOLONKA J., RAJCHEL J. 1972 — Stromatolity z górnej kredy okolic Krakowa. *Kwart. Geol.*, 16: 652–666.

GRADZIŃSKI R. 1961 — Projekt ochrony Bonarki pod Krakowem. *Ochr. Przyr.*, 27: 239–251.

GRADZIŃSKI R. 1962 — Rozwój podziemnych form krasowych w południowej części Wyżyny Krakowskiej. *Rocz. Pol. Tow. Geol.*, 32: 429–487.

GRADZIŃSKI R. 1972 — Przewodnik geologiczny po okolicach Krakowa. Wyd. Geol. Warszawa.

GRADZIŃSKI R. 1977 — Jaskinie In: Przyroda Ojcowskiego Parku Narodowego. *Stud. Naturae*, B-28: 61–62.

GRADZIŃSKI R., GRADZIŃSKI M. 1994 — Budowa geologiczna i rzeźba. In: R. Gradziński, M. Gradziński, S. Michalik — Natura i kultura w krajobrazie Jury. *Przyroda*: 11–54.

KOWALSKI K. 1951 — Jaskinie Wyżyny Krakowsko-Wieluńskiej. Jaskinie Polski. 1. Państw. Muz. Archeol. Warszawa.

KOZŁOWSKI J.K. 1966 — Uwagi o przemysłach oryniackich w Polsce. *Fol. Quaternaria*, 24: 1–37.

LIPIARSKI I. 1969 — Martwica karniowicka — niezwykły utwór geologiczny godny ochrony. *Ochr. Przyr.*, 34: 255–273.

MADEYSKA T., MORAWSKI W., ŚNIESZKO Z., TOMASZEWSKI J. 1994 — Stan badań osadów czwartorzędowych w stanowiskach paleolitycznych Piekary koło Krakowa. *Georama*, 2: 59–67.

MAŁECKI J. 1977 — Morfologia i hydrografia In: Przyroda Ojcowskiego Parku Narodowego. *Stud. Naturae*, B-28: 63–80.

MATYSZKIEWICZ J. 1989 — Sedimentation and diagenesis of the Upper Oxfordian Cyanobacterial-Sponge limestones in Piekary near Kraków. *Ann. Soc. Geol. Pol.*, 59: 201–232.

MATYSZKIEWICZ J. 1997 — Microfacies, sedimentation and some aspects of diagenesis of Upper Jurassic sediments from the elevated part of the Northern peri-Tethyan Shelf: a comparative study on the Lochen area (Schwäbische Alb) and the Cracow area (Cracow–Wielun Upland, Polen). Berlin. Geowiss. Abhandl., E-21.

MATYSZKIEWICZ J., FELISIAK I. 1992 — Microfacies and Diagenesis of an Upper Oxfordian Carbonate Buildup in Mydlniki (Cracow Area, Southern Poland). *Facies*, 27: 179–190.

MATYSZKIEWICZ J., KRAJEWSKI M. 1996 — Lithology and sedimentation of Upper Jurassic Massive Limestones near Bolechowice, Kraków–Wieluń Upland, South Poland. *Ann. Soc. Geol. Pol.*, 66: 285–301.

MOROZEWICZ J. 1909 — O haczetynie i jego Bonarskim złożu. *Kosmos*, 34: 610–624.

RICHTER S., SZAFER W. 1924 — Projekt rezerwatu w dolinie Prądnika. Ojców. Państw. Kom. Ochr. Przyr., 26–30. Kraków.

RÓŻYCKI S.Z. 1953 — Górny dogger i dolny malm Jury Krakowsko-Częstochowskiej. *Pr. Inst. Geol.*, 17: I–VII, 1–412.

SAWICKI L. 1914 — W sprawie ochrony zabytków przyrody okolic Krakowa. Wyd. Tow. Uniw. Lud. im. Mickiewicza w Krakowie. Kraków.

SIEDLECKA A. 1964 — Osady permu na północno-wschodnim obrzeżeniu Zagłębia Górnośląskiego. *Rocz. Pol. Tow. Geol.*, 34: 309–386.

SIEDLECKI S. 1951 — Utwory stefańskie i permskie we wschodniej części Polskiego Zagłębia Węglowego. *Acta Geol. Pol.*, 2: 300–348.

SIEDLECKI S. 1952 — Podłoże melafiru w Regulicach i problem genezy zlepieńców myślachowickich. *Biul. Państ. Inst. Geol.*, 80: 103–129.

SIEDLECKI S. 1954 — Utwory paleozoiczne okolic Krakowa. *Biul. Inst. Geol.*, 73: 1–415.

SMOLEŃSKI J. 1924 — Budowa i rzeźba dorzecza Prądnika. *Ochr. Przyr.*, 4: 69–75.

SZULCZEWSKI M. 1968 — Stromatolity jurajskie w Polsce. *Acta Geol. Pol.*, 18: 1–100.

ZARĘCZNY S. 1894 — Mapa geologiczna okolic Krakowa i Chrzanowa. Atlas Geol. Galicji, 3: 3–290.