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Representative geosites of the Góry Świętokrzyskie (Holy Cross Mts.) and the Nida Basin, Central Poland

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A b s t r a c t . The Góry Świętokrzyskie (Holy Cross Mts.) are formed mainly of Palaeozoic and Mesozoic sedimentary rocks and tectonically framed during the Caledonian, Variscian and Alpine orogenesis. Abundant in mineral resources excavated for many hundreds years, this region has been a matter of geological studies since the end of the 18th century. The Góry Świętokrzyskie combined with Nida Basin are the only area in Poland where sedimentary rocks representing every stratigraphic period from Cambrian to Quaternary are accessible at the surface. This area adjoins vast lowlands, situated to the north, which are almost devoid of outcrops of pre-Quaternary formations what emphasizes the scientific importance of these units. The Nida Basin is famous of Tertiary gypsum with primary depositional structures and secondary karst forms. Regarding mainly the scientific value, 15 geosites are selected as representative for both these regions and proposed for superregional list.

Key words: geoconservation, network of European geosites, Góry Świętokrzyskie, Nida Basin.

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S t r e s z c z e n i e. Góry Świętokrzyskie są zbudowane głównie ze skał osadowych wieku paleozoicznego i mezozoicznego. Tektonicznie zostały ukształtowane w czasie ruchów kaledońskich, waryscyjskich oraz alpejskich. Region ten, obfitujący w kopaliny eksploatowane przez setki lat, był przedmiotem badań geologicznych od końca osiemnastego wieku. Góry Świętokrzyskie wraz z niecką nidziańską stanowią jedyny w Polsce obszar, na którym są dostępne na powierzchni skały reprezentujące wszystkie okresy geologiczne od kambru po czwartorzęd. Obszar sąsiaduje od północy z rozległymi nizinami, pozbawionymi prawie odsłonięć skał przedczwartorzędowych, co uwypukla jego znaczenie dla badań naukowych. Niecka nidziańska jest znana przede wszystkim z występowania trzeciorzędowych gipsów charakteryzujących się obecnością pierwotnych struktur sedymentacyjnych oraz wtórnych form krasowych. Biorąc pod uwagę przede wszystkim wartości naukowe, wytypowano 15 obiektów reprezentatywnych dla obu regionów i godnych wpisania na ponadregionalną listę dziedzictwa geologicznego.

Słowa kluczowe: geoochrona, sieć europejskich stanowisk, Góry Świętokrzyskie, niecka nidziańska.

The Góry Świętokrzyskie (called often in English, but only in geologic publications — Holy Cross Mts.) are formed mainly of Palaeozoic and Mesozoic sedimentary rocks: quar-tzitic sandstones, sandstones, limestones, marls, dolomites, shales, siltstones, claystones, clays and conglomerates. This region was tectonically framed during the Caledonian, Variscian and Alpine orogenic cycles but the most important tectonic structures were modelled during the Variscian tectonic movements. Caledonian and Variscian structures form so called Palaeozoic core of the Góry Świętokrzyskie situated in the central and south part of the unit. Permian and Mesozoic formations surround the core and cover it in a wide outer zone of the Góry Świętokrzyskie (Fig. 1). The Cretaceous and, in places, Tertiary sediments adjoin the Góry Świętokrzyskie from the south, west and east, whereas to the north large Mid-European Lowlands, covered with thick Quaternary sediments, are placed.

Morphologically the Góry Świętokrzyskie represent an upland with some ranges of hills or low mountains (300–600 m a.s.l.). They have been shaped since the beginning of Cainozoic. Intensive and selective denudation in Tertiary period was stimulated by rather warm and humid climate. During the Pleistocene the relief was modelled in periglacial or interglacial climate but some remnants of glacial forms of Mindel and Riss glaciations can be observed, too. Due to climatic conditions and long period of morphogenesis, structural type of relief predominates in this area. Thus the large geologic structures, mainly Variscian, are reflected in the direction and shape of the hill (mountain) ranges. In places surface and subsurface karst (relict karst) forms are well developed in carbonate rocks, whereas different relief forms — tors, block fields, pseudokarst caves — can be observed on sandstone outcrops.

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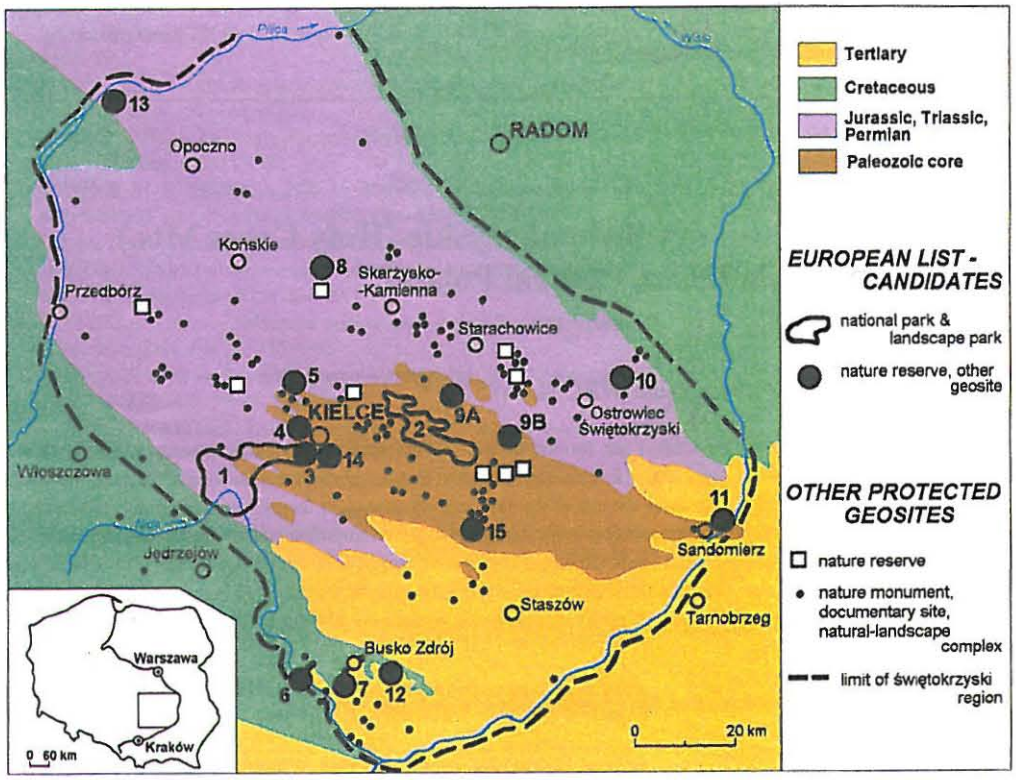

Fig. 1. Geoconservation in the świętokrzyski region; location of the candidates for European list (numbers — see text), inanimate nature reserves and monuments, documentary sites and natural-landscape complexes (reserves and monuments in the Chęciny–Kielce Geologic Landscape Park — see Fig. 2)

The Nida Basin situated to the south-west and south of the Góry Świętokrzyskie, represents a vast and shallow synclinorium formed during the Alpine cycle. Cretaceous marls, various Tertiary rocks and, in places, Jurassic limestones outcrop in this unit (Fig. 1). Tertiary sediments occurring in the south-eastern part of the Nida Basin, were deposited in shallow marine basin and display variegated facies, sedimentary structures and vertical sequences. The variable types of biogenic and detritic limestones as well as gypsum, marls and clays occur in Tertiary sequence. The lithologic variability and complicated tectonic structure determine differentiated relief of this area, in which karst forms — developed mainly in gypsum — play a significant role.

The Góry Świętokrzyskie and the south-eastern part of the Nida Basin are often combined in one physiographic unit and both described as świętokrzyski region (Fig. 1) (Czarnocki, 1975).

Abundant in various mineral resources (iron, lead and copper ores, marbles and other building stones, flynts, potter clays) excavated since Palaeolithe till now, the świętokrzyski region was one of the first area in Poland studied by geologists at the end of the eighteenth and beginning of nineteenth centuries. Also currently this region plays an important role in geological studies of Polish territory and in education of earth sciences: geology, geomorphology, geography and ecogeology (Z. Alexandrowicz *et al.*, 1992; Wróblewski, 1997b, 1998). It is the only region in Poland where sedimentary (not metamorphosed) rocks of older Palaeozoic are accessible at the surface. Outcrops of rocks representing every geological period from Cambrian to Quaternary occur in the świętokrzyski region, whereas lowlands situated to the north are almost totally covered with thick Quaternary sediments. Large outcrops of rocks occurring often in the walls of quarries enable various scientific studies, which are later referred to cores and logs drilled in other regions. The most important geological phenomena studied in the outcrops of the świętokrzyski region represent sequences, fossils and structures of Older Palaeozoic, Devonian and Carboniferous, Variscian–Alpine disconformity as well as depositional structures of Lower Triassic and Lower Jurassic clastics and Tertiary gypsum. To the specific geomorphologic features of high educational and scientific value belong structural morphology and karst forms developed in carbonates and gypsum.

Thus the geologic and geomorphologic sites of scientific, educational and touristic importance in the region represent many types of objects: stratotypes and reference sequences, types of rocks and minerals, depositional and post-diagenetic structures, tectonic and megastructural phenomena, palaeontologic sites, crags and tors, karst and pseudokarst forms, erratic blocks and other forms of relief as well as remnants of ancient mining industry and hydrogeologic objects. The first projects on geosites protection, expressed in the first half of this century (Czarnocki, 1928a, b, 1932, 1949), were realized after the second world war (Z. Alexandrowicz *et al.*, 1975). A systematic registration and evaluation of the geosites in the świętokrzyski region was performed in the 1980s (Urban, 1990). Now, most of the valuable geosites (but not every) are already under legal protection. Within this area 22 inanimate nature reserves, some 150 inanimate nature monuments and 15 documentary sites are localized (Fig. 1) (Z. Alexandrowicz *et al.*, 1992; Wróblewski T. & E., 1996).

Draft list of geosites of superregional value

The importance of described units in geologic studies and education of earth sciences — not only currently, but also in the

past — implies that numerous geosites occurring in the Góry Świętokrzyskie and Nida Basin should be aknowledged to our geologic heritage. The assessment of their value, selection and assigning them to the groups of local, regional and superregional importance are generally based on scientific, educational and aesthetic value (Urban, 1990).

For the superregional (international, European) list of geosites are proposed:

— the most representative sites of the region and sites used for comparative studies with other regions,

— sites of significant educational value, representing typical features, illustrative and accessible to people,

— sites with unique features which can be studied only here.

The following criteria of selection are also taken into account: diversity of geologic features demonstrated by a default geosite, the scientific importance in the past, presentday state of studies, relation to human economic activity (mining, quarrying) in the past and present.

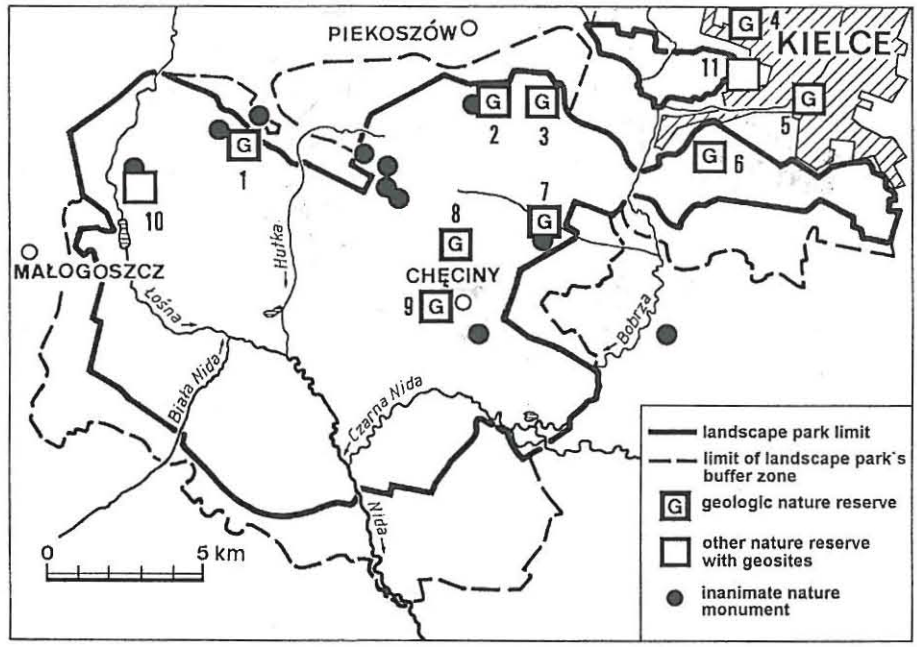

Fig. 2. Sketch of the Chęciny–Kielce Geologic Landscape Park and its vicinity with location of protected gesites; nature reserves: 1 — Góra Miedzianka, 2 — Moczydło, 3 — Chelosiowa Jama, 4 — J. Czarnocki rock reserve (Śluchowice), 5 — Kadzielnia, 6 — Biesak–Białogon, 7 — Jaskinia Raj, 8 — Góra Zelejowa, 9 — Góra Rzepka, 10 — Milechowy, 11 — Karczówka

The proposed list of geosites of superregional value comprises 15 objects and areas (Fig. 1). Their short descriptions are presented hereafter.

1. Chęciny–Kielce Geologic Landscape Park (Figs. 2, 3) in south-western part of the Góry Świętokrzyskie (207–406 m a.s.l.; 50°44'11"–50°52'54"N/20°17'05"–20°39'40"E).

Main features: Variscian–Alpine discordance, Upper Paleozoic sequences, post-Variscian and Cainozoic karst and caves, Pleistocene fauna, Neanderthal site, structural morphology, historic mining.

The park is situated in the marginal zone of Palaeozoic core and Permian–Mesozoic cover. Cambrian sandstones and shales, Devonian carbonate rocks, Permian and Triassic clastics and Jurassic limestones predominated in the geologic structure of its substratum. This park covers a relatively large area (205 km^2), but constitutes less than 2% of whole area of the region. Nevertheless, significant geologic and geomorphologic features typical of the Góry Świętokrzyskie are cumulated in this area, what is the main reason for its scientific and educational importance (Wróblewski, 1991, 1994, 1997a; Wróblewski T. & E., 1996). These are first of all:

— sedimentary rocks representing every stratigraphic periods from Cambrian to Quaternary and — consequently — the significant geologic sections and/or paleontologic sites of Upper Devonian–Lower Carboniferous, Permian and Quaternary (Kotański, 1959; The Palaeozoic..., 1968; Kutek & Głazek, 1972; Rubinowski, 1976, 1978; Głazek *et al.*, 1976; Rubinowski & Wójcik, 1978; Szulczewski, 1978, 1995; Devonian reefs..., 1992; Europrobe..., 1994; Development..., 1995; Lindner *et al.*, 1995);

— patterns of Caledonian, Variscian and Alpine tectonic movements (Kotański, 1959; Bednarczyk *et al.*, 1971; Stupnicka, 1970; Kutek & Głazek, 1972; Kowalski, 1975), among which outcrops of discordance and gap between Devonian and Permian/Triassic related to Variscian orogenesis and post-Variscian uplifting belong to the most important sites (Głazek & Romanek, 1978; Rubinowski & Wójcik, 1978; Wróblewski, 1988);

— Permian/Triassic (post-Variscian) and Cainozoic palaeokarst, also fossil caves filled by sediments (Majchert, 1966; Głazek, 1989; Urban, 1994);

— geologic structures perfectly reflected in morphology (structural morphology — Fig. 3), (Kotański, 1959; Olędzki, 1976);

— numerous remnants of historical mining and quarrying (old mines, open-pits, dumps) (Wróblewski, 1979, 1997a; Paulewicz, 1992);

— site of Neanderthal location (Studies..., 1972);

— caves and currently forming karst (solution) microforms (Kotański, 1959; Gradziński & Wróblewski, 1968; Studies..., 1972; Złonkiewicz, 1994; Urban, 1996a; Urban *et al.*, 1997);

— evidences of hydrothermal processes, outcrops of ore-bearing and calcite veins (Rubinowski, 1971; Migaszewski *et al.*, 1996);

— natural rocky forms, mainly limestone crags on hill ridges (Fig. 3) (Rubinowski, 1976; Rubinowski & Wójcik, 1978).

At least the three first features are of the superregional

scientific importance. The well perceptable structural morphology, Variscian discordance exposed in a few sites, colourful calcite veins, palaeokarst forms as well as limestone crags and rocky ridges with karren might be used in earth sciences education. Picturesque Jaskinia Raj (Raj cave), with various types of speleothems and Neanderthal site, visited yearly by about one hundred thousands people, plays significant role in popularization of inanimate nature of the region.

Chęciny–Kielce Geological Landscape Park was established in 1997, but numerous inanimate nature reserves and monuments were concentrated in this area earlier (Fig. 2). The following nature reserves with significant geologic (geomorphologic) objects are situated within the park: Karczówka (remnants of lead ore mining), Moczydło (Devonian limestones and Variscian/Alpine discordance, remnants of lead ore mining, karst), Chelosiowa Jama (Devonian limestones, Permian/Triassic clastics and Varisian/Alpine discordance, post-Variscian and Cainozoic palaeokarst, one of the longest caves in Poland — Chelosiowa Jama–Jaskinia Jaworznicka, 3670 m, with unique calcite forms), Biesak–Białogon (Lower Palaeozoic formations strongly folded, even overthrust), Góra Miedzianka (abandoned mine of copper ore, rocky hill ridge formed of Devonian limestones, karst and caves, remnants of Pleistocene glacial accumulation), Milechowy (rocky walls and crags formed of Jurassic limestones, caves), Jaskinia Raj (cave mentioned above), Góra Zelejowa (hill ridge with currently developed karst karren in Devonian limestones, large calcite veins, Variscian/Alpine discordance, paleokarst, caves), Góra Rzepka (remnants od lead ore minning, Devonian dolomites, large calcite veins and paleokarst). At least 9 new inanimate nature reserves are projected within the park area. Some valuable geologic objects, e.g. palaeontologic site documenting Pleistocene interglacial period, are protected as a nature monuments (Urban, 1990; T. & E. Wróblewski, 1996).

2. Łysogóry range in the Świętokrzyski National Park in central-eastern part of the region (270–612 m a.s.l.; 50°50'30"–50°58"N/20°48'30"–21°07'E).

Main features: Pleistocene block fields, unique Cambrian fauna.

The park cover the highest mountain range in the Góry Świętokrzyskie called Łysogóry. The range is formed of Cambrian quartzitic sandstone (Orłowski, 1988) and attributed by vast block fields on the slopes and a few tors on the ridge. The geomorphologic studies of the block fields prooved, that they developed in periglacial conditions during the Upper Pleistocene and represent fossil forms (Klatka, 1962; The Palaeozoic..., 1968; Olędzki, 1976; Kowalski & Jaśkowski, 1986). In Holocene the block fields in low mountains (uplands) of Central Europe have been usually overgrown with flora and currently they are rather hardly observed. Thus the block fields of Łysogóry range (in Polish — bald mountains) represent unique remnants of Pleistocene morphology. The outcrops of quartzitic sandstone are also the site of occurrence of unique Cambrian fauna and flora (Sedlak, 1977, 1980).

The Świętokrzyski National Park (76.3 km^2) has been legally protected since 1950 (Łysogóry range as nature reserve — since 1922). The ridge of Łysogóry range with some tors and block fields is partially accessible for visitors and represents one of the most popular tourist objects in the region. The museum of nature with geological exhibition situated within the park is visited by thousands tourists each year.

3. Kadzielnia abandoned quarry in Kielce town, the capitol of the district (250–295 m a.s.l.; 50°51'45"N/20°37'05"E).

Main features: Devonian limestone facies and depositional structures, Devonian fishes and invertebrates, Cainozoic karst and caves, Pleistocene fauna.

Kadzielnia, localized in western part of the palaeozoic core, is one of the best known and the most popular geosite of the region. The Kadzielnia hill and quarry has been a matter of various geological investigations since the beginning of 20th century. In the quarry Frasnian massive limestones and Famennian thin-bedded marls and limestones are outcropped (Czarnocki, 1949; Kotański, 1959; The Palaeozoic..., 1968; Rubinowski & Wójcik, 1978). Numerous types of fossils have been studied here (also new species of fauna have been found); in Frasnian — mainly invertebrates: corals, brachiopods, goniatites, moluscs, stromatoporoids, crinoids, in Famennian — also fishes (Biernat, 1971; Devonian reefs..., 1992; Głuchowski 1993; Ivanov & Ginter, 1997). Also reef and near-reef structures of Frasnian limestone have been a matter of studies (Szulczewski, 1971, 1995). The other important feature of the Kadzielnia quarry is karst (palaeokarst) formed mainly in Neogene and Pleistocene. There were registered more than 20 caves belonging to karst systems developed on two or three levels (Kozłowski et al., 1965; Rubinowski, 1967; Urban, 1996a; Urban *et al.*, 1997). Early Pleistocene vertebrates were found in sediments filling karst cavern (Kowalski, 1958).

Only a small fragment of the Kadzielnia (0.006 km^2) is protected as a nature reserve, but the whole quarry is situated in the city park and visited by many people. The ecomuseum was proposed to set-up here (Rubinowski & Wójcik, 1978), but this project has not been accomplished,yet.

4. Śluchowice (Ślichowice) abandoned quarry in Kielce town (250–300 m a.s.l.; 50°53'15"N/20°35'20"E).

Main features: typical fold, Devonian limestone sequence and facies.

In the high rocky wall separating two quarries, unique fold structure is outcropped (Czarnocki, 1949; Kotański, 1959; The Palaeozoic..., 1968; Rubinowski & Wójcik, 1978). As a typical tectonic form the fold was described in manuals of tectonics (e.g. Jaroszewski, 1980). It is formed in Frasnian bedded limestones, represents different facies than in Kadzielnia quarry (the detrital limestones deposited in the marginal zone of the platform). The sequence, microfauna and depositional structures of the limestones were studied in details (Szulczewski, 1971, 1995).

The rocky wall is protected in a nature reserve (0.0055 km^2), named "Jan Czarnocki* rock reserve".

*Jan Czarnocki — a prominent geologist, which worked in the świętokrzyski region

Fig. 3. The Chęciny–Kielce Geologic Landscape Park from rock ridge of the Góra Miedzianka (nature reserve): the structural relief of core and southern limb of the Chęciny antycline. Photos 3 and 4 by T. Wróblewski

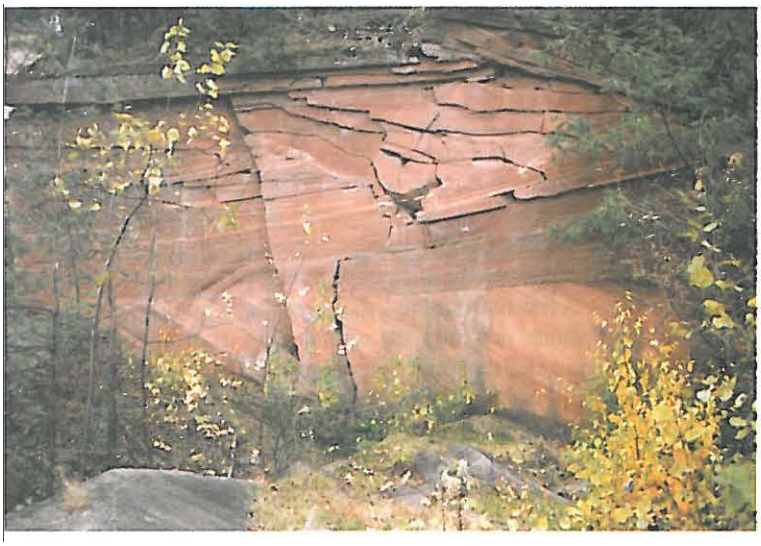

Fig. 4. Abandoned part of the Tumlin–Gród quarry (nature reserve): large-scale cross lamination (fossil dunes) and erosional channel in the Lower Triassic sandstones

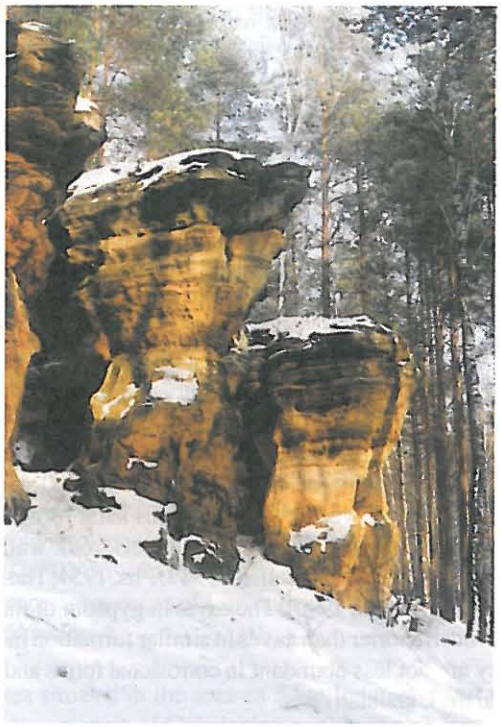

Fig. 5. The Piekło pod Nieklaniem Nature Reserve — tors shaped in the Lower Jurassic sandstones. Photo by J. Urban

5. Tumlin–Gród quarry (Fig. 4) in north-western part of the Góry Świętokrzyskie, to the north of Kielce (350–390 m a.s.l.; 50°58'05"N/20°34'40"E).

Main features: structures of Triassic eolian and fluvial sediments, mechanoglifs, reptiles footprints.

The Tumlin–Gród partially active quarry is the best outcrop of the Lower Triassic sandstones (Tumlin Beds), which are formed mainly of eolian sediments. Fossil dunes (large-scale cross lamination, eolian riples) and interdune flats, remnants of ephemeral water flows and ponds (wave riples, erosional channels, mud cracks and flakes) and even footprints of reptiles can be observed in this quarry (Fig. 4). The exeptionally well exposed depositional structures of Tumlin Beds were thoroughtly studied (The Palaeozoic..., 1968; Gradziński *et al.*, 1979; Gradziński, 1992), what allows to use Tumlin–Gród quarry as a type locality of these — usually seldom found — structures of European importance.

Part of the Tumlin–Gród quarry with the best patterns of the eolian forms are protected in nature reserve (0.1275 km^2).

6. Gacki abandoned quarry situated in the south-eastern part of the Nida Basin (200–250 m a.s.l.; 50°27'50"N/ /20°35'20"E).

Main features: almost complete sequence of Badenian sulphate formation, depositional (primary) structures of gypsum.

Gacki quarry represents the best cross section of the evaporite formation in the northern, peripheral part of the Miocene fore-Carpathian marine basin. Almost whole sequence of the 40 m thick gypsum beds can be observed in this quarry. In the gypsum primary depositional structures formed at the bottom of the Badenian marine basin are preserved. Burried gypsum is easily transformed to anhydrite, thus the primary gypsum is quite seldom found in the sediments. Microcrystalline and macrocrystalline various types of gypsum compose the sequence. Characteristic for the Nida Basin (but unique in Europe) are the glassy ("szklica") gypsum which occurs at the bottom (lowermost part) of the gypsum beds and is formed of the giant (up to 3.5 m high-lenght) blocky crystalline intergrowths (The Palaeozoic..., 1968; Bąbel M., 1987; Kasprzyk, 1993).

The project of Gacki nature reserve has not been formally accepted yet but an outcrop of the fault and the giant crystals of glassy gypsum in the quarry is already protected as nature monument. Next to the quarry a karst cave with archeologic site is situated (Głazek *et al.*, 1994).

7. Skorocice gorge in south-eastern part of the Nida Basin (205–220 m a.s.l.; 50°25'20"N/ /20°40'25"E).

Main features: karst forms in gypsum, caves, depositional (primary) structures of gypsum.

Skorocice gorge represents a typical karst valley developed in gypsum (also in glassy, giant-crystalline gypsum). The valley consists of two parts: upper blind gorge and lower gorge, which are separated by natural rocky bridge and connected by Jaskinia Skorocicka (Skorocice Cave, lenght about 300 m) with water stream in the lowest level. Numerous karst forms occur within the both parts of valley: hums, tunnels, rock walls, numerous caves and concaves (Malicki, 1947; Flis, 1954; The Palaeozoic..., 1968; Wołoszyn, 1990). The caves in gypsum of the Nida Basin are much shorter than caves in similar formation in Ukraine, but they are not less abundant in corrosional forms and speleothems than the Ukrainian ones.

The dome structure, unique and specific for gypsum of Nida Basin is situated just above the gorge slope (Flis, 1954; M. Bąbel, 1986).

As one of the most characteristic karst area in the region and specific biotope the Skorocice gorge has been protected in natural reserve (0.077 km^2) since 1960.

8. Piekło pod Niekłaniem tors group in the north-western part of the Góry Świętokrzyskie (345–365 m a.s.l.; 51°11'05"N/20°40'05"E).

Main features: the most characteristic, well examined sandstone tors.

Piekło pod Niekłaniem is the most scenic (picturesque) representative of about 50 sandstone tors groups or single tors occurring at the outcrops of the Triassic and Jurassic clastics in the northern and western part of Permian–Mesozoic cover of the Góry Świętokrzyskie. The tors of Piekło pod Niekłaniem are formed of the Lower Jurassic sandstones and attributed by exceptional variety of forms and microforms (Fig. 5) (Z. Alexandrowicz *et al.*, 1975; Z. Alexandrowicz, 1990). The investigations of the tors and associated pseudokarst caves prooved that the basic factors stimulating their development (during the last glaciation and Holocene) have been eolian erosion and linear erosion of subsurface and surface water (Lindner, 1972; Urban, 1996b). The advanced stage of studies enables to use the tors group for geomorphology (geography) education.

The Piekło pod Niekłaniem tors group is protected as nature reserve (0.063 km^2).

9 A. Świętomarz–Śniadka (235–290 m a.s.l.; 50°56'30" –50°56'30"N/21°00'30"–21°02'00"E) and **B. Grzegorzowice–Skały** (220–280 m a.s.l.; 50°52'30"–50°54'00"N/ 21°09'00"–21°10'20"E) succesions are both situated in northern part of the Palaeozoic core of the Góry Świętokrzyskie.

Main features: Middle to Upper Devonian sequence with fossil fauna.

The both sites represent the most illustrative litho- and biostratigraphical sequences of the Middle and Upper Devonian and were described as a typical of the north subregion of the Góry Świętokrzyskie, different from the Devonian succesions in the south part of the region (Pajchlowa, 1957; Malec, 1984, 1988; Kłossowski, 1985; Szulczewski, 1995). Each of them consists of a chain of the outcrops scattered at the slopes of creek valley at the stretch of a few kilometres, so it demonstrates fragments but not continuous stratigraphic sequence. These fragments were completed by artificial trenches during scientific investigations. The sequence is documented by fossil invertebrate fauna. A few new species of fossil fauna (brachiopods) were found here (Biernat, 1953).

At least one of the sequences should be choosen for the superregional list. Only parts of both the sequences have been already protected in nature reserve Wąwóz w Skałach and natural-landscape complex Szerzawy.

10. Krzemionki Opatowskie in north-eastern part of the Góry Świętokrzyskie (193–205 m a.s.l.; 50°57'42"–50°58'40"N/ 21°29'35"–21°30'50"E).

Main feature: Neolithic flynt mine, sequence and structures of Oxfordian limestone.

Krzemionki Opatowskie — one of the bigest Neolithic mining fields in Europe — is impressive example of long-lived relations between inanimate nature and human activity. In this area (3–4 km^2) some hundreds Neolitic mines of flynts are cumulated along the outcrop of flynt-bearing horizon (J. Bąbel, 1975). A few of the mines (shafts) are accessible for visitors and demonstrate not only the remnants of ancient mine but the sections and depositional structures of Oxfordian oolithic and micritic limestones as well. In the limestone sequence occurs the horizon with big flynt nodules (Sałaciński & Zalewski, 1987; Michniak, 1992).

The prehistoric mining field is protected as a archaeologic reserve and nature reserve (3.79 km^2). The museum of ancient mining and processing of flynts with geologic exhibition is set there.

11. Góry Pieprzowe (Pepper Mts) on the slope of the Vistula river valley, near the Sandomierz town (145–200 m a.s.l.; 50°41'35"N/21°48'20"E).

Main features: slope morphology, Lower Cambrian shales section, structures and tectonic forms.

The site is situated at the erosional margin of the Palaeozoic core of the Góry Świętokrzyskie overlapped here with slope of the Vistula river valley. It represents the typical morphology of slope formed of rather soft sedimentary rocks, which are being continuously eroded. Some outcrops of the Middle Cambrian shales with siltstone, sandstone and conglomerate inserts are developed on the slope. The shales contain phosphatic concretions and fossil fauna: trilobites, brachiopods (new species). The Caledonian tectonic deformations were studied here, too (Ko-

tański, 1959; Żak, 1962; The Palaeozoic..., 1968; S. W. Alexandrowicz, 1972).

Góry Pieprzowe nature reserve (0.18 km^2) covers the most interesting part of the slope with Cambrian outcrops.

12. Skotniki Małe abandoned quarry in the eastern part of the Nida Basin (270–285 m a.s.l.; 50°25'55"N/20°48'15"E).

Main features: section of Alpine system with two discordances and gaps, Miocene transgresive sediments.

Abandoned quarry in Skotniki Małe represents the best section of the rocks forming the Nida Basin.The sequence exposed there comprises Upper Jurassic limestones and Upper Cretaceous marls and opokas covered with transgressive facies of Miocene marine sediments (The Palaeozoic..., 1968; Radwański, 1969). Two phases of Alpine tectonic movements are perceptible here. The first discontinuity and gap is observed between Oxfordian limestone and Cenomanian sandstone. Thin Cenomanian sandstone layer (with phosphorite nodules) is overlaid with Turonian and Senonian marls and opokas with flynt nodules and horizons (Walaszczyk, 1992). In this sediments remnants of submarine hot water springs are supposed (Migaszewski *et al.*, 1995). The abrasional surface of the Upper Cretaceous is covered by Badenian basal conglomerates which turn into organic limestones in places (Radwański, 1969). Cretaceous and Miocene fauna and its traces were also studied here.

The abandoned quarry in Skotniki Małe is protected as a documentary site.

13. Niebieskie Źródła (Blue Springs) near the Pilica river, close to the north-western margin of the świętokrzyski region (155 m a.s.l.; 51°30'45"N/20°01'50"E).

Main features: typical karst sprigs.

Niebieskie Źródła represent the typical karst springs described in the hydrogelogical manuals as an example of the barier-fault type of springs (Pazdro, 1983). They are related to the Upper Jurassic limestones strongly faulted and bordered by Cretaceous marls. The springs have been well known since XIX century as a landscape phenomenon, too (Olaczek & Tranda, 1990).

Niebieskie Źródła are protected in nature reserve (0.29 km^2).

14. Wietrznia abandoned quarry in Kielce town (250–305 m a.s.l.; 50°51'18"N/20°38'45"E).

Main features: Frasnian and Lower Famennian sequence and differentiated facies, Devonian fauna, hydrothermal chimney in dolomite, Variscian disconformity, post-Variscian denudation and karst.

Wietrznia abandoned quarry, situated in the western part of the Góry Świętokrzyskie Palaeozoic core, is the outcrop of the Middle to Upper Devonian dolomites and limestones (with inserts of shales and marls), covered in places by post-Variscian karst and talus sediments, mainly breccias. Wietrznia represents complex of geologic phenomena and problems (Rubinowski & Wójcik, 1978; Racki, 1988): 1) stratigraphical succession of Upper Givetian, Frasnian and Lower Famennian which have been described in details (Racki & Bultynck, 1993; Development..., 1995); 2) differentiated facies and thickness of the Devonian carbonate rocks due syndepositional tectonic movements (Szulczewski, 1971; Europrobe..., 1994; Development..., 1995); 3) Devonian fauna — fishes, brachiopods, tetracorals, conodonts and others — studied for more than one hundred years (Devonian reefs..., 1992; Głuchowski, 1993; Ivanov & Ginter, 1997); 4) structure of hydrothermal chimney in dolomite, examined in details (Migaszewski, 1991; Migaszewski *et al.*, 1995) as an evidence of hydrothermo-syndepositional dolomitization; 5) Variscian disconformity with traces of post-Variscian denudation and Permian/Triassic palaeokarst forms filled mainly with breccia and megabreccia (Development..., 1995); 6) Cainozoic karst forms — caves (Urban, 1996a).

The project of protection of the site is being prepared.

15. Zalesie–Zbelutka group of outcrops in southern part of the Góry Świętokrzyskie (300–333 m a.s.l.; 50°42'50"–50°43'27"N/21°03'33"–21°07'25"E).

Main features: sequences of Lower Palaeozoic sedimentary rocks with volcanics.

A few sites situated in the area ca 5 km long represent the most complete sequence of Caledonian cycle accessible at the surface in Poland. In the outcrops condensed sequences of Ordovician and Silurian are exposed. In the Chojnów Dół (Chojnice Pit) site the succession begins from Cambrian. The sequences are formed of shales, sandstones, greywackes with veins of diabases and documented by significant fauna of trilobites and graptholites (Czarnocki, 1928; Bednarczyk, 1971; Europrobe..., 1994).

In Zalesie–Zbelutka area 3 outcrops are protected as nature monuments.

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* *

The geosites described above differ in type, size of area and scientific matters. The list is open and should be modyfied and improved as the criteria of selection become more objective, better defined and commonly used for geosites representing every European regions. In this assessment of geosites the Góry Świętokrzyskie should be referred to other Caledonian/Variscian massifs — uplands and so called old mountains — of central and western Europe, whereas geosites of the Nida Basin should be compared first of all with ones in the eastern part of Fore-Carpathian Miocene (molasse) basin in Ukraine. This list ought to be also updated accordingly to the progress of research of both the regions.

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