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DĘBNIK AND PACZÓŁTOWICE "MARBLES" IN THE ARCHITECTURE OF KRAKOW

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Abstract: In the architecture of Krakow we can find many stones which were quarried mostly from deposits situated not far from the town. They gave a unique image of present, visible elements in the architecture. Many artists used a marble as the building and decorative stone, in sculptures and sepulchral art. Since XIVth century one of the most popular types of stone, which have been applied in the architecture of Krakow, is the Dębnik "marble". After polishing, it has a deep black colour and, together with Paczółtowice "marble" has been given the fantastic complement of decorative elements in the monuments.

In the Krakow we can find a lot of places where both "marbles" have been applied as a decorative elements in the architecture. These stones were forming the cultural heritage of Cracow. Usually they are used in sacred architecture. Dębnik and Paczółtowice "marbles" have been applied in many places, for example at the St Mary's Church and at the Wawel Cathedral, as well at Collegium Maius, St Adalbert's Church in Market Square or at St Peter and Paul' Church.

Keywords: carboniferous limestone, Paczółtowice marble, Dębnik limestone, Polish onyx, Dębnik anticline

1. INTRODUCTION

In recent years stone materials used in sculpture and architecture has become an interdisciplinary topic of dynamically developing, as well as geological, archaeological, historical or restoration researches. Stone materials are present in all historical periods.

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Krakow as one of the main artistic – craft centres, with more than a thousand years of history, is a perfect example of the geological valorization. In its architecture, a variety of stones can be seen being used as a building and as decorative materials. This gives a unique, unmatchable image of the town. Stones were originally recovered from the surrounding area of Krakow, and later were imported from further Polish regions and from abroad.

The city of Krakow situates within several geological, regional rank's units: Silesia – Krakow Monocline, Nida Basin, the Carpathian Mountains and the Carpathian Foredeep, allowing use in a wide range of different rocks for the purposes of sculptural and architectural work.

The most important stones within the long tradition of utilization come from the Silesia – Krakow Monocline, due to the proximity of their deposits. For example: Upper Jurassic limestone, black Devonian limestone of Dębnik, Lower Carboniferous "marble" of Paczółtowice, Triassic Diplopora dolomite, Permian porphyry, Holocene travertine etc.

Noteworthy "marbles" of Dębnik anticline are black Devonian limestone of Dębnik and pinkish "marble" of Paczółtowice. These rocks were used in architecture since at least the XIVth century. After polishing, they give a similar effect as the marbles *sensu stricto*, which were often used by many artists and sculptors (Kozłowski, 1986; Kurek and Preidl, 1993). Strong growth of masonry in Poland began primarily in the Renaissance and Baroque periods, in particular great interest was around Dębnik limestone, which was mainly used in sacral architecture. Their wonderful complement were initially Chęciny limestone and later Paczółtowice "marble" (Bochnak and Samek, 1965, 1971).

Dębnik and Paczółtowice "marbles" are the carbonate rocks, called "marbles" because they show similar technical properties like marble *sensu stricto*. These rocks have favourable technical properties with a high decorative value.

Exploitation of Dębnik "marble" carried out in the Dębnik village quarries (hence the name): "Łom Karmelicki" (Fig. 1, 2), "Siwa Góra", "Czarna Góra", "Czerwona Góra", "Cekierowa Góra", "Łom Tomidalskiego" and "Nowy Dębnik" (Fig. 1).

The exploitation of Paczółtowice "marble" was done in several places: on north in Paczółtowice, on east in the Racławka valley, on west in the Eliaszówka valley (Fig. 3) and near Devil's Bridge in the Eliaszówka valley (by the old road from Czerna to Siedlce; Fig. 4.) (Fig. 1). These deposits are situated within the Landscape Park – Krakow Valleys, belonging to the Jurassic Landscape Parks. In connection with the conservation of the region they aren't being exploited.

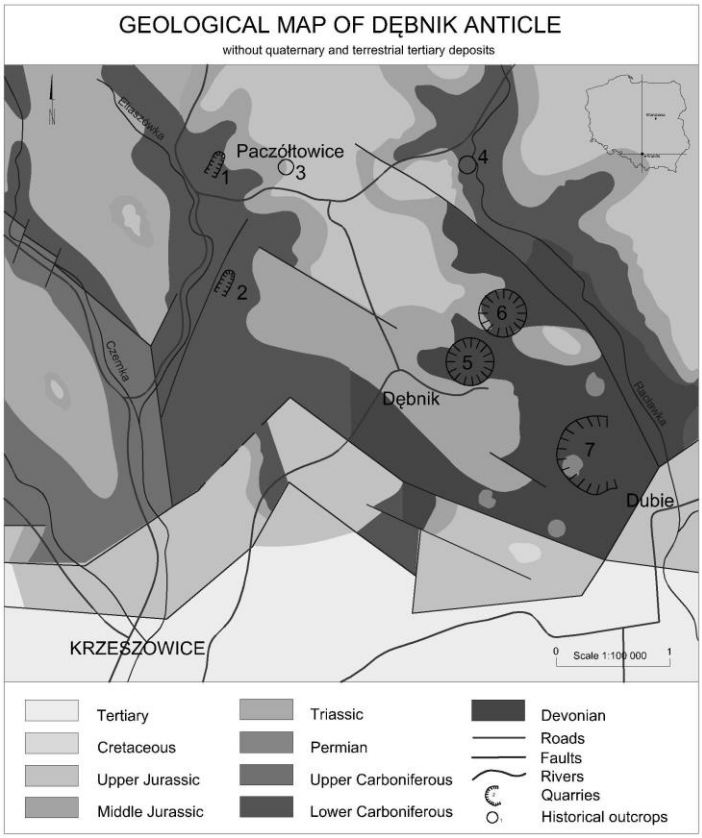

Fig. 1. Geological map of Dębnik anticline's area. Explanations: 1, 2 – Paczółtowice "marble" exploitation's places; 3, 4 – historical outcrops/quarries of Paczółtowice "marble"; 5 – "Łom Karmelicki" of Dębnik limestone; 6 – "Nowy Dębnik" quarry of Dębnik limestone; 7 – Dubie quarry of dolomites

Fig. 2. Present view of Dębnik "marble" quarry – "Łom Karmelicki"

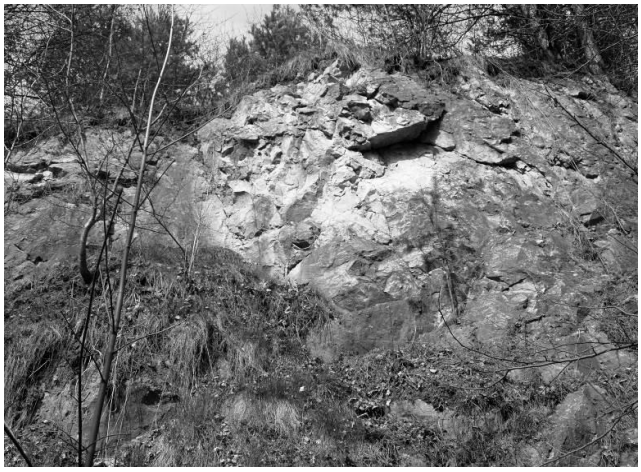

Fig. 3. Present view of Paczółtowice quarry situated west of Paczółtowice village

Fig. 4. Present view of Paczółtowice quarry situated near Devil's Bridge in Eliaszówka valley (by the old road from Czerna to Siedlce)

2. GEOLOGICAL STRUCTURE OF DĘBNIK ANTICLINE

Deposits of Dębnik and Paczółtowice "marbles" are located in the south-eastern part of the Silesian – Krakow Monocline, in the north of Krzeszowice trench and within the Palaeozoic anticline of Dębnik with axis SW–NE which is part of the Krakow Upland. Exposure of carbonate rocks in this region has been a focus of interest to geologists for a long time. Numerous outcrops of these rocks, and the fossils found in them, are providing studies about their sedimentation, as well as paleontological and stratigraphic works (Bogacz, 1967, 1980; Jarosz, 1926; Zajączkowski, 1975; Zaręczny, 1894; 1953). This brachyanticline was created as a result of converting the older horst-folding form through the Permian porphyry intrusion – laccolith and covers the layers from Givetian to the Upper Visean (Hoffman and Paszkowski, 1989).

The west and east wings of the anticline are cut by faults as a result of a tectonic deformation during the Caledonian movements and Variscan movements later. These faults relate to the valley of Krzeszówka, Eliaszówka, Czernka and Racławka (Fig. 5). From the south, the tectonic structure of the anticline is cut by marginal faults of Krzeszowice trench with latitudinal direction.

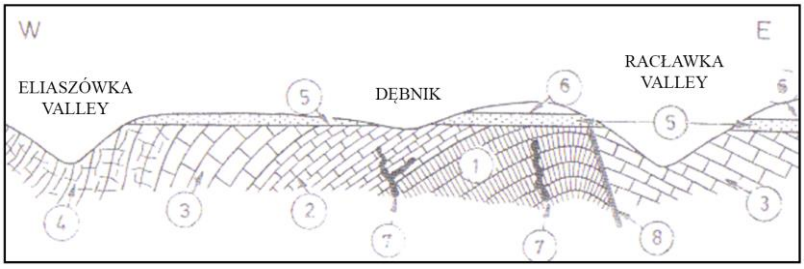

Fig. 5. Schematic cross-section through Dębnik Anticline (Gradziński, 1972): 1- dolomite from Zbrza, 2 – Dębnik "marble" and younger from them – Devonian deposits 3 – Tournaisian limestone, 4 - Visean limestone, 5 - Middle Jurassic sediments, 6 - Upper Jurassic limestone, 7- porphyry intrusions, 8 - Variscan fault

After putting the Czatkowice unit in, the Neo-Variscan elevation of Dębnik anticline occurred as a result of the post-tectonic intrusion of magma. This intrusion is reflected by the presence of multiple porphyry veins on the surface and the accompanying changes in the rocks surrounding the contact (Bojkowski and Jachowicz, 1964; Muszyński and Pieczka, 1994).

The central part of Dębnik anticline is built of the limestones and dolomites of the Middle and Upper Devonian, which are covered by the Dinantian limestones. Carboniferous and Permian rocks are exposed in the west wing of this anticline.

In the vicinity of Dębnik, the oldest Devonian deposits are considered steel blue-gray coloured, bituminous Eifel/Givetian dolomites from Zbrza gorge (Łaptaś, 1989). Younger sediments are mostly black Givetian limestone – Dębnik "marble". Next in

the profile are dark gray, Frasnian limestone and Famennian Stromatopora limestone (Baliński, 1989; Łaptaś, 1983; Zaręczny, 1953).

Lower Carboniferous is represented by limestone facies. In Tournaisian developed green and gray limestone, next are dark gray to black limestone with flints, and then dark gray crinoidean limestone. The Lower Visean deposits were formed by the light gray limestone and next by the gray and beige limestone. In the Upper Visean are the dark brown foraminiferal limestone and the slates with inserts of limestone and marl limestone. The Lower Carboniferous deposits are resulting from the shallow-water platform carbonate deposits sedimentation. At the end of the Tournaisian follows a slight deepening of the sea, where open shelf sediments have been created. (Paszkowski, 1989; Siedlecki, 1954; Zaręczny, 1953).

The Upper Carboniferous deposits have been heavily eroded in this area of anticline and are formatted by sandstone (Hoffmann and Paszkowski, 1989).

Permian deposits are represented by Rotliegend sediments: Karniowice and Myślachowice conglomerate (Bojkowski and Jachowicz, 1964).

At the turn of the Carboniferous and Permian together with Varyscian orogenesis appeared an acidic volcanism. As a result, Carboniferous limestone cracks were filled with hydrothermal, rich in Fe solutions and next were formed with multi coloured calcite veins. The contact zone of this limestone has changed and partially formatted as breccia (Bogacz, 1980; Kozłowski, 1955; Kurek and Preidl, 1993; Gradziński i in, 1994).

3. GEOLOGICAL CHARACTERISTICS OF "MARBLES"

3.1. DĘBNIK "MARBLE"

In Dębnik village Devonian limestones form a hinge part of Dębnik anticline. They are exposed in a few quarries and their series reaches thickness up to 40 m. Excavation area limits a slope of the Racławka valley on the east and the wide Krzeszówka valley on the west.

This "marble" has a beautiful, almost black color and "warm" gloss after polishing (Fig. 6). Quite often it is traversed by white calcite veins. Its dark color came from the admixture of pyrite (FeS_2) and organic matter of the kerogen type (Łaptaś 1983, 1989; Bednarczyk and Hoffmann, 1989). This is a homogenous, micritic, flat-laminated limestone in layers which thickness reaches up 2 m.

Typical for Dębnik limestone are a wavy depositing and usually structure is bulging or knobby. These deposits were formed in the hollow of shelf of the warm Devonian sea with poor aeration in Givetian and Frasnian (Hoffmann and Paszkowski, 1989).

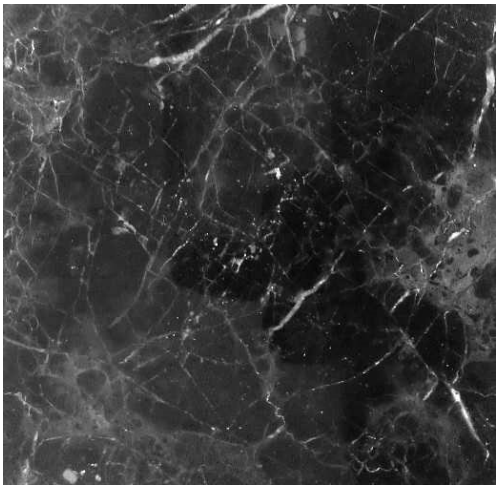

Fig. 6. Sample of the polishing black Dębnik limestone with white calcite veins

Dębnik limestone is diverse in terms of lithology. There are varieties of darker and lighter rocks, sometimes containing black flints, as well as pyrite crystals. Fauna is generally poor. In some parts of deposits you can find the focus of hydrozoans *Amphipora* sp. and the colonies of *Stromatopora* sp. (Gradziński, 1972). Other fossils identified include corals, gastropods, brachiopods and pelecypods.

Limestone colour changes from black to greenish-beige and sometimes to pink. This variation is related to the effects of warm, highly mineralized dilutions related to the Laccolith intrusion (Bogacz, 1977, 1980). It is called dungeon limestone – "marmur lochowy". Their name came from the dungeon – shallow shafts, where this "marble" was exploited. Mainly it was used for making small decorative elements (figures) and to encrustations.

Dębnik "marble" is a difficult rock in the stone works. In hand machining it requires proper, lightweight carrying a chisel. In an uncontrolled way it is chipping small fragments of rock. In particular, this is related to a knobby structure of these rock. Dębnik limestone exposed to weathering loses its unique black colour, fading to grey and even white, and its shiny appearance if polished (Kozłowski and Magiera, 1989). For that reason its architectural application focuses primarily indoors.

3.2. PACZÓŁTOWICE "MARBLE"

The Paczółtowice "marble" is represented by three inhomogeneous varieties of Carboniferous limestone modified in the later Carboniferous – Permian age as a result of plutonic and tectonic activity.

The first variety of the Paczółtowice "marble" is Carboniferous limestone deposited in Tournaisian and Visean. This is fine-crystalline limestone coloured light beige

or gray with break recesses and distinctive veins of white-reddish calcite (Fig. 7). Grids of coloured calcite veins give a high decorative value after polishing. The cracking of this limestone are fairly common manganese dendrites.

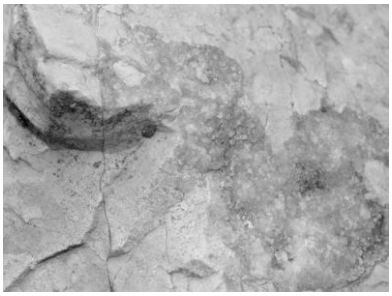

Fig. 7. Paczółtowice "marble" with calcite veins from quarry situated west of Paczółtowice village

The average thickness of the limestone beds usually ranges up to 1.2 m. Carboniferrous limestone has been modified by warm, Fe-rich dilutions related to the plutonic activity known from the Dębnik anticline (Bogacz, 1980; Hoffmann and Paszkowski, 1989; Gradziński i in., 2007).

The second variety of Paczółtowice "marble" was formed as a result filling of cracks in Carboniferous limestone with calcite from hydrothermal solutions and changed a contact zone. It is a calcareous breccia of this Carboniferous limestone joined together with multicoloured calcite (Gradziński i in., 2007).

The third and prettiest variety of the Paczółtowice "marble" is a multicolour (mainly coloured in pink), middling and thickly-crystalline calcite vein (Fig. 8) with thickness up to 20 m. It is probably Permian lateral secretion in the Carboniferous limestone. In these veins there are three stages of calcites filling, which was related to the precipitation of deep water circulation (Paszkowski i in., 2008). This variety is also known as "*polish onyx*" (Bogacz, 1980; Walendowski, 2013).

Fig. 8 Paczółtowice "marble" – white–pink calcite veins from quarry situated west of Paczółtowice village

These are finely crystalline rocks, concise with a very good susceptibility to polishing and grinding (Zaręczny, 1953). The largest size of the blocks, which were extracted from the Paczółtowice deposits, had the dimensions of 70×50×30 cm (Bogacz, 1980; Kamieński, 1975).

4. USE OF DĘBNIK AND PACZÓŁTOWICE "MARBLES" IN THE ARCHITECTURE OF KRAKOW

Strong growth of masonry in Poland began primarily in the Renaissance and Baroque periods, although the begins of "marble" exploitation were not large to architectural – carving purposes, Dębnik limestone aroused a lot of interesting. With its black colour after polishing this limestone enjoyed considerable fame, especially in church architecture. Their beautiful complement were initially Chęciny limestone – "Różanka Zelejowska" and later Paczółtowice "marble" (Bochnak and Samek, 1965, 1971).

Dębnik and Paczółtowice "marbles" were used mainly as a decorative element in the architecture of Krakow. Multi-coloured Paczółtowice "marble" created a unique connection with a matte black Dębnik limestone.

Mainly Dębnik "marble" was used in the sacral architecture. Most likely, in any church or cathedral in Krakow, we can find its usage. A comprehensive study about this limestone used in Krakow architecture is authorship of Władysław Tatarkiewicz (1953).

Most objects made of these "marbles" are located in the Wawel Cathedral (portals, the entrance to the vault, chapels, altars, statues, tombstones, tables) and St. Mary's Church (portals, altars, chapels gates, railings, tombstones, tables) (Tatarkiewicz, 1953). Also it is performed in a series of altars in Krakow churches, for example: in Franciscan Fathers Church, at St. Peter and Paul Church, pp. Discalced Carmelite Church on 44 Copernicus St. or St. Andrew Church (Rajchel, 2004).

A series of portals were also made of Dębnik limestone in particular leading to the sacral buildings, such as the baroque portals of entry to St. Andrew Church (Fig. 9) and Church of the Assumption.

Fig. 9. Portal of main entrance to the Wawel Cathedral made of black Dębnik "marble".

Although this rock material looks best inside of the building it was very often used in outdoor architectural elements such as a well in Late Gothic style (it is contemporary reconstruction; Fig. 10) and a fountain in the courtyard of the Collegium Maius or the column in front of the Church of pp. Discalced Carmelite on 44 Copernicus St. from 1668 (Rajchel, 2004).

Fig.10 Well in the courtyard of the Collegium Maius made of Dębnik "marble"

Paczółtowice "marble" generally was contrasting complement Dębnik limestone and usually was used as components of stone mosaics. For examples the most portals of sacral architecture in Krakow made of these "marbles" such as portals of chapels in the Church of St. Mary, in Wawel Cathedral and the Church of Francis de Sales at 16 Krowoderska St. (Rajchel, 2004; Magiera and Kozlowski, 1995). Baluster railings in

pp. Carmelite Church at 44 Copernicus St., details of the altars and portals leading to the vault and the vestry in Stanislaus Sanctuary on Skałka in Krakow were made of the "polish onyx" (Bochnak and Samek, 1965, 1971).

Gate situated in the Baroque wall surrounding the Wawel Cathedral also has incrustations of Paczółtowice "marble" in variety of breccia (Bochnak and Samek, 1965; Fig. 11).

Fig. 11. Gate in the wall surrounding the Wawel Cathedral on the encrustations carried out Paczółtowice "marble"

Fig. 12. Side chapel of south nave – St. Lazarus chapel in St. Marys Church – encrustations of Paczółtowice "marble" in Dębnik limestone in gates of chapel

St. Mary's Church has many incrustations of Paczółtowice "marble" in black Dębnik limestone. They are found in almost all gates of the side chapels (Fig. 12) as well as in northern and southern chapels nave built in the years 1685–1688 (Bochnak and Samek, 1971). In the southern entrance to the cathedral is a portal from 1689 which is decorated with six elements of the pink variety of Paczółtowice "marble" (Rajchel, 2004). At Veit Stoss altar are plates which are made of this stone found adorning columns within sequence of banisters.

Also, in one of the oldest churches in Krakow, dedicated to St. Andrew, deserves attention the late baroque altar made of Dębnik limestone where sides are decorated with Paczółtowice "marble" (Bochnak and Samek, 1971).

5. SUMMARY

Dębnik and Paczółtowice "marbles" were often used in architecture and sculpture from XIVth century. This allows us to view them not only in the architecture of Krakow, but also in other regions across Poland. Mainly they were used in sacral architecture and small sculpture.

Restoration works of Krakow monuments (and not only) tend to raise this rock materials for reconstruction. Unfortunately, the presence of carbonate rocks in the area of the Jurassic Landscape Parks (in a nature park – Krakow Valleys) or in its immediate vicinity is a rather serious problem of their exploitation on account of the conservation of nature.

Deposits of Dębnik and Paczółtowice "marbles" entirely lie within the park. From a technical point of view, these deposits have favourable conditions for the resumption of their exploitation. As well, qualities of these rock materials tend to offer consideration for the possibility of no conflict in their management. However conservation considerations suggest that these deposits shouldn't be exploited. There is an aggressive conflict between any possibility to resume the exploitation of the deposits and the requirements associated with the protection of nature and landscape, which is demanding we find a way to resolve this conflict.

REFERENCES

BALIŃSKI A., 1989. *Upper Devonian biostratigraphy of the Dębnik anticline*, [w:] Rutkowski J. (red.) - Guide of the 60th Congress of the Polish Geological Society, Wydawnictwo AGH, Kraków, pp. 30-34 (in Polish).

BEDNARCZYK J., HOFFMANN M., 1989. *Dębnik limestone*, [w:] Rutkowski J. (red.) - Guide of the 60th Congress of the Polish Geological Society, Wydawnictwo AGH, Kraków, pp. 40-46 (in Polish).

BOCHNAK A., SAMEK J., 1965. *Catalogue of art's monuments in Poland. Volume 4. City of Krakow. Part 1. Wawel*, Wydawnictwo Instytutu Sztuki PAN, Warszawa (in Polish).

BOCHNAK A., SAMEK J., 1971. *Catalogue of art's monuments in Poland. Volume 4. City of Krakow. Part 2. Churches and monasteries of Downtown*, Wydawnictwo Instytutu Sztuki PAN, Warszawa (in Polish).

BOGACZ K., 1967. *The geological structure of the northern border of the Krzeszowice Graben*, Geological works of the Commission of Geological Sciences PAN, branch Krakow, 41, Warszawa, pp. 1-66 (in Polish).

BOGACZ K., 1977. *The geological structure of the Paleozoic of Dębnik. The tectonics' problems of a north-eastern margin of the Upper Silesian Coal Basin. The materials of a regional conference: Czatkowice*, Polish Geological Society, AGH, Kraków (in Polish).

BOGACZ K., 1980. *Tectonics of the Palaeozoic rocks of the Dębnik region*. Yearbook of Polish Geological Society, Państwowe Wydawnictwo Naukowe, Kraków, t.50, 2, pp. 183-208.

BOJKOWSKI K., JACHOWICZ A., 1964. *Materials for 37th Congress of the Polish Geological Society: Geological and raw material problems of the Upper Silesian Industrial Region. Part 2 – field exposures*, Polish Geological Society, Katowice (in Polish).

GRADZIŃSKI R., 1972. *Guide to the surroundings of Krakow*. Wydawnictwo Geologiczne, Warszawa (in Polish).

GRADZIŃSKI R., GRADZIŃSKI M., MICHALIK S., 1994. *Science and culture in the Jurassic landscape. Nature*, Zarząd Zespołu Jurajskich Parków Krajobrazowych, t.3, Kraków (in Polish).

GRADZIŃSKI M., LEWANDOWSKA A., PASZKOWSKI M., DULIŃSKI M., ŻYWIECKI M., NAWROCKI J., KRYGIER J., LITWINOWICZ R., 2007. *Permian, volcanic-genesis' karst of the Dębnik anticline - preliminary results*, Materials of 41st Symposium of Speleology, Kletno. Sekcja Speleologiczna Polskiego Towarzystwa Przyrodników im. M. Kopernika, Kraków, pp. 51 (in Polish).

HOFFMANN M., PASZKOWSKI M., 1989. *The carbonate rocks of the Paleozoic of the Dębnik anticline*, [w:] Rutkowski J. (red.) - Guide of the 60th Congress of the Polish Geological Society, Wydawnictwo AGH, Kraków, pp. 25-30 (in Polish).

JAROSZ J., 1926. *Current state of the research of the Devonian and Lower Carboniferous stratigraphy in the Krakow region*, Yearbook of Polish Geological Society, t. 3, Kraków, pp. 115-185 (in Polish).

KAMIEŃSKI M. (red.), 1975. *Natural resources of the Cracow region*, Wydawnictwo Geologiczne, Warszawa (in Polish).

KOZŁOWSKI S. 1986. *Rock materials of Poland*, Wydawnictwo Geologiczne, Warszawa (in Polish).

KOZŁOWSKI R., MAGIERA J., 1989. *Deterioration of the Dębnik and Pińczów limestones in the monuments of Krakow*, [w:] Rutkowski J. (red.), Guide of the 60th Congress of the Polish Geological Society, Wydawnictwo AGH, Krakow, pp. 204-208 (in Polish).

KUREK S., PREIDL M., 1993. *Explanation of Detailed Geological Map of Poland, 1:50 000. 358, Sheet: Olkusz*, Państwowy Instytut Geologiczny, Warszawa.

ŁAPTAŚ A. 1983. *Sedimentation of Middle Devonian carbonates of the Dębnik area (Southern Poland)*, Studia Geologica Polonica, 75. Wydawnictwo Geologiczne, Warszawa, pp. 59-100.

ŁAPTAŚ A., 1989. *Dolomites from Zbrza*, [w:] Rutkowski J. (red.) - Guide of the 60th Congress of the Polish Geological Society, Wydawnictwo AGH, Kraków, pp. 34-40 (in Polish).

MUSZYŃSKI M. & PIECZKA A. 1994. *Porphyry of the Dębnik laccolith*, 25/1, Mineralogia Polonica, Kraków, pp. 15-28.

PASZKOWSKI M., 1989. *Dinantian limestones of the Czatkowice region*, [w:] Rutkowski J. (red.) - Guide of the 60th Congress of the Polish Geological Society, Wydawnictwo AGH, Kraków, pp. 46-50 (in Polish).

PASZKOWSKI M., CZOP M., GRADZIŃSKI M., LETKI S., LEWANDOWSKA A., LEŚNIAK T., MOTYKA J. 2008. *Czatkowice quarry - Lower Carboniferous sediments of the carbonate platform of Krakow block - geological history, structural and paleogeographical context; hydrogeological conditions; Permian fossil karst*, [w:] Haczewski G. (red.) - Guide of Field Sessions, 1st Poland Geological Congress, Polish Geological Society, Kraków, pp. 15-28 (in Polish).

RAJCHEL J., 2004. *Stone Cracow: regard of geologist*, Uczelniane Wydawnictwa Naukowo – Dydaktyczne, Kraków (in Polish).

SIEDLECKI S., 1954. *Palaeozoic deposits of the Krakow region*, Geological Institute, Bulletin 73. Wydawnictwo Geologiczne, Warszawa (in Polish).

TATARKIEWICZ W., 1953. *Black marble in Krakow*, Prace Kom. Historii Sztuki PAU, 10/1. Kamieniarstwo, Kraków (in Polish).

WALENDOWSKI H., 2013. *Minimonographs of polish building stones*, Nowy Kamieniarz, nr 66 (2/2013) (in Polish).

ZAJĄCZKOWSKI W.A., 1975. S*tratigraphy and lithology of the Dinantian limestones in Czerna near Krzeszowice*, Bulletin of Geological Institute, 282, XIII, Warszawa, pp. 273-326 (in Polish).

ZARĘCZNY S., 1953. *Geological map of Krakow and Chrzanow*, Wydawnictwo Geologiczne, Warszawa (in Polish).

ZARĘCZNY S., 1894. *Geological atlas of Galicyi. Text to 3rd notebook (oprac. St. Zaręczny)*, Wydawnictwo Komisyi Fizyograficznej Akademii Umiejętności, Kraków (in Polish).