The Stony Cracow: geological valors of its architecture

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The author wants to bring reader's attention to an unusual wealth of geological record available in urban agglomerations. This has been turned to profit by *urban geology*, a new, fast developing branch of geological sciences, formed some years ago. The subject of its scientific interest is the stone matter present in the urban environment in all possible architectonic applications. Respective research procedures are non-invasive, and investigations of old documents and archive materials as well as comparative studies are of substantial importance. The range of issues treated by urban geology has not been closed so far. Comprehensive geological valorization of stone materials used in towns, the processes of stone destruction in the urban atmosphere, all aspects of selecting and applying rocks in architecture, as well as utilizing the teaching, cognitive and touristic values of stone materials should be mentioned here. Urban geology extends and supplements simultaneously one's knowledge of general history, history of art and architecture.

Faced with spontaneous development of tourism, the proposed geological glance at the urban architecture gets a momentum. A whole range of professional guidebooks, although differing in their internal construction, have been written in the last years. They offer a complex description of the wealth of geological record contained in the stony matter of the widely understood architecture of large cities, e.g. Prague (Březinová et al., 1996), Vienna (Seemann & Summesberger, 1998), Berlin (Schroeder, 2006), and also Cracow (Rajchel, 2005).

Rocks in the architecture of Cracow

Cracow, a city with a thousand-year history and a former capital of Poland, is an excellent example of geological valorization. Variability of building rock materials and decorative stones has imparted a characteristic, unmatchable color of the town. Initially, the stones were recovered from the nearest neighborhood of Cracow, the city situated at the junction of several geological units of a regional rank, differing in their structure. Gradually, the petrographical rock inventory became enriched in stones brought from more distant localities and other geological units. Selection of rock materials considerably depended on political and territorial changes of the Polish state. In last years, due to importing decorative stones from all over the world, which increases at an unimaginable rate, the spectrum of the rocks offered is getting richer and more variable. Unfortunately, this new, foreign stone material distorts gradually a historic, traditional landscape of Cracow.

Rock raw materials commonly found and with the longest tradition of utilization in the architecture of Cracow come from the Silesian-Cracow Monocline. To the most important examples belong: white, Upper Jurassic limestone; yellowish Triassic diplopora dolomite; black Devonian limestone from Dębnik; deep red-violet Permian porphyry; pinkish, Lower Carboniferous "marble" from Paczółtowice; and Holocene travertine. The Carpathian Foredeep provided Cracow with white, Miocene limestone from Pińczów and Miocene alabaster; whereas the Carpathian orogen with brownish and greenish, Cretaceous and Tertiary sandstones, Miocene andesite from the Pieniny Mts and Carboniferous granite from the Tatra Mts. The next group is represented by Devonian and Jurassic limestones and calcareous conglomerates, as well as rusty-colored, yellow and white, Triassic and Jurassic sandstones from the Świętokrzyskie Mts proper and their margin. The Ukrainian shield, today outside the Polish borders, provided Precambrian plutonic and volcanic rocks and Devonian sandstones. Other far-localized rocks were brought from the Sudetes and the Fore-Sudetic monocline: they include mainly Precambrian marbles, Paleozoic granites and syenites, also Permian and Cretaceous sandstones (Rajchel, 2005). The rocks were used in defensive walls of the city, sacral and lay constructions, as pavements of streets, squares and sidewalks, monuments and tombstones. Polished slabs of these rocks have been applied as a decorative material.

In the historic architecture of Cracow there are also stones imported from outside Poland, mostly from neighboring countries, e.g. Hungarian marble. They were used for special purposes, for instance in interior designing or in sepulchral stonework. Current import of rocks, whose number exceeds several hundred of types from all over the world, is based mainly on polished stones.

The stone materials applied in the architecture of Cracow, both of domestic and foreign origin, represent different igneous, sedimentary and metamorphic rocks. Their observations make possible determining the mineral composition; texture and structure; signs of weathering that took place both in the deposit itself and after quarrying and architectonic applying; and also, in the case of sedimentary rocks, instructing somebody in a whole range of sedimentary structures and numerous fossils. Sometimes we can also learn about the methods of stone quarrying and dressing.

Having at one's disposal such a huge and diversified spectrum of stone materials utilized over the ages and imported in our times, it has been an intention of the author to give a short characteristic and indicate examples of architectonic uses of selected rock types from the area of Cracow.

Rocks from the Silesian-Cracow Monocline

Selected rocks from the Silesian-Cracow Monocline are described below (Rajchel, 2005), following the frequency of their occurrence in the architecture of Cracow. Moreover, the most interesting examples of their applications in this architecture, both historic and modern are also given.

White Jurassic limestone. It is the Oxfordian rock of the Upper Jurassic, commonly occurring both in the vicinity of Cracow and within the town limits of the modern and

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the old Cracow, and forms several facies varieties, i.e. rocky, coarse-bedded with flints, chalky and platy limestones (Dżułyński, 1952; Matyszkiewicz, 1989). The color of the fresh rock is slightly yellowish or pinkish, being white on the weathered surface. The rock often contains fossils, mainly calcitized siliceous sponges, belemnites and ammonites, sometimes purposefully exposed. The limestone belongs to the oldest and the most important rocks utilized in the architecture of the city, commonly applied in the form of irregular blocks and regular elements. The broken stones were used in erecting city fortifications, e.g. defensive walls of the burgher Cracow and the royal castle Wawel, and also paving streets and squares. Just of this type was the several hundred year-old stony surface of the main Market Square removed in 1964 (Fig. 1); regularly cut limestone blocks were also used in other pavements.

Fig. 1. An old pavement constructed of fragments of the Upper Jurassic limestone; the old, removed pavement of the Main Market square looked the same. All photos by J. Rajchel

Utilization of Jurassic limestone had its apogee in Romanesque and Gothic times. In the Romanesque period, the limestone was dressed into brick-shaped small blocks (*petit appareil*), used mainly in constructing walls of sacral buildings, the finest example of which being the Church of St. Andrew (Fig. 2). Large limestone blocks (*grand appareil*) were used in Gothic times, often in combination with dark tan-colored, hand-made bricks. The Jurassic limestone was widely used in architectonic stonework: columns, consoles, cantilevers, portals, window frames, cornerstones, floors, windowsills, drip caps, street guards, and also pinnacles, traceries (maswerks) and stone ornamental openworks. A whole array of these forms can be seen, e.g., in the City Hall Tower, the Wawel Cathedral, and also the city basilica churches of St. Mary's, St. Catherine's, St. Trinity's, and Corpus Christi.

Black Dębnik limestone. This rock, usually described as a "marble", is a strongly lithified Devonian limestone (Givetian-Frasnian). The only place it can be found is the area of Dębnik, a hamlet of the Paczółtowice village situated N of Krzeszowice, and was quarried starting from at least 14th century (Kozłowski, 1986). It occurs in a range of color varieties, from black to grey; a separate class is formed by the limestones altered in hydrothermal processes: pink-, greenish- and even white-mottled. The Dębnik limestone owes its unusual popularity, extending over centuries in Poland and outside the country, due to its color and capability of taking a beautiful mat polish, simultaneously being "warm". The rock early-diagenetic structures: wavy, bulging and nodular, are common as well as are fossils, lighter in color than the rock background: usually twig-like *Amphipora* sp., bulging *Stromatopora* sp. and single *Tetracorallia* sp. Its highest quality — the black color — becomes unstable when exposed to weather conditions, thus the limestone has found its applications mainly indoors. It was widely used in church interior architecture: altars, menses, lavaters, baptismal fonts, holy-water basins, memorial and epitaph tablets, and elsewhere in manufacturing portals, floors, banisters, columns, stairs, monuments, mantelpieces (Fig. 3), and even sarcophagi and tombstones (Tatarkiewicz, 1953). The interior of St. Mary's Church is a good example of diversified applications of the black limestone from Dębnik: the rock can be found in four portals, 23 altars, six small gates (so-called portons) leading to side chapels, four banisters, not mentioning a range of tombsto-

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Fig. 2. The Romanesque church of St. Andrew built of limestone blocks (*petit appareil*) and a Carpathian sandstone; the end of the 11th century

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Fig. 3. The well built of the black Dębnik limestone in the inner courtyard of Collegium Maius. The Collegium building dates back to the turn of the 14th century, the well comes from the 1950s

Fig. 4. The Baroque portal from 1636 of the Wawel Cathedral constructed of the black Dębnik limestone

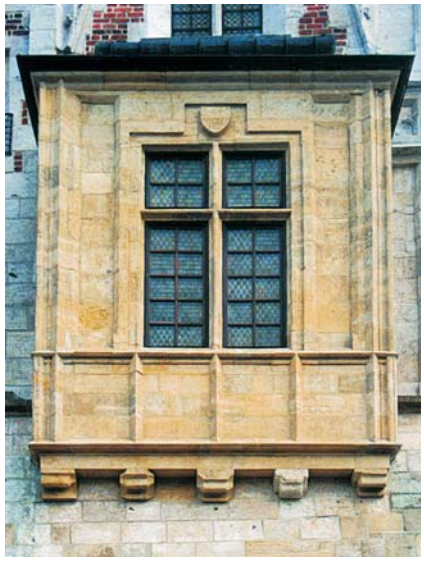

Fig. 5. The Gothic Town Hall tower from the 14th century; the bay window made of diplopora dolomite was reconstructed in the 1960s

nes and epitaph tablets. The Wawel cathedral is another such an example that includes two portals (Fig. 4), portons of the treasury and all side chapels except for the Sigismund chapel, all altars apart from the high altar and the altar of the Sigismund chapel, interiors of five chapels, more than one hundred of monuments, tombstones, sepulchral and memorial tablets and, finally, the cathedral floor. The best known sites outside Cracow where the black Dębnik limestone was used are represented by the monasteries of the Carmelite monks in Czerna near Krzeszowice and the Pauline monks on the Jasna Góra Hill in Częstochowa. One of many applications outside Poland is represented by the high altar of St. Stephen's cathedral in Vienna, constructed in the years 1640–1647 by Johan Jacob Pock of more than 100 tons of this rock (Koziński, 1959).

Diplopora dolomite. In the architecture of Cracow, the diplopora dolomite (Muschelkalk, Middle Triassic) has been used at least from the end of the 14th century. It is the yellow-brownish rock, with a characteristic irregular porosity exceeding even 20% that formed in the eogenetic stage of diagenesis. The rock was quarried at its outcrops spreading NW of the Krzeszowice and Olkusz areas; the most important were the quarries around Libiąż (Czeżowski, 1946–1948). It is usually the rock with a micritic texture, less frequently of the wackstone, micritic grainstone or dolosparite character; reveals the presence of oolithic, pseudooolithic, oncolithic, laminite and stromatolite structures; its beds can be interlayed by conglomerates and intraformational breccias, and — exceptionally — epigenetic flints (Myszkowska, 1992, 1993). Fragments of rock-forming algae *Diplopora* sp., trochites of crinoids, and also trace fossils *Palaeophycus* isp. in the form of flattened small rolls of a small-finger thickness (traces of living activities of *Polychaeta* sp.) are relatively common. All these features of the diplopora dolomite can be inspected in architectonic elements cut of this rock. Notwithstanding the high porosity and variability of physical parameters, the diplopora dolomite reveals a substantial resistance to weather conditions. It is a building stone but also used for decorative purposes: in slab facings, portals (Fig. 5), window framings, cornices, floors, stairs, curbs, and even pavements; however the rock does not take polish (Kamieński & Rutkowski, 1975). Beautiful examples of dolomite stonework executed in the Baroque times starting from the beginning of the 17th century include the wall with gates bordering the Wawel cathedral (Fig. 6) from the south and the west and the facade of the Church of St. Peter and Paul

Fig. 6. The Gothic Wawel Cathedral from the 14th century. The walls built of the Jurassic limestone ashlars (*grand appareil*); the Baroque wall surrounding the cathedral and the gate constructed of the Triassic diplopora dolomite date back to 1619

in Grodzka Street. The rock is also the main building material of the Church of the Holiest Heart of Jesus from the beginning of the 20th century in Kopernika Street and the facade of the National Museum facing the 3rd May Avenue. Huge anti-flood hydrotechnic structures, constructed along the Vistula River in the first half of the 20th century, are by far the largest "dolomitic investment" in Cracow.

Porphyries of the Krzeszowice area. Lower Permian porphyries of the Krzeszowice area, a locality situated west of Cracow, are — in fact — rocks intermediate between rhyolites and dacites (Muszyński, 1995). Quarried for the use of Cracow architecture, they derive from the lava cover of Miękinia or a large laccolith of the Zalas region. The rocks have porphyritic texture with phenocrystals of feldspars, biotite and quartz. The Miękinia porphyry is mainly violet, whereas its Zalas counterpart changes from green-bluish to pale cherry-red to yellow-brownish (Fig. 7). This variability results both from ongoing weathering processes and filling the Zalas laccolith with magmas of slightly different composition (Harańczyk, 1989). The stone inventory cut of the porphyries includes paving blocks, floor slabs, boles and curbs (Czeżowski, 1946–1948). They have been utilized since the middle of the 18th century in Cracow streets and squares (Rajchel, 2005), imparting them a specific color. Remnants of these pavements can be

Fig. 7. The sidewalk from the 19th century made of the porphyry paving stone quarried in the Krzeszowice area

seen, among others, at the Small Market, at the front of the Wawel cathedral, and in Franciszkańska, Kanonicza, Loretańska, Jagiellońska and Karmelicka streets. Combinations of the porphyry blocks with marble (white), limestone or granite blocks have composed beautiful mosaics, e.g. around the monument of Adam Mickiewicz at the Main Market Square or along Szpitalna Street passing into the Holy Spirit Square.

Paczółtowice "marble". The Paczółtowice "marble" is a commonly used term of the Lower Carboniferous (Tournasian), decorative limestone, quarried near Paczółtowice, 6 km north of Krzeszowice. The rock is situated in the W limb of the Dębnik anticline, within a vertically oriented breccia-and-vein tectonic zone up to fifteen or so meters thick. There are two varieties of the "marble": a grey-reddish limestone with veins of white calcite, whereas the other, called the "Polish onyx", is a similar but brecciated limestone, unusually rich in veins of pink and violet calcite (Kamieński & Skalmowski, 1957). Only possible to win were small blocks of this rock. After polishing the Paczółtowice "marble" was mainly used as a stone marquetry component; in such a combination it has been the "inseparable companion" of the black Dębnik "marble"

Fig. 8. A fragment of the portal of the St. Adalbert Church made of the black Dębnik limestone with a marquetry of the Paczółtowice limestone. The church, about 1000 years old, is one of the oldest in Cracow; its late Baroque portal comes from the 18th century

(Fig. 8). Such marquetries can be seen, among others, in the Baroque portals made of the black Dębnik limestone in St. Mary's Church and St. Adalbert's Church at the Main Market Square and St. Francis de Sales in Krowoderska Street. The same combination of the two rocks occurs in most of the chapel portons of the Wawel cathedral, makes the floor around the confession of St. Stanislaus as well as elements of the confession banister. In the same character, the Paczółtowice "marble" decorates small columns set in the banister at the front of the famous Veit Stoss altar in St. Mary's Church at the Main Market Square. The rosettes of the Paczółtowice "marble" also decorate the facade of the Church of St. Peter and Paul (Fig. 9) in Grodzka Street (Rajchel, 2005).

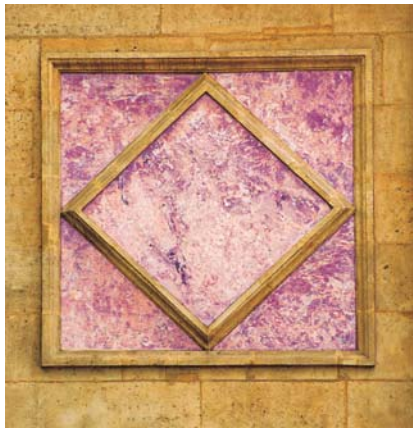

Fig. 9. The decorative element made of the Paczółtowice limestone in the facade (ca 1630) of the Church of St. Peter and Paul

Travertine. The travertine used in Cracow is a calcareous rock occurring in Będkowska, Szklarka and Racławka valleys situated north of the Krzeszowice Trough and inci-

Fig. 10. A shrine built in the 1930s of the Holocene travertine next to the church of the Lord Good Shepherd

sed into the Upper Jurassic limestones. The rock originated in the Holocene from karst waters enriched in Ca^{++} and HCO_3^- (Rutkowski, 1991) and formed bioherm-like accumulations or detrital travertine. Aragonite is the main component of this cryptocrystalline rock of a very high although variable porosity. It can be easily worked and represents a stony material self-hardening after extracting from the deposit. The rock found its applications in the sepulchral art and small sacral architecture. Irregular blocks of the travertine were used in constructing tomb memorials, particularly at the Rakowice cemetery, at the beginning of the 20th century, as well as in roadside small shrines (Fig. 10). Considering its low density, the rock was used in constructing the vault of St. Andrew's Church (Świszczowski, 1949).

Porphyry tuff. Cracow is not short of architectonic applications of tuff, either. The rock occurs in the Silesian-Cracow Monocline, near the village of Filipowice, N of the Krzeszowice Trough. Its name, the Filipowice tuff, derives just from the locality. It is a Lower Permian rock of the ignimbrite character (Parachoniak & Wieser, 1985; Harańczyk, 1989), with the attractive wild strawberry color, finely spotted in white, deep red and black. The tiny spots represent grains of sanidine and chloritized biotite, quartz and fragments of basement rocks, embedded in the uniform, microcrystalline sanidine background. The rock also contains volcanic bombs (porphyry), bigger fragments of volcanic rocks, Carboniferous limestones, sandstones and shales. The tuff is highly porous, with a low bulk density, but simultaneously competent and durable to weather conditions (Kozłowski, 1986). The Filipowice tuff is one of

Fig. 11. A fragment of the wall at the Wawel Hill built of the Filipowice tuff

the most radioactive rock materials in Poland (Rajchel, 2005). It was quarried since the middle of the 19th century as a building and slab facing stone. The building of the former Insurance Company at the corner of the Main Market and St. John Street has its ground floor facade lined with just such slabs. The retaining wall situated between the Sandomierz Tower and the Thief Tower at the Wawel Hill has also been constructed of this rock (Fig. 11).

Jurassic flints. The last of the selected, although atypical rock present in the architecture of Cracow is represented by flints, originating — as the above described rocks do — in the Silesian-Cracow Monocline. They are spherical, cylindrical or irregular, early-diagenetic and less frequently epigenetic concretions of navy blue or brownish color composed of chalcedony and crypto-crystalline quartz, occasionally opal (Pawlikowski et al., 1978; Świerczewska, 1989). Spiculae of opal sponges were the main source

Fig. 12. A bulging flint concretions in a "crystal" column of the Collegium Maius inner courtyard

of the flint silica. They are an inherent component of architectonic elements cut of thick-bedded Oxfordian limestones (Matyszkiewicz, 1989). In many places they have been intentionally exposed by giving them the bulging relief, e.g., in "crystal" columns of the Collegium Maius courtyard (Fig. 12). Fixing broken fragments of concretions into a facade is another application of the flints, exemplified by the dwelling house at No. 18 Czysta Street.

Fig. 13. A mascaron carved in the Pińczów limestone in the mid-16th century (the Cloth Hall attic)

Fig. 14. Present-day replicas of late-Baroque (beginning of the 17th century) sculptures of apostles, carved in the Pińczów limestone, placed at the front of the Church of St. Peter and Paul

Stone raw materials from outside the Silesian-Cracow Monocline

Selected rocks located outside the Silesian-Cracow Monocline that have become "naturalized" in the Cracow architecture are only described. Moreover, the most interesting examples of their applications in architecture, both historic and modern are also given.

Pińczów limestone. The Pińczów limestone is a phytogenic calcarenite or calcilutite with the calcite contact cement, the rock of a high porosity and a bulk density of 1.5–2 g/cm^3 (Bromowicz, 2001). It formed from accumulated detritus of the algae *Lithothamnium* sp. and fragmented calcareous skeletons of other marine organisms, with a subordinate admixture of quartz grains and clays. It is a Miocene rock from the Lower Badenian stage and occurs along the northern margin of the Carpathian Foredeep from the vicinity of Miechów to Pińczów, then toward Biłgoraj and farther to SE toward Lvov and the Podole area (Peryt & Peryt, 1994). These limestones have found their application as building stones, facing slabs, in portals, cornices, etc., but first of all they represent an indispensable stone for sculpting. The Pińczów limestone belongs to the rocks self-hardening after being quarried. During dressing it does not take polish. The oldest, currently active region of its quarrying is situated in the Pińczów area.

The Pińczów limestone has been used in the architecture of Cracow since the 12th century, with the peak of its popularity in the Renaissance. It was the very stone in which excellent sculptors executed their masterpieces, forming the cultural heritage of Cracow, spread all over the city. One can find the Pińczów stone in the 16th-century Renaissance canopies over the sarcophagi of kings Ladislaus Jagiello (curved by Jan Cini of Siena) and Casimir the Great (cured by an unknown artist) in the Wawel cathedral. An excellent Renaissance sculptor and architect Jan Maria Padovano curved in this stone ornamental masks of the Cloth Hall attic (Fig. 13). Regarded the most beautiful in Poland is the attic of the Boner family mansion in the Main Market Square, curved by Santi Gucci, another Italian architect and sculptor. The same stone was used earlier by Veit Stoss to curve the figures of the Gethsemani chapel of St. Barbara's Church and a huge crucifix in St. Mary's Church. A younger monument was formed by supernatural figures of twelve apostles standing at the front of St. Peter and Paul's Church in Grodzka Street, curved in 1715 by David Heel (Fig. 14). Unfortunately, they have had to be replaced by replicas cut in the same stone. The Pińczów limestone was used in stone masonry of the finest in Cracow, 14th-century portal of the Gothic Church of Saint Trinity, with floral ornamentation (leaves of *Bryonia* sp.) hiding apotropaic dragons (Fig. 15). This light-weight limestone was also used in constructing huge rosette windows during the Gothic and Renaissance, for instance the dodecahedral rosette of the Wawel cathedral. The Pińczów limestone represents an architectonic stone still used in Cracow; there is even increased interest in applying this material as facing slabs outdoors (Rajchel, 2005).

Fig. 15. Apotropaic dragon carved in the Pińczów limestone from the 13th-century portal of the Holy Trinity Church

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Fig. 16. The Chapel of St. Catherine from the beginning of the 17th century at the Church of the Holy Trinity: the sculpture of Jerzy Zbaraski executed in alabaster, interior lined in the black Dębnik marble, the column made of the Sigismund calcareous conglomerate from the Świętokrzyskie Mts

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Fig. 17. The alabaster sculpture (the second half of the 17th century) of duchess Grzymisława in the Franciscan Church

Alabaster. Alabaster or fine-crystalline gypsum is another stone coming from the Carpathian Foredeep and applied in Cracow. It occurs in the Dniestr river-basin at Podole (Rychlicki, 1913; Nowak, 1938), where it was quarried in Kołokolin and Żurawno as early as at least 16th century. It forms a range of petrographic varieties within evaporites of the Middle Badenian (Miocene). These varieties include: the white alabaster, very fine-crystalline, translucent; the light yellowish one with darker, thin veins and spots; the grey one, horizontally laminated; the brecciated one. All of them take excellent polish that gives optically a feeling of the "warm" surface. The alabaster can also been found indoors as a decorative stone, in small architectonic details and in sculptures.

Most of alabaster-made monuments in Cracow date back to the beginning of the 17th century (Rajchel, 2005). The finest examples include the statues of Krzysztof and Jerzy Zbaraski (Fig. 16) in Holy Trinity Church (Tatarkiewicz, 1953). Other statues from the same period represent prince Boleslaus the Shameful and his mother, princess Grzymisława (Fig. 17), in the church of Franciscan friars. Boleslaus was the very ruler of Poland who granted Cracow the city charter in 1257, when the city was heavily destroyed after a Tartar raid in 1241. Of the similar age is a bas-relief of St. Mary and the Child in the Church of Corpus Christi executed in the alabaster from Żurawno.

Another example of a figurative, alabaster sculpture are two 18th-century eagles from the Church on the Rock of St. Stanislaus. From the 1930s comes a rich architectonic alabaster interior of the churches of St. Philip and of the Calced Carmelites (Fig. 18) as well as of the old building of the Jagiellonian Library (Rajchel, 2005). As the alabaster deposits have belonged since the end of the World War II to the Ukraine, this stone practically has not longer been used in Cracow, although its quarrying continues (Mitrofanow & Szpanow, 1970).

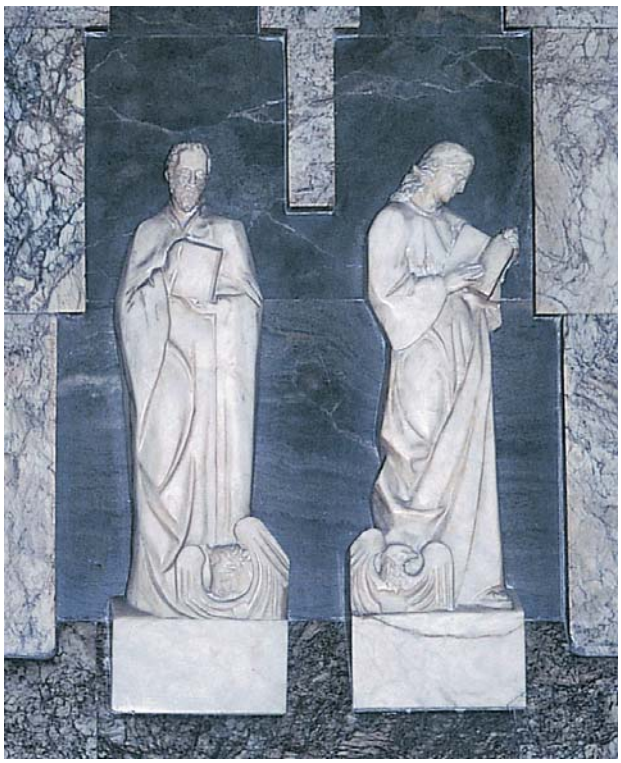

Fig. 18. Alabaster sculptures from the 1930s set in the pulpit of the Church of Calced Carmelites

Carpathian sandstones. The sandstones from the Outer (i.e. Flysch) Carpathians were the first stone materials used in Cracow (Bromowicz et al., 1976). Of the highest architectonic importance were polymictic and lithic Istebna and Godula sandstones, of the lesser the Ciężkowice, Krosno, Lgota and Magura sandstones. They were used in the oldest, Pre-Romanesque and Romanesque structures of the Wawel Hill, i.e. the so-called quadrilateral building (under the surface of the arcaded courtyard), the Rotunda of Virgin Mary (also called the Rotunda of St. Felix and St. Adauctus). Two Romanesque cathedrals: the first (or Boleslaus the Brave's) one, and the second (or Ladislaus Herman's) one (Bromowicz & Magiera, 2003) had their walls, columns, column bases and capitels made of such sandstones, carefully worked to shape (of the latter cathedral only the crypt of St. Leonard still exists). In Romanesque times, the Carpathian sandstone was a material complementary to the dominant limestone small blocks (*petit appareil*), used as cornerstones, portals and window frames. The best examples of such applications can be seen in the churches of St. Andrew (Fig. 3), St. Adalbert and the Holiest Salvator. The sandstone played a similar role in city fortifications, for instance in St. Florian's Gate. After a longer break, the Carpathian sandstone was used again on a larger scale in the Renaissance. The finest Renaissance chapels, the Sigismund and the Vasa chapels of the Wawel cathedral, were erected then of the greenish Godula and the yellowish Istebna sandstone, respectively.

Currently, the Carpathian sandstones seldom represent building stones, being mainly used as a decorative material such as wall and floor slabs, either cut or broken to shape and with diverse surface texture. Good examples can be found in the facades of the Cracow-Balice Airport building, the new building of the Academy of Fine Arts (Fig. 19) and the building of the "Bagatela" theatre; all of them utilize the Istebna sandstone. Some parts of the facade of the Museum of Japanese Art and Technology in Konopnicka Street have been made of the grey-blue Krosno sandstone (Rajchel, 2005).

Fig. 19. A fragment of the present-day facade of the building of the Academy of Fine Arts built of the Istebna sandstone (Carpathian Mts) and Jurassic white Szydłowiec sandstone (the margin of the Świętokrzyskie Mts)

Tatra Mts granite. The granite of the crystalline basement of the Tatra Mts has minor but spectacular applications in the Cracow architecture. Carefully chosen pebbles of this granite (about 2 millions of stones!) line the walls of the Church of Our Lady Queen of Poland, commonly called the Ark of Our Lord (Fig. 20), which has been the first

Fig. 20. The Church of the Arc from the 1970s, the first post-war church in Nowa Huta; its walls are lined with pebbles of the Tatra granite

church of Nowa Huta built in communist times (Rajchel, 2005). Huge pebbles of appropriate shapes have been used by a contemporary Cracovian sculptor B. Chromy to create stony animals (Fig. 21). A huge block with a weight of 26 tons, located close to the margin of the Cracow Błonie, commemorates Pope John Paul II and is the most unusual Tatra granite block in Cracow (Fig. 22). Another, much smaller granite block with pegmatite veins was placed in 1860 at the top of the Thaddeus Kościuszko mound.

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Fig. 21. The Tatra granite pebbles converted into the sculptures of sheep from the 1960s (author: Bolesław Chromy)

Fig. 22. The monument to the Pope John Paul II in the form of the huge Tatra granite block in the Cracow Błonia meadow. Inscription "You are the rock" is adapted from the Bible which says "...you are Peter, and upon this rock I will build my church" Mt. 16:18

Fig. 23. The pavement from the 1930s made of the Precambrian Volhynian basalt

Volhynian basalt. This basalt comes from an extensive lava cover associated with the Vendian activization of the East-European platform. The rock is exposed in Volhynia (it is the Ukraine after the World War II), in the basin of the Horyń River, and has been quarried there since at least the 17th century (Kamieński, 1930). The rock has the black color with a dark navy blue tint, porphyritic or intersertal texture and massive structure. It is an excellent paving material and as such it was used in Cracow for almost 100 years. The Volhynian basalt blocks arranged in rows have been preserved in many street pavements of Cracow, for instance in Szewska Street and Karmelicka Street (Fig. 23).

Strzegom granite. Granite of the Strzegom-Sobótka batholith occurs within the Fore-Sudetic block. As a result of four intrusive stages, it has several petrographic varieties, differing in their mineral compositions and grain sizes,

but displaying a similar, grey color (Majerowicz, 1972). The main variety is a medium-crystalline hornblende-biotite granite, composed of white orthoclase and oligoclase, grey quartz, black biotite and hornblende. The history of its quarrying on the slopes of Mount Ślęża dates back to prehistoric times (Wójcik, 2003). In Cracow, streets were paved with blocks of the Strzegom granite already some 150 years ago, as exemplified by Floriańska Street (1860), Grodzka Street (1861) and Wiślna Street (1863); also flagstones for sidewalks and sharpen curbs were applied (Rajchel, 2005). Such historic, uniform pavements have been preserved only in fragments. In 1964 the Main Market Square was re-paved, and the Strzegom granite was its dominant element. The same happened in 2006 during a next refurbishing of the town centre and the Strzegom granite is further used in paving streets and sidewalks of the Old City. The most famous stone product made of the Strzegom granite can also be found in the Old City, although not in Cracow but in Warsaw. It is a column of king Sigismund III Vasa monument, executed in 1948; its length is 9.2 m and diameter 1.2 m.

The changes, but do they lead to the better?

Unfortunately, within the span of the last fifteen or so years we face a dramatic change in the stony architectonic inventory of Cracow. Due to political and economic transformations, mass import of decorative stones has began almost from all over the world, mainly from Italy, but also from China, India and Brazil. It is astonishing that despite costs of so long transportation, the foreign stone is cheaper than the domestic one.

Introducing such new stone raw materials in newly built constructions improves their beauty and is economically viable. Unfortunately again, those stones have been introduced into the historic part of Cracow, effectively destroying the former color of the city. Moreover, in some so-called revalorization practices, the domestic stone materials that never have been applied in Cracow are used, either as the component stone or a replacement of the traditional stones! It must be stressed that such unfamiliar stones destroy and falsify the historic landscape of Cracow.

However, this advancing unification of the stony Cracow outlook that looses its original, authentic appearance and atmosphere brings about also some advantages. The wealth of the decorative stones used from various countries gives a chance to make interesting geological observations and promotes development of urban geology.

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References

BŘEZINOWÁ D., BUKOVANSKÁ M., DUDKOVÁ I. & RYBAŘIK V. 1996 — Praha kamenná. Narodni muzeum, Praha: 287.
BROMOWICZ J. 2001 — Ocena możliwości wykorzystania skał z okolic Krakowa do rekonstrukcji kamiennych elementów architektonicznych. Gosp. Sur. Miner., 17: 5–73.
BROMOWICZ J. & MAGIERA J. 2003 — Materiał kamienny wnętrza Kaplicy Zygmuntowskiej. [In:] Bromowicz J. (ed.), Kamień architektoniczny i dekoracyjny. Mat. Konf. Nauk., Kraków AGH, 23–24 września 2003 r.: 5–12.
BROMOWICZ J., GUCIK S., MAGIERA J., MOROZ-KOPCZYŃSKA M., NOWAK T. & PESZAT C. 1976 — Piaskowce karpackie, ich znaczenie surowcowe i perspektywy wykorzystania. Zesz. Nauk. AGH, Geologia, 2: 3–95.
CZEŻOWSKI A. 1946–1948 — Obróbka i przeróbka kamienia. [W:] Kamieniołomy, t. 1–3. Inst. Bad. Budown.
DŻUŁYŃSKI S. 1952 — Powstanie wapieni skalistych jury krakowskiej. Rocz. Pol. Tow. Geol., 21: 125–180.
HARAŃCZYK C. 1989 — Rozwój wulkanizmu krakowskiego. [In:] Rutkowski J. (ed.), Przewodnik LX Zjazdu Pol. Tow. Geol. w Krakowie. Wyd. AGH: 51–58.
KAMIEŃSKI M. 1930 — Bazalty wołyńskie. Kosmos A, Lwów, 54: 675–701.
KAMIEŃSKI M. & RUTKOWSKI J. 1975 — Surowce skalne. [In]: Kamieński M. (ed.), Surowce mineralne regionu krakowskiego. Wyd. Geol., Warszawa: 86–145.
KAMIEŃSKI M. & SKALMOWSKI W. (eds.) 1957 — Kamienie budowlane i drogowe. Wyd. Geol., Warszawa: 361.
KOZIŃSKI W. — O europejskiej karierze marmuru z Dębnika. Prz. Geol., 7: 318–321.
KOZŁOWSKI S. 1986 — Surowce skalne Polski. Wyd. Geol., Warszawa: 538.
MAJEROWICZ A. 1972 — Masyw granitowy Strzegom–Sobótka. Studium petrologiczne. Geol. Sudet., 6: 7–96.
MATYSZKIEWICZ J. 1989 — Sedimentation and diagenesis of the Upper Oxfordian cyanobacterial-sponge limestones in Piekary near Kraków. Ann. Soc. Geol. Pol., 59: 201–232.
MITROFANOW G.K. & SZPANOW I.A. 1970 — Oblicowocznyje i podjełocznyje kamni SSSR. Facing and semiprecious stones occurring in the USSR (in Russian). Izdatjelstwo Njedra, Moskwa.
MUSZYŃSKI M. 1995 — Systematic position of igneous rocks from the north-eastern margin of the upper Silesan Coal Basin. Miner. Pol., 26: 33–49.
MYSZKOWSKA J. 1992 — Litofacje i sedymentacja dolomitów diploporowych (środkowy wapień muszlowy) wschodniej części obszaru śląsko-krakowskiego. Rocz. Pol. Tow. Geol., 62: 19–62.
MYSZKOWSKA J. 1993 — Diageneza dolomitów diploporowych (środkowy wapień muszlowy) wschodniej części obszaru śląsko-krakowskiego. Kwart. AGH, Geologia, 19: 179–202.
NOWAK J. 1938 — Dniestr a gipsy tortońskie. Der Dniestr-Fluss und tortone Gipse (in Polish, German abstract). Rocz. Pol. Tow. Geol., 14: 155–194.
PARACHONIAK W. & WIESER T. 1985 — The nature and origin of Filipowice Tuff. [In:] Wieser T. (ed.) Carpatho-Balcan Geological Association XIII Congress, Cracow, Poland, Guide to Excursion 1, Wyd. Geol., Warszawa: 16–22.
PAWLIKOWSKI M., TARKOWSKI J. & SIKORA M. 1978 — Wyniki mineralogiczne badań wapieni i krzemieni jurajskich z Brzoskwini koło Krakowa. Geologia Zesz. Nauk. AGH, 4: 89–100.
PERYT T.M. & PERYT D. 1994 — Badenian (Middle Miocene) Ratyn limestone in Western Ukraine and Moldavia: microfacies, calcareous nannoplankton and isotope geochemistry. Bull. Pol. Acad. Sc., Earth Sc., 42: 127–136.
RAJCHEL J. 2005 — Kamienny Kraków. Spojrzenie geologa. Uczelniane Wydawnictwa Naukowo-Dydaktyczne, Kraków.
RUTKOWSKI J. 1991 — Holocen doliny Racławki. Holocene deposits of the Racławka Valley. Kwart. AGH, Geologia, 17: 173–191.
RYCHLICKI J. 1913 — O hypsometrycznym rozmieszczeniu gipsu na południowo-zachodniej krawędzi płyty podolskiej. Über die hypsometrische Lage der Gipsablagerungen am südwestlichen Rande des podolischen Plateau (in Polish, German abstract). Kosmos, Lwów, 38: 179–202.
SCHROEDER J.H. 2006 — Naturwerksteine in Architektur und Baugeschichte von Berlin. Führer zur Geologie von Berlin und Brandenburg, 6: 276.
SEEMANN R. & SUMMESBERGER H. 1998 — Wiener Steinwanderwege. Die Geologie der Großstadt. Verlag Christian Brandstätter, Wien.
ŚWIERCZEWSKA A. 1989 — Krzemienie z wapieni górnego oksfordu okolic Ujazdu. [In:] Rutkowski J. (ed.), Przewodnik LX Zjazdu Pol. Tow. Geol. w Krakowie. Wyd. AGH: 88–90.
ŚWISZCZOWSKI S. 1949 — Kościół św. Andrzeja w Krakowie. Ochrona Zabytków, 2: 93–108.
TATARKIEWICZ W. 1953 — Czarny marmur w Krakowie. Pr. Kom. Historii Sztuki PAU, 10, Kamieniarstwo, Kraków: 74.
WÓJCIK A. 2003 — Wykorzystanie granitu z rejonu Ślęży w prehistorii i we wczesnym średniowieczu. Świat Kamienia, 21: 92–94.