Katarzyna Koper

QUARRIES AS GEOTOURISTIC OBJECTS - PRESENTED ON THE BASIS OF POST-MINING OBJECT FROM THE ŚWIĘTOKRZYSKIE (HOLY CROSS) MOUNTAINS (CENTRAL POLAND)

This paper presents the geotouristic attractiveness evaluation of given quarries situated in the Świętokrzyskie Mountains. Their geotouristic potential comprising accessibility for touring, scientific and educational values as well as visual values, has been assessed. The level of research object geotouristic arrangement was also analyzed. On the example of the study objects, features enforcing the assumption that quarries may constitute geotouristic attractions have been pointed out. Creating the geotouristic arrangement of post-mining objects such as preparing a information about quarries which will be formulated in a very approachable way for tourists, especially for those who do not have a specialized knowledge of geology and geomorphology is a condition for their use in geotourism.

Key words: geotourism, geotouristic objects, geotouristic attractiveness, quarries, Świętokrzyskie Mountains (The Holy Cross Mountains)

Introduction: Geotourism is a kind of tourism which is based on exploring objects as well as geological and geomorphological processes. The exploration does not only apply to objects advantages' admiration (e.g. of monumentality, visually attractive structures, rocks or fossils) but it mainly deals with acquiring knowledge connected with geology and geomorphology by tourists who do not possess it (Hose 1995, 2000, Słomka, Kicińska- Świderska 2004).

Geotourism has become a very popular branch of tourism and it has been developed in Poland throughout the last few years. Geotourism has been characterised in many ways so far, not only by definitions but also in scientific and methodical bases (Miśkiewicz el al. 2007). It meets with a keen interest of local authorities, scientific circles, tourism organizers as well as of tourists themselves. Geotourism develops on the basis of geotouristic attractions that are understood as geological and geomorphological objects and processes which may be attractive for tourists (Słomka, Kicińska- Świderska 2004). Post-mining objects especially sites of opencast mineral resources exploitation take important place amongst a lot of geotouristic objects types (Słomka, Kicińska- Świderska 2004). The extraction of compact rock resources in quarries condition the appearance of lanscape interiors with unveiling geological and geomorphological peculiarities which are available for observation. Because of this reason, the before-mentioned objects are unusually valuable for geotourism. It is because they uncover geological structure's elements which in many other places are simply unavailable for observation without drilling or making rock outcrops. The quarries are not only geotouristically attractive because of possessing scientific and educational values but also thanks to their touring availability and visual values (Czajkowska et al. 2006). A man can equally influence shaping these objects attractiveness by preparing them for touring (i.a. by geotouristic arrangement, providing information boards as well as publications in a form of guidebooks or geotouristic paths) (Miśkiewicz et al. 2007).

The aim of my work is to present opportunities of using the post-mining objects in geotourism on the basis of quarries in the Świętokrzyskie Mountains.

The research method: The accomplishment of the previously-mentioned purpose required conducting geotouristic attractiveness evaluation of given quarries in the Świętokrzyskie Mountains. The evaluation has been carried out according to the author's scheme (fig. 1.). Within such a defined geotouristic attractiveness, values demonstrating object's geotouristic potential (accessibility for touring, scientific and educational value, as well as visual value) but also their preparing for geotouristic needs, are to be included (fig. 1.) (Ludwikowska-Kędzia, Koper 2010).

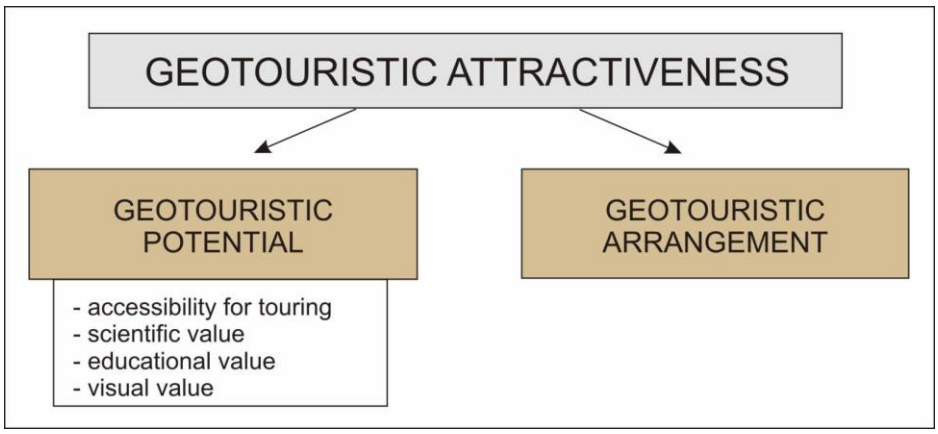

Fig. 1. The components which constituting the geotouristic attractiveness (own elaboration)

The location of the object, which is relative to a communication infrastructure and tourist trails as well as its terrain accessibility and legal accessibility, condition its touring opportunities (Alexandrowicz et al. 1992). The terrain accessibility is a result of presence of obstacles or their lack while visiting the excavation (the obstacles are the ones which require additional skills from a tourist such as snorkeling or climbing). The legal accessibility is connected with the object's legal condition (e.g. an on-going exploitation, private property, high protection order) which influences touring the excavation.

The object's scientific value results from its uniqueness in the region scale and presence of unveiling geological and geomorphological elements which are valuable from the scientific point of view (Alexandrowicz et al. 1992). The object's educational value is connected with a possibility to acquire some knowledge about geology and geomorphology. The value mainly depends on legibility of revealed structures but also on accessibility of popular science works which convey geological and geomorphological data in a very approachable way (Alexandrowicz et al. 1992).

Quarries' visual value enhancing interest of tourists go as follows: significant sizes (e.g. of height or area) and uniqueness relating to a given area. However, flora hindering observation, gruss covering geological structures as well as manifestations of object's devastation have an influence on reducing visual advantages. Geotouristic arrangement is the second of geotouristic

attractiveness components, right next to potential. It is defined by a whole action of a man allowing a tourist to visit a given place. Adjusting the object for geotouristic needs (i.a. by providing access or safety while sightseeing) as well as actions connected with popularization a specialized knowledge within the scope of the Earth science (i.e. placing information boards, drawing up guidebooks, brochures, organising conducted trips) may be accounted as elements of geotouristic use. While making a comprehensive geotouristic attractiveness evaluation of potential geotouristic objects (including quarries), each of the previously-mentioned components should be taken into consideration.

Study area: The Świętokrzyskie Mountains is a geological region situated in the southeastern part of Poland (fig. 2 C). This area belongs to the Paleozoic Platform and consists of the Paleozoic Core and Mesozoic Marginal Zone (fig. 2B). The Paleozoic Core is geologically diverse and while Cambrian and Devonian rocks greatly contribute to its structure, the Triassic and Jurassic formations build the Mesozoic Marginal Zone of the Świętokrzyskie Mountains (fig. 2 A) (Mizerski 2009).

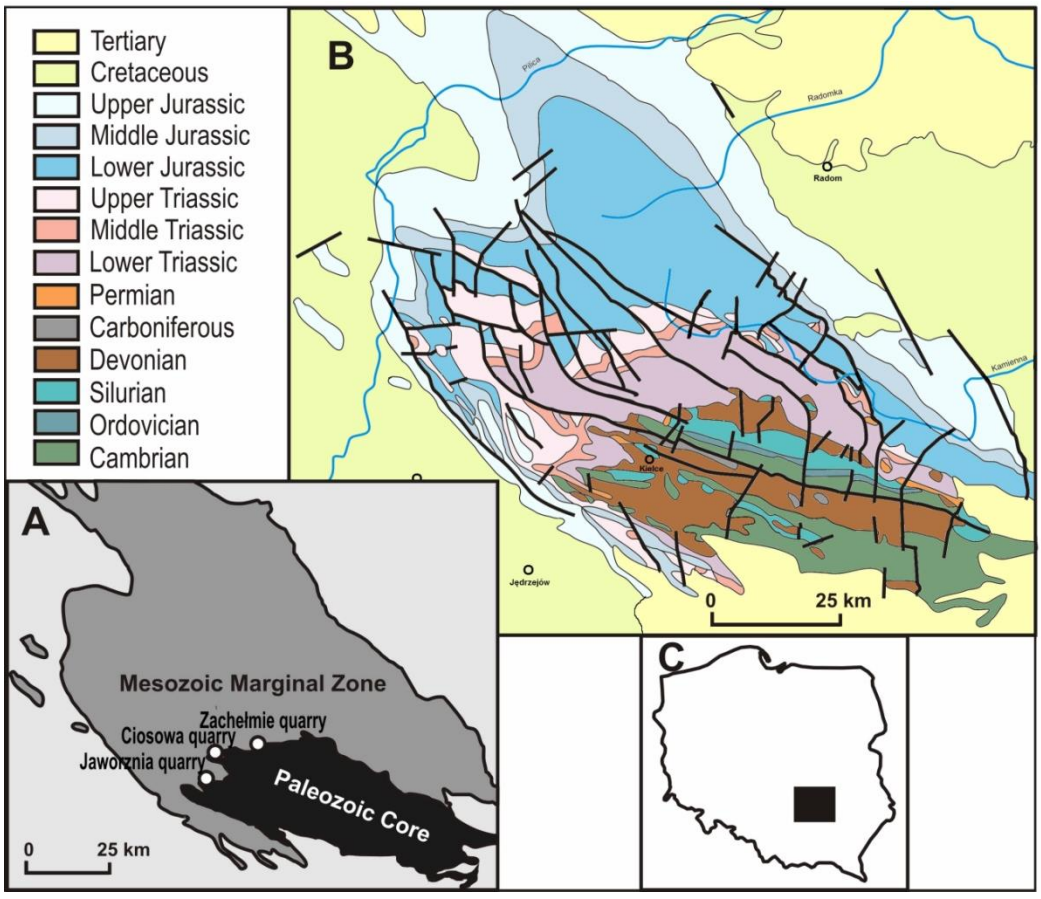

Fig. 2. The Świętokrzyskie Mountains: A- geological structure scheme, B- geological map (based on the geological map by Filonowicz 1996- 1976), C- Location in Poland (own elaboration)

The Świętokrzyskie Mountains geologic structure decides about geodiversity. This area is characterized by occurrence of rocks outcrops which

represent all geological periods from the Cambrian till the Quaternary (Mizerski, 2007). The rocks emerging on the surface, which represent various environments and sedimentation conditions, usually include numerous fossils and natural processes footprints (Mizerski, 2009). The mineral resources exploitation had a huge influence on enhancing the current diversity of abiotic environment components which are available for observation in the Świętokrzyskie Mountains. Exploitation of rocks resources, which had its roots already in 18th century, was a key importance. The post-mining remnants of opencast mining in a form of sizeable quarries have become a permanent part of the Świętokrzyski region. Raw materials exploitation revealed Paleozoic profiles which are valuable from the scientific point of view. A couple of them, by virtue of their rareness, have been qualified for preservation (Rubinowski, Wójcik 1978, Urban 1990). Due to a significant diversity of abiotic environment components (so called giodiversity), the Świętokrzyskie Mountains is an area designed for geotouristic development. Scientific and educational values of this region's post-mining objects have been discovered long ago (Kotański 1959, 1968) along with need for inanimate nature protection (the first Polish inanimate nature reserve - Jan Czarnocki Reserve in Ślichowice was established in 1952). Despite a numerous amount of inanimate nature elements, this area's geotouristic development has still been in its infancy. Only few objects are adjusted to visitors and equipped with information boards or geotouristic paths (i.a. Wietrznia nature reserve of Z. Rubinowski memory). Kielce Geoeducation Geopark Centre, which is a unit erected by Kielce City Council, undertakes geotouristic initiatives and actively supports geotourism development in the Świętokrzyskie Mountains.

Results: The research conducted in this work related to evaluation of geotouristic attractiveness of the following quarries: Zachełmie quarry, Jaworznia quarry and Ciosowa quarry which are all located on the border of the Paleozoic Core and Mesozoic Marginal Zone (fig. 3). In each of the objects, exploitation contributed to the occurrence of permanent landscape interiors of determined parameters.

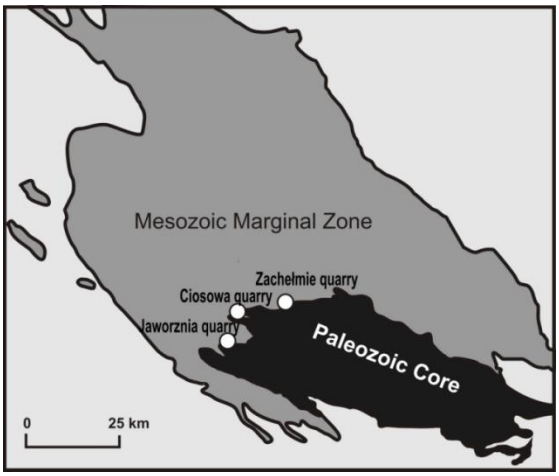

Fig 3. Location of particular research objects in the Świętokrzyskie Mountains (own elaboration)

Jaworznia quarry, which has the greatest area and depth, is distinguished amongst the analyzed quarries. The one which is the smallest of all of them is Ciosowa quarry. Each of the objects is covered with legal protection (while Zachełmie and Jaworznia are inanimate nature reserves, Ciosowa is an inanimate nature monument).

Fig. 4. Rudimentary parameters of research objects (own evaluation)

Quarries parameters	*Zachełmie quarry*	*Jaworznia quarry*	*Ciosowa quarry*
Excavations area	4,5 ha	9,5 ha	0,5 ha
Dimensions	450 m/ 180 m	1000 m / 300 m	100 m / 50 m
Rock pillars height	30-40 m	20- 60 m	1-20 m
Protection form	Inanimate nature reserve	Inanimate nature reserve	Inanimate nature monument

Zachełmie quarry:

Zachełmie quarry in a post-mining object that appeared after dolomites exploitation. This object is situated 3 km away from European Route E77 and 11 km from Kielce. There is an asphalt road (with road signs enabling access) which leads to the quarry. There are no obstacles which could hinder reaching the quarry. Three regional hiking trails for tourists run in a distance of 5 km from the quarry and also quarry is situated on a thematic trail of Regional Tourist Organization called Świętokrzyski Archeo-Geological Trail. Restraints of availability for visiting are related to object's legal protection and the fact that 1/3 of the object area is a private property. Touring is hampered because of flora covering rock pillars. Contact of the Middle Devonian formations (dolomites) with the Lower Triassic formations (breccias, sandstones, mudstones) is exposed in Zachełmie quarry (Kuleta, 2000). Stratigraphic gap and angular unconformity between the formations are clearly noticeable. (fig. 5.) (Wiatrak 2007). The presence of legible angular unconformity, structures resulting decissation and tetrapods tracks, which were found on the dolomites bed-surfaces, demonstrate scientific meaning of the quarry. (fig. 6.) (Niedźwiedzki at al. 2010). The tetrapods tracts discovered in Zachełmie quarry are the oldest ones, which are known to the scientific community, have changed views concerning the evolution of the first quadruped (Niedźwiedzki at el. 2010). A numerous fossils (Ptaszyński, Niedźwiedzki 2004, Kuleta at al. 2006) and hematite mineralization manifestations (Nieć 1962) are also exposed in the quarry. Zachełmie quarry can be used at different education levels even at universities but also in geotourism. Illustrativeness of the geological structures and information boards, which accessibly present the objects' elements available for observation, support the object educational value. They definitely help in cognitive classes realization but also facilitate conducting more practical classes (such as performing geological measurements). Visual values derive from the object's considerable area and height as well as from rock pillars' inclination thanks to which the quarry creates a closed space and becomes clearly distinguished in the landscape and simultaneously enriches its attractiveness.

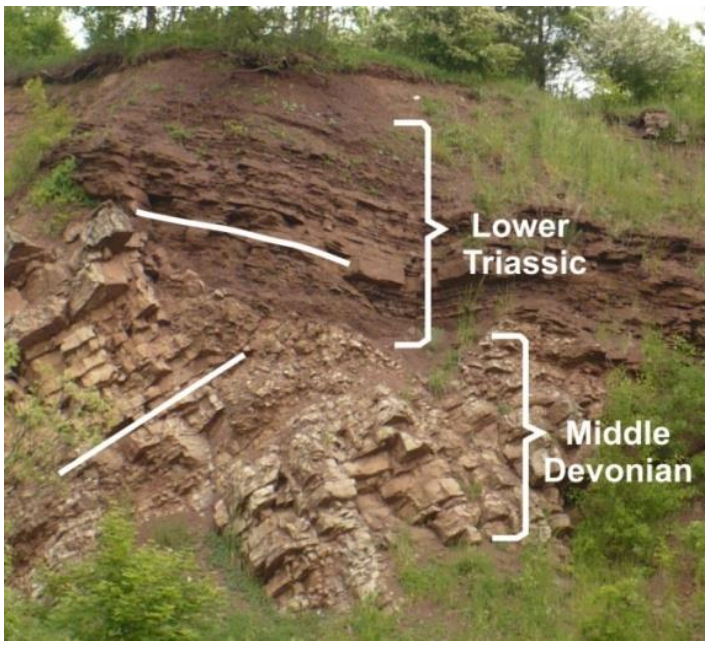

Fig. 5. Angular unconformity and stratigraphic gap exposed in Zachełmie quarry (own elaboration)

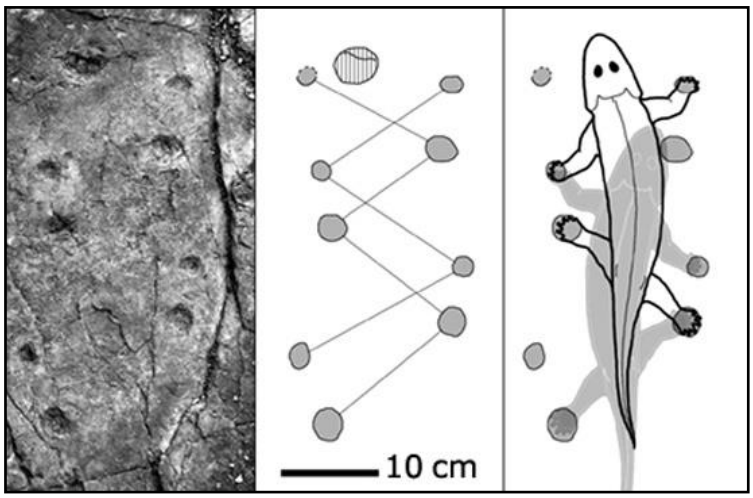

Fig. 6. The oldest tetrapods tracks present on dolomites bed-surface in Zachełmie quarry (source: Niedźwiedzki at al. 2010)

The presence of Chełmowa Góra hill (399, 4 m. above sea level) and a church, which are located directly above quarry's upper edge, raises these values while vegetation covering its edges and interior reduces them.

Zachełmie quarry is a place which only partially meets geotourism's needs. Five informational and didactic boards , which provide tourists with easy-to-understand geological and geomorphological data, belong to the object. Benches and litter bins are also found in the quarry. Furthermore, there are a helpful signs which had been placed along roads which lead towards the quarry and the Polish Geological Institute created a virtual tour around the object which enable to visit the place and read the information. However, geotouristic arrangement the quarry is not sufficient enough and the object should be

supplied with some tourist facilities (e.g. car parks or tourist information points), conducted tours and popular science publications.

Jaworznia quarry: Jaworznia quarry is a place of former limestones exploitation. It is situated approx. 7 km from Kielce and 300 m. from European Route E77. The excavation is located just next to an asphalt road and can be clearly visible from it. Three regional hiking trails for tourists run in a distance of 5 km from the object and Świętokrzyski Archeo-Geological Trail can be found 4 km from it. The quarry's terrain accessibility (especially its lowest levels) is restrained by a compulsory crossing a private property by a steep path. What is more, pervasive flora largely hinders getting around the territory. Visiting the place requires preserving caution because of the presence of unprotected deep excavations connected with a former exploitation. The quarry is fully protected as a natural reserve. As a result of exploitation, the contact of Devonian formations (limestones) belonging either to Middle Devonian (Kozłowski 1962) or to Upper Devonian (Kuleta, 1999) with overlapping Lower Triassic formations (mudstones, sandstones, conglomerate) (Głazek, Romanek, 1976, Kuleta, Zbroja, 2006) has been uncovered. In a profile, there is a stratigraphic gap (fig. 7) and angular unconformity between the formations.

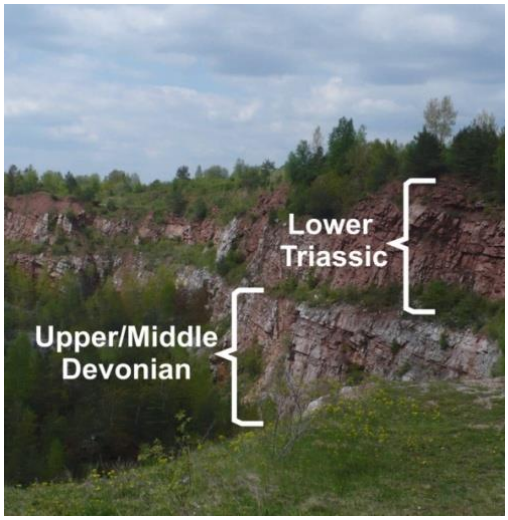

Fig. 7. The stratigraphic gap exposed in Jaworznia quarry (own elaboration)

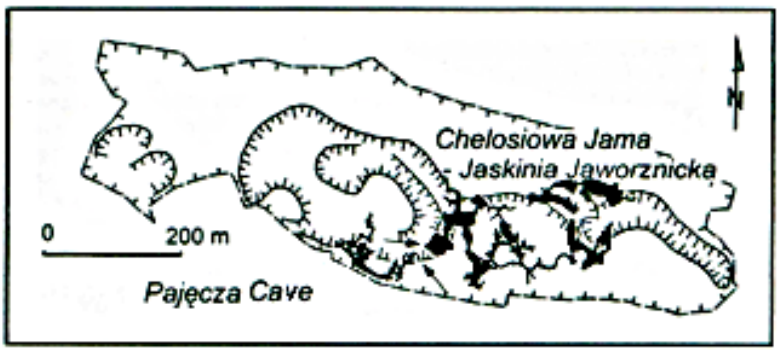

Fig. 8. Cave systems relative to Jaworznia quarry's borders (source: Szelerewicz, Urban 2006, modified)

Karstic processes, which contributed to the occurrence of varying age kras forms, take place in limestones exposed in the quarry. The most grandiose ones emerged in Tertiary and they form caves system (fig. 8). The longest cave is called Chelosiowa Jama- Jaskinia Jaworznicka cave (3670 m) which abounds with speleothems (Urban 1996). Furthermore, in the quarry are exposed results of jointing (Głazek, Romanek 1976).

High scientific value of the quarry is not commensurate with its didactic value. The caves system, which is the most precious quarry's value, is not and probably will not be soon available for direct observation by virtue of difficult conditions to exploration. Lack of informational boards causes limitations conducting classes on the quarry's premises and impedes development of geotourism.

High visual values, which result from the quarry surface and depth, simultaneously create two individual landscape interiors separated by a bank from which a view on panorama stretches. The presence of ruins connected with limestones processing in a form of the lime kiln chimney positively influences the visual values. However, excessive presence of flora on the bottom of the object as well as location on a quarry's edge of an active industrial enterprise producing noise and dust, reduce them.

Jaworznia quarry is an object entirely unprepared for geotouristic development. There are no touristic facilities such as informational boards which should be equipped with caves interiors' photos. The quarry may be dangerous mainly because of lack of steep walls protection or unprotected deep excavations connected with a former exploitation. Periodic devastation of hard-to-reach caves' entries helps people, who do not think about possible hazard, reach the caves. It is also required to remove excessive vegetation and vandalism manifestations such as rubbish throwing.

Ciosowa quarry: Ciosowa quarry is a remnant of sandstones exploitation. It is located 11 km from Kielce and approx. 5 km from European Route E77. The quarry lies close to an asphalt road and a steep forest path leads towards it. A regional hiking trail for tourists and thematic Świętokrzyski Archeo-Geological Trail run through the quarry. There are no other trails within the distance of 5 km. The object is situated in the forest and is overgrown with vegetation which reduce the terrain accessibility. Ciosowa quarry is fully protected as a nature monument.

Lower Triassic formations (sandstones) were uncovered there. Sandstones are red owing to the presence of iron and they consist of frosted grains. The sandstones in Ciosowa quarry are cross-bedding of thickness up to a few mm (fig 9) and by joining layers together, the formations create a series of layers reaching from a few centimeters until a few meters (fig. 10). They emerged in the aeolian environment and are accompanied by ripple marks and structures resulting decissation. The sandstones, which are exposed in the quarry, have horizontal and vertical joint which divide them into blocks (fig. 11) (Gągol, Karpiniec 1974, Gągol et al. 2006).

Fig 9. Sandstones cross-bedding exposed in Ciosowa quarry (own elaboration)

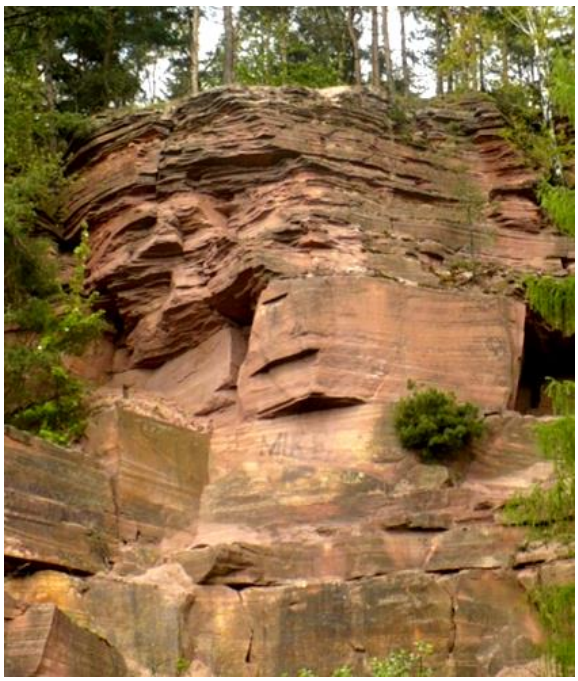

Fig. 10. Diversity of sandstones series thickness exposed in Ciosowa quarry (own elaboration)

Fig.11 Jointing within Ciosowa quarry's sandstones (own elaboration)

Ciosowa quarry is characterized by a great scientific value resulting from geological structures illustrativeness. That is why, it can be useful in such fields as education and geotourism. Nevertheless, the lack of informational boards as well as popular science publications reduce its geotouristic potential.

In comparison with other quarries, Ciosowa quarry is the smallest one. It is also covered with flora which reduces rock pillars visibility. Another major problem is devastation manifested in a form of littering, illegal climbing or cover rock with spray. However, the proximity of the forest and the view on the Świętokrzyskie Mountains improve the quarry's visual values.

Ciosowa quarry does not unfortunately have any opportunities that could raise geoutourism's development. It is exposed to flora natural succession and periodical devastation. Climbing on the rock walls is the most adverse human activity. As a result, rocky layers crumble and weathering appears more often. The quarry requires adaptation for geotouristic development (e.g. informational boards and popular science publications). Another action, which should be done, is appointing the management board which role would be to prevent vandalism manifestations destroying unique values of sandstones.

Geotouristic attractiveness evaluation of particular quarries from the Świętokrzyskie Mountains within the scope of their geotouristic potential and geotouristic arrangement has been carried out. Each of the objects is characterized by the same good touring accessibility due to a location near Kielce and presence of numerous tourist trails including Świętokrzyski Archeo-Geological Trail. What hinders observation and thereby terrain accessibility is excessive flora. Furthermore, quarries' legal protection decreases tourists activity. In case of Zachełmie and Jaworznia quarries, some of the objects' parts or their surroundings belong to a private property. Each of the analyzed quarries is also known for high scientific value which represents unique geological or geomorphological structures. However, Zachełmie quarry can be distinguished from this list thanks to its scientific worldwide discovery of tetrapod tracks. The remaining ones possess only a regional significance.

As far as educational value is concerned, it is differential among all three quarries. The one which stands out is Zachełmie quarry. Its didactic value is a result of informational boards' presence which provides tourists with geological and geomorphological data about the quarry. The other ones do not own such facilities what reduces geotouristic exploitation of the object.

Visual value of the previously mentioned quarries is very high because they create closed interiors enriching their area's landscape. Ciosowa quarry possesses the smallest area but has a similar rock pillars height. What is more, the quarry location on the upper part of the hill, which enables admiring a panorama of the Świętokrzyskie Mountains, also raise its visual value.

The geotouristic arrangement of the analyzed quarries is also various in each case. Only Zachełmie quarry is partially prepared for geotouristic development (there are informational boards, benches and litter bins). However, a lot of action is required here to be done such as tourists security improvement, building of the car parks or tourist information points. This area had been

partially prepared for geotourism when the discovery of tetrapods tracts took place and was then described in «Nature» magazine (Niedźwiedzki et al. 2010). Because of that the scientific circles, local authorities and tourists became interested in this territory. The other quarries also possess great educational values but not as big as Zachełmie quarry. Although they are unique within the area, their values, which may be useful in geotourism, have not been pointed out yet. Probably the only stimulus which could cause their geotouristic arrangement and thereby geotouristic development will have to be connected with a scientific discovery as in the case of Zachełmie quarry.

Conclusions: Uncovering the geological structures (which are unavailable in many other places) for direct observation is one of the main quarries' values as far as geotourism is concerned. The quarries help us gain a lot of significant information about the Earth's geological past and are called open-air museums. They usually create closed areas which raise the attractiveness of landscape.

However, the post-mining objects are still regarded as economic wasteland and also as artificial elements of natural environment. That is why, they are very often devastated, littered and also subjected to illegal exploitation.

Geotouristic development, which notices quarries values, ensures a transformation of inactive post-mining object into geotouristic object and simultaneously cause their economic development. Around the world, even in the Świętokrzyskie Mountains, examples of quarries' new ways of use (e.g. recreational, sports and ecological functions) also including their vulnerability for geotouristic needs can be pointed out. Nevertheless, there are many other places whose values have not been noticed yet and they are still subjected to devastation. The analysis shows that quarries in the Świętokrzyskie Mountain are very attractive object for geotourism what depends on high scientific value, good touring accessibility and great visual values. On the other hand, the attractiveness is reduced by lack of proper geotouristical arrangement what negatively influences quarries' didactic value. The quarries may be useful for geotouristic purposes even when they are only partially prepared for this purpose.The example of Zachełmie quarry showed that even if it was only partially prepared for geotourism needs and the cost of this arrangement was low, tourist movement has raised and Zachełmie has become a must-see place of many trips in the Świętokrzyskie Mountains. Quarries, which are regarded as economic wasteland, have a second chance of being exploited economically as geotouristic objects. However, it is necessary to notice their advantages, draw up brochures for tourists, as well as appoint the board which will prevent actions of devastation. Moreover, the tourists and local habitants should change their perception of the quarries. They have to notice that quarries may not only constitute tourists attractions but can also contribute to region's economic activation as well as to creation of new infrastructure objects and workplaces.

References:

1.Alexandrowicz Z., Kućmierz A., Urban J., Otęska-Budzyn J., 1992 – Waloryzacja przyrody nieożywionej obszarów i obiektów chronionych w Polsce (z mapą 1:75 000 i 9 załącznikami). Państw. Instytut Geol., Warszawa, p.140

2.Czajkowska E., Urban J., Wróblewski T., 2006 – Geopark Kielce – potencjał geoturystyczny i praktyczne możliwości jego wykorzystania, source:geopark-kielce.pl [date of access: 24.03.2012]
3.Filonowicz P., 1966-1976 – Szczegółowa Mapa Geologiczna Polski w skali 1:50 000. Wyd. Geol., Warszawa, arkusze: Nowa Słupia, Morawica, Bodzentyn, Kielce Daleszyce
4.Filonowicz P., 1973- Objaśnienia do Szczegółowej Mapy Geologicznej Polski, Arkusz Kielce. Wydawnictwa Geologiczne, Warszawa, p. 29
5.Gągol J., Karpiniec J., 1974 – Warstwowanie i struktury sedymentacyjne w piaskowcach tumlińskich. Kwartalnik Geologiczny, t. 18, nr 2, p. 448-449
6.Gągol J., Kuleta M., Ptaszyński T., Niedźwiecki G., 2006 – Lądowe osady pstrego piaskowca w północnym obrzeżeniu Gór Świętokrzyskich: warunki sedymentacji, tropy kręgowców, walory surowcowe. Wycieczka W2-Stanowisko 2- Kamieniołom „Tumlin Gród" koło Kielc [w:] Skompski S., Żylińska A. (red.) Procesy i zdarzenia w historii geologicznej Gór Świętokrzyskich – LXXVII Zjazd Naukowy Polskiego Towarzystwa Geologicznego. Materiały konferencyjne, Ameliówka k. Kielc, 28-30 czerwca 2006. Pol. Tow. Geol., Państw. Inst. Geol., Wyd. Geol. Uniw. Warszawskiego, Warszawa, p. 179-196
7.Głazek J., Romanek A., 1976 – Tektonika, wykształcenie i surowce mineralne starszego mezozoiku oraz ich stosunek do podłoża waryscyjskiego. Wycieczka III B, punkt 4 – Jaworznia [w:] Pożaryski W. (red.), Przewodnik XLVIII Zjazdu Polskiego Towarzystwa Geologicznego, Starachowice 24-26.IX.1976, Wydawnictwa Geologiczne, Warszawa, p. 240-246
8.Hose T. A., 1995 - Selling the story of Britain's stone. Environmental Interpretation, 10, 2, p. 16-17.
9.Hose T. A., 2000 - European geoturism – geological interpretation and geoconservation promotion for turists. [w:] Barretino D., Wimbledon W.A.P., Gallego E. (red.) Geological Heritage: Its Conservation and Management. Instituto Tecnologico GeoMinero de Espana, Madrid, p. 127-146.
10. Kicińska-Świderska A., Słomka T., 2004 – Projektowanie tras geoturystycznych. Folia Turistica, 15, s. 179 - 184
11. Kotański Z., 1959 – Przewodnik geologiczny po Górach Świętokrzyskich t. 1 i 2. Wyd. Geolog., Warszawa
12. Kotański Z., 1968 – Z plecakiem i młotkiem w Góry Świętokrzyskie. Przewodnik geologiczny dla turystów. Wyd. Geolog., Warszawa, p. 225
13. Kozłowski S., 1962 – W sprawie utworów czerwonego spągowca w rejonie Jaworzni w Górach Świętokrzyskich. Przegląd Geologiczny t.8, p. 430-431
14. Kuleta M., 1999 – Nowe dane o osadach dolnego pstrego piaskowca w synklinie piekoszowskiej – kamieniołom Jaworznia. Posiedzenia Naukowe PIG, nr 55, p. 141-144
15. Kuleta M., 2000 – Osady pstrego piaskowca w kamieniołomie „Zachełmie". Pos. Nauk. Państw. Inst. Geol., 56, p.128-130
16. Kuleta M., Zbroja S., 2006 – Wczesny etap rozwoju pokrywy permsko-mezozoicznej w Górach Świętokrzyskich [w:] Skompski S., Żyliński A. (red.), Procesy i zdarzenia w historii geologicznej Gór Świętokrzyskich. LXXVII Zjazd Naukowy Polskiego Towarzystwa Geologicznego. Materiały konferencyjne, Ameliówka k. Kielc, 28-30 czerwca 2006. Pol. Tow. Geol., Państwowy Instytut Geologiczny, Wydział Geologii Uniw. Waszawskiego, Warszawa, p. 104-125
17. Kuleta M., Zbroja S., Gągol J., Niedźwiedzki G., Ptaszyński T., Studencka J., 2006 – Lądowe osady pstrego piaskowca w północnym obrzeżeniu Gór Świętokrzyskich: warunki sedymentacji , tropy kręgowców, walory surowcowe. Wycieczka W2-Stanowisko 1- Zachełmie k. Zagnańska. [w:] Skompski S., Żylińska A.(red.) Procesy i zdarzenia w historii geologicznej Gór Świętokrzyskich – LXXVII Zjazd Naukowy Polskiego Towarzystwa Geologicznego. Materiały konferencyjne, Ameliówka k. Kielc, 28-30 czerwca 2006. Pol. Tow. Geol., Państw. Inst. Geol., Wydz. Geol. Uniw. Warszawskiego, Warszawa, p. 174-178
18. Ludwikowska-Kędzia M., Koper K., 2010 – Potencjał geoturystyczny kamieniołomu Zachełmie koło Zagnańska (Góry Świętokrzyskie) – perspektywy jego wykorzystania. Zeszyty Naukowe Szkoły Wyższej Przymierza Rodzin w Warszawie, seria geograficzno-turystyczna, nr 3, z. 4, p.149-174.
19. Miśkiewicz K., Doktor M., Słomka T., 2007 – Naukowe podstawy geoturystyki – zarys problematyki. Geoturystyka, nr 4 (11), p. 3-12
20. Mizerski W., 2007 – Geoturystyka w Górach Świętokrzyskich, Przegląd Geologiczny, 55, p. 959-960
21. Mizerski W., 2009 – Geologia Polski. Wydawnictwo Naukowe PWN, Warszawa, p. 119, 122, 166-167

22. Nieć M., 1962 – Wycieczka III D. Trasa: Kielce – Słupia – Rudki – Nieczulice – Wzdół – Zagnańsk – Kielce. [w:] Żakowa H. (red.), Przewodnik XXXV Zjazdu Pol. Tow. Geol.. Kielce, 16 – 19 września 1962, Warszawa, p. 212-213

23. Niedźwiedzki G., Szrek P., Narkiewicz K., Narkiewicz M., Ahlberg P. E., 2010 – Tetrapod trackways from the early Middle Devonian period of Poland. Nature, 463, p. 43-48

24. Ptaszyński T., Niedźwiedzki G., 2004 – Conchostraca (muszloraczki) z najniższego pstrego piaskowca Zachełmia, Góry Świętokrzyskie. Przegląd Geologiczny, 52, p. 1151- 1155

25. Rubinowski Z., Wójcik Z., 1978 – Odsłonięcia geologiczne Kielc i okolic oraz problemy ich ochrony i zagospodarowania. Prace Muzeum Ziemi, z. 29, Warszawa p. 95-121

26. Szelerewicz M, Urban J. (red.), 2006 – Przewodnik sesji terenowych. Stanowisko 2 Rezerwat „Chelosiowa Jama" – polifazowy kras z systemem jaskiniowym Chelosiowej Jamy-Jaskini Jaworznickiej oraz Jaskinią Pajęczą. Materiały 40. Sympozjum Speleologicznego Sitkówka-Nowiny 20-22.10.2006, Kraków, p. 11-13

27. Urban J. (red.), 1996 – Jaskinie regionu świętokrzyskiego. Polskie Towarzystwo Przyjaciół Nauk o Ziemi, Warszawa, p. 89-123

28. Urban J., 1990 – Ochrona obiektów przyrody nieożywionej w krainie Gór Świętokrzyskich. Rocznik Świętokrzyski t. 17, PWN, Warszawa-Kraków, p. 47-79

29. Wiatrak M., 2007 – Wartość merytoryczna i dydaktyczna kamieniołomu Zachełmie koło Zagnańska (Góry Świętokrzyskie). [w:] Ludwikowska-Kędzia M., Wiatrak M., (red.), Różnorodność środowiska geograficznego Gór Świętokrzyskich w badaniach regionalnych. Nauki Geograficzne w Badaniach Regionalnych, tom VIII, Kielce 2007, p. 35-44