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Most significant geosites of the Cieszyn Foothills, Outer flysch Carpathians, Poland and Czech Republic

The article provides a review of the most important geotouristic attractions within the Cieszyn Foothills, Outer Flysch Carpathians in Poland and adjacent part of the Czech Republic. The best geosites, which can be visited during a short 1-2 day visit in the Polish Carpathians were selected. The present paper contains the description of the classic localities exposing the oldest deposits and igneous rocks of the Silesian Unit. The geotouristic objects are important because the represent scenic sites as well as geosites with educational values supplying limitless information about the geological history, as well as the history of earth sciences research.

Keywords: geology, geotourism, geosites, Carpathians

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Introduction

This article provides a review of the most important and significant geotouristic attractions within the Cieszyn Foothills, Outer Flysch Carpathians in Poland and the adjacent part of the Czech Republic. The best (based on educational value, exposure and accessibility according to the subjective opinion of authors) geological outcrops and geotouristic sites, which can be visited during a short 1-2 day visit in the Polish Carpathians, were selected. The present paper contains the description of the classic localities exposing the oldest deposits and igneous rocks of the Silesian Unit.

The Silesian unit is part of the flysch zone of the Outer Western Carpathians representing the complex of allochthonous nappes (Ślączka et al., 2006). In its present form, the Outer Carpathians consist of the Outer Group of Nappes divided from the lowest to the highest into the Subsilesian, Silesian, and Fore-Magura units and the Magura Group of nappes. The whole nappe allochthon is thrust over the Miocene sediments of the Carpathian Foredeep for a distance of more than 60 km (Picha et al. 2006).

During the Mesozoic, the Outer Western Carpathian domain rimmed the southeastern margin of the North-European Platform. The Late Jurassic–Early Cretaceous basinal facies observed in the Silesian Unit originated during early carbonate flyschoidal stages within the develop proto-Silesian Basin. They are represented by the Vendryně Formation; the Cieszyn Limestone Formation and the Cisownica Member of the Hradišťe Formation. The igneous rocks known as teschenites occur in the form of several intrusions cutting through Jurassic and Lower Cretaceous rocks in Poland and Czech Republic.

These oldest rocks building the Silesian Nappe crop out In the Cieszyn Foothills. The most spectacular sites occur in this region. Analysis of these rocks supplied a large amount of data allowing geologists to reconstruct the early evolution of the proto-Silesian Basin. The classical lithostratigraphic units like the Lower Teschen Shales (now the Vendryně Formation; Teschen Limestones (now Cieszyn Limestone Formation) and Upper Teschen Shales (now the Cisownica Member of the Hradišťe Formation) were distinguished in the XIX century by Hohenegger (1861).

The history of geological investigation in this area reaches even the XVII century. Five geological objects (Fig. 1) were selected within the Cieszyn Foothils. In the authors' opinion they represent key geosites providing exceptional educational value.

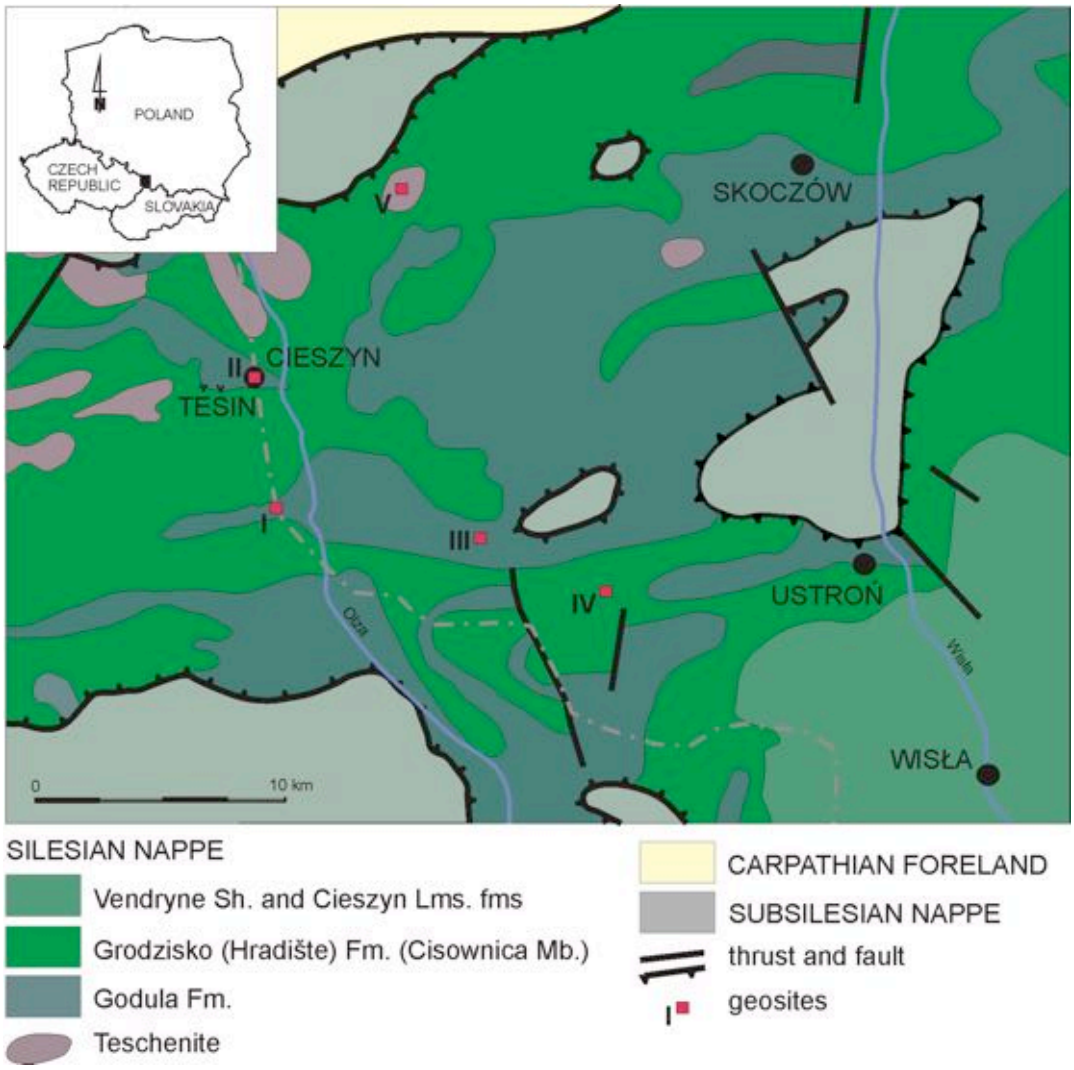

Fig. 1. Geological map of the Cieszyn Foothills, Outer Flysch Carpathians in Poland and the adjacent part of the Czech Republic with location of geosites. Geology simplified after Lexa et al. (2000).
Geosites: I – Olza River in Wędrynia, II – Olza River in Cieszyn, III – Jasieniowa Hill in Goleszów, IV – Cisownica stream, V - Quarry with chapel in Zamarski.

The Olza (Olše) River outcrops in Wędrynia, Czech Republic – Fig 1, site I

The oldest sediments of the Silesian Unit can be examined along the Olza (Olše) River bank near the village of Wędrynia (Czech name Vendryně) – the type locality for the Vendryně Formation (Fig 2, Photo 2a and 2b). This formation was originally described as the Lower Těšín Member (Teschen in German; Cieszyn in Polish) by Hohenegger (1861).

Recently it was renamed by Eliáš et al. (2003) as the Vendryně Formation. The rocks exposed on the right bank of the Olza River are represented by dark-brown calcareous shales. Occasional thin beds of siltstones, peliticor detritic limestones occur within calcareous shales. Calcareous concretions are rare. The dark grey marly shales with a few intercalations of redeposited detrital limestones display chaotic structures, indicating that these sediments

represent slump deposits derived from the adjacent carbonate platform, where pelitic sediments forms. The Vendryně Formation rocks represent synrift deposits, corresponding to the initial opening of proto-Silesian Basin at the end of Jurassic period (Ślączka et al., 2006, Golonka et al., 2008). The age of this 350–600 m thick formation is Oxfordian to Tithonian, possibly to Early Berriasian (Skupien 2003).

The Olza (Olše) River outcrop in Cieszyn (Těšín) Poland and the Czech Republic – Fig 1, site II

The Hohenegger's (1861) type locality of the Cieszyn Limestone Formation was located on the slopes of the Castle Hill in Cieszyn below the famous Cieszyn Castle built by the Piast princes. Cieszyn was the capitol of the principality, an autochthonous province within the Austro-Hungarian monarchy in the XIX and beginning of the XX century. This principality was divided between Poland and Czechoslovakia after World War I. Today the limestones are not very well exposed because the slopes of the castle are covered by vegetation. They can be observed in natural outcrops in the bottom of the Olza River along the Polish-Czech border (Fig. 2, Photos 1a and 1b) directly below the castle. The river bottom is easily accesible from the Czech side. The Schengen agreement allows geotourists to cross the border access the river or through the Friendship Bridge visible on Fig. 2, photo1a.
The Cieszyn Limestone Formation is built here by thin-bedded pelitic or/and fine-grained detritic limestones passing gradually into medium- and even coarse grained pelitic limestones. Limestones layers are interbedded by bioturbated marly shales gray in color.

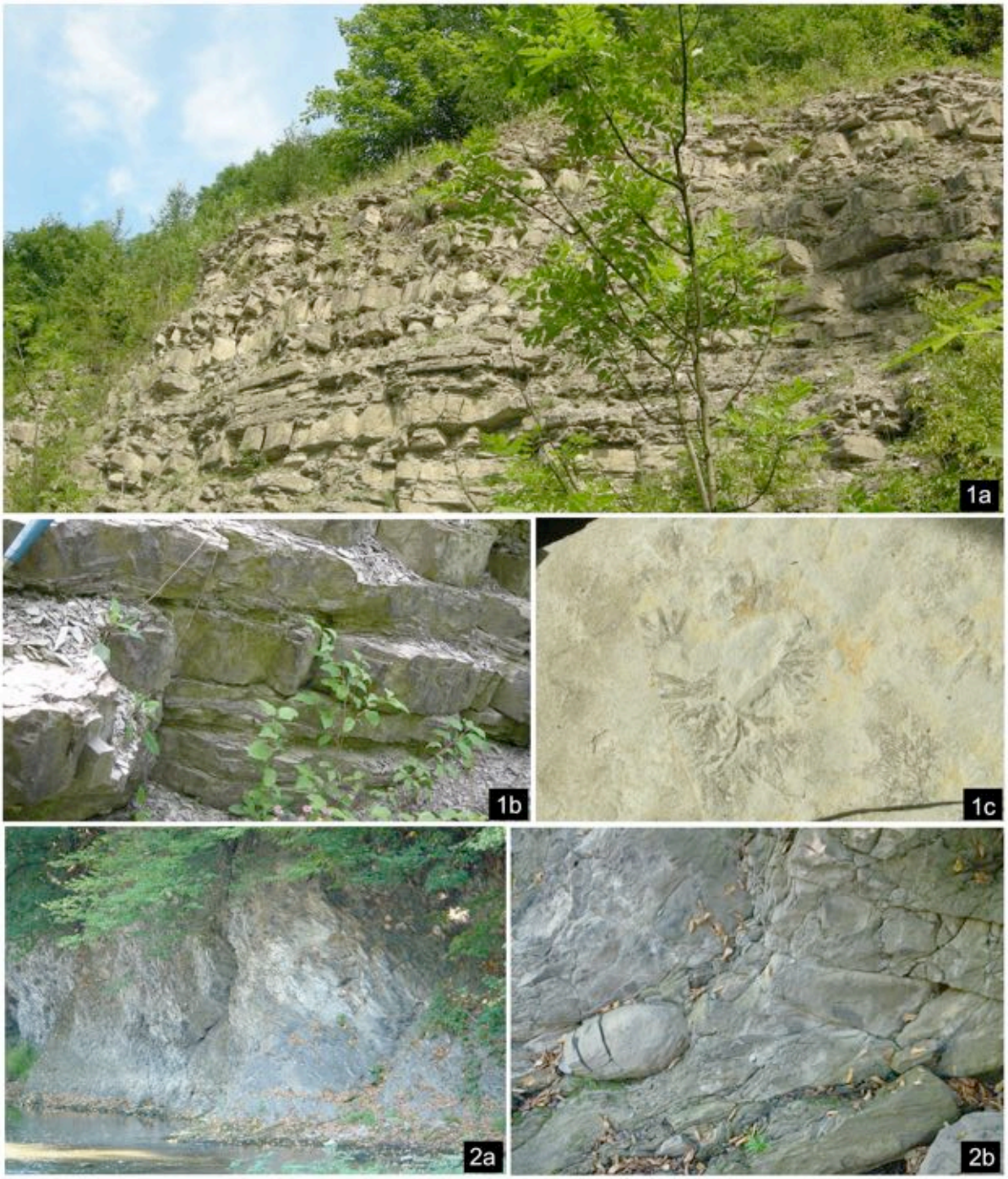

Fig. 2. Outcrops of the Cieszyn Limestone Formation and Vendryně Formation. 1: Abandoned quarry Jasieniowa Hill in Goleszów (Poland): 1a - Cieszyn Limestone Formation in the Jasieniowa Hill quarry, 1b - The thick layers of the Cieszyn Limestone Formation, 1c - Trace fossils on the limestone layer surface. 2: Olza (Olše) River near Wędrynia (Vendryně), Czech Republic: 2a. outcrop of the Vendryně Formation, right bank of the Olza River, 2b – calcareous concretion within marly shales of the Vendryně Formation.

The Jasieniowa Hill outcrop in Goleszów, Poland – Fig 1, site III

The Cieszyn Limestone Formation rocks are splendidly exposed in the Jasieniowa Hill abandoned quarry located on the northeastern slope of the hill (Ślączka & Kaminski, 1998, Waśkowska-Oliwa et al. 2008) (Fig 3, Photos 1a, 1b and 1c). The local touristic-educational trail leads from the Goleszów town to the quarry, displaying a section through calcareous turbidites. The clastic material comprising the detrital limestones was derived from the adjacent shallow water calcareous platform, while to a large extent the pelitic limestones represent a Coccolithus – Nannoconus microfacies similar to the Maiolica Alpine microfacies. The lower surfaces of the beds are covered with numerous sole marks, mainly of organic origin, and on surfaces of internal laminae organic traces (called fucoids), of varied size are often visible. In the upper part of the quarry we can observe intercalations of thick- and very thick-bedded, graded, coarse grained and conglomeratic, bedded limestones. The coarse basal part of these limestones consists of organic detritus (fragmented shells of lamellibranches, aptychi, crinoids, urchin spines, along with algae & gastropods). Quartz grains, fragments of dark Tithonian limestones, and Carboniferous coal are also present indicating that the erosion in source area had already reached the basement of the Jurassic calcareous rocks. The age of rocks cropping out here was estimated as Tithonian-Berriasian based on the macro- and microfossils (Geroch & Olszewska, 1990; Golonka et al., 2006). The Jasieniowa Hill quarry belongs to a spectacular group of outcrops, which have complex and rich geological documentation, as well as good visibility and accessibility. Therefore this site was proposed as a reference section of the Cieszyn Limestone Formation.

The outcrop in Cisownica stream, Cisownica, Poland – Fig 1, site IV

A good exposure of the Cisownica Member rocks (Hauterivian-Barremian, locally Aptian) can be seen in the Czantoria Valley in Cisownica village. The valley of the small Cisownica stream looks like a gorge or canyon. The gorge's few-meter-high walls contain rock outcrops available for observation (Fig. 2, Photos 2a and 2b). This post-rift turbiditic sequence consists of dark grey marly and calcareous shales interbedded by dark calcareous sandstones with mica (Ślączka & Kaminski, 1998, Waśkowska-Oliwa et al. 2008). Dark sandstones are thin- and medium bedded and fine-grained, with parallel, sometimes wavy or convoluted lamination and numerous flute casts and trace fossils.

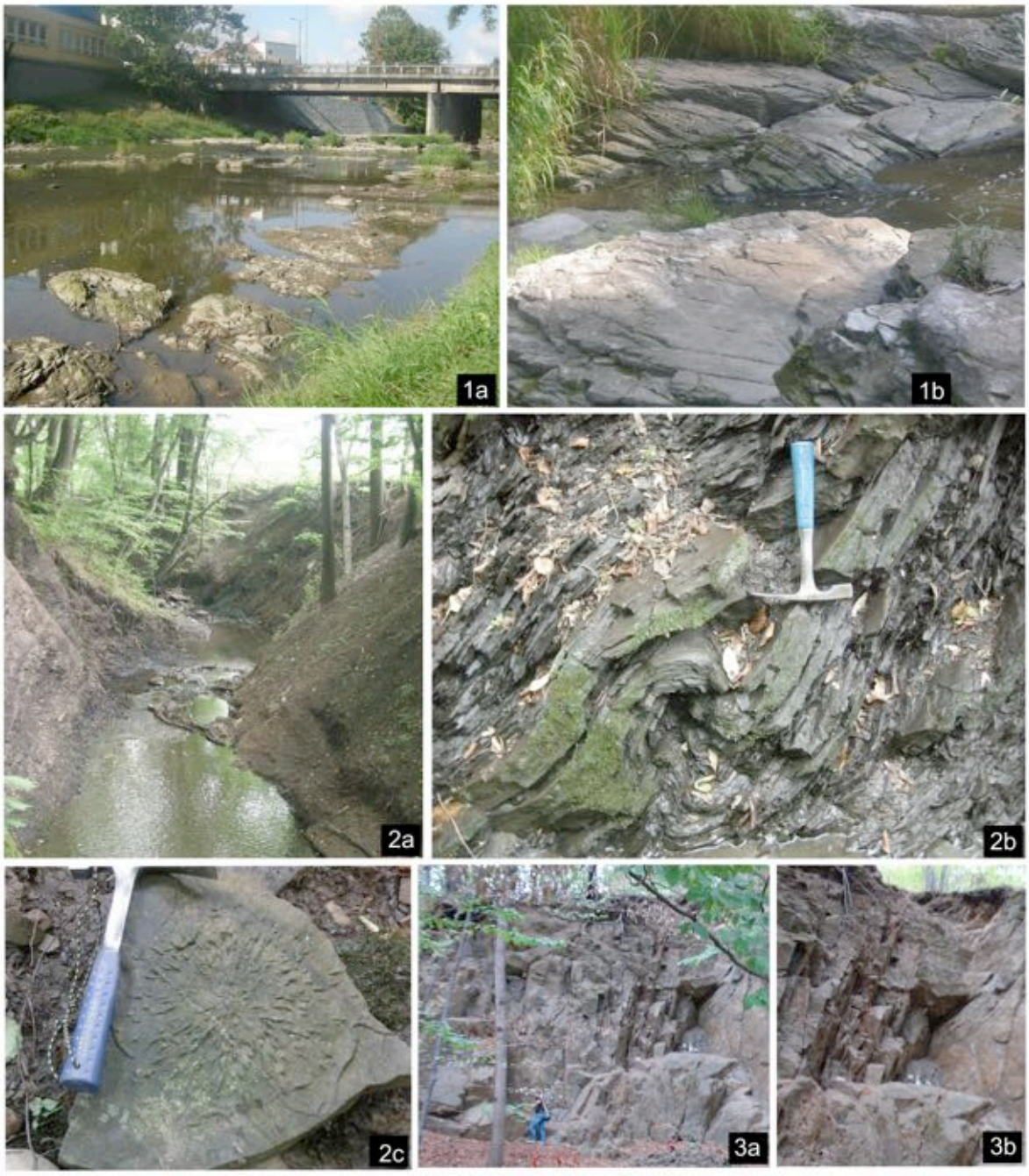

Fig 3. Outcrops of the Cieszyn Limestone Formation, Hradište Formation - Cisownica Member and teschenites, 1: Olza (Olše) River in Cieszyn, Poland and Czech Republic: 1a - Outcrops of the Cieszyn Limestone Formation in Olza; the Friendship Bridge in the background, 1b - Enlarged fragment of the Cieszyn Limestone Formation in Olza River. 2: Cisownica Stream, Goleszów Common, Poland: 2a. outcrops of the Cisownica Member of the Hradište Foramation, 2b - Folds within the Cisownica Member rocks, 2c - Trace fossils on the surface of sandstone layer. 3: Quarry with chapel, Zamarski village, hamlet Rudów, Haźlach Common, Poland. 3a - outcrop of a teschenite dike, Dr. Arjan de Leeuw for scale. 3b - Fragment of the teschenite dike with the figure of the Virgin Mary in the small grotto cave.

Layers of detritic limestones sporadically occur within the sequence. These deposits also contain numerous spherosiderites, which were mined until the XIX century as iron ore. The shales and sandstones layer are strongly folded. Numerous small folds representing a variety of structurs a are numerous here. The Cisownica outcrop was selected as the type locality of the Cisownica Member of the Hradiśte Formation. The Cisownica section is also important for micropaleontology because the Berriasian index taxon Pseudoreophax cisovnicensis Geroch was first described here in 1961. This taxon is an index species in the standard biostratigraphy of the Cretaceous deposits of the Outer Carpathians.

The Quarry with the chapel in Zamarski, Poland–Fig 1, site V

This geosite is located on Kamienna Street in Zamarski village, hamlet Rudów, Haźlach Common, northeast from Cieszyn (Włodyka & Karwowski, 2009, Kasprowska-Nowak, 2014).

The igneous rocks known as teschenites occur in the form of several intrusions cutting through Jurassic and Lower Cretaceous rocks in Poland and the Czech Republic. They form dikes up to 20 m thick (Grabowski et al., 2008). This site is actually the largest and best-exposed outcrop of teschenitic rocks in the area. The 10 m high walls expose a variety of teschenite rocks (Włodyka & Karwowski, 2009). The intrusion's radiometric age was estimated as 122.3 ± 1.6 mln years (Lucińska-Anczkiewicz et al., 2002), placing it within the early Aptian stage. The teschenite, contains numerous microphenocrysts of clinopyroxene and olivine, also feldspars, amphiboles, analcite, zeolites, albite, adularia, and calcite occur here (Włodyka & Karwowski, 2009). The abandoned teschenite quarry is known as the "Quarry with the chapel". It is also known as "Grotana Rudowie" quarry (Kasprowska-Nowak, 2014).

Conclusion

The geotouristic objects of the Cieszyn Foothills are important and precious because represent scenic sites as well as geosites with educational values supplying limitless information about the geological history as well as history of earth sciences research. They belong to classic outcrops, well established in the geological tradition, where several generations of earth scientists conducted their studies. These studies cover the wide spectrum of specialties from general geology through paleontology, stratigraphy, petrography tectonics and so on. The geosite's documentation is rich and complex (Waśkowska-Oliwa et al., 2008).

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References

Eliáš M., Skupien P. & Vašíček Z., 2003. Návrh úpravy litostratigrafického členění nižší části slezské jednotky na českém území (vnější Západní Karpaty). *Sborník vědeckých Prací Vysoké Školy báňské -TU, Řada hornicko-geologická,* Monografie 8, 7-14.

Geroch S., 1961. *Pseudoreophax* nowy rodzaj otwornic z dolnej Kredy Karpat fliszowych [Pseudoreophax, a new genus of foraminifera from the Lower Cretaceous of the Carpathian Flysch]. *Rocznik Polskiego Towarzystwa Geologicznego*, **31**, 159-161.

Geroch S. & Olszewska B., 1990. The oldest assemblages of agglutinated foraminifers of the Polish Flysch Carpathians. – *In:* Hemleben, C. *et al.* (eds), *Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera.* NATO ASI Series C-327, 525-538. Kluwer Academic Publishers.

Golonka J., Krobicki M. & Słomka T., 2006. Field trip A – From Tethyan to Platform Facies. Stao A-10- Jasieniowa Hill (abandoned quarry) – Cieszyn limestones (Thithonian – Berriasian/Valanginian). In: Wierzbowski A., Aubrecht R., Golonka J., Gutowski J., Krobicki M., Matyja B.A, Pieńkowski G. & Uchman A. (eds). Jurassic of Poland and adjacent Slovakian Carpathians. Field trip guidebook. *7th International Congress on the Jurassic System, 6-18 September 2006, Kraków, Poland*, 49-50.

Golonka J., Krobicki M., Waśkowska-Oliwa A., Słomka T., Skupien P, Vašíček Z., Cieszkowski M. & Ślączka A., 2008. Litostratygrafia osadów jury i dolnej kredy zachodniej części Karpat zewnętrznych (propozycja do dyskusji). Lithostratigraphy of the Upper Jurassic and Lower Cretaceous deposits of the western part of Outer Carpathians (discussion proposition). In: Krobicki, M. (ed.).Utwory przełomu jury i kredy w zachodnich Karpatach fliszowych polsko-czeskiego pogranicza. *Kwartalnik AGH - Geologia*, 34(3/1): 9-31.

Grabowski J., Krzemiński L., Nescieruk P. & Szydło A., 2008. Skały cieszynitowe. In: Krobicki, M. (ed.).Utwory przełomu jury i kredy w zachodnich Karpatach fliszowych polsko-czeskiego pogranicza. *Kwartalnik AGH - Geologia*, 34(3/1): 123-127.

Hohenegger L., 1861. Die geognostischen Verhältnisse der Nordkarpathen in Schlesien und den angrenzenden Teilen von Mähren und Galizien, als Erläuterung zu der geognostischen Karte der Nordkarpathen. *Justus Perthes*, 8: 1-50. Gotha.

Kasprowska-Nowak K., 2014. The importance of some quarries in landscape and tourism of Cieszyn Foothills. *Dissertations of Cultural Landscape commission*, 26: 175-187.

Lexa J., Bezák V., Elečko M., Mell J., Polák M., Potfaj M. & Vozár M.(eds.) (2000). *Geological Map of Western Carpathians and Adjacent Areas. Geologická Mapa Západných Karpát a Priľahlých Území 1: 500 000*. Štátny geologický ústav Dionýza Štúra.

Lucińska-Anczkiewicz A., Yilla I.M., Anczkiewicz R. & Ślączka A., 2002. $^{40}Ar/^{39}Ar$ dating of alkaline lamprophyres from the Polish Western Carpathians. *Geologica Carpathica,* 53: 45-52.

Ślączka A. & Kaminski M.A., 1998. A guidebook to excursions in the Polish Flysch Carpathians. *Grzybowski Foundation Special Publication*, 6: 171pp.

Ślączka A. & Kaminski M. A., 1998. A Guidebook to excursions in the Polish Carpathians: Field Trips for Geoscientists. *Grzybowski Foundation Special Publication*, 6: 173pp.

Skupien P., 2003. Palynologie tithonu – spodního hauterivu slezské jednotky na profilu Skalice. *Sborník vědeckých prací Vysoké školy báňské – Technické univerzity Ostrava, řada hornicko-geologická*, 49, Monografie 8: 15-31.

Ślączka A., Kruglow S., Golonka J., Oszczypko N. & Popadyuk I., 2006. The General Geology of the Outer Carpathians, Poland, Slovakia, and Ukraine. In: Picha F. & Golonka J. (eds), The Carpathians and their foreland: Geology and hydrocarbon resources. *American Association of Petroleum Geologists, Memoir*, 84: 221-258.

Picha F., Stráník Z. & Krejčí O., 2006. Geology and Hydrocarbon Resources of the Outer West Carpathians and their foreland, Czech Republic. In: Picha F. & Golonka J. (eds), The Carpathians and their foreland: Geology and hydrocarbon resources. *American Association of Petroleum Geologists, Memoir*, 84: 49-175.

Waśkowska-Oliwa A., Krobicki M., Golonka J., Słomka T, Slaczka A & Doktor M., 2008. Stanowiska najstarszych skał osadowych w polskich Karpatach fliszowych jako obiekty geoturystyczny. Sections of the oldest sedimentary rocks in Polish Flysch Carpatians as geotouristic objects. In: Krobicki, M. (ed.). Utwory przełomu jury i kredy w zachodnich Karpatach fliszowych polsko-czeskiego pogranicza. *Kwartalnik AGH - Geologia*, 34(3/1): 83-121.

Włodyka R. & Karwowski Ł. 2009. Field trip – Cretaceous alkaline magmatism from the Polish Outer Western Carpathians. *Mineralogia, Special Papers*, 34: 65-68.