A geotourist treasure – abandoned greywacke quarry in Stará Ves

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ABSTRACT

A great many localities of a scientific interest may, on one hand, be fascinating for experts among geologists, palaeontologists, biologists, etc., as well as they may have a high tourist potential. In this respect, the newly developing form of tourism – geotourism – may thus appreciate the abandoned greywacke quarry in Stará Ves near Bílovec, which enriches the offer of tourist attractions in the Moravia-Silesian Region. From the scientific as well as tourist point of view, it is a unique but undervalued geosite. The article describes the geosite in terms of geotourist requirements. It also gives a clear description of the genesis of the Variscan fold-thrust belt documenting the orogeny at the end of the Palaeozoic, sedimentary evolution of the individual rock strata, including the explanation of the genesis of the diverse geological features that can be admired in the quarry. The geosite is also described from the mineralogical perspective, which is equally attractive.

Key words: geosite, fold-thrust tectonics, flysh, Bílovec Microregion, Moravia-Silesian Region

INTRODUCTION

The geosite under investigation is found on the north-eastern edge of the municipality Stará Ves (Altstadt in German) below a hill top with ground elevation of 356 m.a.s.l. The municipality has the population of about 564 citizens and an area of 1,165 ha, thus belonging to the largest out of the six municipal parts of Bílovec town. The municipality spreads on 6 km along both river banks of the Bílovka. The population of Bílovec is approximately 7.5 thousand citizens and together with 11 municipalities it covers 118.93 km^2 forming the Bílovec Microregion. The microregion is situated in the centre of the Moravia-Silesian Region (Fig. 1) and thus it is easily accessible from the surrounding cities - Opava c. 24 km, Ostrava c. 31 km, and Nový Jičín c. 26 km. The microregion is intersected by the motorway D1 (Prague - Ostrava) and a high-speed railway corridor. An international airport is located in nearby Mošnov (c. 17 km).

As for the tourist industry, the microregion is found between two significant areas of natural wealth potential, the Beskydy Mts. and the Hrubý Jeseník Mts. Even if scientists are familiar with the locality, the tourist potential of the municipality itself is low. From the archaeological point of view, archaeological discoveries of the 'Bohunician' of the Neolithic age and the Micoquien have been made in the cadastre of the municipality (Jelínková, 2007). With respect to the number of the documented Middle Paleolithic localities, Diviš (2002) considers the Bílovec Microregion the most important locality settled by the Micoquien culture (Neanderthal culture) in the Moravia-Silesian Region.

The most attractive site in the municipality, especially for geologists, is the abandoned quarry (Fig. 3), where the sediments of the Kyjovice Member of the Hradec-Kyjovice Formation used to be extracted. This locality has become a sample locality documenting the tectonic evolution of the Nízký Jeseník Mts. This outcrop is referred to in numerous scientific

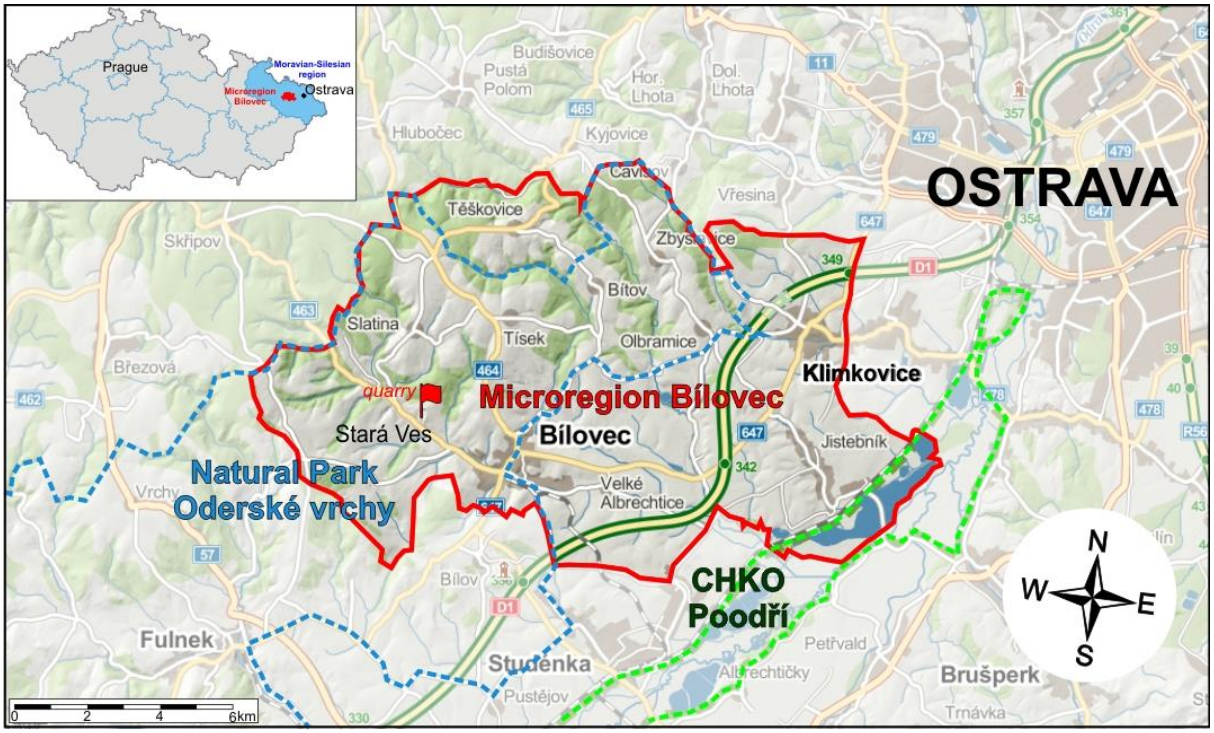

Fig. 1 Location of the study area the Bílovec Microregion and the quarry Stará Ves.

works (Dvořák, 1999; Grygar & Vavro, 1995; Grygar, 1997, Zimák et al., 2002). The locality is also interesting from the point of view of sedimentology and mineralogy (occurrence of rock crystal and ankerite). The locality is registered by the Czech Geological Survey and belongs among significant geological localities recommended for protection (www.1). The reason for this is the above mentioned exposure of the fold-thrust tectonics and the occurrence of 46 specially protected animal species.

Interestingly, the locality has become an excursion destination and a geological and biological geosite for students from the whole Czech Republic (CR), as well as for local and foreign experts. Unfortunately, it remains undisclosed to the wider public.

TOURISM IN THE BÍLOVEC MICROREGION

As for tourism, the Bílovec Microregion is situated in the tourist region of Northern Moravia and Silesia. The natural wealth potential of the tourist development is not high in the microregion. However, the microregion reaches into the natural park of Oderské vrchy and partly falls into the nature reserve Poodří (Fig. 1). Apart from the beautiful landscape with numerous ponds and forests, it offers a number of sights of village architecture and urban conservation area in Bílovec.

The natural park Oderské vrchy was established in 1994 by the district authority in Nový Jičín. The mission of the park is to preserve the characteristic nature of the landscape of the Nízký Jeseník, which is rich in mixed forests with numerous rock exposures and natural attractions. The natural park can be visited all year long and is suitable for hiking and cycling.

Another area of a higher natural wealth tourist potential is Poodří. It is a well preserved landscape along the watercourse of the Odra River. The dominant is the Poodří Nature Reserve with its unique alluvial forests, wetland meadows and pond systems. The frequent river meanders create an irreplaceable image of a live and captivating landscape. It is worth mentioning that there are many nature trails, where it is possible to observe the majority of birds nesting in the CR. Poodří is ideal for those interested in hiking and

Fig. 2 Renaissance church of St. Jakub in Stará Ves.

cycling. The unique natural landscape is livened up by a number of chateaus and industrial monuments (www.2).

As for the social localisation factors (Vystoupil & Šauer, 2011) the potential of the microregion is much higher. Among the most prominent sights directly in Stará Ves there is a filial Roman Catholic church of St. Jakub with the Renaissance core from 1569. The church is enclosed by a well preserved outer cemetery wall with an entrance gate. The church is a single-nave structure with a recessed and longer sanctuary of a polygonal termination. The structure has high tent roofs. The western access front is dominated by a prismatic tower topped with a Baroque helmet (www.3). Another attractive sight in Stará Ves is the remnants of a Slavic site of an ancient settlement dating back to the 10 and 12 centuries. The site is located on the northern side of a nameless hill with the ground elevation of 356 m.a.s.l. (Fig. 3).

A tourist attractive locality of the microregion is a windmill of the German type (Fig. 4). The windmill is a unique landmark. It is isolated in the middle of the fields, about 2.5 km westwards from Stará Ves, between the villages of Horní Nový Dvůr and Bravinné (Fig. 3). Between 2000 and 2001 the windmill was restored. The majority of the inner technical equipment, including the mill, is well preserved. The unique features of the windmill are the two cog wheels. The windmill wheel is 16 m in diameter. The windmill is last of that type in the district of Bílovec, where 52 windmills could be found back in 1890. In the region wind millery belonged among the most important rural industries at the end of the 19 century (www.4).

Other tourist attractive sights of the microregion are situated outside the cadastre of Stará Ves, namely in the town Bílovec. The most popular tourist sites are the municipal architectural reserve and the Renaissance chateau of the Sedlnitzký Family of Choltice dating back to the 16

century. The chateau was rebuilt into a Baroque mansion between 1736 and 1740. Unfortunately, at the end of the Second World War it was ransacked and set on fire. Since 2011 the chateau has been under a gradual reconstruction and restoration. A valuable part of the premises is the Renaissance gate and former chateau chapel of St. Hyacinth.

The church of St. Mikuláš is also worth visiting. It has a 51-mtere tall tower and was rebuilt in the Gothic style in 1422. Interesting are also the Renaissance building of the town hall built in 1593, the building of the municipal museum of the second half of the 18 century and a villa of the factory owner Salcher of 1908 (Kuchta, 2008).

In the microregion of interest there is also a smaller late Baroque chateau Slatina with a small park. It is a single-storey, rectangle building with a mansard roof and buttresses in the middle of both main faces terminated by a frontispiece (www.5).

Another chateau can be found in Klimkovice. This two-storey building with a closed courtyard was damaged by fire back in 1854. Only the valuable Renaissance staircase survived from the original furnishings. Nowadays, the chateau is run by the municipal authority. The Poodří Museum is situated there. Another chateau, a former Renaissance treasure, is in Bravantice and it is surrounded by an English park. However, it is derelict and the public is not admitted there (www.7).

A high potential as for the development of tourism is seen in the Klimkovice Convalescent Homes, which are a modern spa with a unique medicinal source: iodine-bromine brine. The iodine-bromine brine is used in the spa in the form of baths and packs, it helps to treat the organs of motion, neurological disorders and gynaecological problems, and it has a favourable effect on the vascular system (www.8).

As for the technical infrastructure, in the Bílovec Microregion there is a number of signposted footpaths criss-cross the whole region (Fig. 3). Bílovec is the starting point for four signposted tourist footpaths; Bílovec – Jakubčovice (16 km), path

Fig. 3 Location of the quarry, ground elevation of 356 m.a.s.l. and the windmill. The tourist footpaths are marked by blue and red lines. The cycle paths are marked by purple lines (www.6 modified).

Bílovec – Fulnek (13 km) passing through the forests with the panoramic views of the Oderské vrchy and the Beskydy Mountains, an undemanding trail Bílovec – Studénka (9 km) with an optional visit of the Wagon Works Museum in Studénka, and path Bílovec – Panský mlýn (10.5 km) passing through the valleys of the brooks Jamník and Sezina.

Two nature trails have been established in the vicinity of the microregion in the Poodří Nature Reserve. The nature trail 'Kotvice' is 3 km long and its six stops focus on ornithology and botany. The second nature trail 'Zámecká' is 5 km in length and its 12 information boards familiarise the public with the current state of the agricultural landscape, the adjacent wetlands, ponds, forests, flora, fauna and the architectonic monuments of Bartošovice.

Fig. 4 Windmill in Stará Ves near Bílovec.

In addition, cycle paths also rank to the technical infrastructure. The microregion is intersected by 8 registered cycle paths. The most important one is the long-distance cycle path called 'Amber Trail' connecting Vienna and Krakow, which transits through the Poodří Nature Reserve. Another significant cycle path is the 'Silesia Radegast Cycling Track' passing through the undulating terrain of the Moravian Gate, Poodří Nature Reserve, natural park of Oderské vrchy and the Ostrava Basin. The other cycle paths are of a lower order and do not exceed 20 km.

The winter tourist infrastructure in the microregion is represented by a shorter ski lift in Slatina and cross-country tracks through a valley called 'Údolí mladých', a beautiful valley of the Jamník, all the way to Pustá Polom.

The basic tourist infrastructure also includes accommodation facilities, restaurants and transport infrastructure (Vystoupil & Šauer, 2011). According to the public database of the Czech Statistical Office, in the Bílovec Microregion there are 8 accommodation facilities, namely two three-star hotels, two boarding houses, two hostels (highest accommodation capacities) and two closely unspecified facilities. The offer is not very wide and, moreover, higher standard accommodation (four to five-star hotels) is completely missing.

In some categories the information on the number of beds is not available and none of the facilities discloses the exact number of lodging nights. Nevertheless, the overall attendance in 2013 was 4,118 visitors. The majority were the guests from the CR, i.e. 3,490. The number of lodging nights was 8,755 (www.9). The data reveals that the majority of the visitors come for shorter periods only, which can be related to short holiday/weekend stays. The low number of lodging nights may thus also be explained by a lower tourist appeal of the microregion.

GEOLOGICAL EVOLUTION OF THE REGION

The Bílovec Microregion is located on the border of two geomorphological provinces, i.e. the Czech Highlands and Western Carpathians. In the east the province of the Western Carpathians is represented by the unit of Moravian Gate and the sub-unit

Odry Gate, which has the character of a flat upland. The mean altitude is 260.9 metres. The Czech Highlands forming the north-western part of the microregion is represented there by the spur of the Nízký Jeseník unit and the sub-unit Vítkov Upland. The mean altitude is 429.8 metres. The highest, western part of the Nízký Jeseník Mts. reaches as high as 800 m. It steeps eastwards all the way to 350 m (Demek et al., 1987). The interest geosite is found in this above described part of the Nízký Jeseník Mts.

This landscape character is given by the geological structure of the area. Within the microregion there are two completely different geological units of the Bohemian Massif and Western Carpathians (Fig. 5).

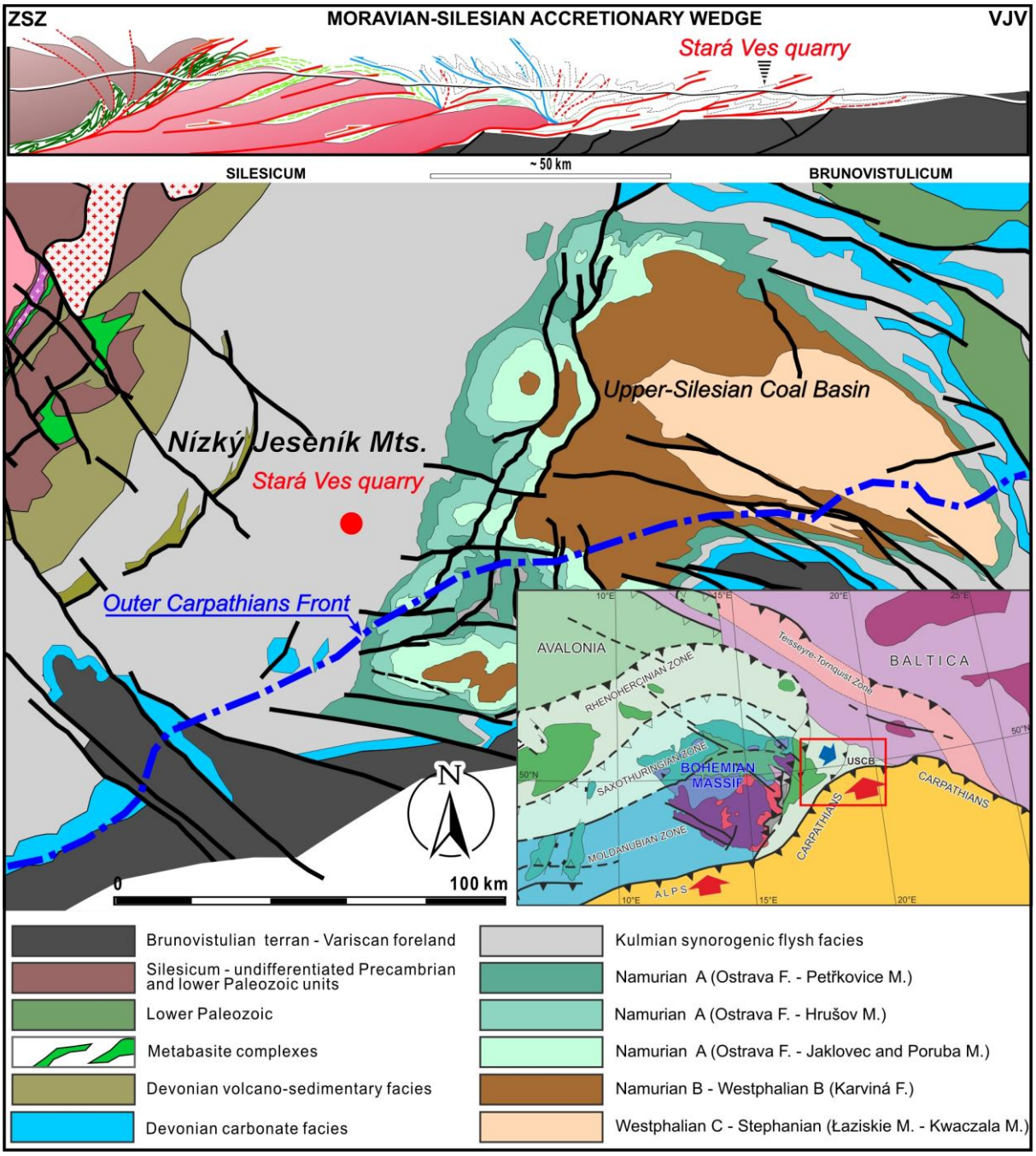

Fig. 5 Simplified uncovered structure-geological map of eastern area of the Bohemian Massive with position of the Upper Silesian Coal Basin and pre-Alpine exhumed Brunovistulian terrane. Small scheme represent its position in the frame of European Variscides. Uppermost figure is the schematic structural cross-section represents accretionary wedge of the Moravosilesian zone. Front thrusts are drawn by red lines whereas back thrusts by blue lines. (modified by Grygar & Waclawik, 2011).

The geological unit of the Bohemian Massif formed via the Variscan orogeny at the end of the Palaeozoic. The Carpathian orogenic belt formed as a result of the processes of the Alpine orogeny towards the end of the Cenozoic.

Therefore, the Nízký Jeseník Mts. is one of the geological units in the Central Europe. It is predominantly made up by Palaeozoic, Culm sedimentary rocks, conglomerates, greywacke and slate. This Culm massif lies on the Devonian base of earlier sediments and volcanic rocks that had formed via intense volcanic activities on the bottom of the Devonian sea.

In the Late Palaeozoic, in the Lower Carboniferous Culm the territory of the Nízký Jeseník Mts. was flooded with a shallow sea. At that time, the rivers from the contemporary Hrubý Jeseník Mts. washed away the gravel, sand and mud, which settled on the bottom of the Devonian sea in layers as thick as several kilometres. Gradually, the sediments of the flysch character formed, resulting in the Andělská Hora Formation, Horní Benešov Formation, Moravice Formation and the Hradec-Kyjovice Formation.

Each sedimentation process which starts off quickly and fades away slowly produces gradation. The ideal arrangement is usually apparent in the flysch sediments deposited by the turbidity currents. A turbidite (Fig. 6) is a higher density water current due to an increased quantity of suspended sedimentary material that flows downslope near the bottom under the influence of gravity. Such currents may be the consequences of submarine slides, earthquakes as well as the contribution of concentrated water suspensions (especially during floods) into lakes or sea, for example. In the thin currents containing clay, silt and sand, the grains are suspended due to turbulence.

Flysch is a typical sequence deposited in the deep-sea areas by the turbidity currents. In the seas the turbidity currents flow down the shelf edges, often through the submarine canyons (the flow rate may reach as fast as 100 km/h). The adrift material deposits mainly on the continental rise, where deep-sea fans are formed. The sedimentary sequences caused by the turbidity currents are called turbidites (Fig. 6), and the thickness of the individual layers varies from several decimetres to 1 or 2 metres. The discrete particles deposit according to the laws of gravity.

The lower part of the turbidite current is frequently made up by conglomerates. The boulders of quartz, granitoids,

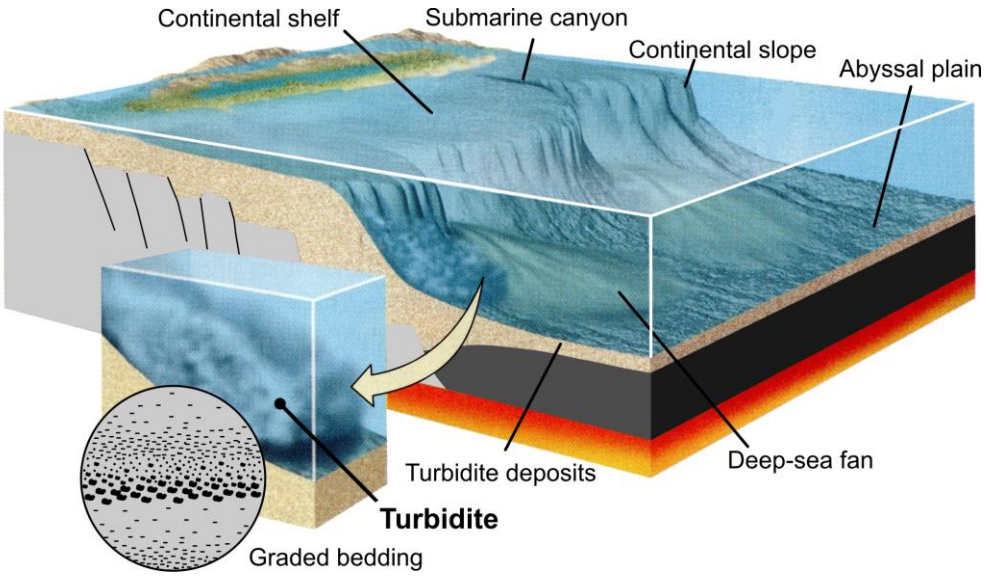

Fig. 6 Scheme is showing formation of the turbidite deposits and graded bedding (modified by Grotzinger et al. 2007).

metamorphic rocks and sedimentary rocks (Fig. 7I) float in the fine-grained material whose composition corresponds to greywacke. The conglomerate positions have uneven bases and well perceivable gradation in places. A material corresponding to greywacke frequently follows. Greywacke has a dark grey, black-grey or grey-green colour, and the texture is usually sheeting (Fig. 7B). The top part is represented by siltite and claystone. The substance of the rock is a clayey matter that may contain silt and fine grains of diverse minerals (especially quartz) and organic matter. Slate is always more or less significantly layered. After settling the material partially recrystallized under normal temperatures and formed authigene flaky clayey minerals and hydromica that were arranged as parallel. In the fine-grained members of the formation there is less favourably preserved fauna (e.g. *Posidonia* sp.), ichnofauna is abundant though; there are also plant fossil remains, e.g. fragments of horsetail of *Archaeocalamites* genus (Fig. 7H). The plant fragments are the remains of clubmoss and horsetail which had been redeposited from the continent or the littoral areas. They are mostly indefinable and considerably carbonised remains (Fig. 7D). In several places of the quarry it is possible to observe a clear orientation of the larger plant fragments, which corresponds to the direction of the sea currents.

The irregularities of the bedding planes are an important feature of the sediments and the indicator of the sedimentation conditions. The sedimentary rock deformations most frequently are the sole marks and the biogenic sedimentary structures.

The irregularities of the mechanical origin (sole marks) had been produced by gullies on the clayey bottom either by the particles tracted by the current along the bottom (groove marks) or by the overall erosion of the flow (flute marks - Fig. 7E). The formed depressions in the clayey bottom were filled with sandy sediments. After the consolidation of the sediments, the casts in the depressions have been preserved as fine elevations on the sole of the coarse-grained positions (Fig. 7C). Immediately after deposition, casts form on the bottom of the overlying bed of the conglomerates and sandstone when in contact with the underclay. These form as a result of the differential squeezing of the fast deposited coarser clastic positions into the underlying unconsolidated pelites. Therefore, they can be observed as irregular swellings on the undersurface of certain sandstone positions.

Biogenic sedimentary structures represent the fossil traces of the presence of organisms on the surface of the sediments predominantly of the sea bed. These are traces of crawling, resting, motion, dwelling and eating the sediments. The irregularities of the bedding planes are most often preserved in the form of raised fillings; the succession of strata can be deduced according to those (Fig. 7F).

The series of strata in the flysch basin settled via the processes described above, i.e. the so-called turbidity currents. This type of a sedimentary basin is typical for all orogens irrespectively of age and it characterises the final stages of the orogeny. It is referred to as the foredeep, which develops and is simultaneously filled with eroded and transported sediments due to the culminating collision between the foreland of the orogen and its internal zones (internides). In the Variscan orogeny, to which the Moravian-Silesian Foredeep belongs, it is the case of a collision of the inner zones of the Moldanubicum and Saxothuringicum with the foreland ranking to the so-called Brunovistulicum (Dudek, 1980; Cháb et al., 2010). Within the zonality of the European Variscides, the Moravian-Silesian area itself makes part of the Rheno-Hercynian Zone. In general, the foredeep basins are characteristic of a prominent wedge-like asymmetry in the transverse section. Considering the fact that huge amounts of sediments got accumulated and thus significant

accretionary expansion of the zonal orogen occurred, they are labelled as sedimentary accretionary wedges. At the same time, as a result of the increasing collision with the foreland, the sedimentary accretion causes thrusting of the extensive overlying rocks, accompanied by folding in the style of markedly asymmetrical drag folds. We talk of a tectonic accretionary wedge, whose activity was fading away from the internides on the west to the eastern foreland of the Brunovistulicum (Fig. 5). The most eastern overthrusts of the Moravian-Silesian accretionary wedge (Grygar & Vavro, 1995) may be observed eastwards all the way to the mining area of ČSM Mine in the Upper-Silesian Coal Basin (Grygar & Waclawik, 2011). The studied locality demonstrates the described evolution of an accretionary wedge and evidences the tectonic development of the Nízký Jeseník Mts.

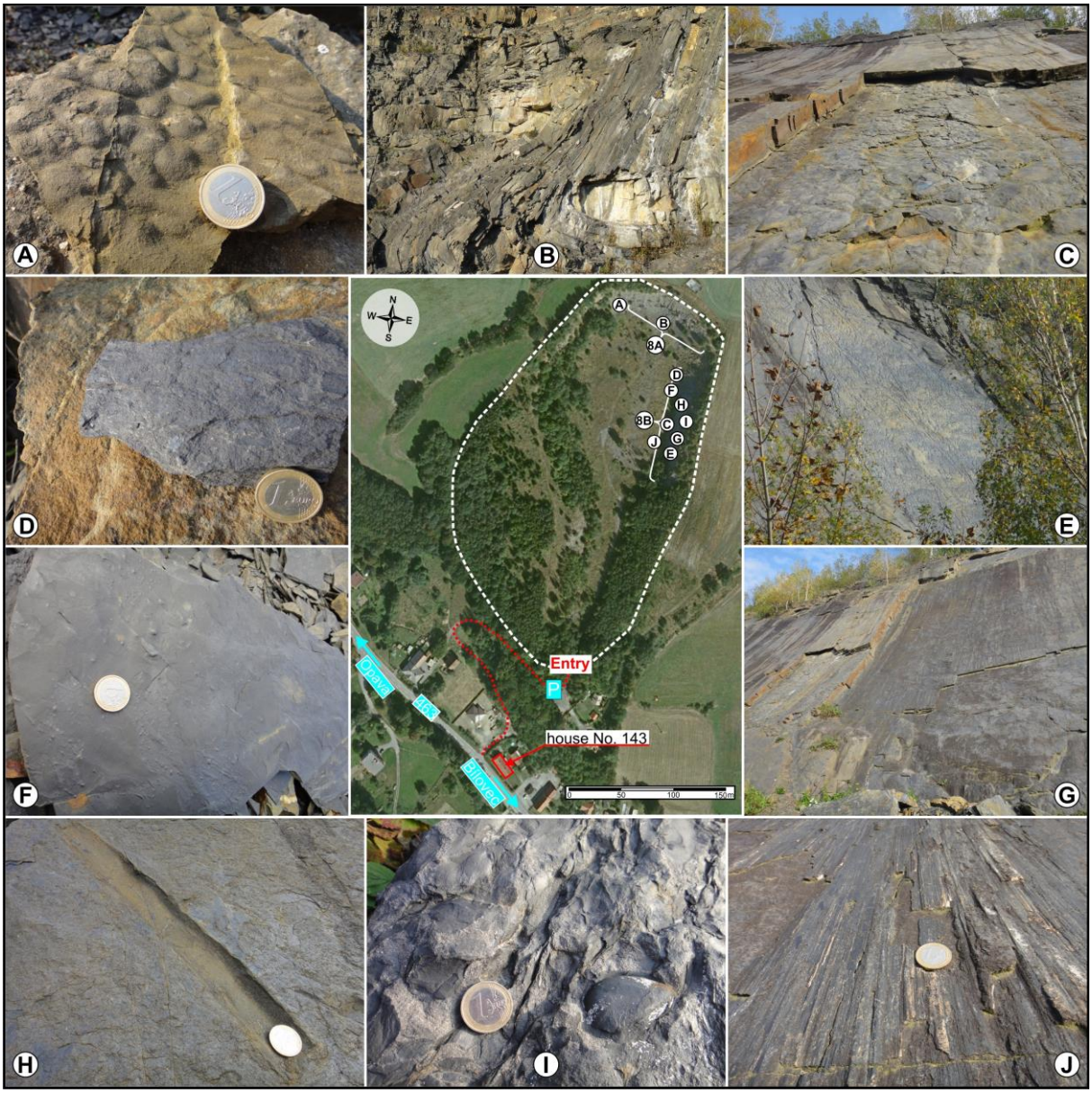

Fig. 7 Aerial photograph of the quarry with the access road and documentation points. Legend: A, C – Load casts and flute casts on the undersuface bedding plane; B – Shear fault cutting overturned limb of anticline represents rudimentary stage of the thrust fault; D – Coalfield plant debris in the siltstone; E, F – Bounce and flute marks on the undersuface bedding plane; G and J – Tectonic lineations (striations – J is more detail view) on bedding plane of overturned limb of anticline structure are consequence of flexure-slip mechanism of fold-thrust tectonics; H – Imprint of the horsetail of *Archaeocalamites*. I – Slump balls.

Erosion began to dominate after the Variscan orogeny had stabilised. The erosion or weathering in the Mesozoic levelled the mountainous relief into a worn-down plain. At the end of the Mesozoic and the start of the Cenozoic, the alpine orogeny broke the Variscan chain down into blockmasses that formed the block relief consisting of horsts and fault-block valleys. The Hrubý and Nízký Jeseník Mts. were lifted, while the area of the Upper-Moravian Valley and Kladsko sank. The Cenozoic sea again flooded the Upper-Moravian Valley as well as the Moravian Gate. It also swallowed a substantial part of the old Variscan chain.

DESCRIPTION OF THE GEOSITE - GREYWACKE QUARRY IN STARÁ VES

The geosite is easily accessible from the road No. 463 from Bílovec to Opava. Near the house No. 143 the route turns right and continues up a gentle slope along a not much maintained, but paved road all the way to the gate of the quarry (Fig. 7). The quarry is abandoned and thus accessible all year long.

Having entered the quarry, approximately after 150 m the face of the quarry can be viewed. The visitor can admire the exposure of the fold-thrust tectonics (Fig. 8) disrupting the sediments of the Kyjovice layers of the Hradec-Kyjovice Formation (Viséan age). The sedimentary succession of the strata is characteristic of the altering beds of fine-grained greywacke, siltstone and silty claystone (Fig. 7B). The greywacke is dark grey, frequently thinly bedded in the parallel direction, or almost laminated in places. The thickness of the individual bed positions is from 10 to 120 cm, and in places it is possible to observe gradation bedding documenting the undersea slides (turbidity currents) caused by earthquakes due to the movement of the lithospheric plates during the collision of the Brunovistulicum and the Lugicum.

The black-grey micaceous siltstone and silty slates are prominently laminated in the parallel direction. In the greywacke they appear as several-centimetre thin or several-decimetre thick positions. Flute marks have been preserved on the lower bedding planes (Fig. 7A, 7E, 7F) documenting the longitudinal (from S to N) filling of the Culm basin. These flute marks may be most easily perceived on the eastern wall of the quarry, which constitutes of the east-vergent limb (Fig. 7C, 7G). Apart from the so-called drags, it is possible to observe load casts (Fig. 7C) and biogenic sedimentary structures.

Plant debris has been identified in the sediments: *Lepidophloios sp.*, *Archaeocalamites*, *Calamites sp.*, and

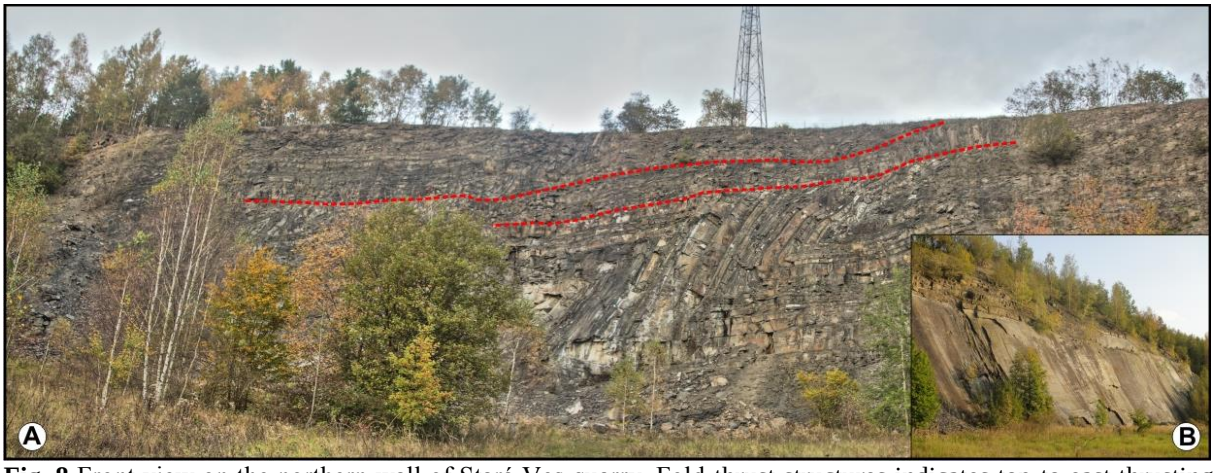

Fig. 8 Front view on the northern wall of Stará Ves quarry. Fold-thrust structures indicates top-to east thrusting (vergency) typical for nappe tectonic of Variscan accretion wedge. Overturned limb of large anticline structure crop out in eastern wall of the quarry on small figure B.

fragments of gymnosterms (Fig. 7D). On the sedimentary surface of the medium shank, a fragment of about 30-cm plant stem can be seen (Fig. 7H). The most fascinating geo-phenomenon that the majority of the visitors come to admire is the geological structure documenting the tectonic evolution of the Nízký Jeseník Mts. The face of the quarry belongs among the best exposures of the fold-overthrust tectonics in the Culm basin (Fig. 8). In the quarry there are a number of inverted to overturned east-vergent folds which had been disrupted with thrusts. The significantly asymmetrical flexures of the flexure-slip fold type are accompanied by interbed dislocations (Fig. 7G) subparallel with flat limbs of the flexures.

The evidence of the movements along the bedding planes are the findings of frequent slickings, striations (Fig. 7J) and fault polishes. Those features may be discovered not only on the large lumps loosened from the face of the quarry, but especially on the eastern limbs of the overturned folds (Fig. 7). All those phenomena correspond to the concomitant deformations related to the mechanism of flexural slips, when during the fold-thrust deformations slipping between the discrete layers of the flysch strata of different rheology occurred (petrophysical characteristics). While the above described sedimentary lineation generally heads towards the NNE-SSW, i.e. subparallel to the axis of the flysch basin and the subsidiary folds, the fault polishes and striations mostly bear along the fall line of the bedding planes in the fold limbs, i.e. ESE-WNW.

The described orogeny processes participating in the geological structure of the locality were accompanied by the secondary mineralisation. The reason why the majority of the visitors come is to admire the manifestations of this mineralisation. The rocks, especially the greywacke, are interveined by a net of veins constituted of quartz (Fig. 9A, 9B) and carbonates (calcite dominates over carbonate of the dolomite-ankerite family Fig 9B, 9C). In places there are grey-green aggregates of chlorite clinochlore-chamosite family, barite is rare; in the springs sulphides are represented by pyrite; exceptional are chalcopyrite and sphalerite. Those minerals may be discovered below the face of the quarry.

CONCLUSION

The geotourist potential of the discussed locality may be seen as very high. Moreover, the Bílovec Microregion and its surroundings offer a number of touristic attractions, both landscape/natural and social/localisation factors. The tourist rate in the studied locality could be enhanced, for example, by improving the quality of the accommodation facilities, especially of

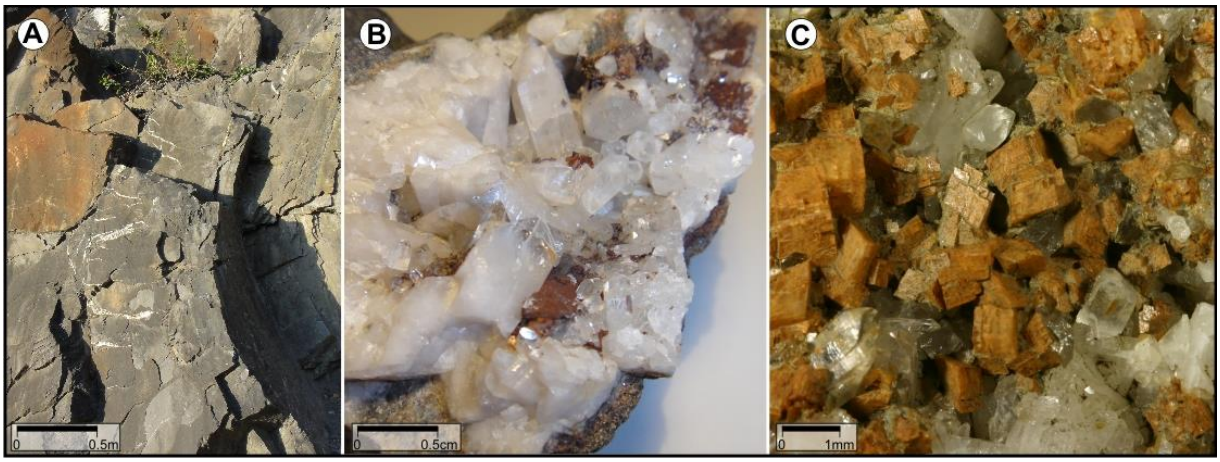

Fig. 9 Mineralisation: A – net of veins constituted of quartz, B – crystals of quartz with ankerite, C – detail of crystals of quartz and ankerite (www.10).

the touristy character. It would also help if the geosite was reclassified from category of protection B (locality recommended for protection) into the category A (protected locality).

What may also help to improve the tourist rate in the region is building a geotourist trail connecting the individual, interesting geosites in the Oderské vrchy. The most important move, though, is to promote the geosite under description, which is also the aim of this paper.

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