Vestiges of Glacial Action in Ostrava: Their Significance for and Application in Geotourism

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Abstract. The territory of Northern Moravia and Silesia is outstanding from the geological point of view. The abundance of different mineral resources has largely contributed to the intense development of the territory, particularly in the 19th century. Mineral resources were discovered already in the pre-historic period, when pre-historic man found coal at the coal seam exposures in Ostrava-Landek. They also used some raw materials that had been transported there by glacial action of the last Saale glaciation. Flint fragments and other travelled material may be frequently found in many localities to date. Large pieces that are called glacial boulders have been removed and exhibited for more than a century in many towns of the region. These vestiges of glacial action represent one of the many stages the Earth has passed through its history. At present, such findings mainly have an aesthetic function. Particularly interesting specimens have been protected as national monuments. The geomorphology of Ostrava has been responsible for the findings of the largest glacial boulders within the Czech Republic. Many of the formations are fascinating specimens that enrich the list of numerous geomontane sights in the City of Ostrava.

1. Introduction

As for its diversity, the geological structure of the Czech Republic is a perfect example of the action of endogenous and exogenous factors. Moreover, the territory of the Northern Moravia and Silesia is a territory that was affected by glacial action in the past. Glacial deposits, which are highly abundant, are important both as mineral resources and as study materials for petrographers and palaeontologists. Large pieces of rocks, the most interesting specimens of which are found in this region, are called glacial boulders. These large vestiges of glacial action also have a cultural-aesthetic function. They may be found as exhibited in local geoparks, or in many towns, where they are often protected as national monuments. As for petrography, it is an interesting material, which had been carried here from the northern parts of Europe, namely Scandinavia and the area around the Baltic Sea. As for geotourism, Ostrava is the best locality to learn about these large formations. Apart from many other geomontane sights, throughout the city there are many specimens of glacial boulders of diverse petrographic compositions. It is also possible to collect glaciation materials of all sizes in the surroundings of the city. These may be interesting specimens of rocks, the mineralogical composition and structure of which correspond to the exhibited glacial boulders, as well as interesting specimens of flint. This rock may be found in many colour varieties and interesting shapes, sometimes including interesting fossil remains.
2. The Quaternary and Quaternary Glaciation in Moravia-Silesia

The studied area was significantly influenced by Pleistocene continental glaciation. The vestiges of the last Saale glaciation have become standard parts of the capping mass in the territory. Due to the co-influence of other exogenous factors, the territory has become a perfect example of the development of the Quaternary in the Czech Republic, and thus has a spatial status as for its development and conservation. It is possible to study all types of Quaternary deposits in the area. The deposits have been long extracted and used as non-ore mineral resources. These are gravel, gravel-sand, sand, loam, etc. Particularly important to determine the stratigraphic system of the studied area in relation to the geological-stratigraphic structure is the region of Bohumín and its deposits. Other interesting regions are the regions of Hlučín, Ostrava and Český Těšín. Such features of uniqueness may be exploited in the new forms of tourism. Geotourism and the development of geoparks have been thriving recently and are becoming a new form of education when combined with active leisure activities [1, 2, 3].

3. Glacial Materials, Their Origin, Composition and Brief Classification

The classification of glacial sediments is based on the character of transport and sedimentation means. In the Czech Republic we may encounter three subgroups, which divide further. The most important subgroup are glacial sediments (s.s.), which were transported from the northern areas of Europe, and they contain varied petrographic material. The fetched material in its original form contained loose, unsorted or low sorted fragments by water, which are referred to as till. The matrix is of a marlaceous or clayey character (boulder clay or boulder loam). Boulder loam also refers to clastic material with the lowest limit for the fragment size of 1 cm. This term was introduced by Cyril Purkyné at the start of the 20th century from the German term “Geschiebe”. The term describes the drift of the material by a mountain or continental glacier from the original site of occurrence into the distance reaching several meters or even thousands of kilometres. If the size of the fragment exceeds 25 cm, we use the term of glacial boulder (drift boulder/ erratic boulder). Especially large glacial boulders that are found in the studied area are interesting vestiges of the Quaternary glaciation because of their varied mineralogical composition and textures. Closer investigations of the material confirm that the source areas is the north of Europe with a Scandinavian centre. Sometimes, the term of erratic boulder is used for any isolated rock on the earth surface inappropriately if it has no relation to glaciation.

Another subgroup of glacial sediments is glacifluvial sediments. These are sediments that have deposited in the flowing aquatic environments that had the direct contact with glaciers, or even in some distance of the glacier. A substantial part of the clastic material is thus material transported by glaciers. An important criterion is the paleogeographic relation with glaciers.

The third subgroup is the Czech Republic are glaciolacustrine sediments. These are lacustrine (lake) sediments forming in the foreland of glaciers, made predominantly by sand and clay. The classifications and occurrences of such sediments have been described in many expert publications in the last decades [4, 5, 6, 7, 8, 9].

4. Geological Importance of Glacial Material in The Czech Republic

The continental glacier originating in Scandinavia brought volumes of materials onto the territory of the Czech Republic from the areas it was drifting through. On its route of 1,500 km it travelled through the current Sweden, Finland, Denmark, Baltic Sea, the Netherlands, Germany, Poland and a large part of the former USSR. The resulting glacial sediments deposited in the territory of Northern Moravia and Silesia have long provided a wide range of materials that are used for industrial, scientific as well as cultural purposes.

4.1. The extraction of mineral resources

As mentioned above, the industry has long exploited the sediments as non-ore raw materials. Via the fluvial action, the materials eroded and later redeposited. The material has been used in the region as well as in many localities in Europe since the beginning of human civilisation. At first, man only collected the material, e.g. flint. In the Middle Ages, glacial boulders were used as building stone in the
construction of castles, fortifications and churches. This happened in such European countries that had a shortage in the building stone. Next, they were used as millstone, milestones, landmarks, or parts of monuments. At war times they were used as cannon balls, or in the 20th century as anti-tank obstacles. At present, attention focuses on another group of materials that formed via glacial action. In many localities, local extraction of sand, gravel-sand and gravel has been under way. Such materials are of a high-quality, they contain durable elastic of various sizes, mainly of quartz and other hard-wearing rocks.

4.2. Science
The scientific significance of the material lies in its use in many geological disciplines. The erosional activities of the glacier have been responsible for bringing very varied material that represents sufficient supplies of new study materials. A high number of different rocks have been identified in the sediments. Closer investigations making use of comparative analyses help to identify the primary deposits of the rocks. Such information may be used to determine the route of the continental glacier’s movement. The rocks also provide rich paleontological materials, in which many new fossils have been discovered and described.

4.3. Culture
The cultural value of the material may be considered especially in bigger glacial boulders that have been distributed along concourses in towns. Besides their documentary and educational functions, they mainly have an aesthetic function. Glacial boulders of smaller sizes may also be found in private plots, where they also have an aesthetic function. This function may also be exploited for the needs of geotourism, which has lately received increased attention on the part of those interested in the inanimate nature as well as scientists. As for petrography, these are interesting rock types that significantly differ from the autochthonous ones. From the point of view of geotourism, these large-size exhibits may be used as demonstrations of the action of exogenous factors as well as for petrographic investigations.

5. Description of Selected Glacial Boulders in Ostrava and Their Significance for Geotourism
In the Czech Republic the occurrence of glacial or erratic boulders has been documented on a rather small area [10, 11, 12, 13, 14]. Out of the overall surface area of the Czech Republic, these deposits may be found on approximately 5% of the territory. In the Northern Bohemia glacial boulders reach the size of up to 1 m, while in the Moravia-Silesian Region such findings are common, but there are also frequent boulders of 2 m in size. As for the altitude (193 – 336 m a.s.l.), Ostrava is the most ideal location for the occurrence of glacial boulders. At higher altitudes, e.g. 400 m a.s.l., the size of glacial boulders falls under 2 m, and at the altitude of 500 m a.s.l. glacial boulders are smaller than 1 m in diameter. As for petrography, among glacial boulders there are magmatic rocks (e.g. granites, pegmatites), metamorphic rocks (e.g. gneiss, migmatite) and sedimentary rocks (e.g. sandstone).

5.1. Glacial boulder in Ostrava–Kunčice
This glacial boulder is located in the Ostrava quarter of Kunčice in the Vratimovská Street. The official name of this natural monument is “Kunčice Glacial Boulder” and it is the largest and heaviest glacial boulder in the Czech Republic. It is of a regular, elliptic shape and its dimensions are 320 x 250 x 155 cm. It weighs 17.5 t. The surface of the boulder is rather smooth and unweathered. The glacial action had been responsible for drifting this formation for about 1,100 km, the most likely from the area of today’s central Sweden. From the petrographic point of view, it is a coarse-grained, porphyric, synkinematic granite (a banded rock, the so-called “gneissic granite”). As for mineralogy, this rock has pronounced weathered insets of about 1-2 cm of pinkish to yellowish potash feldspar. The other minerals are grey to yellowish quartz, larger aggregates of black biotite, plagioclase, magnetite, apatite, and epidote.

The glacial boulder was found in 1954 during excavation works to make foundations for a large foundry plant of the former Nová hut' Klementa Gottwalda. This glacial boulder was found at the depth
of 6.8 m together with several smaller boulders in a bed of gravel. The bedrock included Miocene malm rock, in the overburden there was a half-meter-layer of peat topped with a four-meter layer of alluvium. Because it became an obstacle in the construction works, the workers first wanted to remove it by blasting. When they realised it was a glacial boulder, it was transferred some tens of meters away. It was placed on a concrete base near the foundry entrance, where it may be seen to date. As been unique, it was included on the list of national monuments as of 1st January 1990. As a national monument, it has been regularly cleaned and maintained.

5.2. Glacial boulder in Ostrava–Poruba

The second largest glacial boulder in the Czech Republic is the “Poruba Glacial Boulder”. It was discovered in 1928 in the channel of a stream in the contemporary village Poruba. It had been considered the largest boulder until 1954. It is exceptional also because its longest axis has 370 cm. The others have 170 and 120 cm. The overall weight of the formation is 10.8 t. The surface of the boulder is irregular. As for petrography, it is an identical rock as above. From the mineralogical point of view, the size of potash feldspar is analogous (microcline) as well as the abundance of other minerals.

Thanks to a local teacher J. Hurník, in the village the glacial boulder was used in the construction of a memorial to celebrate the 10th anniversary of the establishment of Czechoslovakia. Some citizens were against moving the boulder because of old superstitions related to it. From the end of the Second World War to 1968 the boulder was located in front of a contemporary people’s committee in Poruba. From there, it was finally moved into the Vřesinská Street in Poruba, where it may be found to date. It was added onto the list of national monuments on 1st January 1990. This boulder is placed on a base made of polished crystalline limestone. At present, the authorities have been planning reconstruction works and construction of a triplet memorial, including a memorial to commemorate the fallen of the Second World War, a monument of inanimate nature – glacial boulder and a monument of animate nature – a memorial linden.

5.3. Glacial boulders in Ostrava–Pustkovec

In this quarter of the city there are several glacial boulders that differ in size and petrography.

5.3.1. Glacial boulder in Pustkovec. This glacial boulder is located in a small park at the crossroads of the Pustkovecká Street and Street 17. listopadu. It is a very interesting type of glacial boulder as for its petrography, shape or sculpture. It is the largest boulder made of sedimentary rock in the Czech Republic. It is of a rather flat and subangular shape, which is evidenced by its dimensions of 2.6 x 2.4 x 0.7 m. This shape is closely related to perpendicular dikes formed in rock massif, from which the boulder originates. On the surface there are frequent isolated or connected cup-shaped holes reaching 25 cm in diameter. Most likely, such surface was formed later on in the channel of the Šibraňka stream. The boulder weighs nearly 10 t. The petrographic composition of the boulder is interesting as it is quartzy sandstone (with iron-quartz matrix). Sedimentary rocks are not usually that resistant to withstand such a long transport. A question thus remains whether it had been brought from Scandinavia or from Poland.

From the bed of the Šibraňka stream the boulder was removed on 18th February 1938 and transported onto a playground, where it was supposed to form a base for a memorial to commemorate the 20th anniversary of the establishment of Czechoslovakia. This was not implemented in the end. During the WWII people built an anti-shell-fire shelter below the boulder. In 1979 the boulder was moved near the new sports hall, where it became parts of rock garden. It was transported to its current location in 2002, when the quarter Pustkovec celebrated 625-year anniversary of its establishment. Nowadays, the boulder is placed flatways on a low concrete base.
5.3.2. Glacial boulders as parts of the Memorial to the Fallen during the WWII. Near the Fire Station in the Pustkovecká Street there are several smaller boulders. In this quarter of Ostrava there is a set of glacial boulders that make the substantial parts of a memorial to the 311 fallen during the WWII. The three largest ones are located on a stone base, and two smaller ones are sunk into the ground. As for petrography, it is variotinted - grey, red-brown, light-brown, brown and grey-pink granite. All the granite has originated in Sweden.

5.3.3. Glacial boulder as parts of Petr Bezruč Memorial. Several meters further on, behind the building of the local council there is another glacial boulder together with a memorial linden. The dimensions of the boulder are 103 x 80 x 55 cm. It is a light-grey to pinkish, coarse-grained granite originating in Sweden. The granite includes a 2-3-cm-thick veins with pinkish feldspar. There is a commemorative plaque on the boulder and it is placed on a stone base.

6. Conclusion
The region of Ostrava belongs among interesting localities for its intense development of geomontane tourism. The rich history of the mining and metallurgical industries has been recently exploited in a more extensive manner via this non-traditional form of tourism. The existing sights of interest may be enriched with the discoveries of glacial boulders that document the forces of the continental glacier that had travelled in the past geological periods all the way therein. The interesting natural formations have interested the local inhabitants for decades and become noticeable decorations in the public space of the surrounding towns and villages. The findings of Ostrava glacial boulders rank first in the Czech Republic as for their size. Several of them are located directly in the City of Ostrava. Non-traditional forms of tourism have recently gained increased attention. The recent publications inform about geo-tourism from the theoretical point of view as well as on specific forms of implementation of sights for such purposes [15, 16, 17, 18, 19]. Such experience may also be used in the preparation of different expert field trips. The tours of prominent glacial boulders may be combined with tours of active sand pits, for example. Such options are usually planned for students, especially those at university. At such localities, visitors may admire interesting findings of smaller of glacial boulders and other palaeontological and petrographic findings, e.g. flint and fauna. Due to the fact that the vestiges of the continental glacier may be found on one twentieth of the Czech Republic, the region is outstanding not only because of the scientific reasons, but also thanks to the developing geotourism.

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