

UNESCO World Heritage Site Karlovy Vary and its geotourism development opportunities linked with architecture

Miloš Duraj¹, Dominik Niemiec¹, Jan Kubáč^{1}, Marian Marschalko¹, Radek Pohanka¹, David Sysala¹, Jindřich Vlček¹ and Erik Sombathy¹*

¹VŠB-Technical University of Ostrava - Faculty of Mining and Geology - Department of Geological Engineering, 17 listopadu 15, 708 33, Ostrava, Czech Republic

Abstract. Today's appearance of spa towns in the country is represented by the architecture of the 19th and 20th centuries. We mainly find elements of empire, neo-renaissance, and art nouveau in them. Even Karlovy Vary, even though its history goes back to the past, presents itself with this architecture. Even though the spa was here at the very beginning of the city's foundation, nothing was left of the original buildings due to natural disasters. If they were not natural disasters, they were also remediation that freed up space for the construction of new buildings. Apart from hotel buildings, typical objects of spa architecture are mainly spa buildings and pavilions, construction modifications of springs or colonnades. An essential part of these centres is also greenery and water supplements that balance the mass of these buildings. However, the favourable geological, especially hydrogeological and geomorphological conditions of these locations play the most important role for the development of the spa industry. From the point of view of tourism in Karlovy Vary, the aim of this work is to connect the classic spa tourism of this city, which was already supplemented by film tourism in the middle of the 20th century with geotourism.

1 Introduction

For several centuries, Karlovy Vary and its surroundings have been among the sought-after centres of tourism not only on a domestic but also a global scale. Archaeological research in the nearby area revealed the facts that this area was already inhabited in prehistoric times. But the city was created much later. Its establishment is due to the occurrence of thermal springs, which, according to legend, were discovered here by King Charles IV. It was also he who granted the city freedoms and rights in 1370. The city then received privileges during the following centuries. The city is situated in a picturesque natural scenery.

* Corresponding author: jan.kubac@vsb.cz

2 Brief overview of geological structure

The city of Karlovy Vary is situated in the western region of the Czech Republic, which is very interesting from the point of view of geological development [1-4]. The studied area belongs to the Saxon-Thuringian region (Saxothuringikum) of the Bohemian Massif. The Ore Mountains (Karlovy Vary) pluton is found in this area, which is made up of granite. This rock also appears in outcrops on the surface in some parts. This granite, as well as granitoids occurring in the vicinity, were intruded over a wide range of time. The granitoids intrusion belongs to the Upper Carboniferous. Among the cover formations, unconsolidated deluvial sandy-loamy to clay-sandy sediments are represented here. From fluvial sediments, there is a small occurrence of Tertiary gravels and from Quaternary deposits in the beds of the rivers Ohře and Teplá. Another interesting feature of this area is the fact that to this day movements of the earth's crust are still taking place in this area and its surroundings. One of the manifestations of these movements is the surveying of this area, which has been observed since the second half of the 19th century. During these movements along faults, frequent seismic manifestations also occur. It is very important for every city, especially if there are deteriorated geotechnical conditions in certain selected places, special foundations, e.g. using pile structures [5].

3 Geoturistic interests of Karlovy Vary

3.1 Mineral water springs in Karlovy Vary

The uniqueness of the geological structure, influenced by ancient volcanic activity, as well as the favourable geomorphology of the area, played an important role in the creation of the famous mineral springs. From the conducted research, the conclusions are made that mineral waters [4, 6-10] were created by the descent of rainwater into the deeper parts of the mountain massif. This descent of waters, which reaches a depth of several kilometres, is made possible by systems of fractures and faults. Here, water saturated with mineral substances subsequently rises to the surface along a significant break. The total process takes approximately 2 to 3 years. However, these springs have different water temperatures (35 to 73 °C), which is also related to the different content of carbon dioxide dissolved in them. However, the mineral content of the waters is roughly the same. The yield of the springs is around 3 million liters of water per day (containing 18 tons of mineral salts). From a chemical point of view, it is hydrogen-carbon-sulphate-hydrochloric-sodium acid water. Of today's 13 so-called large springs, 10 springs are currently used for various spa procedures. The hottest spring is Vřídlo, whose temperature is 72.7 °C. The only cold spring is Štěpánka with a temperature of 10 °C. There are also other unused springs here. In total, there are 60 mineral springs. Mineral water has also been exported in bottles all over the world since 1843.

3.2 Karlovy Vary Aragonite („Vřídlovec“ in Czech)

Mineral springs formed here by precipitation in the long geological past of powerful sinter bodies. Mineralogical composition is made up of two varieties of aragonite ("Vřídlovec" and "Hrachovec" in Czech) [3, 6, 9, 11-13]. The thickness of this body, the so-called hot spring plate, exceeds 8 m. The hot spring stone is found in the bedrock, for example, of the Hot Spring Colonnade or the Church of St. Mary Magdalene. This nature has been used for several centuries to produce souvenirs from these spas. The most famous is the so-called Karlovy Vary stone rose. It will form over the course of a few days. This is a process of incrustation, in a short period of time, hot water precipitates on the inserted paper rose.

Currently, other souvenirs (amphorae or various animals) are also produced in this way. Visitors can also see the beauty of historical objects made from mined hot springs in the collections of the local museum. The greatest popularity of this item was from the middle of the 19th century to the 20th century, although the beginnings of this production can be found as early as the 17th century. This ribbon form of aragonite has been used to decorate many objects. These were various curiosities as well as items of daily use (weights, vases, cases, frames). It was used as a piece or for marquetry. It was also used in jewellery. The souvenir from the hot spring has kept its position until today. From the point of view of use in geotourism, these are all the more interesting objects.

3.3 Karlovy Vary Spa

Currently, mineral water is mainly used for spa purposes. Due to the approximately the same mineral composition of the spring waters, acid salts are prescribed to patients according to the temperature of the waters of the individual springs (these waters come from the same source). The waters are used to treat various health problems. They are effective for the treatment of digestive problems, disorders of fat metabolism, metabolism, obesity, some disorders of the locomotor system, periodontitis and some others. The most common treatment procedures are baths or drinking treatments. Other natural resources used for medicinal purposes are peat and bog, as well as hot spring gas. The surrounding nature of the city and the local climate also play a big role here. The spa's worldwide fame is evidenced by its numerous clientele. Around 70,000 people visit here every year for spa treatment [3, 6-10, 14].

3.4 Historical development with respect to the city's spa architecture

By granting municipal rights to the small village on August 14. 1370 by Charles IV. the construction of the first spa buildings begins, into which mineral water was fed through troughs. Nothing has survived from this Gothic and later Renaissance stage of construction. The city was affected by many natural disasters. The first of them was a great flood in 1582, which destroyed almost the entire city. Before long, in 1604, the city that was being restored was hit by a fire. After this fire, only 3 houses remained in the town. The subsequent Baroque construction of the city in the 17th and 18th centuries expanded the spectrum of purpose-built buildings (more luxurious spa buildings, colonnades or hospitals). After another flood in 1759, the construction of new buildings in the classicist style began at the beginning of the 19th century. In this period, new springs become available and, in addition to the construction of new buildings, attention is extended to the construction of forest promenades and parks. A significant event was the connection of the city with the surrounding world by railway. After another flood in 1890, some classicist buildings were renovated. A new construction took place in their place, which includes buildings in the styles of historicism, eclecticism and art nouveau. From an overall perspective, the years 1870 – 1915 are the era of the greatest construction of the city. The subsequent period of wars and economic crisis slowed down the development of the city. Construction during the socialist period was concentrated on the construction of panel apartment buildings. The construction of other, new spa buildings rather disturbed the overall colour of the historical part of the city [3, 10, 14-17].

4 Selected spa architecture of the city

4.1 Colonnades

4.1.1 Mill colonnade

The purpose of the construction of the colonnades [3, 4, 14, 18, 19] in Karlovy Vary was for the spa ensure that guests can drink mineral water directly at the springs, even in bad weather. Another one the meaning was the possibility of relaxing walks. Today's Mill Colonnade is part of five colonnade in Karlovy Vary and is also the largest.

The construction of the first wooden colonnade in Karlovy Vary took place in 1792-1793. This colonnade was built above the Nový pramen spring (today's Rusalčin spring) near Mlýnské Spa. Soon, in 1811, a new empire-style colonnade of the New Spring was built here. It was also a wooden building. The Dresden architect and builder Johann August Giessel undertook the implementation. As early as the forties of the 18th century, the construction of a grander colonnade was considered. This colonnade was supposed to replace an inadequate wooden building. The architectural competitions had the task of selecting the design of a new representative building. But none of the proposals passed. At the end of the 1960s, the city management invited the prominent Prague architect Josef Zitek to implement it. The construction of today's Neo-Renaissance colonnade took place in 1871-1881. The ceremonial opening took place at the beginning of the new spa season on June 5, 1881. By excavating part of Bernard's rock in the early nineties, the colonnade could be extended beyond the Skalní spring. The colonnade covers a total of five springs (Mlýnský spring, Rusalčin spring, Prince Wenceslas spring, Libušin spring and Skalní spring). The decoration of the balustrade is completed by 12 sandstone sculptures depicting the months of the year. Their authors are the sculptors Alfred Schreiber and Karl Wilfert. The colonnade's orchestra area is decorated with reliefs by the sculptor Václav Lokvenc. The length of the colonnade is 132 m. The roof of the colonnade is supported by 124 Corinthian-style columns. Currently, the colonnade is also used to organize social events. In 2014, the upper terrace of the colonnade was made accessible. The terrace is open during the main spa season and provides the most beautiful views of the historic centre of the city and the hot spring break. It has been a cultural monument since May 3, 1958.

4.1.2 Hot Spring Colonnade

The colonnade is located in the center of Karlovy Vary on the right bank of the Teplá river, under the church of St. Mary Magdalene. This colonnade also covers the most famous mineral spring Vřídlo. In the past, this spring was covered by several period buildings. The colonnade was built between 1969 and 1975. The architect of this building was Jaroslav Otruba. The colonnade covers various souvenir shops, exhibitions are also held here. There are facilities for pumping and distributing mineral water in the underground spaces. There is also an excursion route with sinter decoration of corridors [3, 14, 18, 19].

4.2 Church of St. Mary Magdalene

This church in the city centre was built in 1733-1736. As stated in works [3, 14, 16, 19, 20], this is a highly baroque building designed by the well-known Czech architect Kilián Ignác Dientzenhofer. In the second half of the 14th century, the medieval Gothic church of St. Mary Magdalene, which was surrounded by a cemetery. Already in 1516, the church was rebuilt in the Renaissance style. The city fire in 1604 also affected this building, which decayed

for a long time and later threatened to collapse. The newly built church, which was consecrated on September 1, 1736, was affected by another fire in 1759. The original cemetery was in 1784 by order of Emperor Joseph II. Abolished and the remains of the deceased were transferred to the underground chapel of the church and to the cemetery of the church of St. Andrew. In 1861, the church was repaired and the towers rebuilt. The church underwent further repairs at the end of the 19th century and also in the 20th century. In the interior of the church, the rich Baroque decoration, two Gothic Madonnas and the underground burial crypt with the remains of the deceased from the original closed cemetery are worth a visit. The church was included in the list of national cultural monuments in 2010.

4.3 Hotels

4.3.1 *Grandhotel Pupp*

The beginnings of this hotel date back to 1701. The history of the hotel's creation, as described in works [3, 16, 19, 20], is multi-staged and varied. In this year, the local mayor Anton Deiml had a ballroom built here. One of the contributors to this building was the Saxon elector Friedrich August, who regularly visited Karlovy Vary (which is also why the name Saxon Hall came to be used for this building over time). In 1708, another of the mayors, Andreas Wenzel Becher, had a new building built on the opposite plot, later called the so-called Bohemian Hall (in this case, the seasonal staff came mainly from Prague). In 1717, the Saxon Elector August Silný had a wooden building built next to the Saxon Hall to host theatre, concert and artistic performances. In 1730, the U Božího oka house (property of the Deiml family) was built between the Saxon and Bohemian Halls. In 1767, the local confectioner Mitterbacher employed Jan Jiří Pop, who later began to sign himself as Johann Georg Pupp. From 1775, until 1778, the gradual purchase of shares in the Czech Hall from the previous owners began with his marriage to the employer's daughter Franziska. In 1890, the Pupp family also bought the competing Saský sál. In 1892, the demolition of both halls began. The new Grandhotel Pupp was built on the rehabilitated areas. The ceremonial opening took place on May 13, 1894, when the new spa season began. In the years 1905 - 1907, the neo-baroque reconstruction of the hotel took place. In 1934, after a long effort, it was also possible to buy the U božího oka building. After the rehabilitation of this building, a hotel extension was created here. After the Munich Agreement, this area was annexed to Germany. At that time, the hotel was called Grand- und Park-Hotel Pupp. After World War II, the hotel was nationalized. In 1951, the hotel was renamed Grandhotel Moskva. During the years of socialism, the clientele of the hotel also changed. At first, it was primarily workers from the Eastern Bloc, and since 1957, the city has again been visited by traditional clientele from Western countries as well. In 1964, a new reconstruction of the hotel began. At the end of 1989, the hotel acquires its original name Grandhotel Pupp [3, 16, 19, 20].

4.3.2 *Hotel Imperial*

The history of this hard-to-classify hotel begins at the beginning of the 20th century. Here we discover the basis of art nouveau, elements of art deco or historicism [3, 16, 19, 20]. In 1910, Karlovy Vary banker and businessman Alfred Schwalbe began to finance the construction of a new impressive building, which rose on the elevated site of Helena's courtyard. The building was designed by the prominent French architect Ernst Hebrard. The building was also the first to use the new cast concrete technology. The opening of the hotel took place on June 18, 1912. The construction of two ground cable cars was also planned here for the transport of tourists. The first was put into operation in 1907, it led through a

tunnel and is still in use today. The second was surface, from 1912, which was cancelled in 1959 due to poor technical condition. From the very beginning, the hotel was one of the most luxurious hotels visited by important clients from all over the world.

4.3.3 Hotel Thermal

The construction of the hotel began in 1968. Unfortunately, an area was chosen as the construction site where around 30 houses, mostly from the end of the 19th century, had to be renovated. Among the most important were, for example, the Mattoni villa, the Alice house, the Pošta hotel or the Comenius School. Věra and Vladimír Machoninova won the architectural competition for the construction of the hotel. For financial reasons and because of groundwater seepage, the construction lasted until 1977. The main structure of the hotel complex is a 65 m high reinforced concrete building. The architects were inspired by the Brutalism of Le Corbusier and British architects. In 2019, an extensive renovation of the hotel began, the sensitivity of which was criticized by the professional and lay public. The hotel complex is also the main centre of the International Film Festival [3, 16, 19, 20].

5 Conclusion

Karlovy Vary is a classic example of a historic spa town. Both in the past and in the present, it is one of the most important spas in the country. Favourable geological and geomorphological conditions allow the groundwater to be richly saturated with mineral substances. The temperature range of individual springs is also interesting. The healing effects of mineral waters were already known in ancient times, and they were responsible for the establishment of this important city. In the past, the city had the honour of being visited by many important guests from all over the world. Today, Karlovy Vary offers many forms of tourism. From the point of view of tourism, this city and its surroundings offer a wide range of interesting locations. The history of this city is long and is reflected in the many objects that are located here and create a pleasant environment for spa relaxation. In addition to spa tourism, this city is also a popular centre for film tourism. The geological conditions of this locality have a great assumption in the future that these tourist activities will be supplemented with geotourism activities.

Acknowledgments

Authors thank the Faculty of Mining and Geology, VSB – Technical University of Ostrava for the support of the project SP2023/055 and SP2024/096 which is the base of this article.

References

1. V. Blecha, M. Štemprok, And T. Fischer, Geological interpretation of gravity profiles through the Karlovy Vary granite massif (Czech Republic). *Studia Geophysica et Geodaetica*, 53: 295-314, 2009. <http://doi.org/10.1007/s11200-009-0019-5>
2. V. Blecha, and M. Štemprok, Petrophysical and geochemical characteristics of late Variscan granites in the Karlovy Vary Massif (Czech Republic)-implications for gravity and magnetic interpretation in shallow depths. *Journal of Geosciences*, 57.2: 65-85, 2012. <http://doi.org/10.3190/jgeosci.115>
3. S. Burachovič, Encyclopedia of spas and healing springs in Bohemia, Moravia and Silesia (*Encyklopedie lázní a léčivých pramenů v Čechách na Moravě a ve Slezsku*). Libri, p. 464. 2001, ISBN: 978-8072770489. (in Czech).

4. I. Chlupáč, R. Brzobohatý, J. Kovanda and Z. Stráník. Geological history of the Czech Republic (Geologická minulost České republiky). Prague: Academia Prague, 2002. 436 pp. Edition number 2483. ISBN 80-200- 0914-0 (in Czech).
5. F. Gago, J. Mužík, and R. Bulko. The slope stability solution using meshless local Petrov-Galerkin method. *Transportation Research Procedia*, 2019, 40, 686-693 pp.
6. M. Janoška, Mineral springs in Bohemia, Moravia and Silesia (Minerální prameny v Čechách, na Moravě a ve Slezsku). Academia, p. 495, 2010. ISBN:978-80-200-1615-7. (in Czech).
7. M. Jašek, The thermal waters of western Bohemia and the energy potential of Vřídla (Termální vody západních Čech a energetický potenciál Vřídla), 2011 (in Czech).
8. J. Krásný, Underground waters of the Czech Republic (Podzemní vody České republiky). In: XIV. Hydrogeological congress and II. engineering geological congress. 2014 (in Czech).
9. R. Květ, Mineral waters of the Czech Republic: origin, history and current status (Minerální vody České republiky: vznik, historie a současný stav). Accent, 2011 (in Czech).
10. M. Sarova, Czech Spa and Its History Karlovy Vary traditional drinking cure with mineral water and treatments. *The Journal of the Japanese Society of Balneology, Climatology and Physical Medicine*, 2006, 70.1: 9-12.
11. J. Tvrdý, The National Geopark Egeria - a Globally Important Area of Mineralogical Researches (Národní geopark Egeria-celosvětově významné území mineralogických výzkumů), Slavkov, Krásno-Horní., 2015 (in Czech).
<https://doi.org/10.13140/RG.2.1.2850.1920>
12. T. Vylita, et al. Evolution of hot-spring travertine accumulation in Karlovy Vary/Carlsbad (Czech Republic) and its significance for the evolution of Tepla valley and Ohre/Eger rift. *Zeitschrift für Geomorphologie*, 2007, 427-442.
<https://doi.org/10.1127/0372-8854/2007/0051-0427>
13. T. Vylita, K. Žák, Travertine deposits of the Karlovy Vary thermal water system. *Environmental geology*, 58:1639, 2009. <https://doi.org/10.1007/s00254-008-1484-9>
14. S. Burachovič, Karlovy Vary: the spa metropolis of Western Bohemia (Karlovy Vary: lázeňská metropole západních Čech). Regia publishing house, p. 208, 2018. ISBN 9788087866375. (in Czech).
15. M. Hýsková, World Spa? Karlovy Vary 1850-1918 (Světové lázně? Karlovy Vary 1850-1918), 2016. (in Czech).
16. S. Burachovič, Chapters in the history of Karlovy Vary, 2009.
17. S. Burachovič, The Story of the Grandhotel Pupp: Chapters from the History of the Most Renowned Hotel in Karlovy Vary. Promenáda Publishing, p. 163, 2010. ISBN: 978-80-86092-51-5.
18. R. Šrek, Architecture of public buildings in Karlovy Vary in the years 1780-1850 (Architektura veřejných staveb v Karlových Varech v letech 1780-1850). *Arts/Art*, 2009, 57.6 (in Czech).
19. L. Zeman, Karlovy Vary architecture guide (Průvodce architekturou Karlových Varů). National Monument Institute, p. 511, 2012. ISBN 9788087104637. (in Czech)
20. D. Roubínková, and Z. Roubínek. Historicism in the architecture of Karlovy Vary (Historismus v architektuře Karlových Varů), p. 99, 1996 (in Czech).