Adršpach-Teplice Rocks and Broumov Cliffs—Large Sandstone Rock Cities in the Central Europe

17

Jan Vítek

Abstract

Structural plateaus and cuestas underlain by sedimentary formations of Late Cretaceous age are a part of Intra-Sudetic Basin in the northeastern Bohemia. Processes of erosion, weathering, and gravity-driven slope movements created important rock cities which originated in differently resistant and tectonically jointed sandstones. Rock cities are systems of rock towers, pillars, ridges, and cliffs separated by deep canyons, narrow gorges, and crevices. Some of these rock formations are as much as 100 m high. Mesoforms and microforms of weathering and denudation, especially rock perforations (rock arches, windows), various types of pseudokarst caves, tors, mushroom rocks, rock hollows, rock basins, and karren are common. The largest and the most visited rock cities are the Adršpach-Teplice Rocks (Adršpašsko-teplické skály) and the Broumov Cliffs (Broumovské stěny) which belong to Broumovsko Protected Landscape Area.

Keywords

Adršpach-Teplice Rocks • Broumovsko • Sandstones • Late Cretaceous • Intra-Sudetic Basin • Rock cities

17.1 Introduction

Rock cities and other rock formations built of Late Cretaceous sandstones are a part of the submontane landscape which occurs east of the highest mountain range of the Czech Republic—Krkonoše Mts. The term "rock city" depicts a complex ("labyrinth") of solitary rock towers and cliffs which are separated by narrow gorges, cracks, or crevasses one from another. The rock cities in northeastern Bohemia are part of *Broumovsko Protected Landscape Area,* named after the nearby town of Broumov. The most important rock cities are located within the Adršpach-Teplice Rocks (Czech *Adršpašsko-Teplické skály*) and the Broumov Cliffs (Czech *Broumovské stěny*). They are characterized by a huge variety of landforms and are easily accessible for tourists, belonging to the most visited places of the Czech nature. These sandstone formations continue in Poland in the Góry Stołowe National Park, where similar sandstone rock formations can be found.

17.2 Geological and Geomorphologic Setting

Broumovsko Protected Landscape Area with its rock cities is a part of the geomorphologic unit known as Broumovská vrchovina (=Highland) (Demek et al. 2006). In terms of regional geological division of the Bohemian Massif, this area is part of the Intra-Sudetic Basin which is a long active sedimentary basin between older (Precambrian and Lower Paleozoic) crystalline complexes of Krkonoše Mts. and Orlické hory Mts. (Chlupáč et al. 2002). The Intra-Sudetic Basin contains Carboniferous and Permian sediments, to a lesser also paleovolcanites of from these periods, followed then by and sediments of Mesozoic age (Triassic and especially Late

J. Vítek (✉)
Department of Biology Faculty of Science, University of Hradec Králové, Rokitanského 62, 500 03 Hradec Králové, Czech Republic
e-mail: jan.vitek@uhk.cz

T. Pánek and J. Hradecký (eds.), *Landscapes and Landforms of the Czech Republic*, World Geomorphological Landscapes, DOI 10.1007/978-3-319-27537-6_17

Cretaceous period) (Tásler et al. 1979). Carboniferous sediments (conglomerates and arkoses with coal seams) create the southwest part of the Intra-Sudetic Basin, with an asymmetric mountain ridge of Jestřebí hory (Žaltman, 739 m). It is delimited by tectonic fault (Hronov-Poříčí Fault) against the Krkonoše-piedmont Basin. Permian sediments (mostly "red sandstones") fill the northeastern part of the Intra-Sudetic Basin, along the shallow valley of Stěnava River. Permian volcanic rocks include rhyolites, andesite, and basalts. They create rugged highlands along the borders with Poland, with the highest peaks approaching 900 m a.s.l. (Královecký Špičák, 880 m, in Vraní hory, and Ruprechtický Špičák, 880 m, in Javoří hory). In the overburden of Permian sediments sandstones of Triassic age appear in some places which is the only occurrence of Triassic rocks in Bohemian Massif.

The central part of the Intra-Sudetic Basin is created by the Police Basin (named after the town Police nad Metují), where lithologically diverse sediments of Late Cretaceous age occur (stratigraphic unit Cenomanian, Turonian, and Coniacian). The thickness of Cretaceous sediments reaches up to 500 m (Dvořák 1968). Two main types of sediments may be distinguished. The fine-grained sediments (marls, claystones, calcareous siltstones etc.) create the major part of the area. These sediments can be found, e.g., in rock outcrops on slopes of the river Metuje valley and its tributaries. The second main type is quartzose and arkosic sandstones. Important landform assemblages, including 'rock cities', came into existence primarily in the so-called block sandstones whose breakdown typically proceeds along two sets of vertical joint, perpendicular to each other, and horizontal partings, which may follow bedding surfaces. For sandstones of the Police Basin, distinctive diagonal bedding is typical (Adamovič et al. 2010).

The Police Basin has a brachysyncline structure, with an axis elongated in NW–SE "Sudetic direction" (Fig. 17.1). Both sides of the basin are typified by stepped morphology and the occurrence of homoclinal (cuesta) ridges, whose gentle slopes are inclined toward the middle of the basin according to the dip of the strata, whereas rocky escarpments occur on the opposite steep escarpments (Fig. 17.2). The evolution of Police Basin and its landforms was controlled by the presence of tectonic faults established during the Paleozoic. In the Cenozoic faults were revived under the influence of Saxonian tectonics and thereby some parts of the area moved about tens or even hundreds of meters in

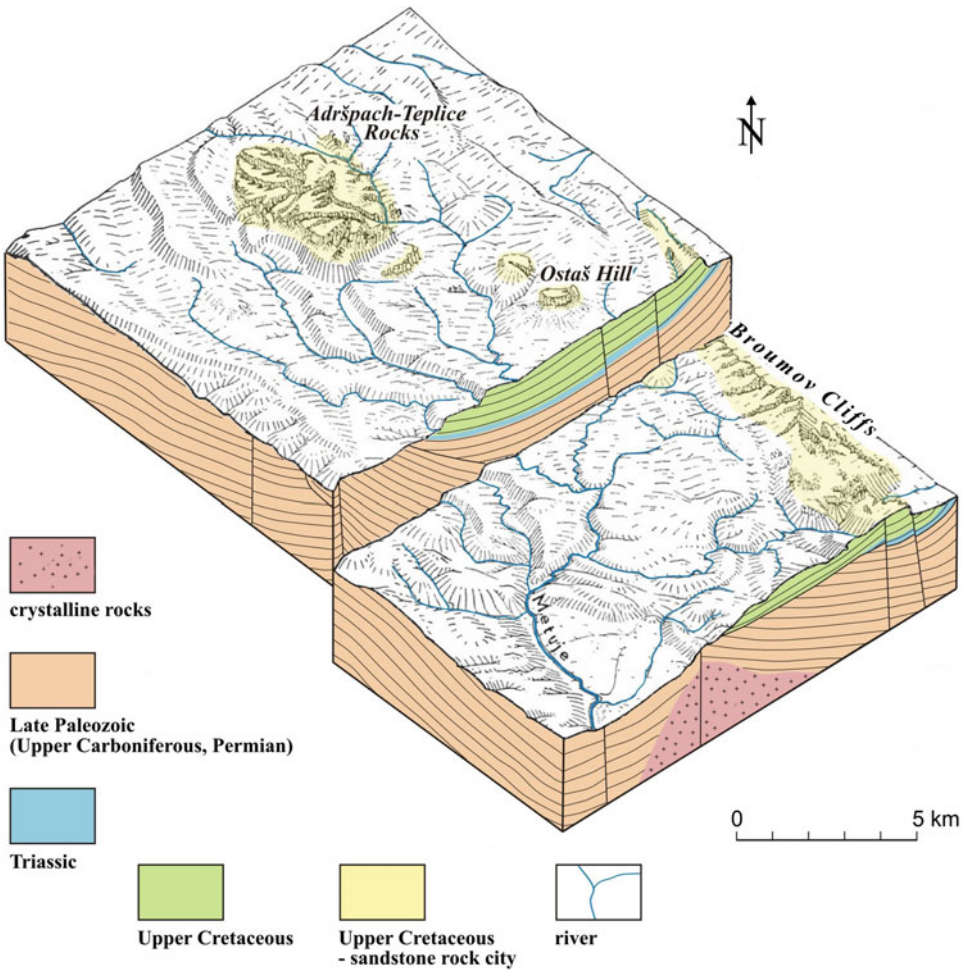

Fig. 17.1 Position of the rocky areas of Adršpach-Teplice Rocks and Broumov Cliffs in Police Basin (Modified after Bína and Demek 2012)

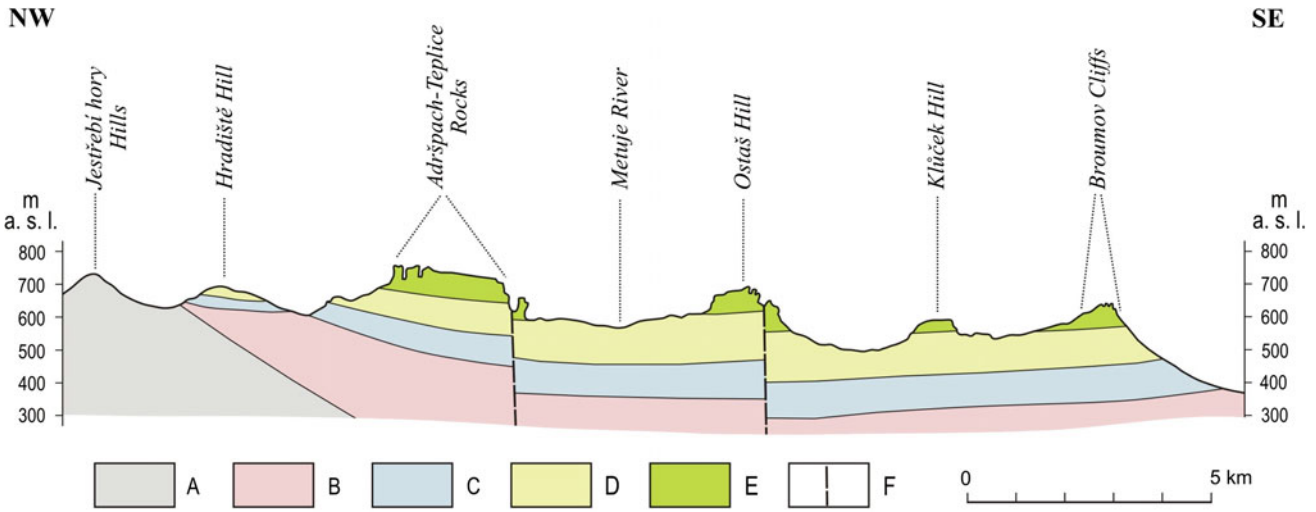

Fig. 17.2 Profile of the central part of the Intra-Sudetic Basin in the northeastern Bohemia. *A* Upper Carboniferous, *B* Permian, *C* Triassic, *D* Late Cretaceous, *E* Late Cretaceous—block sandstones with rock cities, *F* Signifiant faults (Modified after Tásler et al. 1979)

horizontal and also in vertical direction (Tásler et al. 1979; Vejlupek 1986). The most distinctive fault is the Police Fault (or Police Fault zone) running in NW–SE direction and the most distinctive cross fault is the Skály fault in perpendicular SW–NE direction. Joint systems in sandstones and other compact rocks have practically identical directions. The brachysyncline of the Police Basin is an important reservoir of drinking water which is accumulated in the Late Cretaceous sediments.

17.3 Plateaus and Cuestas

Rock cities in the thick-bedded sandstones of the Broumov Highland have evolved within tableland plateaus or on smaller mesas, or they are parts of asymmetric ridges—cuestas (Fig. 17.3). Most of these elevations create significant dominants of the landscape. From the morphogenetic point of view tablelands, mesas, and cuestas are denudational landforms whose origin and evolution was largely controlled by structural (lithological and tectonic) conditions. They were formed by activity of stream erosion, weathering processes, and gravitation slope movements (Balatka and Sládek 1984; Demek and Kopecký 1994; Härtel et al. 2007). Sandstone tablelands and mesas, which appear in the central part of Police Basin, are relicts of presence of the youngest layers of Late Cretaceous sediments (stratigraphic unit Turonian—Coniacian) in the Intra-Sudetic Basin (Dvořák 1968; Vejlupek 1986). Quartzose sandstones—with grains of diameter of 0.1–0.5 mm big—with clayey and also ferruginous cement are predominant. Ferruginization of sandstones happens particularly near by faults (Adamovič et al. 2002). Inclination of sandstone layers is low in flat, central part of the Police Basin (on average 5° to the axis of the basin), and it increases toward its margins. Proper conditions for the formation of rock cities occurred especially along the jointed edges of table plateaus and mesas (Fig. 17.4).

The most extensive tableland (almost 20 km^2) is the plateau of *Adršpach-Teplice Rocks* situated in the northern part of the Police Basin. From the northern up to the eastern edge of this tableland, the Metuje River incised into the plateau and separated smaller sandstone rocky hills (mesas): Křížový vrch Hill (668 m), Lada Hill (623 m), Lysý vrch Hill (611 m) etc. The narrow sandstone ridge named Skalský hřbet (698 m) was dislocated by tectonic fault (Skály fault) from the southern slope of tableland of Adršpach-Teplice Rocks.

The mesa of Ostaš (700 m), exceeding its surrounding by about 200 m, forms a distinct elevation in the middle part of the Police Basin. The structural plateau on the top is 500 × 400 m in dimensions and inclined in SW-SSW direction, following the dip of sandstone layers. This plateau is bordered by rocky walls on all sides. These rocky walls can be up to 40–60 m high. The NE slope is of tectonic origin and the block of Kočičí skály (rock city Dolní bludiště—Lower Labyrinth) was downthrown along the Police Fault due to faulting in the Neogene. In the apical part of the structural platform of Ostaš there are frequent forms of weathering and denudation of siliceous sandstones (rock city Horní bludiště—Upper Labyrinth, with tors, mushroom rocks, rock windows, rock hollows, and small caves). The western edge of the plateau and the adjoining part of the slope are affected by rock creep processes, with creation of deep crevices (including crevice-type caves), a system of deflected and collapsed rock blocks (Vítek 1979; Demek and Kopecký 1994). These processes, conditioned by inclination

Fig. 17.3 Southeastern part of Broumov Cliffs with its asymmetric table hills of Božanovský Špičák (on the *left*) and Koruna (on the *right*) (*Photo* J. Vítek)

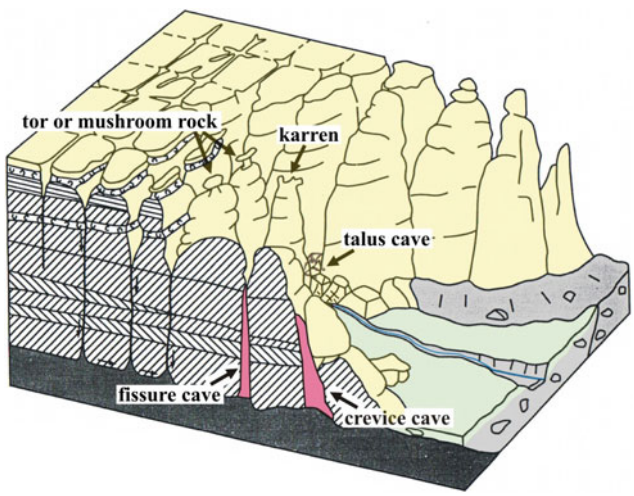

Fig. 17.4 Scheme of development of a sandstone rock city and pseudokarst forms (Modified after Čech and Gawlikowska 1999)

of layers of block sandstones, are recently active (Stemberk et al. 1994).

The marginal parts of the Police Basin are composed of discontinuous cuesta ridges in the NE, NW, and SW part of the basin. Inward backslopes of cuestas, broadly concordant with the inclination of layers, are low angle surfaces, while front escarpments are steep, with rocky rims in some places. Slopes of cuestas are dissected by canyon-like valleys which are filled with fallen boulders. Distinct rock cities of block sandstones (stratigraphic unit Middle Turonian, Dvořák 1968) were created particularly in the Broumov Cliffs (Broumovské stěny). In the SW part of this area, largely on the territory of Poland, they are followed by the Góry Stołowe mountains, protected in the Góry Stołowe National Park (Witkowski et al. 2008). The top of the sandstone table mountain of Szczeliniec Wielki (919 m) is the highest peak in the whole area of the Bohemian Cretaceous Basin.

17.4 Adršpach–Teplice Rocks

The best known and also the largest rock city occupies the table plateau of Adršpach-Teplice Rocks (Adršpašsko-teplické skály). It covers an area of 20 km^2 and is the most extensive, continuous complex of sandstone rocks in the Czech Republic (Mikuláš et al. 2007). The present-day tableland is a relict of an originally more extensive area made up from quartzose block sandstones in the northern

part of the brachysynclinal Police Basin. The axis of the basin slopes slightly from the northeast to the southwest, whereas sandstone layers are inclined toward the axis line of the basin, to SW and NE on respective side of the syncline. The highest hill—Čáp (786 m)—is located in southwestern part of the plateau. The thickness of the sandstone layer (stratigraphic unit Turonian–Coniacian) reaches up to the 120 m (Dvořák 1968; Čech and Gawlikowska 1999). Distinct sandstone units with diagonal bedding may be seen in the stratigraphic column exposed in the rock cities (Adamovič et al. 2010). The plateau is disrupted by tectonic faults and fissures which have had huge importance for the development of landforms, including rock cities. The area is split into two parts. The smaller part in the north is called the Adršpach Rocks (*Adršpašské skály*), named after the nearby village of Adršpach. The Teplice Rocks (Teplické skály), named after the town of Teplice nad Metují, are located in the south. A canyon-like valley named Vlčí rokle crosses the table plateau in WNW–ESE direction and defines a 6-km-long border between these two rock cities. The whole area of Adršpach-Teplice Rocks is largely covered with spruce forests, also birch trees and European mountain ashes are frequent. The remains of the native pine vegetation are preserved on the exposed rock outcrops.

Adršpach-Teplice Rocks National Nature Reserve—Národní přírodní rezervace Adršpašsko-teplické skály (with an area of 18.03 km^2) was established in 1933.

17.4.1 Adršpach Rocks—Breathtaking Rock City

A typical rock city is represented particularly by the Adršpach Rocks, located in the north of the table plateau (Fig. 17.5). The sandstone plateau is dissected by deep canyons and gorges; its development was mainly controlled by the presence of subvertical fissures or joints systems. The narrow parts of gorges are locally called "streets" and the wider parts are called "squares". River erosion has influenced the development of gorges, whilst mechanical weathering (mainly gelivation) of sandstones in the zones of increased frequency of subvertical joints significantly contributed to the evolution of gorge walls (Vítek 1979) (Fig. 17.6). The upper reach of Metuje River is located in the

Fig. 17.5 Northeastern edge of the plateau of the Adršpach-Teplice Rocks (rock group "Království"—Kingdom) (*Photo* J. Vítek)

Fig. 17.6 Narrow canyons and fissure caves are formed by weathering and erosion of densely fissured sandstones ("Sloní náměstí"—Elephant Square in Adršpach Rocks) (*Photo* J. Vítek)

main valley of the Adršpach Rocks. In the central part of the rock city, the river makes two waterfalls, with the Upper Waterfall—Horní vodopád, open to public, being 16-m-high and hidden in a rocky shaft. The gorge above the waterfall has been modified to a man-made small lake where tourists can enjoy boat rides.

As a result of erosion and weathering processes as well as gravity-driven slope movements, the northern edges of the sandstone plateau and narrow rock ridges are divided into solitary towers and groups of pillars which create a typical rock city (Fig. 17.7). The most massive towers are 70–100 m high. Most of them are close to tourist trails. The towers have various names, e.g. Milenci (Lovers) (Fig. 17.8), Starosta a Paní starostová (Mayor and Mrs. Mayor) (Fig. 17.7), Král (King) (Fig. 17.5), Homole cukru (Sugar Loaf), etc. The rock cities are favorite destination of rock climbers.

Many minor landforms were formed by processes of differential (mechanical and chemical) weathering and denudation which exploited unequal resistance of different units within the sandstones. These processes formed various rock perforations (Fig. 17.8)—rock arches and windows (e.g. Čertův most—Devils` Bridge, Džbán—Pitcher, etc.). The surface of rock walls has a rich mosaic of microforms—rock ledges on harder bedding planes (some of them highlight the progress of diagonal bedding), small rock hollows, rock basins (also weathering pits), and karren. Unlike other areas of sandstone in the Bohemian Cretaceous Basin microforms genetically related to salt weathering, such as honeycombs, are rare (Mikuláš et al. 2007).

17.4.2 Mysterious Teplice Rocks

The Teplice Rocks occupy a bigger, southern part of the plateau of the Adršpach-Teplice Rocks. A distinct ferruginization of sandstone cement occurred close to the tectonic faults, particularly secondary cementation by iron oxyhydroxides (Adamovič et al. 2002). Massive rock walls are typical for the area of Teplice Rocks. These walls are

Fig. 17.7 Adršpach rock city with its rock towers "Starosta a Paní starostová" (Mayor and Mrs. Mayor) (*Photo* J. Vítek)

hundreds of meters long and up to the 60 m high (e.g. Chrámová stěna and Martinská stěna in the southernwest part of the area). More expensive rock cities are rare and can be found, e.g., around the perimeter of Skalní ostrov, in Anenské údolí, Supí skály, Skalský hřbet, and in other places.

The sandstone plateau is dissected by a system of canyons and gorges. Their orientation follows the orientation of fissures and joint systems. Major valleys are Vlčí rokle and the canyon of Skalní potok. A number of side gorges runs to these valleys. Some of these valleys are connected with each other at almost right-angles; they are very narrow and tens of meters deep, e.g., gorges named Siberia (Sibiř) and Underworld (Podsvětí), Large and Small Temple Square (Velké a Malé Chrámové náměstí), etc. Many of these gorges are inaccessible because their bottom is filled with collapsed blocks and boulders. In some gorges, talus caves exist in gaps between collapsed boulders. These caves are usually hardly accessible or require crawling. For example, the of cave Teplická jeskyně (Teplice Cave), situated in boulder chaos at the bottom of one canyon, is 1065 m long and it is the longest pseudokarst cave in the Czech Republic (Cílek and Kopecký 1998). Weathering of sandstones creates narrow and deep fissures along the joint systems, while gravitation movements of rock blocks transform them into open crevices and crevice-type caves (Vítek 1979); the example of such a cave is Skalní chrám—Rock Dome (45 m long, 50 m high and 1–2 m wide) which is close to the marked hiking trail. The total length of "pseudokarst system" in the central part of the Teplice Rocks is estimated to be 20 km (Mlejnek et al. 2009), but the research is not complete so far. In one smaller pseudokarst cave of the Teplice Rocks, the presence of the so-called root stalagmites (Fig. 17.9) was recorded for the first time in the Czech Republic (Vítek 1980).

Mesoforms and microforms of selective weathering and denudation of sandstones are abundant in the Teplice Rocks. Rock formations (tors) stand out from the surface of the sandstone plateau in some places. They are characterized by

Fig. 17.8 Rock formation "Milenci" (The Lovers), situated in the middle of the Adršpach Rocks, belongs to the highest rock towers (over 100 m) in the sandstone rock cities of the Czech Republic. Diagonal bedding is noticeable (*Photo* J. Vítek)

Fig. 17.9 Root stalagmite at the bottom of a talus cave in the Teplice Rocks (*Photo* J. Vítek)

diverse shapes. Following variable resistance of adjacent layers, mushroom rocks are created. The "cap" of a mushroom rock is formed from more resistant layers and the "stem" is built by less-resistant layers, usually more porous, and/or thinly bedded. Other surface microforms are rock hollows, karren (e.g. on the top of the formation called Rock Crown–Skalní koruna, Fig. 17.10), rock basins (weathering pits), etc. Contoured shapes of ferruginous incrustations close to the Police Fault in the southern part of the Teplice Rocks are remarkable (Adamovič et al. 2002, 2010).

17.5 Broumov Cliffs

A distinctive sandstone area in the northwest Bohemia is the Broumov Clifs (Broumovské stěny) which are made of quartzose sandstones and arkosic sandstones of Middle Turonian age (Dvořák 1968; Čech and Gawlikowska 1999). The asymmetric ridge (cuesta) of Broumov Cliffs takes an area of 10 km^2 and divides the Police Basin in the south-west from the Intra-Sudetic Basin in the northeast (Fig. 17.2). The ridge is 12 km long in NW–SE direction and gets higher in the same direction (from Honský Špičák, 662 m, at the NW edge to Božanovský Špičák, 773 m, at the SE extremity). The sandstone area continues from the pass of Machovské sedlo (620 m) in the southeasterly direction and makes Góry Stołowe Mts. in Poland (Migoń 2008). The southwestern slope of the cuesta follows the dip of sandstone layers pointing into the middle of the Police Basin. The opposite northeast-facing front slope creates the escarpment of Broumov basin up to 250 m high (Fig. 17.3). Somewhat different situation is in the southeast, highest part of this area (Adamovič et al. 2010). Slightly inclined structural plateaus (hills Velká kupa. 708 m, Signál, 708 m, Koruna, 769 m, Božanovský Špičák, 773 m) are set aside according to the tectonic faults. The total height of the escarpment exceeds 300 m. The whole area is covered by forest, with predominance of spruce, birch, and pine.

Both the front and the backslope of the cuesta of Broumov Cliffs are not continuous but dissected by a series of rocky gorges. Consequent valleys, which incise into the

Fig. 17.10 Teplice Rocks—"Skalní koruna" (Rock Crown) rock tower, with sandstone karren at the top (*Photo* J. Vítek)

gently inclined southwestern slope, are longer and occupied by left-side tributaries of river Metuje (itself a tributary of the Labe (Elbe) river). The most attractive example is a 1.5 km long and up to 70-m-deep canyon named Kovářova rokle (Blacksmith's Gorge) (Fig. 17.11) between the tourist cottage Hvězda and the village of Hlavňov. Obsequent rocky gullies, which intersect the steep northeastern slope, are shorter and contribute runoff to the river Stěnava (Odra drainage basin). For example, Zaječí rokle, Třešňová rokle and others are highly rugged and up to 70 m deep. The bottom of some gorges is filled with collapsed sandstone blocks and boulders. Hardly accessible talus caves were created in gaps between boulders (e.g., 400-m-long cave Jeskyně pod Luciferem). Gravitational deflection of rock blocks in the edge area of the cuesta creates narrow crevices and pseudokarst crevice caves. An impressive rock formation is 5-m high rock gate Kamenná brána (Rock Gate) (Fig. 17.12) on the top of Velká kupa hill.

Typical rock cities, with their characteristic assemblages of high rock towers and pillars, are not plentiful in the Broumov Cliffs. There are only small clusters, e.g., in the upper part of the canyons of Kovářova rokle (Skalní divadlo—Rocky Theater) and Zaječí rokle, in the segmented edge of the cuesta (Strážná hora, 689 m, Modrý kámen, 686 m, Signál, 708 m). Weathering and denudation of sandstone layers dissimilar resistance underpins various rock shapes, including rugged tors in the upper parts of plateaus and ridges. The so-called mushroom rocks, present among others above the villages of Slavný and Bělý, on the plateaus of

Fig. 17.11 Consequent valley in Broumov Cliffs—sandstone canyon "Kovářova rokle" (Blacksmith's Gorge) (*Photo* P. Migoń)

Fig. 17.12 Rock formation "Kamenná brána" (Rock Gate) has come into existence by disintegration of the rocky edge of the cuesta of Broumov Cliffs (*Photo* J. Vítek)

Fig. 17.13 Sandstone tor (mushroom rock) on the plateau of Broumov Cliffs near the village of Slavný (*Photo* J. Vítek)

Božanovský Špičák, Signál, and in many other places, are the most characteristic examples (Fig. 17.13). The top surface of the Božanovský Špičák hills is particularly rich in emerging rock formations of diverse shapes, often resembling animals. Hence, the whole area is informally named 'Skalní zvěřinec" (Rock Menagerie), with individual formations such as Velbloud—Camel, Želva—Turtle, Varan—Monitor, Kočička—Cate, Kačenka—Duck.

Rock basins (weathering pits) and karren are the most common examples of rock microforms (Vítek 1979). For example, in a part of Strážná hora hill (688 m) at the northwestern edge of the Broumov Cliffs rock basins up to 2 m wide and 0.5 m deep are cut into the rock surface. Some of them are filled with soil and overgrown. In the same locality and in other places (e.g., in Božanovský Špičák), one can also find 10–40 cm deep rillen karren.

In the central part of the Broumov Cliffs, in a place called Hvězda (Star), a baroque chapel from the year 1733 and stylish inn are located and contribute to the cultural heritage of the area (Fig. 17.14).

Fig. 17.14 Baroque chapel "Hvězda" (*Star*) in the central part of Broumov cliffs (*Photo* J. Vítek)

17.6 Rock Cities and People

Rock cities in the Broumovsko Protected Landscape Area—especially the Adršpach-Teplice Rocks and the Broumov Cliffs—belong to the most attractive and the most popular natural areas in the Czech Republic. Humans were interested in these rocks already from the Middle Ages (Cílek et al. 1998; Härtel et al. 2007; Adamovič et al. 2010; Migoń and Latocha 2013). Three castles were built on the marginal rocky cliffs: Adršpach was built on Starozámecký vrch next to the village of Dolní Adršpach, Střmen was built in the entry part to the Teplice Rocks and Skály (Katzenstein) was built on Skalský hřbet in the vicinity of Teplice nad Metují. The purpose of these castles was to guard the borders of the land. Nowadays, we can see only small rests of these castles. Historical data tells us that people began to permeate the hardly accessible rocky terrain relatively late. First access roads were made for the purpose of tree felling and timber transport. From the first half of the eighteenth century, these paths were rearranged to provide easier access for visitors. Already in the year 1790, the German poet and geologist J. W. Goethe visited the Adršpach Rocks and the Teplice Rocks. Today, the most interesting places are accessible via marked hiking trails and educational trails. About 250,000 tourists visit the Adršpach Rocks and about 50,000 tourists visit the Teplice Rocks every year (entry into the both rock cities is chargeable).

Sandstone rock formations in the Broumovsko Protected Landscape Area belong to the most valuable climbing terrains in the Czech Republic, offering also the most demanding climbing. Over 1800 rock towers were climbed in the Adršpach-Teplice Rocks (Adamovič et al. 2010). Rock climbing is also possible in selected terrains of the Broumov Cliffs, on the mesa of Ostaš, in the Kočičí skály Rocks and on Křížový vrch hill.

17.7 Conclusion

The Adršpach-Teplice Rocks and the Broumov Cliffs belong to the most precious and most visited geomorphological sites in the Czech Republic. They are strictly protected and are listed as National Nature Reserves. Both localities are representative examples of sandstone relief which has developed on the sharply demarcated plateaus and asymmetric ridges (cuestas). The course and pace of geomorphological processes, especially erosion and gravitational slope movements, were significantly controlled by lithological, structural, and tectonic conditions. Some sandstone landforms in

these rocky areas have record dimensions within the sandstone areas of Central Europe. For example, the Adršpach Rocks are the most extensive continuous rock cities and some rock towers are over 100 m high. Another example is the longest pseudokarst talus cave (Teplická Cave). It is situated at the bottom of the craggy canyon of Teplice Rocks and is 1065 m long. Also some mesoforms and microforms of sandstone relief, e.g., rock perforations, mushroom rocks, rock basins (weathering pits), various types of karren, which attract the attention of the visitors. It is unquestionable that many extraordinary geological formations are still waiting for discovery in the rugged and hardly accessible rocky terrain.

References

Adamovič J, Cílek V et al (2002) Ironstones of the Bohemian Cretaceous Basin. Knihovna České speleologické společnosti. Praha, 38, 170 pp

Adamovič J, Mikuláš R, Cílek V (2010) Atlas pískovcových skalních měst České a Slovenské republiky. Academia, Praha, 460 pp

Balatka B, Sládek J (1984) Typizace reliéfu kvádrových pískovců české křídové pánve. Rozpravy Československé akademie věd, Řada matem. přír. Věd. Academia, Praha, 94, 6, 80 pp

Bína J, Demek J (2012) Z nížin do hor. Geomorfologické jednotky České republiky. Academia, Praha, 344 pp

Cílek V, Kopecký J et al (1998) Pískovcový fenomén: klima, život a reliéf. Knihovna České speleologické společnosti, 32. ČGS, Praha, 174 pp

Čech S, Gawlikowska E (1999) Góry Stołowe, mapa geologiczno-turystyczna. Adršpašsko-teplické skály, geologická mapa pro turisty. Państwowy Instytut Geologiczny, Český geologický ústav. Warszawa, Praha

Demek J, Kopecký J (1994) Geomorphological processes and landforms in the southern part of the Polická vrchovina Highland (Czech Republic). GeoJournal 32(3):231–240

Demek J, Mackovčin P et al (2006) Zeměpisný lexikon ČR. Hory a nížiny. Agentura ochrany přírody a krajiny ČR, Praha, Brno, 582 pp

Dvořák J (1968) Stratigrafie, litologie a podloží svrchní křídy ve vnitrosudetské pánvi. Věstník Ústředního ústavu geologického 43:423–430

Härtel H, Cílek V, Herben T, Jackson A, Williams R (eds) (2007) Sandstone Landscapes. Academia, Praha, 496 pp

Chlupáč I et al (2002) Geologická minulost České republiky. Academia, Praha, 436 pp

Migoń P (2008) Rzeźba i rozwój geomorfologiczny Gór Stołowych. Przyroda Parku Narodowego Gór Stołowych. In: Witkowski A, Pokryszko B, Ciężkowski W (eds) Przyroda Parku Narodowego Gór Stolowych. PNGS, Kudowa Zdrój, pp 49–69

Migoń P, Latocha A (2013) Human interactions with the sandstone landscape of Central Sudetes. Appl Geogr 42:206–216

Mikuláš R, Adamovič J, Hájek A, Spíšek J (2007) Adršpašsko-teplické skály Cliffs and Ostaš Hill (Czech Republic). In: Härtel H et al (eds) Sandstone Landscapes. Academia, Praha, pp 332–335

Mlejnek R, Ouhrabka V, Růžička V (2009) Poseidon – a complex system of underground spaces in sandstone in the Czech Republic. NSS News 67(8):4–7

Stemberk J, Košťák B, Kopecký J (1994) Deformations in sandstones due to table hill desintegration. Zeszyty Naukowe Akademii Rolniczej we Wrocławiu 255(7):187–193

Tásler R et al (1979) Geologie české části vnitrosudetské pánve. Ústřední ústav geologický, Academia, Praha, 296 pp

Vejlupek M (1986) Strukturní stavba polické a svatoňovicko-hronovské pánve. Věstník Ústředního ústavu geologického 61(3): 139–148

Vítek J (1979) Pseudokrasové tvary v kvádrových pískovcích severovýchodních Čech. Rozpravy Československé akademie věd, Řada matem. přír. Věd. Academia, Praha, 89, 4, 58 pp

Vítek J (1980) Die Wurzelstalagmiten auch in Sandsteinhöhlen Böhmens. Der Höhlernforscher, 12, 1, pp 1, 12

Witkowski A, Pokryszko B, Ciężkowski W (2008) Przyroda Parku Narodowego Gór Stolowych. PNGS, Kudowa Zdrój, 404 pp