B GEOLOGICAL HERITAGE

B.1 Geological conditions of the area

Regional geological characteristics of the Iron Mountains National Geopark

The Iron Mountains National Geopark (IMNG) lies around the contact of several regional geological units. The Bohemian Massif is the most extensive relict of the Variscan Orogen in Europe. As such, it often attracts visitors for its varied geological composition. Geological variety of the Iron Mountains over a relatively small area can be presented within one or two days, which makes this area an exceptional phenomenon within the whole of Europe (see the practical sample of the geological excursion "History of the Earth in two days", freely available also at website http://www.geovedy.cz/cs/files/Geovedy_Brozura_ZS_A5_web.pdf). Scientists and renowned geologists of the past were aware of this fact and studied the Iron Mountains region. Historical line of their activities is shown in Fig. 9.

Fig. 9. Early times of geology and history of research in the Iron Mountains. Source: IMNG Archive.

General geological characteristics of the IMNG area are based on the regional geological pertinence of its separate parts (Fig. 10). Much like the whole Bohemian Massif, the Iron Mountains represent a component of the Variscan Orogen. Based on current knowledge, the western part of the IMNG area is ranked within the Teplá-Barrandian Zone – the so-called Bohemicum. This includes the so-called Iron Mountains Proterozoic and the Iron Mountains (or Chrudim) Paleozoic. Central

part of the IMNG area is formed by plutonic rocks of the Iron Mountains plutonic complex (Iron Mountains or Nasavrky pluton) and the Oheb Crystalline Complex. This complex belongs, in terms of the regional geological subdivision, to the Kutná Hora–Svratka region which is, in turn, ranked to the Moldanubicum *s. l.* The eastern part of the area is formed by rocks of the so-called Hlinsko Zone (Rhenohercynicum) and rocks of the Polička Crystalline Complex (Moldanubicum). The area is also reached by rocks of the Kutná Hora Crystalline Complex (Chotěboř area) and the Svratka Crystalline Complex (area of Otradov and Proseč).

These pre-Variscan and Variscan units are overlain by post-orogenic rocks of the "platform" units. The oldest of these rocks are represented by a relict of the Permo-Carboniferous Jihlava Graben near Kraskov. Cretaceous sediments are of wide areal distribution, located along the western, northern and eastern limits of the IMNG. They concentrate to the „Long Furrow" area and the Chrudim area. Tertiary rocks are dominated by volcanics at the Košumberk Castle near Luže (Fig. 11).

Quaternary rocks have a wider distribution in the area of Rosice and Chrtníky. They have the character of loess rich in molluscan fauna. Quaternary processes (mostly weathering and erosion) are prominent at a number of sites, taking their share in the geomorphic character of the whole area. As such, they pose a vital aspect of the Geopark geology. Below, you can find the descriptions of the individual regional geological units lying in the Geopark territory.

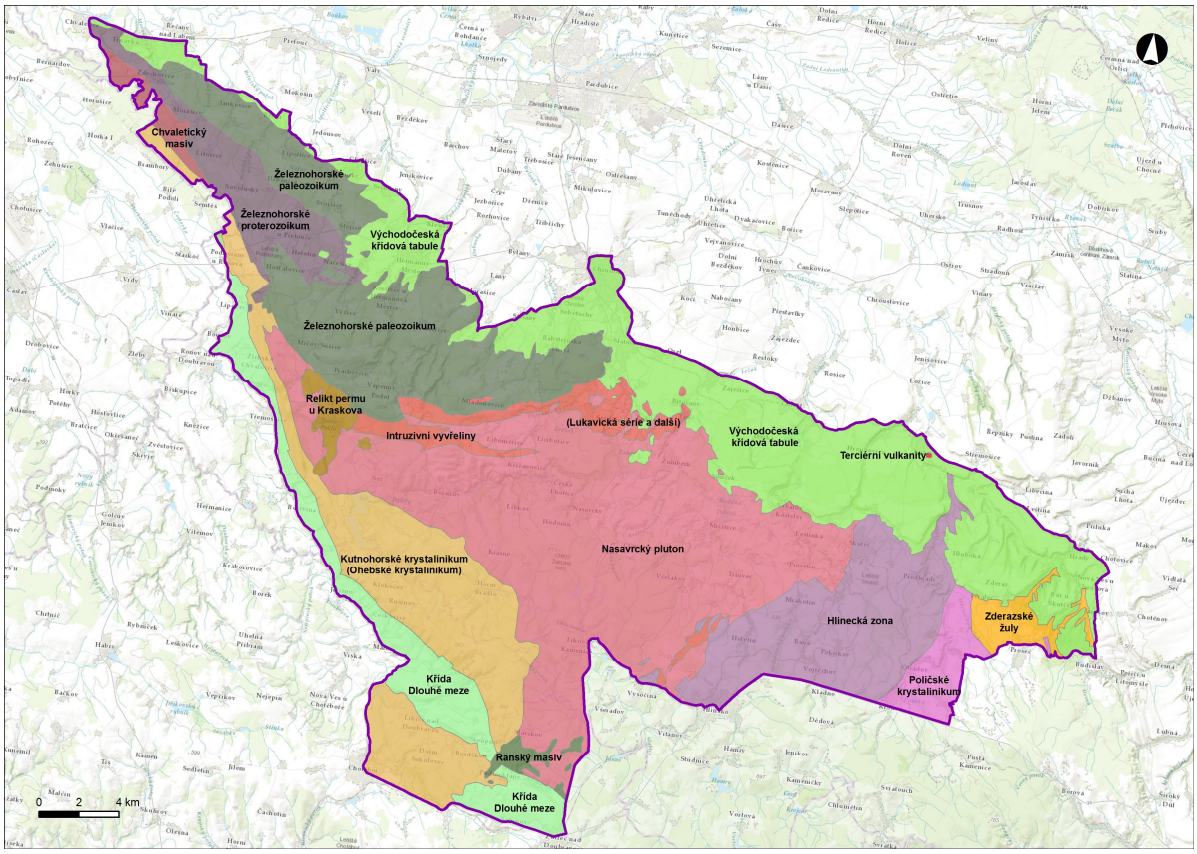

Fig. 10. Geological subdivision of the territory of the Iron Mountains National Geopark with designated regional units.

Fig. 11. Ruins of the Košumberk Castle built on Tertiary basalt (a painting from the 19th century).

Iron Mountains in different periods of geological history

Proterozoic

Proterozoic is the oldest geological unit represented in the Geopark territory. It is generally constrained by ages 2.5 billion years to 542 million years. The oldest rocks within the Geopark have been dated to less than 700 million years. During their long history in the Iron Mountains, the Proterozoic rocks were subjected to several major pressure and temperature changes. As a result, most rocks of this age have been markedly metamorphosed.

The Proterozoic era in the Iron Mountains is connected with two important phenomena. One of them is volcanic activity, both subaquatic and subaerial. Prominent superficial products like volcanic cones have not been preserved till these days. In spite of this, there are many sites displaying clear evidence – often very peculiar – of volcanic activity.

Another phenomenon is linked with the presence of the Iron Mountains Fault. This major structure is now well visible because it was associated with the uplift of the Iron Mountains by 600 m or more (Fig. 12). This uplift did not take place within a single day, of course: it lasted several million years. The presence of major deep-reaching ruptures allows the ascent of hot fluids. Such process along the Iron Mountains Fault resulted in the origin of ores and other minerals. Large accumulations of minerals represent deposits which can be – in ideal case – exploited. The high number of mineral deposits along the Iron Mountains Fault also gave name to the adjacent mountain range.

Fig. 12. The range of the Iron Mountains from the southeast (12a) and northwest (12b).

Moldanubicum

Moldanubicum is represented by several lower-order units in the territory of the IMNG. The largest area is covered by the Oheb Crystalline Complex in the SW and W parts of the area, a unit ranked to the Kutná Hora–Svratka Region (Moldanubicum *s. l.*). Lithologically most abundant types are red orthogneisses intercalated with fine-grained biotite paragneisses and amphibolites. Quartzitic paragneisses and serpentinites are also present. Stratigraphic rank of the meta-sedimentary units and the age of pre-Variscan orthogneisses are unknown.

Rocks pertaining to the Kutná Hora Crystalline Complex are exposed to the south of the Oheb Crystalline Complex, in the E and NE surroundings of Chotěboř. They are represented by reddish orthogneisses, banded migmatites and biotitic greywacke paragneisses. Two-mica migmatites and biotitic migmatites are present in the immediate surroundings of Chotěboř. Rocks in the E part of the Geopark area (around Otradov and Proseč) are ranked to the Svratka Crystalline Complex. They are dominated by porphyroclastic orthogneisses with frequent intercalated bodies of amphibolites, limestones and skarns.

Paleozoic

Paleozoic is the general term for the era constrained by the ages of 542–251 million years. This long stage in the Earth history is subdivided into several periods. Each of the periods is represented – at least to a limited degree – in the Geopark territory. The Paleozoic era is linked with one of the most typical and most famous fossil representatives: a trilobite. This ancient arthropod can be found at several sites in the IMNG. Its finds are sporadic and rare, with only several dozens of individuals collected during the whole history of paleontological research in this area (Fig. 13). Much more abundant fossil finds in the Geopark territory include cephalopods with straight, conical shells (genus *Orthoceras* or similar), brachiopods (a group similar to bivalves), and crinoids which belong to the group of echinoderms. The Mrákotín area yielded finds of yet another interesting group: graptolites. At a first glance, graptolites resemble shiny lines on dark stone; in fact, these are colonies of tiny organisms ranked among the group of hemichordates.

Paleozoic rocks in the Geopark territory posed an important source of building material, especially in the past. Very hard Ordovician quartzites were used for the construction of buildings. Today, one of the largest and most attractive quarries in the Geopark – the Prachovice Quarry – is opened in the Paleozoic rocks: Silurian and Devonian limestones (for Silurian geology in the IMNG. The importance of this area in the past and present is stressed by the educational trail “Around the Prachovice Quarry”. The trail also provides views of otherwise inaccessible mining area. Occurrences of Late Paleozoic (Permo-Carboniferous) rocks in the IMNG area are rare, being concentrated solely to the area of Kraskov near Seč. Reddish fluvial sandstones to conglomerates locally contain finer-grained tuffitic beds.

These fluvial sediments were reported to yield rare finds of fossilized wood (araucarites). The relict near Kraskov documents the southern end of the so-called Jihlava Graben, which developed on the deep-seated Přibyslav Fault. Besides this relict, isolated occurrences of Permo-Carboniferous rocks of the Jihlava Graben have been also described from the SW surroundings of Hradec Králové.

Fig. 13. Brloh. A quarry face in quartzite (Paleozoic – Ordovician) and boulders of the surf facies (Mesozoic – Cretaceous). The quartzites contain trilobite fauna.

Mesozoic

In contrast to the Paleozoic record, Mesozoic rocks preserved in the Geopark represent only a relatively short time span (ca. 100–85 million years). In spite of this, the Geopark features sites with unique geology, which are worth our attention.

The period represented by the preserved Mesozoic sediments was marked by the biggest known flooding of land surface in the whole Earth history. This flooding resulted in the origin of a number of shallow, relatively warm seas with flourishing life. Then, most of the Geopark area was lying under the water. Some places, however, were lying near the shoreline. Such places now display effects of ancient sea surf – large, abraded boulders (Fig. 13).

After moving only a few hundred metres basinward, the visitor finds himself in an "open" sea full of sharks, fish, bivalves and cephalopods. Abundant remains of these organisms can be also found in the sedimentary record today (Fig. 14.).

The wide variability in environmental conditions over a small area is also documented by the occurrences of freshwater and swamp environments. Such sites contain fragments of Cretaceous coal together with remains of leaves and stems of plants inhabiting the Cretaceous swamps.

Fig. 14. Chrtníky. A quarry in basaltic rocks (Ordovician) and marlstones (Cretaceous) containing marine fauna. Excursion of the secondary grammar school from Chrudim.

Tertiary

Tertiary rocks are not too abundant in the IMNG area. Notable is the intrusion of olivine basalt at Košumberk Hill near Luže, which is the easternmost product of Neoidic volcanism in Bohemia. Besides olivine nodules, the rock displays typical columnar jointing.

Among other Tertairy rocks, worth mentioning are especially fluvial clayey-silty gravels found in a small relict SW of Trhová Kamenice, ca. 13 m above the present flood plain of the Chrudimka River. Tertiary gravels have been reported also from the Seč area.

Quaternary

Quaternary sediments in the territory of the IMNG are represented by relatively monotonous complexes (loams, eluvial sediments). Accumulations of colluvial sediments have been mapped on the slopes of the Iron Mountains. Relatively instructive outcrops are those in relics of fluvial terrace sediments along the Chrudimka and Novohradka rivers, and the accumulations of loess loams in the Chrudim area. The latter were formerly subjected to exploitation for brick production. Sporadically developed eolian sediments form rather significant accumulations in the areas of Sovolusky, Litošice and Chvaletice.

B.2/B.3 Geosite list and descriprion

At present, more than 100 sites and geosites are described in detail from the territory of the IMNG. Besides their scientific and educational values, they have a potential for the development of "geological stories". Their positions are shown on a map (Fig. 15).

The selection of the geosites is based on 40-years' experience of regional geologists († Dr. Vodička, † Dr. Hruška, † Dr. Chlupáč and Dr. Smutek) from Charles University in Prague, Czech Geological Survey in Prague and from the company of Water Resources Chrudim.

Geologically significant sites – geosites, supplemented with general descriptions in Chapter B.2, are listed in a simplified review (Fig. 15.). The list of geosites also includes significant geological sites registered by the Czech Geological Survey (www.geology.cz).

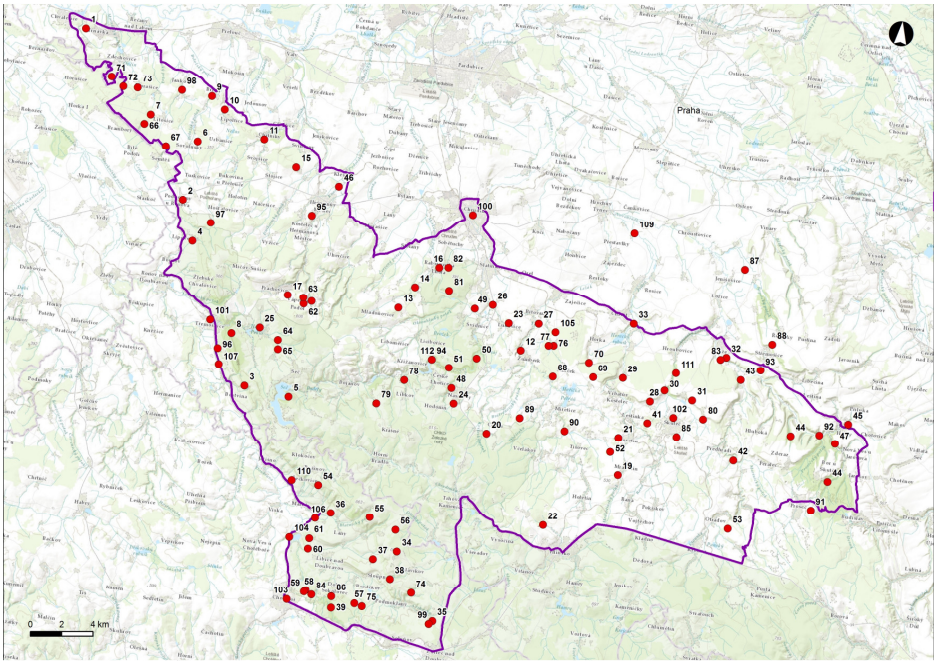

Fig. 15. A map of geosites in the Iron Mountains Geopark.

Determination of significant geological sites, geosites, and their descriptions

The table below gives a full list of geosites in the Iron Mountains Geopark, consistent with the database of significant geological sites registered by the Czech Geological Survey in Prague (www.geology.cz).

Site name	Identification No.	Site name	Identification No.
Chvaletice	1	Křemenice	56
Podhořany	2	Ševcova skalka near Obora	57
Běstvina-Javorka	3	Koukalky	58
Licoměřice	4	Chotěboř B82	59
Oheb	5	Libice nad Doubravou – skarn	60
Skalka u Sovolusk	6	Hradiště – sand pit	61
Litošice	7	Podolská jeskyně Cave	62
Lichnice-Kaňkovy hory	8	Páterova jeskyně Cave	63
Brloh	9	Havířské jámy	64
Lipoltice	10	Žďárec u Seče	65
Chrtníky	11	Semtěš-Vlčí skála	66
Žumberk	12	Semtěš – lime kiln	67
Deblov	13	Bošov	68
Rabštejn	14	Hlína	69
Raškovice	15	Mezihoří	70
Na Skalách	16	Obří postele	71
Prachovice	17	Morašice – quarry	72
Vápenný Podol	18	Morašice – waste dump	73
Mrákotín u Skutče	19	Hudeč	74
Ctětín	20	Obora – calc-silicate rocks	75
Prosetín	21	Studená Voda – quarry	76
Srní	22	Kamenné stádo	77
Lukavice	23	Libkov – quarry	78
Nasavrky	24	Polánka – limestone	79
Kraskov	25	Malhošť	80
Škrovád	26	Jeskyně u tyrolského domku Cave	81
Bítovany-Farář	27	Podhůra – quarry	82
Skutíčko	28	Novohradka River valley downstream of Košumberk	83
Vrbatův Kostelec-Farář	29	Geofond area	84
Přibylov	30	Humperky	85
Štěpánov u Skutče	31	Horní Sokolovec – sand pit	86
Luže-Košumberk	32	Jenišovice	87
Podlažice	33	Střemošická stráň	88
Vestec	34	Švihůvek	89
Horní Studenec	35	Ležáky	90
Blatnice	36	Proseč – quarry	91
Kladruby u Libice	37	Kapalice	92
Sloupno – quarry	38	Bílý Kůň – spring	93
Doubrava River valley	39	Křižanovice	94
Leštinka area quarries	41	Kostelec u Heřmanova Městce – quarry	95
Rychmburk – Šilink Mine	42	Skalky u Lhotky	96
Doly near Luže	43	Březinka	97
Maštale	44	Seník	98
Pivnice	44	Horní Studenec – quarry	99
Nákle	46	Bezlejov	104

Roudná	47	Studená Voda – field	105
Nasavrky – quarry	48	Hranice u Malče	106
Hrobka	49	Křížovka	107
Strádovské peklo	50	Týnec nad Labem	108
Krkanka	51	Blansko	109
Mrákotín u Skutče	52	Čečkovice	110
Otradov	53	Skuteč-Sv. Anna	111
Horní Lhotka	54	Chvaletice – granite quarry	112
Nehodovka	55		

Selected geosites:

- **(01) Chvaletice:** an abandoned quarry, where Fe-Mn mineralization was exploited in rocks of the Iron Mountains Proterozoic (Chvaletice Group). The quarry is now used as a repository of communal waste and ash from the near Chvaletice power plant. It is an instructive example of a possible use of old quarry workings in compliance to environmental knowledge (problems of mine waters and subsequent pollution; possible collection of secondary minerals on adjacent spoil tips; a transgression of Cretaceous sediments over Proterozoic rocks is visible to the north of the quarry edge).
- **(02) Podhořany:** an abandoned, freely accessible quarry, where Proterozoic garnet-bearing gneisses were exploited. These are the oldest rocks in the Geopark territory and can be collected with no restrictions.
- **(03) Běstvina – Javorka community:** a former fluorite and barite mine; an example of post-mining reclamation. The site displays negative impacts of wet conservation of the mine on groundwater quality, necessitating remediation measures (Fig. 16).
- **(04) Licoměřice:** One of the sites where uranium mineralization was exploited in the Iron Mountains. An instructive example of a mining area reclamation and mine-water remediation.
- **(05) Oheb:** A rocky spur with the ruins of the Oheb Castle functions as one of the "abutments" of the dam of the Seč Reservoir. It is formed by the Oheb orthogneiss as a representative of the regional geological unit of the Oheb Crystalline Complex. The whole site is an exemplary case of the role of geological structure and fluvial erosion in relief shaping and their significance in dam construction.
- **(06) Skalka u Sovolusk:** an example of Proterozoic volcanic activity with a preserved outcrop of pillow lavas. A nearby site displays banded schists and stromatolitic buildups.
- **(07) Litošice:** outcrops of Proterozoic volcanics and Litošice conglomerates. Phosphate and sulphide minerals can be found on local spoil tips; they are of European significance and can be collected with no restrictions.
- **(08) Lichnice-Kaňkovy:** forested western crest of the Iron Mountains around the Lichnice Castle. The area is formed by gneisses of the Oheb Crystalline Complex, and by rocks of the Podhořany Crystalline Complex in the NW. It features extensive rocky outcrops, talus fields and gorges (Lovětínská and Hedvikovská gorges). A ruin of the Lichnice Castle is located in the northern part of the area.
- **(09) Brloh:** A quarry, now abandoned, and a series of rocky outcrops along a stream. At this sites, Cambrian rocks pass into Ordovician rocks, whose age is documented by the presence of fossils. The quarry displays a transgression of Cretaceous littoral gravel facies over Ordovician quartzites with ichnofossils. Free collection of samples is permitted. (Fig. 13).
- **(11) Chrtníky:** an active quarry in Ordovician diabases (basaltic rocks) displaying transgression of Cretaceous

sediments over these Paleozoic rocks. Cretaceous sediments are deposited in narrow depressions and have the character of surf sediments. Abundant fossil finds. Loess with molluscan fauna is exposed in the eastern part of the quarry.

- **(12) Žumberk:** an active quarry with an example of extraction of abyssal magmatites (Žumberk granite, porphyroids of the Lukavice Series). Significant pyrite mineralization.
- **(13) Deblov:** an outcrop of bedding planes of Ordovician quartzites with examples of ichnofossils. The area has the size of a few hundred square metres. It is a type locality of European significance to show and describe paleoichnological methods.
- **(14) Rabštejn:** a transition from compact quartzite cliffs to boulder fields displaying the features of frost weathering. The near outcrops show extremely large individuals of the ichnogenus *Skolithos*.
- **(15) Raškovice:** a number of quartzite quarries at Horní Raškovice and in the surrounding forests. The extracted material was used, among others, for the production of millstones. The site is now accessible through an educational trail and contains the Barborka lookout tower providing a good view of the Bohemian Cretaceous Basin (the region around Pardubice, Kolín, Hradec Králové). The village of Horní Raškovice is a typical example of an old stonemason community.
- **(16) Na Skalách:** a geological protected site (nature monument) with a system of abandoned quarries after sandstone extraction. A transgressive boundary between the marine Cretaceous sediments and the underlying Ordovician quartzites of the Iron Mountains Paleozoic has been exposed at several places for demonstrative purposes. The site also features thick accumulations of boulder conglomerates evidencing high-energy surf action (Fig. 17).
- **(17) Prachovice:** an extensive quarry, partly still in operation (owner: CEMEX Cement, k. s.). Silurian and Devonian limestones are being exploited, containing fossil organisms and numerous minerals. Stratotype of Prachovice Formation has been defined in the eastern part. The upper levels of the quarry show frequent pseudokarst features including the occurrence of soils of Terra Rossa type. A display of mining and reclamation methods (Fig. 23).
- **(18) Vápenný Podol:** The accessible cliff near the church is the last relict after limestone mining in this village. Not far from the cliff, an old lime kiln has been proclaimed a techical monument. Relicts after the former service railway (cuts, bridges, embankments) which served stonemason purposes can be observed in the village and its vicinity.
- **(19) Mrákotín u Skutče:** a site located in the Hlinsko Zone (Paleozoic – Mrákotín Formation). It is renowned for the presence of rich graptolite fauna with the possibility of unrestricted sample collection on the fields and in the forests.
- **(20) Ctětín:** an active granodiorite quarry near the village with instructive examples of spherical weathering of granites. The quarry includes a space for the processing of extracted material: its working into paving stones, kerbs and other products. The site thus poses a display of pit mining and subsequent processing.
- **(21) Prosetín:** a typical stonemason village, surrounded by several active and abandoned granodiorite quarries. Numerous stonemasonry products can be viewed in their making. The site also displays many examples of weathering of Be-mineralized granites.
- **(22) Srní:** the active Matula Quarry and the neighbouring abandoned quarry

were opened as a granodiorite deposit. Granodiorite is being extracted by typical pit mining with the use of a cableway. The area offers displays of granodiorite processing into stonemasonry products. The site is incorporated in the MAGMA educational bicycle trail.

- **(23) Lukavice:** The village was affected by underground mining of pyrite for the production of sulphuric acid. An old school and an extensive spoil tip are located in the village centre. A good example of adverse effects of mining on the environment. The site is incorporated in the MAGMA educational bicycle trail.
- **(25) Kraskov:** an area with the so-called Kraskov relict of Permian rocks. The rocks are represented by conglomerate containing rare finds of fossilized wood. Mining pits after gold mining have been preserved in the valley of the Zlatý potok Stream.
- **(26) Škrovád:** exposures of Cretaceous sediments in a series of quarries. Quartzose, kaolinite-containing and glauconitic sandstones are of Cenomanian age.
- **(27) Bítovany-Farář:** an exposure in the right bank of a stream. A significant geological site of clayey and quartzose sandstones evidencing the phenomenon of Cretaceous transgression. Beds of conglomerate and claystone with coal seamlets are locally visible. The Cretaceous sediments are underlain by strongly weathered granite of the Žumberk type.
- **(28) Skutíčko:** a village with documented past exploitation of Cretaceous coal with finds of fossil plants and amber.
- **(29) Skála:** The site is contained in this list for its high outcrop series in the valley of the Žejbro Stream. The outcrops are formed by Cretaceous spiculitic marlstones with abundant fossils.
- **(29) Vrbatův Kostelec-Podskála:** Several geological phenomena are displayed in the valley of the Žejbro Stream. Outcrops of basic abyssal magmatites banded with acidic magmatites lie closer to Vrbatův Kostelec. The stream channel contains varied pebble material mixing rocks from the marginal part of the Nasavrky pluton. North of Vrbatův Kostelec, laterites are visible in outcrops, passing across rooted paleosols into Cenomanian fossiliferous calcareous sandstones and beach sands. The Podskála site features a large outcrop series of calcareous siltstone. Siltstones are underlain by glauconitic sandstones with rich fauna and flora, and storm sediments. The community of Podskála (originally a spa) was renowned for its spring issues, which can be still observed today. Calcareous tufa accumulations, locally containing imprints of fossil flora, are developed in the neighbourhood.
- **(30) Přibylov:** a partly active quarry exploiting Lower Turonian spiculitic marlstones (“opukas”) of the Bílá hora Formation. It is one of the last quarries in Bohemia where high-quality opukas for the purposes of historical-monument restoration can be extracted. Rare specimens of fossil fauna and flora can be collected. Problems of opuka exploitation in combination with the preservation of groundwater resources can be demonstrated in the nearby Skuteč-Sv. Anna withdrawal area.
- **(32) Luže-Košumberk:** the Košumberk Castle, partly ruined, lying on the southernmost relict of Tertiary volcanic products in the Czech Republic. Columnar jointing of basalt and the associated pyroclastics can be observed. Important groundwater withdrawal areas are located in the Novohradka River valley. The alluvial plain of the river also demonstrates the geological and

tectonic controls on modelling of the river channel.

- **(33) Podlažice:** a significant hydrogeological site in the scale of the Czech Republic – a withdrawal area supplying the population of 80,000.
- **(35) Horní Studenec:** a significant hydrogeological site with unique examples of utilization of groundwater issues (adits, galleries) (Fig. 18).
- **(36) Blatnice:** a significant hydrogeological site with historical consequences.
- **(37) Kladruby u Libice:** a significant hydrogeological site with an example of a ponor stream.
- **(38) Sloupno – quarry:** An active quarry near the village of Štikov, exploiting rocks of the Iron Mountains pluton – metadiorites and metagranitoids, amphibolites, metagabbros.
- **(39) Doubrava River valley:** a canyon-like valley of the Doubrava River with multiple rocky outcrops. It provides a perfectly exposed section, showing structural elements and mutual relations among rocks. The numerous geomorphic elements displayed include many examples of frost weathering and effects of fluvial erosion on Moldanubian migmatites and orthogneisses.
- **(41) Leštinka area quarries:** abandoned but accessible granodiorite quarries, now mostly flooded. The whole area features numerous artefacts after quarrying activities (relics of buildings, railway siding, mining technologies and others).
- **(42) Rychmburk – the Šilink Mine:** active quarries and a rocky outcrop series along the Krounka River. Mining of the Rychmburk greywackes of the Hlinsko Zone. The Rychmburk Castle lies atop a rocky spur in the village of Předhradí.
- **(43) Doly near Luže:** analogous with the site of Skutíčko. The valley of the Krounka River exposes a large outcrop of Cretaceous coal containing fossil plants and gypsum. The whole exposed section features the basement (Rychmburk greywackes) and a great facies variability of Cenomanian sediments.
- **(44) Maštale:** sandstone rock formations and canyon-like valleys (Cenomanian) proclaimed as a geological nature reserve. The basement rock is mostly the so-called Zderaz granite. Cretaceous sediments form various geomorphic elements due to erosion. The boundary between the Cenomanian and Turonian is exposed near Zderaz.
- **(44) Pivnice:** a canyon-like valley of the Pivnický potok Stream between Zderaz and Dolany incised in Cretaceous sediments (Cenomanian). Numerous geomorphic elements and pseudokarst features were formed due to erosion: gorges, slot canyons, potholes, rock shelters, niches etc.
- **(45) Nové Hrady:** a significant hydrogeological site is located in the valley of the Hradecký potok Stream – the Nadymač spring.
- **(46) Nákle:** exposed volcanic diabase body. Depressions on the pre-Cretaceous surface are filled with Upper Cretaceous sediments with very rich fossil fauna. The site is protected as a nature monument, and is incorporated in the geological educational trail "Heřmanův Městec – the town of two seas."
- **(47) Roudná:** a type section of the transgression of Cretaceous sediments over rocks of the Polička Crystalline Complex.
- **(48) Quarry near Nasavrky:** an abandoned but accessible quarry with a steep face. Various lithotypes within the Iron Mountains plutonic complex can be observed, and samples can be taken at no restrictions. The site is incorporated in the MAGMA educational bicycle trail.

- **(49) Hrobka:** an outcrop in Cretaceous sediments, now covered with vegetation. It is important mostly for its entomological and botanical values.
- **(50) Strádovské peklo:** a deeply incised valley of the Chrudimka River with numerous rock outcrops. It exemplifies various rocks of the Iron Mountains pluton.
- **(51) Krkanka:** see Strádovské peklo.
- **(52) Mrákotín near Skuteč:** a complex of abandoned and flooded granodiorite quarries with examples of spherical weathering of granite.
- **(53) Otradov:** old quarries, boulders and blocks of rocks of the Polička Crystalline Complex. Examples of spherical weathering of granodiorite.
- **(54) Horní Lhotka:** a vegetated abandoned quarry featuring a contact of amphibolite with the ambient migmatite. Both rock types are ranked within the Oheb Crystalline Complex.
- **(55) Nehodovka:** a disintegrated outcrop on an elevation in the middle of a field, utilized as a source of building stone, and a small quarry. These represent exposures of a serpentinized ultrabasic rock, forming a body in paragneisses of the Oheb Crystalline Complex. Abundant finds of secondary minerals.
- **(56) Křemenice:** a land-filled pit quarry, in which a quartz vein was exploited as material for glass production. Fragments of quartz veins now found in the vicinity come from the neighbourhood of serpentinite bodies. Documented finds of amethyst. The body is enclosed in rocks of the Oheb Crystalline Complex.
- **(57) Ševcova skalka near Obora:** a notable outcrop of orthogneiss, showing numerous examples of frost weathering.
- **(58) Koukalky:** cliffs in the rocks of the Kutná Hora Crystalline Complex, represented by orthogneisses and migmatites.
- **(59) Chotěboř B82:** a complex of abandoned quarries exploiting orthogneiss and metabasalt. A body of metatrachyandesite is present.
- **(60) Libice nad Doubravou – skarn:** An outcrop of a skarn body on the river bank in rocks of the Kutná Hora Crystalline Complex.
- **(61) Hradiště – a sand pit:** a sand pit in limited operation, exploiting sandstones of Cenomanian age.
- **(62) Podolská jeskyně Cave:** a limestone cave and an important wintering refuge of bats (cave code JESO-K123 40 10 J00002).
- **(63) Páterova jeskyně Cave:** a limestone cave and an important wintering refuge of bats (cave code JESO-K123 40 10 J00001).

16a 16b 16c

Fig. 16 – Minerals of the Iron Mountains. Quartz (16a) and fluorite (16b from Běstvina and calcite (16c) from Prachovice.

Fig. 17. Rabštejnská Lhota – Na Skalách. Transgression of Cretaceous sandstones over Ordovician quartzite.
Fig. 18. Horní Studenec. Groundwater source – an adit near the church.

B.4 Other tourist attractions in the Iron Mountains Geopark

- **Castles, chateaus, ruins**

In the Geopark there are a number of historically significant objects - castles, chateaus and ruins. The castle ruins Lichnice (Fig. 27.) and also a large castle ruins Košumberk near Luž are important monuments and landmarks of the Iron Mountains. Other significant castle ruins in the Geopark include for example Oheb over Seč dam, Rabštejn, Strádov or Žumberk – they are freely accessible. In the Geopark there is a total of six chateaus (Nasavrky, Choltice, Nové Hrady, Slatiňany, Chrast, Chotěboř).

Fig. 19. Chateu in Nové Hrady - aerial photo.

- **Observation towers**

Also places of distant views and a lookout towers are tourist destinations. There is a beautiful view from the castle ruins Lichnice and Oheb, from the tower in Slatiňany chateau and also the magic of Střemošice hillsides is quite unique. The lookout towers include some year-round open such as Jahůdka at Luž, the lookout tower Na Kopečku at Licoměřice and Bára in Podhůra recreational forests (Fig. 20.) as well as Boika at Nasavrky. The lookout tower at Zuberský hill near Trhová Kamenice and Vojtěchovská lookout tower can only be visited during the tourist season. Viewpoint and observation towers that are freely accessible can be viewed as goals of activities aimed to promote the off-season tourism.

Fig. 20. Bára lookout tower.

- **Heřmanův Městec –** the skylight of Heřmanův Městec is dominated by the baroque church of the St. Bartholomew in the Náměstí Míru as well as the chateau with the adjacent park, which belongs to the NATURA 2000 sites. Also the Jewish part of the town with a synagogue and Jewish cemetery is important.

- **Veselý Kopec and Hlinsko Christmas Crib** - a set of folk architecture and architectural reserve, museum in nature, recently they placed within the top 5 visited sights in the Pardubice region, carnival masks and beats at Bethlehem are registered on the UNESCO list.

- **Chrudim Architectural Reserve** - a valuable history of the town with a number of important monuments and museums - Museum of Baroque statues, Regional Museum with an exhibition of Alfons Mucha and Puppet Museum (museum unique in Europe Museum) (Fig. 21.).

- **Pious place Ležáky** - The village of Ležáky was burned by the Nazis in response to the assassination of Reinhard Heydrich. Originally it was a stonecutter village (there are numerous quarries in the area). After the World War II monuments have been erected on the site of the burned buildings. It is an important pious area (Fig. 22).

Fig. 21. Chrudim Architectural Reserve.

Fig. 22. Ležáky.

- **Podlažice Monastery** The Benedictine monastery from the 12th century, is renowned for archaeological finds and finding of the so called Devil's Bible (Codex Gigas). The exhibition of findings of this monastery is located in a nearby chateau in Chrast near Chrudim.

- **Selected cultural, social and sports events:**

In the Geopark territory many cultural, social and sporting events, both of regional and nationwide character are organized. Below see the list of the most significant events of this type. Apart from them, numerous concerts, fairs, sports tournaments and other activities focused mainly on the inhabitants of the region are organized there:

- Nasavrky Grand Prix - Nasavrky and surroundings - April,

- Chrudimská rally - Chrudim and surroundings - April,
- Tomáškova and Novákova musical Skuteč - Skuteč - May,
- International dance festival - Skuteč - May,
- Brass band festival - Chrudim - June,
- Puppeteer Chrudim - Chrudim - July,
- MTB Marathon Manitou the Iron Mountains - Chrudim and surroundings - July,
- Lughnasad - Nasavrky - July,
- „Košumberk Summer festival"- Luže - July-August,
- Salvator pilgrimage - Chrudim - August,
- Hlinsko folk sausage - Hlinsko - August,
- Bartholomew Fair - Heřmanův Městec - August,
- Slatiňany Grand Prix - Slatiňany and surroundings - August,
- Memorial of Michael Denk - Hlinsko - September
- The Chrudim puppet - Chrudim - October.

C GEO-CONSERVATION

C.1 Current or potential threats to the landscape and geological heritage

The Iron Mountains National Geopark covers a territory, which is of 90 % made up by a landscape with a significantly highland nature and with a high share of forests (36 %) and agriculturally used areas (57 %). Urbanized areas represent 5 % of the area (Fig. 1). The total area of the Geopark (777 km^2) includes the protected landscape area of the Železné hory (almost 30 %) and CHOPAV - Protected areas of natural water accumulation (over 15 %).

The above indicates that the negative impacts of industrial and agricultural production are marginal in the Geopark territory in comparison with the surrounding areas.

Despite certain risks being perceived, see below, the impact of industrial production is concentrated in the periphery of the Geopark (Třemošnice, Chrudim, Hlinsko and Ždírec nad Doubravou); more significant risks can be seen in the mining industry and agricultural production. However, in all cases, these anthropogenic activities only have minor impacts on the own identity and cultural heritage of the Iron Mountains Geopark.

The risks of negative impacts on the current landscape and geological heritage include:

a) mining activities
b) intensive breeding of cattle, sheep and goats
c) fossil fuel burning
d) landfills for municipal solid waste.

Sub a) In the territory of the Geopark more than 300 quarries and little quarries have been mapped; currently there are 18 active quarries here. Mining is accompanied by increased levels of dust, noise and freight traffic; on the other hand, active quarries are a major employer and an important partner for the needs of the Geopark (Fig. 23.).

Sub b) Agriculture combines crop and livestock production. At higher altitudes after a long time livestock farming on permanent grasslands has developed; the landscape has not been affected by intensive agriculture and thus it preserved scenic and rugged character (Fig. 24.).

Sub c) At the northwestern boundary of the Geopark territory, a former open-pit mine of the Chvaletice Thermal Power Plant, where fossil fuels are burned, is located. The fly ash is deposited in the quarry in the environmentally friendly manner and gaseous pollutants are disposed of using modern technologies (Fig. 25.).

Sub d) Three large landfills (Srní, Nasavrky and Zdechovice) are operated and monitored in compliance with the legislation whereas no negative impacts on the environment have been reported. With other hazardous environmental damages positive significant changes occurred during the last 25 years; a significant portion of them have been remediated and reclaimed (Fig. 26.).

The protection of surface water and groundwater has not been a problem due to the geomorphological nature of the territory; the reason is the long-term functioning of the legislative measures in the protection of their quantity and quality. The territory of the Iron Mountains belongs among unique areas within the context of the Czech Republic. This is also the reason for the inclusion of the hydrogeology topic in the Geopark logo.

Fig. 23. Prachovice. Quarry in limestone (Silurian, Devonian) and nearby cave system.

Fig. 24. Breeding deer, goats and sheep in the Iron Mountains

Fig. 25. Chvaletice power plant

Fig. 26. Rabštejnská Lhota. A reclaimed landfill and tower Bara.

C2 Current status of protection of geological and non-geological sites

The Czech Republic has a number of legal norms protecting the landscape, natural and cultural heritage. Some of them are based on EU directives but a significant part of them are the specific Czech laws.

Below see the summary of acts and the authorities responsible for their administration.

Sites of Community Importance (SCI)

In the Geopark territory there are 13 areas, which are protected under the Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora. These areas are a part of the Czech part of the European network of protected areas NATURA 2000. Geosites are a part of 5 SCI. Caring for SCI is done by the so-called set of recommended measures, which are approved individually for each SCI.

List of SCI

Name	Acreage in ha	European code	Geosite
Slavická obora	744760	CZ0533501	
Hubský-Strádovka	762302	CZ0534054	
Krkanka-Strádovské peklo (Fig. 27.)	277495	CZ0534053	*
Podolská a Páterova jeskyně (cave)	003979	CZ0533693	*
Boušovka	112970	CZ0533296	
Choltická obora	695926	CZ0533302	
Rybník Moře	226360	CZ0533312	
Hluboký rybník (pond)	652290	CZ0533310	
Anenské údolí (valley)	393975	CZ0534051	
Heřmanův Městec	625764	CZ0533300	*
Lichnice-Kaňkovy hory	451240	CZ0530500	*
Chrudimka	23001	CZ0533303	*
Malá Straka	360220	CZ0533002	

Fig. 27. Krkanka. SCI location.

Other protected areas

The Geopark encompasses the whole protected landscape area of the Iron Mountains (Železné hory), which was declared in 1991 in the territory of 286.30 km^2. The long-term objective of nature and landscape protection in the Iron Mountains PLA is to preserve the typical character of a harmonious landscape (with a mosaic of forests, meadows, pastures, water and agricultural areas and small municipalities), preservation of landscape and natural and semi-natural communities with rare species of flora and fauna. Nature and landscape protection is graded by the four-grade zoning with the strictest protection in the 1st zone. The state administration in nature protection for the Iron Mountains PLA ANCLP is exercised by the Administration of the Iron Mountains PLA.

In the Geopark territory there is a system of small-scale specially protected areas with the graded protection according to the category (national nature reserve, nature reserve, nature monument). Caring for each protected area is governed by the approved plan of care. The table below reviews the small-scale protected areas (MCHÚ) which are geosites at the same time.

Small-scale protected areas

Name	Category	IUCN categories	Area (ha)	Geosite
Lichnice-Kaňkovy hory	NPR	IV	375,35	*
Anenské údolí (valley)	PR	IV	74,19	
Hluboký rybník (pond)	PR	IV	14,38	
Hubský	PR	IV	12,09	
Choltická obora	PR	IV	69,56	
Krkanka	PR	III	104,93	*
Maršálka	PR	IV	7,67	
Maštale	PR	III	1 080,46	*
Mokřadlo	PR	IV	13,40	
Oheb	PR	IV	24,68	*
Polom	PR	IV	20,24	
Spílavá	PR	IV	28,91	
Strádovka	PR	IV	46,43	
Strádovské Peklo	PR	IV	88,19	*
Svatomariánské údolí (valley)	PR	IV	14,08	

Údolí Doubravy	PR	III	93,18	*
Vápenice	PR	IV	42,12	
Zlatá louka (meadow)	PR	IV	11,41	
Zubří	PR	IV	29,16	
Boušovka	PP	IV	1,04	
Buchtovka	PP	IV	5,52	
Farář	PP	IV	8,82	*
Heřmanův Městec	PP	III	63,86	
Hrobka	PP	IV	1,46	*
Chuchelská stráň	PP	IV	1,83	
Kaštanka	PP	V	1,09	
Na Obůrce	PP	IV	1,42	
Na Skalách	PP	III	3,90	*
Písník u Sokolovce	PP	IV	0,51	*
Pivnice	PP	III	33,54	*
Podskala	PP	IV	3,72	*
Polánka	PP	IV	0,31	
Rybník Moře (pond)	PP	III	2,69	
Skalka u Sovolusk	PP	III	0,74	*
Střítežská rokle	PP	III	16,44	
Upolíny u Kamenice	PP	IV	1,98	
V Koutech	PP	IV	0,50	

Small individual protected areas are very close to significant landscape elements (SLE). Pursuant to the Act No. 114/1992 Coll., SLE are protected against damage and destruction. A part of SLE is a type specified directly by law (e.g. forests, floodplains) and others are designed for registrations by both regional authorities. Outside the PLA there are in total 19 SLE in the Geopark, which include some old quarries and rocky hillside caves.

The Act also explicitly protects all caves against damage, destruction or adjusting. There are about 10 caves registered in the Geopark territory.

Caring for the geosites in the SCI and in specifically protected areas is carried out according to the approved documents. The care is provided by the administration of the Iron Mountains PLA and the two regional offices, primarily in cooperation with the owners and tenants of lands and with the Iron Mountains National Geopark or as actions taken purely on demand. The Iron Mountains Geopark mainly acts as a consultant, it performs cares for some locations itself within ongoing projects. Most frequent measures carried out with the geosites is cutting of trees and raids, refining outcrops. A natural part of nature protection is to inform about the importance of maintaining sites and nature trails.

The Geopark has understandably determined and described many other geological locations outside protected areas. Currently, the list includes more than 100 geosites (see Sec. B.3).

In addition to the direct protection of the sites, *ex situ* specimens are also protected in the Czech Republic. Samples of rocks and minerals, rocks and fossils are protected under the Act No. 71/1994 Coll. on Sales and export of cultural values according to the Act No. 122/2000 Coll., on protection of museum collections. If a mineralogical or paleontological site is encountered during construction works, it is possible according to § 176 of the Building Act No. 183/2006 Coll. to force

the suspension of works and provide the site exploration or rescue collecting.

The territorial system of environmental stability (ÚSES, § 4 of the Act No. 114/1992 Coll.) is a network of environmental corridors and centres where the ecological functionality takes precedence over other interests in land use. Throughout the Geopark the local territorial system of ecological stability is defined. The Chrudimka River valley is a supra-regional bio-corridor of ÚSES with two supra-regional bio-centres - Polom and Lichnice; in the south of the Geopark there is another supra-regional centre ÚSES - Doubrava Valley. In the Geopark territory there are 49 memorial trees and 15 groups of protected trees and alleys.

Virtually all streams in the Geopark territory were evaluated as surface waters that are, or become, suitable for sustainable life and reproduction of indigenous species of fish and other aquatic animals (Government Regulation No. 71/2003 Coll., In the sense of Council Directive 78/659/EEC of 1978).

The eastern edge of the Geopark partially merges with the Protected Area of Natural Water Accumulation East Bohemian Cretaceous (Government Regulation No. 85/1981 Coll.). Protected area of natural water accumulation Žďárské vrchy extends into the Geopark in the south (Government Regulation no. 40/1978 Coll.). The whole Geopark is a sensitive area of surface water pursuant to the Act 254/2001 Coll. on Water Resources, characterized by the use, current or prospective, of drinking water sources and by the need for increased wastewater treatment.

C.3 Management of geological sites – geosites

A number of defunct quarries are located in the territory of the Geopark. Here, stone was quarried for building needs of local residents. In the period of 1870–1930, fauna (trilobites, crinoids, brachiopods) was found in quarries in Paleozoic sediments; the results were used for the construction of the first geological maps of the Iron Mountains.

Works on revitalization of quarries were performed at 9 locations in the years 2013–2014–. The reason was to make the type exposures available for educational purposes as well as for the needs of newly established natural amphitheaters for the local community (Figs. 28., 29.).

Fig. 28. Management of the Brloh quarry - before the intervention and after revitalization (2014).
Fig. 29. The quarry is alive! The first year of the Brloh trilobite, 2015, organized by the municipality.