ABSTRACT BOOK

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Sandstone Landscapes: Diversity, Ecology and Conservation

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Origin of sandstone bodies of the Bohemian Cretaceous Basin (BCB)

Although considerably poorer than shales or limestones in the content of preserved fossil organisms, sandstone bodies generally provide invaluable and highly time-sensitive data for the reconstruction of the depositional system operating in sedimentary basins. Their distribution and large-scale geometries indicate the location of sources of detrital material and the tectonic regime controlling the deposition. Tectonic reactivation of blocks inside and outside the basin much like the changes in base level have major bearing on the character of boundaries of sandstone and conglomerate bodies and their stacking patterns. Internal architectures and sedimentary structures are indicative of the depositional environment. Finally, material composition and grain-size distribution of the sandstone reflect the petrographic composition of the source area, the type and intensity of weathering and the mode of sediment transport.

The individual clastic wedges in the BCB (Middle Cenomanian to Lower Santonian), wedges of coarse clastics (87 to 98 % quartz) consist of sandstone packages several metres to tens of metres thick, characterized by coarsening (i.e., shallowing) upwards. This is caused by progressive basinward shift of facies (progradation) during continued sediment supply. The typical lithofacies are: 1) silty and clayey fine-grained sandstones, either bioturbated or showing hummocky or swaley cross-stratification, interpreted as lower shoreface deposits; 2) medium- to coarse-grained quartzose sandstones, horizontally stratified or cross-bedded, interpreted as upper shoreface deposits; 3) conglomerate beds tens of centimetres thick, interpreted as beach and fluvial(?) deposits.

The upwards-coarsening sandstone packages often contain gently inclined (1–10°) bedding planes (clinoforms) truncated by the conglomerate beds at their tops. Dips of clinoforms represent the former surfaces of the prograding sandbodies and indicate the direction of progradation. In the Teplice Formation of northeastern BCB, such sandbodies pose subaquatic deltas whose foresets are represented by the clinoforms (Uličný 2001). In contrast, sandbodies of the Jizera Formation in Lusatian region probably represent linear, shore-parallel sand bodies, as suggested by along-strike paleocurrent directions and distinct tidal imprint (Adamovič 1994). Most of the conglomerate beds at tops of the packages overlie unconformity surfaces. This can be explained by large-scale basinward shifts of upper shoreface/beach facies at rapid relative sea-level falls. The size of pebbles in the conglomerate beds, much larger than that of pebbles in the sandstone below the beds, led to the conclusion that the tops of conglomerate beds pose a combination of sequence boundaries and ravinement surfaces. A detailed knowledge of the architecture of sandbodies in the BCB and its comparison with other basins should thus refine the scale of high-frequency global sea-level fluctuations.

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The microclimatic conditions in a part of Saxon Switzerland and its influence on vegetation. An example in the region of "Grosser Zschand"

The sandstone ravines of the Saxon Switzerland have a reducing and delaying effect on temperature fluctuations. This effect increases in deep and narrow ravines. During cold fronts, the bottoms of the ravines are warmer than the plateaus and reefs. During warm fronts, the bottoms are colder than plateaus and reefs. The highest temperatures were measured on south exposed, sheltered, nearly vegetation free ledges of the first rock floor. The vegetation cover also dampens extreme values (forest climate).
In times of radiation weather in winter, the plateaus are only a little warmer during midday than the bottoms. Normally, they are colder. In times of high air pressure in summer, the bottoms are only a few degrees warmer (1 to 2 K) than the plateaus in the morning. Otherwise they are noticeably colder (up to 10 K) than the plateaus and reefs.
For the distribution of vegetation in the ravines, the climate, among other factors (e.g. soil, relief, competition, humidity), is of great importance. In the ravines, the share of boreo-montane, coldness and humidity loving species is much higher than on the plateaus. Dryness resistent species are more common on the plateaus.
The bryophytes reflect microclimatic differences far better than phanerogames since they have narrower amplitudes in regards to ecological factors and a higher species diversity.
In areas more distant to the bottoms, small special habitats (e.g. shaded niches and caves) exist with climatic conditions similar to the bottoms and with isolated sites of bryophytes preferring low temperatures and high air humidity bryophytes. Mylia taylorii, for instance, is widely distributed in the bottoms and has a wide ecological amplitude, it is restricted to microclimatic different special habitates whereas on upper slopes. On the other hand, also in the bottoms exist small areas of more exposed, bare rocks with different climatic parameters and a different bryophyte vegetation.
The climatic parameters are in harmony with the indicator-values "temperature figure" and "moisture figure" of ELLENBERG, but the calculations of the "continentality figure" show no gradient.

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Sandstone phenomenon of the East Greenland

Weathering of the Jurassic thick-bedded quartzose sandstones in East Greenland (Jameson Land) is controlled chiefly by freezing water. Less cemented parts are weathered away leaving high cliffs and pinnacles of the harder material. Lichens grow on these hard surfaces. Very large lichen specimens and very slow growing (centuries old) show that the hard cemented sandstones weather very slowly. Some pinnacles have castellated tops. Verticals walls are ornamented almost exclusively by horizontal (or oblique, if cross-bedded or fallen) ledges. Honeycomb surfaces of tafoni-like forms are rare; they are irregular, showing pits and hollows of a broad range of sizes and shapes. Manifestations of case hardening (rock crusts) are almost absent, apparently because of insufficient evaporation of water solutions form the sandstone surfaces.

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The relief formation of sandstone castellated areas of the Czech Republic

Introduction: Castellated sandstone areas known in Bohemia as „rock cities“ are formed by a maze of narrow dry gorges and fissures often 1m wide that follow the tectonical setting. The vertical rocks, overhanging cliffs, detailed surface morphology, occasional caves and many other features developed by the combination of rock type and several basic processes that can be chronologically described as the succession of phases:
1.Preparatory phase: The sandstone massif is submerged under the ground water level. The circulation of fluids is taking place not only through the sandstone pores but along tectonical fissures and their vicinity. We may observe at some places that the sandstones are within a zone 0,5-4m wide along tiny vertical fissures softened by circulation and viable to selective erosion. Some of the fissures are covered by ferrugineous crusts or even chalcedony veinlets – so their Tertiary age should be expected.
2. Initial phase: The sandstone massif appears above erosional base due to uplift and/or downcutting. The already softened sandstone is removed and vertical fissures are exposed. The melt-freze cycles of ice ages seem to play extremely important role resulting in microgelivation of more humid/porous parts of the sandstone strata.
3. Mature phase: No important uplift and erosion is taking place but the exposed surfaces are being modelled by weathering processes. They are mostly associated with capillary water that activates both – destructive and protective processes. Biological erosion and salt weathering are the most important erosive processes, while the surface hardening caused mostly by free silica impregnation of the surface parts helps to prevent the surface stability. E.g. isolated sandstone towers are relict features protected by surface hardening. The other important process is the origin of exfoliation or desquamation scales – these are typically 20-80 cm wide layers parallel to surface that tend to fall down. Some of the overhanging rocks and arches are marked by these processes.
4. Senile phase: The slope processes, creep and cambering, rock collapses and continuous action of salt and biological weathering is taking place resulting in the origin of flat or gently undulating sandstone plateaus where relict rocks (often in form of „inselbergs“) can be found.
Conclusion: Sandstone relief of the castellated formations represents a mixture of some extremely old (Tertiary) and extremely young (Holocene) processes and phases that are unified in outlook by the intricate interactions between weathering and surface hardening.

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Digital terrain models of sandstone rock landscapes in the National Park "Sächsische Schweiz" for supporting conservation and ecological monitoring

The landscape of the National Parks "Sächsische Schweiz" and "České Švýcarsko" is characterized by dense deciduous and coniferous forests as well as by solitary sandstone rock and cliff formations. The presented paper discusses the combined application of airborne laser scanner data and colour-infrared imagery in the National Park region „Sächsische Schweiz" for mapping and digital modelling of the rugged sandstone relief of the region.

Airborne laser scanning is a direct method of remotely sensed spatial data acquisition. It provides an enormous number of digital three-dimensional surface data with a very high accuracy. There are many advantages over conventional data acquisition techniques. The capability to penetrate vegetation and thus measure ground points in wooded areas with high density is probably one of the most distinctive features. The basic principle of an airborne laser scanner system - consisting of three main components - is simple: The whole system is mounted onto an airborne platform. A laser scanner emits high-energy light pulses (mostly in the near infrared) towards the ground. The running time of the pulses to and from points of reflection is measured. The precise determination of the position and attitude of the airborne platform, e. g. aircraft, is achieved by both differential kinematic GPS measurements and registrations of an Inertial Naviagtion System (INS) respectively.

Raw unfiltered laser data describe the surface with all their natural and artificial objects like trees, rocks and cliffs or buildings. For generating a digital terrain model (DTM) based on airborne laser scanning, data have to be separated into laser points representing the ground surface, and into laser points representing surfaces of vegetation layers like tree crowns by applying specific filter algorithms. But there is some evidence that these algorithms do not work without mistakes in some cases, e. g. for representing extremely rugged wooded terrains. The resulting DTM will show smoothed hill-like features, where rugged and steep rock formations extend in the real world.

In this paper we present our experiences in generating and analysing high-quality DTMs of rock and cliff formations in the National Park Sächsische Schweiz by means of a semi-automatic methodology of digital modelling. High-resolution mapping of rocks and cliffs is supported by colour-infrared aerial photointerpretation. After the selection of laser points belonging to the rocks, it is possible to filter the entire raw data to extract the ground surface. In a final step the data representing the ground surface are combined with the selected rock data. Now the calculation of a DTM, which perfectly represents the roughness of the topographic surface, is made possible. Additionally this high-resolution DTM supports the high-precision ortho-rectification of colour-infrared imagery. The combined analysis of CIR-ortho-imagery and of the DTM provides both accurate large-scale landcover and landuse maps of the National Park region as well as GIS-based multi-thematic modelling and visualization of the sandstone landscapes of the National Park.

Thus integrating high-resolution DTMs with large-scale orthoimagery is a conditio sine qua non for establishing concepts of large-scale environmental monitoring of mountaineous regions in general and of rugged sandstone rock and cliff landscapes particularly.

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Nature of the Stolowe Mountains

The Stolowe Mountains, literally Table Mountains form the north-eastern edge of the North Bohemian Sandstone Plate. The Mountain range numbered among Middle Sudetes spreads on the length 45 km crossing twice Polish-Czech border.
Isolated, strongly cracked rocky tablelands stand out in the relief of this region are raising here up to the elevation of 919 m a. s. l. above plateau lifted 750 m a. s. l.. Stolowe Mountains built with completely flat layers of sedimentary rocks (sandstone and marl) are the only example of that sort of mountains in Poland. Different resistance of sandstone to the erosive factors and long lasting weathering process has led to formation of numerous fabulous rocky shapes in the form of mushrooms, clubs, pillars, animals and human beings, as well as deep fissures and rocky labyrinths.
The pioneer lithophyte's plants- numerous species of mosses, lichens and liverworts are an important part of the mountains flora. Among them the most interesting are the phytocenosis of the marls exposures, containing a variety of flowerless plants and rare species of saxifrage, which only grows this area in Poland. Plant species characteristic for high moor peat bog together with mountain pine, andromeda and marsh tea can be found mainly on the Wielkie Torfowisko Batorowskie - second in size peat deposit in Sudeten. Meadows overgrown with many protected and rare species (nine species of orchids amongst them) are the habitat of the globe flower which is considered a symbol of this region. The precious elements of mammal fauna besides of badger, pine marten weasel, are small, nocturnal animals like dormouse. The characteristic environment of cracks and crevices of sandstones makes an ideal habitat for a number of bats. As for rare birds one can come across black stork, hazel grouse, woodcock, hobby, honey buzzard and characteristic for the taiga region pigmy owl and Tengmalm's owl. Rocks are the nesting places of eagle owl, kestrel, raven, nuthatch and black redstart. Rare amphibians like salamander, smooth newt and alpine newt can be sometimes spotted. The world of insects is still hardly investigated, but what attracts attention is rich in species long-horned beetles family and protected species of Carabidea family. The snow insects and archnids with relic species living in cold wet sandstone fissures are also very intresting.

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Invasive behaviour of Pinus strobus in sandstone areas in the Czech Republic

The highly broken sandstone areas with species poor vegetation give many possible spots for newly introduced species. The species fully making use of the variable environment seems to be the North American conifer tree Pinus strobus. Studying P. strobus propagation from plantations we focused on the following tasks:
1/ To find all localities of natural regeneration of Pinus strobus in different sandstone areas (Český ráj, Kokořínsko, Adršpaško-teplické skály) and evaluate how they are related to the position, age and extend of P. strobus plantations.
2/ To compare habitat preference for Pinus sylvestris and Pinus strobus natural regeneration.
3/ To describe Pinus strobus dispersal and age structure of new stands.
4/ To evaluate Pinus strobus impact on composition and abundance of herb and moss layers.
Our results revealed that 1/ P. strobus wildings and saplings are distributed mainly under seed trees and in their surroundings. Only few localities were found further then 100 m. Period of P. strobus introduction into the area was not significant for area, density and age of new stands. Important was distance from seed stands and their age and area. 2/ Pinus strobus naturally regenerates in wide range of ecological conditions. Its wildings rarely survive on dry, sunny, and windy rock tops or in narrow, wet, and shady valleys. The most preferable sites were plateaus and upper slopes. Pinus sylvestris regenerates in narrower range of ecological conditions - at open insulated places at rock tops, plateaus and upper slopes. At the last two it competes with P. strobus and low shrubs Vaccinium myrtillus, Vaccinium vitis-idaea. 3/ P. strobus fundamentally reduces the composition of understory vegetation. Its population age structure and mortality point to the still increasing number of trees in the area (of Bohemian Switzerland). This behaviour corresponds with the behaviour of invasive species.

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Flora and Vegetation of the Elbe Sandstones: a comparison with other sandstone regions of the Bohemian Cretaceous basin

The natural vegetation and flora of sandstone regions in the Bohemian Cretaceous basin can be considered as a consequence of combination of following factors resulting in following ecological gradients: (1) geology (acidophilous-calciphile vegetation) - responsible for sharp interface between rich flora on calcerous sandstones and extremely pure flora on acidic sandstones, (2) macroclimate (oceanic-continental vegetation), (3) altitude (colline-montane vegetation), (4) geomorphology - a crucial factor, reflecting in micro-(meso)climatic conditions of sandstone rock ecosystems that are locally more important for vegetation pattern of sandstone regions than the macroclimate.
The Elbe Sandstones, known also as Saxonian-Bohemian Switzerland, is an erosion landscape extended along the Elbe valley on both sides of the German-Czech border. This region (ca 700 km^2) was formed during the Cretaceous period and it represents a typical manifestation of sandstone phenomenon resulting i. a. in the vegetation inversion - Viola biflora, Petasites albus, Dentaria enneaphyllos and other (sub)montane species can be found at heights even less than 150 m a. s. l. The frequent presence of sub-Atlantic species (Chrysosplenium oppositifolium, Juncus squarrosus, Hypericum humifusum etc.) and some rare Atlantic species (Trichomanes speciosum - gametophytes only, Hymenophyllum tunbridgense (extinct in the area), Luronium natans, Hypericum pulchrum) is also characteristic for this region. The natural vegetation of the Elbe Sandstones is determined by dominant acidophilous beech forests (Luzulo-Fagetum) on sandstones, enriched by herb-rich beech forests (Melico-Fagetum) on volcanic hills. Typical communities on the sandstone rocks are pine (Dicrano-Pinetum) and oak-pine forests (Vaccinio vitis-idaeae-Quercetum). In comparison to other sandstone regions in the Bohemian Cretaceous basin, the Elbe Sandstones are the region with the strongest oceanic influence and with submontane character, while the Broumovsko region and Gory Stolowe Mts. are the most continental ones and the most montane ones and the Kokořínsko and Český ráj regions have the most thermophilous character.

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Denudation/accumulation dynamics and vegetation patterns in sandstone regions

Since sandstones are generally water-permeable, rainfall water tends to soak instead of flowing horizontally on the soil surface or at the soil/bedrock transition. As a result, horizontal transport of matter by water is thus reduced and the landscape is often a bizarre mosaic of cliffs, deep valleys or gorges and steep slopes. This strong vertical differentiation accounts for the well-known mesoclimatic differentiation and other features of sandstones. In addition to this, it underlies dynamic transport processes that strongly affect vegetation in sandstone regions.
(i) First, the vertical differentiation enables matter transport that accounts for disturbance (erosion/sedimentation) dynamics that periodically rejuvenates vegetation at slopes and bottom parts of the valleys. As a result, the sandstone vegetation is rather a mosaic of patches of different successional stages. This acts as a strong selective force on plant species that occur there; particularly the bottoms tend to occupied by species that possess mechanisms that enable them to withstand disturbance (either by avoidance or tolerance). (ii) Second, the vertical differentiation leads to the creation of specific habitats (namely talus cones) due to matter (sand) transport. Owing to the relative constancy of the processes that generate them, the talus cones are recurrent structures that may bear specific biota. (iii) Third, organic matter (e.g. litter, moss carpets etc.) is often transported over the cliff-bottom gradient; in this way nutrients are carried from the cliffs to the valley bottoms. This may play an important role as the sandstone bedrock is often very poor in nutrients; valley bottoms are typically more nutrient-rich than the denudation areas on the cliffs.
All these three kinds of processes are essential for the typical vegetation differentiation found in sandstone regions. As in similar types of habitats, protection of the biota and habitat should primarily concentrate on protection of these processes. Strict conservationist approach is likely to fail in this context.

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Matter transport and its influence on the sandstone vegetation

Tall rock formations (up to 200 m) and deep gorges are typical for the Adršpašsko-Teplické Rocks in North East Bohemia. The bottoms of the gorges have richer flora than common elsewhere in sandstone regions, which are extremely poor of nutrients. Matter transport from the tops of the rocks and rock walls is likely to affect the vegetation of the gorges.
The aim of this study is to quantify the transport of organic matter and nutrients to the bottoms of gorges in Adršpašsko-Teplické Rocks and identify its ecological meaning. Vegetation recordings were made at 151 sites (0.5x0.5 m^2) in 11 treeless gorges differing in their depth, temperature and geomorphology. Matter collectors were placed into these sites. The matter is collected fives a year, weighed and analysed to determine its content of main nutrients. The main components fallen to the collectors are needles, leaves, mosses and liverhoots, twigs and humus and soil. The decomposition rate of spruce needles, spruce twigs and Mylia taylori is determined using the ”Litter bag” method.

Keywords: sandstone vegetation, matter transport, litter bags method

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Postglacial development of the mammalian fauna in the N-Bohemian sandstone regions

Study of the Holocene debries series in several areas of the N-Bohemian sandstone region revealed 16 fossiliferous sites which provided 60 community samples covering 30 mammal species and a period from the early to middle Holocene. At the early Holocene, the woodland species, particularly Clethrionomys glareolus, occured regularly together with the mesic open ground elements such as Microtus agrestis, Microtus oeconomus and Sicista sp. Such a species combination, locally specific with high percentages of aquatic and semiaquatic forms, is particularly characteristic of the Boreal period. Surprisingly, the lithophilous W-Mediterranean element, Eliomys quercinus, appeared here first as early as in just the Boreal time. The middle Holocen record revealed considerable predominance of woodland species, though the open ground elements apparantly survived here too.

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Sandstone landscapes in Ghana

Sandstones are mechanically formed rocks from sedimentary rocks. They are formed from the deposition, layer to layer, of all kinds of organic or inorganic substances on dry lands or in water bodies. These substances are known to have been deposited by wind and running water. In Ghana they have been first deposited in the sea and in lakes and then became exposed when the sea withdrew from the land or when the inland lakes dried up or was drained off.
Excellent examples of sandstone deposits are found in Ghana. These are in the Afram Plains in the eastern region and in the Nauli area in the western region. The most spectacular example are in the southern Volta Plateau which the Kwawu Mountains forms part. As one drives through the town of Nkawkaw one sees the escarpment or cliff face of the Kwewu Mountain and the exposed layers of sandstone of which the mountain is made. Another spectacular example is seen in the so-called Gambaga escarpment in the upper east region, which is better known as the northern Voltain Plateau. Sandstone deposits are also found from plants, which get buried, and the skeletal and shelly remains of tiny marine creatures. The buried vegetation forms coal, a major fuel. Another unique feature of sandstone in Ghana is the Voltarian sandstone basin. That basin is made up of sedimentary rocks with sandstone forming the major component alongside limestone, muds and shales. It covers two fifths of the whole country and is the largest single physical region. Also closely associated with sandstone features is the umbrella rock in the eastern region. This was formed by wind effect. " Small rocks carrying a big rock " is the name given to it by the local people.
Especially in the western part of Ghana, most of these sandstone features have lakes close to it or rivers and also associated with the deciduous forest. There is a wide range of animal and plant species in such areas. Pisciculture is carried out in areas where there are lakes or rivers. Fish mostly found are the Oreochromis spp and the mudfish. Game hunting is associated with such areas with the glasscutters, snails, and crabs being the main animals hunted. Ghana gets most of it timber species from these areas especially the western parts. Celtis triplochiton and the Kyaya Senegalensis are the main timber species found alongside other forest trees and plant species. The elephants, leopard, the zebra, monkeys and chimpanzees are some of the wild animal species found in these areas.
Tourism, the most fasters growing sector of the Ghana's economy attracts about a million tourists to the country annually. Most of these tourists actually visit these areas. Eco-tourism is also been encouraged in these areas. Visitors are mostly attracted to the shrines of the local peoples who occasionally visit to perform certain rites to their ancestors. Certain portions are considered sacred. Ghana's main means of conserving or maintaining sites of such nature is by laws and replanting schemes.

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Neue Farne der Böhmisch-Sächsischen Schweiz

Das Elbsandsteingebirge ist seit jeher seines Farnreichtums wegen berühmt.
Botaniker wie WÜNSCHE, PAPPERITZ, SCHORLER, WOHLBEREDT und weitere machten hier Mitte bis Ende des 19. Jh. bedeutende Funde. Zu diesen zählen die Entdeckung von Asplenium viride, Phyllitis scolopendrium, Botrychium multifidum, Polystichum braunii, Osmunda regalis und Hymenophyllum tunbrigense. Die 5 zuletzt genannten Farne sind z.T. bereits seit Anfang des vorigen Jh. erloschen. Seit 1960 gelangen einer neuen Generation von Botanikern bzw. botanisch Interessierten Nachweise weiterer Farn-Taxa, die auf Grund ihrer z.T. schwierigen Bestimmbarkeit bislang unentdeckt geblieben waren. Das sind u.a. Dryopteris affinis ssp. borreri, Polypodium x mantoniae, Asplenium trichomanes ssp. pachyrachis, Dryopteris expansa, Dryopteris x ambroseae, Trichomanes speciosum, Dryopteris affinis ssp. affinis var. disjuncta, Dryopteris x complexa nssp. critica, Dryopteris x deweveri.

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The sequence of polygenetic soils developed of sandstone and marl in the Stolowe Mountains, Poland

The Stołowe Mountains are formed of successively developed sandstone and marl layers of the Cretaceous (Turonian) age. General features of surface sculpture were formed during Tertiary and Pleistocene periods. Slope sediments (slope covers) are normally stratified and their particular layers correspond with following changes of land-forming phenomena according to changes of climate as well as the intensity of weathering and denudation processes.
Soils, that developed within such slope covers, are, in general, poligenetic soils. The formation of an arctic brown earth (Cambisol) was first stage of theirs development. A new, sandy layer was accumulated on the surface at the beginning of the Holocene period and soils started an evolution to Podzol type. Only the soils developed from marl and free of sand covers preserved features of brown earth (Dystric Cambisols). The newest stage of soil development followed a forest cutting down until XVI and XVII centuries, and the erosion initiation, that resulted in covering of some Podzols and developing of the youngest sandy slope cover.
The aim of our study aws a sequence of soils in a slope catena, developed from sandstone and marl of Turonian age, at the altitude of 710-770 m a.s.l.

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Sandstone landscapes in The Broumovsko Protected Landscape Area, Czech Republic

The Protected Landscape Area Broumovsko (PLA) was established in 1991 by the act No 157/1991 Sb. on the area 410 km^2. The most popular sight of this region is the unique cretaceous sandstone relief. Six nature preserves and natural monuments are declared in this area: Adršpach-Teplice rocks, Broumov walls, rocky hills Ostaš and Křížový vrch, Kočičí skály rocks and the rocky outcrop Borek covering in total almost 3000 ha. One can find sandstone rocks also in parts of the first and second zone of PLA Broumovsko on hills Hejda, Lada and Bor (together about 100 ha).

The altitude of sandstone rocks in Broumov upland varies from 550 to 786 m. Average annual temperature is in the range from 5 to 7°C and average annual precipitation varies from 700 mm to 900 mm. There are grate climatic inversions in deep rocky gorges. The rocks were created from upper cretaceous marine sediments (middle Turonian and Coniacian). Earth movements on the faults, water erosion, ice and frost formed the relief and final shape of the rocks. The highest sandstone towers are more than 100 m high. The longest pseodocarst caves originated in rushed boulders in deep gorges. The cave "Teplická jeskyně" is about 2 km long system. Some caves shelter bats, together 12 species. Other caves are decorated with root stalagmites.

Because of acidic rock bed and poor soils flora of sandstone areas is not that diverse. Most interesting and preserved species can be found in wider gorges along the creeks: Leucojum vernum, Lunaria rediviva, Lycopodium annotinum, Oxycoccus palustris, Ledum palustre, Lilium martagon, Neottia nidus avis, Daphne mezerum, Eriophorum vaginatum, Rosa pendulina, Thalictrum aquilegifolium and Viola biflora.

Birds ranks among the most interesting animals of the rocks, especially birds of prey and owls. We can meet Falco peregrinus, Accipiter nisus, Bubo bubo, Glaucinium passerinum, also Ciconia nigra, and others. In total there are more than 70 nesting species. The spider Bathyphantes simillimus, a glacial relict, is the specialty of cold gorges. Rocks and little peat lakes are home of various mollusks, dragonflies, amphibians and reptiles.

Management of forests changed its structure and the composition of species during last 300 years. Today Norway spruce prevails. It causes the low ecological stability of the forests. Nature conservation in sandstone landscapes in Broumovsko does not mean only the regulation of tourism and sport. The main task of future is the restoration forests.

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Bark beetles on white pine in Bohemian Switzerland National Park

The main coniferous tree species in the Bohemian Switzerland National Park are Norway spruce (Picea abies), Scotch pine (Pinus silvestris) and white pine (Pinus strobus). While the first two species are native in the region, Pinus strobus belongs to the introduced exotic species. Because of the mission and management rules in the national park, the target stage is the forest stands consisting of native tree species only. Pinus strobus is eradicated therefore. On the places where removing of cut trees is difficult, logs are left on site. No chemical treatment is used within the national park. It developed the questions, if possible bark and wood boring insects, mainly bark beetles, attracted to this host material could increase their population density and make some additional damages on native tree species in neighboring stands consequently. The bark beetle species synusia on cut wood are observed and the risk of this management to other conifer tree species is evaluated. The most frequent insect species are Ips amitinus (Eichhoff) and Pityogenes chalcographus (L.) here.

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The effect of burial by sand on vegetation of sandstone regions

In sandstone rocks, burial by sand is a regular event influencing the physical and biotic microenvironment of plants. In this study, the effect of sand deposition on vegetation structure and the response of individual plant species to burial were investigated. Structure of natural sand deposits was observed and two types of permanent-plots with burial treatments (burial by sand to depth of 5 cm and both aboveground and belowground biomass removing) were established.
Two types of responses to burial were observed. First, buried plants regenerated, and new shoots penetrated the sand deposits. Their cover restored soon after the treatment. Species showing this type of response occurred on the natural sand deposits in early stages of succession. It was common for rhizomatous plants with clonal integration, such as Calamagrostis villosa and Polytrichum commune. Second, buried plants died off, and disturbed patches were colonized by lateral growth of adjacent populations. Their cover restored slowly. These species became abundant in later stages of succession. It was typical of everygreen plants with aboveground rhizomes and shallow roots, such as Deschampsia flexuosa, Polytrichum formosum and Sphagnum spp. Besides these, spreading by diaspores took place, primarily in species typical of bare sand and woody species.

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Weisstannen imn Nationalpark von Góry Stołowe

Die Bearbeitung stellt die Ergebnisse der Bestandsaufnahme von Weißtannen (Abies alba Miller) auf dem Gebiet des Nationalparks von Góry Stolowe (Heuscheuer) - PNGS. Die Inventararbeit wurde zum ersten Mal so ausführlich durchgeführt und sie ist eine Einleitung zum Programm der Rückerstattung der Tannen, also der Vergrößerung des Anteils an den Tannen im Gattungsaufbau des Wald-Ökosystems im Nationalpark, von 0,1 % zu 18 %. Die Population der Tannen im PNGS beträgt 5626 Exemplare, und vor der Bestandsaufnahme wurde schätzungsweise auf 2500 gesetzt. Es sind in der Mehrheit die Exemplare, die zum Tragen fähig sind - die größte Zahl der Bäume mit den Zapfen zeigt sich in den Gesundheitsklassen: gut und sehr gut. Unter 30 % der Exemplare wurde Auftreten des Nachwuchs festgestellt: 22 % Selbsaat, 2% Aufwuchs und 12 % Stangenholz. Der verminderte Anteil des Aufwuchs im Verhältnis zur Selbsaat ist (wahrscheinlich) ein Ergebnis eines negativen Einflusses des Rotwilds auf die natürliche Tannenerneuerung.

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The Pteridophytes of the 'Petite Suisse' area in Luxembourg. Diversity, surveys and conservation

The 'Petite Suisse' area in the eastern part of the Grand-Duchy of Luxembourg is known for it's sandstone outcrops, deep and often narrow crevasses, extended forests and special microclimatic conditions which offer life conditions for a great diversity of pteridophytes. It is therefore not surprising that the majority of ferns and fern allies known for Luxembourg occur in this area.
The area is internationally known for the relictual populations of Tunbridge filmy-fern (Hymenophyllum tunbrigense). This fern was first discovered in this continental island in 1821 but the location of the major colonies remained uncertain until the early 20th century following its re-discovery in 1873. In 1993 the gametophytes of another filmy fern, the Killarney fern (Trichomanes speciosum) were first discovered for continental Europe in the same region. In total 30 fern species (not counting subspecies and/or varieties) are known from this area; more than 90 percent of the species known for Luxembourg. Besides Hymenophyllum tunbrigense and Trichomanes speciosum (for the second species, only gametophytes), rare or interesting species and/or subspecies are Blechnum spicant, Dryopteris affinis, Asplenium csikii (= A. trichomanes subsp. pachyrachis), Polystichum setiferum, Polystichum x bicknelii, … Unfortunately a certain number of species (for example Osmunda regalis, Asplenium viride, Asplenium billotii and Polystichum lonchitis) are considered to be extinct in the 'Petite Suisse' area. The area offers good conditions for horsetails, especially for Equisetum hyemale and Equisetum telmateia. Considering the clubmosses, from the 5 known species for the area, 4 are considered to be extinct, and the status of Huperzia selago is rather unknown.
Special conservation measures are take so far only for Hymenophyllum tunbrigense. Following an initial field survey, a series of conservation measures where introduced to secure the survival of the species. In 1993 the Ministry of the Environment finally decided to withdraw public access to the main site by setting up gates and diverting the existing path. Further measures included setting up ramps in strategic places along public footpaths to avoid people straying off the signed paths. These direct measures in the field were supported by a new set of local bylaws governing the legal conditions under which rock climbing is permitted. Due to lack of support, a further attempt to enhance the legal protection of rare species sites and boost conservation initiatives in the area by officially designating the entire forest as a national nature reserve failed so far.

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The 'Petite Suisse' sandstone area in Luxembourg, a region of outstanding biodiversity

The conspicuous outcrops of Jurassic sandstone in the eastern part of the Grand-Duchy of Luxembourg offer life conditions for an outstanding biodiversity. The region, known under the name of 'Petite Suisse luxembourgeoise' is characterised by a great concentration of natural, cultural and historical treasures. The typical relief is formed by large plateaus, cliffs, more or less steep scree-covered slopes and wet valleys. The extended beach forests which occupy the great majority of the slopes, can be characterised as 'ancient' woods. The sandstone formations and the dense canopy cover are responsible for a special microclimate with high humidity and buffered temperatures. This conditions, as well as the multiplicity of habitats contribute to an extraordinary biodiversity. Vertical rock faces of deep and often narrow crevices are even characterised by exceptional microclimatic conditions which tend to mimic the oceanic climate of the European Atlantic fringe and offer therefore life conditions for a great number of rare species.
The 'Petite Suisse' sandstone area is internationally known for the relictual populations of Tunbridge filmy-fern (Hymenophyllum tunbrigense), first discovered in this continental island in 1821. It was therefore not a surprise that the gametophyte of another filmy fern, the Killarney fern (Trichomanes speciosum) was first discovered for continental Europe in the same region in 1993. Apart from pteridophytes, the 'Petite Suisse' area is considered being one of the 50th most important regions of bryological interest in Europe. On a faunistic point of view, the caves offer, for example, quarters for almost all bat species known in Luxembourg. On a prehistoric viewpoint, the region is well known for its Mesolithic past and it is not surprising that the oldest skeleton ever found in Luxembourg, the so called 'Loschbur Man' was discovered in this area.
Since the 19th century, tourism has played a major role in the economic development of this region and over the years, the stunning scenery of the woods and sandstone outcrops has led to the creation of an extensive network of public footpaths which exploit almost every corner of the forest and include most of the outstanding rock formations. Many outdoor activities cause pressures which are no longer tolerable in sites of extraordinary natural value. So efforts have to be made to conserve the beauty and integrity of the landscape and to protect species from whom it is assumed that their isolated inland occurrences within the European continent are a testimony to the once wider distribution earlier in this interglacial.

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Decomposition of litter in Pinus sylvestris and Pinus strobus forests in the Bohemian Switzerland National Park

The aim of the study was to evaluate:
1/ Differences in the rate of needle litter decomposition of two pine species, autochtone Pinus sylvestris and northamerican Pinus strobus, in their forests on the tops of the sandstone rocks in Bohemian Switzerland Natonal Park. Litter-bag method was used during three years period; both kinds of litter were incubated in both types of forests. 2/ Litter production, litter and superimposed humus physical properties and chemical composition (nutrients, lignin and pH), ecological conditions (soil moisture and temperature) and stand characteristics. 3/ Mycoflora (Ascomycetes) and Acarina (Oribatidae) colonisation of the pine needle litter in the process of decomposition.
1/ Litter-decomposition of both litters was faster in Pinus strobus forest. It doesn´t depend on litter type, except for three months at the beginning of the decay. After three years, the decomposition approached simmilar rates in both forests and litters.
2/ Pinus strobus litter fell earlier in the summer (june, july) comparating to Pinus sylvestris, burring herbs and tree seedlings. There were not important differences in litter chemical composition of both species and in humus from different forests. Net release of nitrogen began after 1.5 years of the exposition and is higher in Pinus sylvestris stand. Most of the ecological conditions diffeedr in Pinus strobus monoculture comparing with forests of P. sylvestris and mixed forests, resulting in humus and nutrient accumulation and herb layer species decline.
3/ 41 Ascomycetes species were determined on needle litter. 29 species colonized needles of both species, 5 species were found only on P. strobus, 7 only on P. sylvestris. Three species were found as new for the Czech Republic: Tympanis neopythia, Septonema ochracea a Pseudocercospora deightonii.

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Falcon (Falco peregrinus) in sandstones of The Broumovsko Protected Landscape Area, Czech Republic

The population of Falco peregrinus in Czech Republic reached the highest observed number in years 1940 – 1950. In this time falcon nested almost in all rocky areas with the total number about 60 – 80 pairs. Nests in Broumov upland were concentrated in Adršpach-Teplice Rocks, Broumov walls and on the rocky hills Ostaš and Bor. Generally, the population decreased rapidly after 1950 and last nesting pairs were registered in Czech Republic in 1968.
The restriction of using pesticides based on DDT, preservation of the species Falco peregrinus and its biotops and wide reintroduction programs in Western Europe helped its return. In the present the core of the Czech falcon population is located in The Elbe Sandstones and it represents about 40% of total 17 nesting pairs in Czech Republic.
After the long nesting absence first pair settled in Teplice rocks in 1998. Later observations confirmed the nest was left desolate probably because of the frequent illegal mountain climbing in this locality. Second pair nested successfully in the rocks of the hill Křížový vrch in 2000 and brought up two young ones. Another territorial pair was registered in Broumov walls in the locality Koruna in 2000 but these birds did not nest. Monitoring of potential nesting stands in Broumov region in spring 2001 proved repeated nesting on the hill Křížový vrch. But these falcons were disturbed by mountain climbers and consequently the pair left the nest.
Since 1995 a series of re-introductions of Falco peregrinus has been carried out to support the small population. The total number of 26 individuals were released in Broumov upland till 2001, mostly the way of free flight from the cage. The method of adoption of young ones falcons into the nest of hawk Accipiter gentilis was successfully practiced in years 2000 – 2002. In spite of this effort the real effect of the re-introduction program does not correspond with the expectations. Till the present time none of released birds has been observed on nesting places and regular stands in Broumov upland. Observations suggest that the mortality of released falcons is probably considerably higher to wild individuals (more than 40 %). Limited telemetric observations of released birds show that the surviving individuals leave our territory and fly to Poland (mountains Gory Stolowe, Legnice).

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Late Glacial and Holocene vegetation in a landscape with strong geomorphological gradients

Adršpašsko-teplické skály Mts. are one of acid sandstone areas, a typical phenomenon in the Czech landscape. They support deep and narrow valleys and gorges, which often form complicated network with a specific microclimate and hydrology. Ecological specificity of the sandstones (climatic inversion on the bottom of the gorges due to very low irradiation, very low poor nutrient content) underlie strong gradients over spatially small scale. Today's vegetation in the gorges is well defined against the rest of the landscape and constitutes a montane vegetation; in contrast, plateaus, margins of plateaus and the rest of the landscape have more or less mesic character.
This is a study of the vegetation cover during the Holocene by mean of pollen analysis; more specifically we studied, whether we can identify differences between gorges and the surroundings. The next object was the monitoring of pollen deposition at various stands and gorges by mean of pollen traps and moss polsters to identify their variability. Results should help interpreting fossil pollen spectra.
The pollen analysis shows a vegetation development during the past 10 000 years. There can be found some differences between the profiles. They show the distribution in vegetation on various habitats of the sandstone area. The comparison with previous studies was made and the results provide, that profiles situated in deep gorges reflect more local vegetation than those in shallow and marginal valleys. This theory support outputs of the pollen monitoring too showing more local pollen sedimentation in the gorges in comparison with plateaus and the surroundings. All results were verified by numerical ordinations.

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Comparision of the sandstone landscapes of the Stolowe and Bystrzyckie Mountains, Sudetes, SW Poland

The issue of plateau relief development and the controlling factors involved concern two adjacent mountain ranges situated in the SW Poland: the Stołowe and Bystrzyckie Mountains, which are formed of the Upper-Cretaceous rocks, largely sandstones and marls of the Intrasudetic Basin.
In the Stołowe Mountains the main landscape features are extensive planar surfaces situated at different altitudes, which are separated by distinct denudational escarpments, often of a rock cliff type. A vast rock-debris piles accumulates at the foothill of cliffs. There is an evident structural control upon the landforms. Highly resistant sandstone builds rock cliffs, while the vast flats are underlain of weak marls. Other characteristic feature of the Stołowe Mountains are rock outcrops of different sizes and shapes, which form rock labyrinths on the plateaus or within the escarpments. Yet, the area lacks deeper erosional valleys.
The relief of the northern part of the Bystrzyckie Mountains is characterized by an extensive slightly undulating summit surface, dissected by numerous deeply cut erosional valleys. There are both gentle and very steep slopes, which do not form many rock cliffs though. Both steep and gentle slope are form within sandstones, marls and gneisses as well, the latter forming the base for Cretaceous sedimentation. Other features are multiple local morphological flats at different altitudes, cut across both sedimentary and crystalline rocks.
The differences of main landforms in both mountain ranges result from lithological variation, differential tectonics and various time scales of relief development. The sedimentation of sandstones and marls in the Intrasudetic Basin differed locally considerably which is reflected in the characteristics of sediments – they differ e. g. in cement type, content of silica and calcium carbonate, type of bedding, dip and strike of beds, thickness of layers, type and density of fissures and joints. These features, decisive for rock resistance and strength, could have induced different development of the adjacent areas. As for the tectonics, the post-Cretaceous movements dissected the plateau of Bystrzyckie Mountains into many blocks, which were subsequently differentially uplifted. On the contrary, tectonics did not affect Stołowe Mountains so much, so that the Cretaceous sedimentary cover was not broken into segments and in no place older bedrock emerges on the surface. The development of structure-controlled landforms is also time dependent. Intensive tectonic movements in the Bystrzyckie Mountains, resulting in the increase of stream erosion and development of deeply incised valleys, has led to relief rejuvenation. At the same time, in the Stołowe Mountains, where the influence of tectonics was much less intense, denudational processes could have exploited structure without interruption.
Following these three main factors, responsible for different conditions for landform development, the relief of the Stołowe Mountains can be defined as lithology-and-structure controlled, while in the Bystrzyckie Mountains as tectonic-and-structure controlled.

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Environmental history of sandstone areas in the light of changes in molluscan fauna

At present, the north-Bohemian Cretaceous sandstone areas are characterised by sandy lime-deficient soils covered by acidophilous vegetation, so that they are not suitable for snails to live in. In contrast to this, the fills of numerous sandstone rock shelters and caves include Early and Middle Holocene horizons that are calcareous and include rich snail assemblages reflecting environmental conditions which were much more favourable than those at present. Their dramatic depauperization took place at the close of the Holocene Climatic Optimum. This event raises the question of the source of calcium carbonate that made possible both the fossilization of shells and the development of rich snail communities at that time. Several lines of evidence indicate that the lime was derived from loesses and possibly also from the sandstones which were later deeply decalcified. It may also be assumed that the existence of rich malacocoenoses was supported by the occurrence of trees whose litter contains the calcium citrate and the fossilization of shells in rock shelters by the activities of prehistoric humans, since the fossil shells occur in many cases in archaeological horizons. The Late Holocene ecosystem depauperization can be traced in wide regions of Central Europe, however, in the sandstone areas in question, it affected their environments in such a way that it may be considered local environmental collapse.

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Sandstone landscapes in the NW part of the Intrasudetic Depression, Sudetes Mountains

The Intrasudetic Depression is an extensive basin of tectonic origin in the central part of the Sudetes, which comprises a discontinuous sedimentary sequence from Late Carboniferous to the Late Cretaceous. The most distinctive relief is developed upon Late Cretaceous sandstones and mudstones and is typified by the 'rock cities' near Adršpach and Teplice, sheer cuesta of Broumovské stěny and the Table Mountains (Góry Stołowe) in Poland. Sandstone landscape in the NW part of the Depression is less spectacular and therefore less known, but it also merits attention, chiefly because a variety of structural controls upon relief can be demonstrated.

Two main geomorphic units are the Zawory plateau in the south and the Krzeszów Basin in the north, separated by a steep W-E trending scarp c. 100 m high. The east and west sides of the plateau are formed by steep structural escarpments up to 200 m high, built of Cenomanian sandstone capping less resistant Triassic sandstones. The Zawory plateau has developed upon the tectonic structure of Łęczna brachyanticline. Towards the north the brachyanticline passes along the flexural slope into the Krzeszów brachysyncline, which supports the morphological Krzeszów Basin. It is a NW-SE elongated structure, drained towards NW and delimited from NE and SW by distinct cuestas up to 150 m high, built of Cenomanian and Lower Turonian sandstones. The inner part of the Basin has subdued relief, except for a short asymmetric ridge built of resistant feldspar-rich Middle Turonian sandstones present amidst weaker calcareous facies of sandstones of the same age.

Escarpments and cuestas bear interesting signs of long-term retreat, including scars left by shallow landslides, spring niches, longitudinal clefts along the scarps, block streams produced by rock avalanches from the caprock, and beheaded valleys on the dip-slope.

In contrast to the more southerly parts, rock outcrops are relatively rare in the NW part of the Intrasudetic Depression which is probably related to lower mechanical strength of sandstone, but possibly also to smaller degree of erosional dissection. The majority of rock cliffs, pedestal rocks ('rock mushrooms') and tor-like features is developed within the feldspar-rich variant of sandstone. The highest cliffs are up to 17 m high and remain protected in a nature reserve.

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The role of large-scale slope failures in sandstone landscape evolution

Many sandstone landscapes around the world, especially in epiplatform tectonic settings, are characterised by the occurrence of distinct escarpments forming cuesta faces or plateau edges. Often, top parts of these escarpments assume the form of a vertical or steeply inclined rock slope, the height of which varies from a few to hundreds of metres. Cliff-forming sandstones are usually massive, poorly jointed, quartz-rich and well cemented, which accounts for their high rock mass strength and the ability to cope with high tensional stresses present within vertical, occasionally undercut rock slopes. Case hardening additionally contributes to high strength of sandstone exposed within a cliff.

Lower slopes of plateau edges are often mantled by extensive chaotic talus accumulation, apparently derived from large-scale rock falls and slides from the upper rock slope. Amphitheatral scars, niches and alcoves within the rock slope mark the place of failure. Usually initial failure takes place at the contact of caprock and underlying weaker rock and then propagates upwards along developing tensional cracks. Rock slope segments affected by individual events could be as much as 200 m high and 300 m across, as in the Ram sandstone area in SW Jordan. Apparent absence of sorted talus and regular debris cones indicates that continuous supply of debris from the rock face plays a minor part in the rock slope evolution.

The absence of talus cannot be equalised with the absence of past massive rock failures from rock slopes. Evidence from the Colorado Plateau and the Middle East demonstrates that talus disintegration at the footslope proceeds very fast, which is primarily attributed to the presence of aggressive weathering environment. Moreover, many sandstone blocks readily disintegrate on impact. There are examples of massive scars and niches within the cliff and very scanty talus beneath.

Punctuated rock slope evolution, with long periods of relative stability interrupted by episodes of massive failure and scarp retreat, appears to be a characteristic sandstone landscape phenomenon, unparalleled in other rock types, although it would be wrong to consider it unique for sandstone. Similarities can be sought in the development of marine cliffs. Possible consequences for living world include repeated exposure of fresh rock surfaces for colonisation by organisms, interruption of biological succession within both rock face and talus, and occasional destruction of habitats in the lower slope. Likewise, it remains an open question to what extent plants and animals contribute to increasing slope instability and eventually, failure.

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Relief and its memory: Minute forms in sandstone surfaces

Rock surfaces of weakly lithified sandstone rock are a specific "memory register": it is relatively easy to form a "record" (e.g., scratch, salt erosion feature, bioerosion feature, hardened body) but its durability may be surprisingly high. Little attention has so far been paid to this aspect of the sandstone meso- and microrelief; however, the temporal analysis of the surfaces may help to date various events, e.g., fall of rock block, deforestation, and soil degradation. Especially rich record can be obtained from honeycomb surfaces. Arcuate honeycomb pits usually show gravity-controlled orientation of their flat bottoms (probably because they function as "rock dishes" in specific situations). In result, surfaces of fallen blocks often bear pits of double or triple shape. 1, symmetrical arcuate ones with oblique bottoms (i.e., the oldest, non-reconstructed generation). 2, "reconstructed" honeycombs, usually larger than the previous type; their upper parts are inclined and somewhat asymmetrical, bottoms are flat. 3, symmetrical arcuate pits with flat bottoms (i.e., the youngest, post-event generation; cf. Mikuláš 2001a).
Less frequent but well interpretable shapes of sandstone surfaces are oblique "ledges" formed through rising of soil moisture in sidewalls of sandstone pillars. Therefore, an oblique ledge may mark long-lasting unchanged position of soil cover along the walls. In the area of historic settlement of Hradsko (Kokořín Nature Reserve), several ledges can be observed on the walls of sandstone coombs. In this case, the possibility to correlate individual ledges and episodes of deforestation seems to be realistic (cf. Mikuláš 2001b).
Rock crusts, rock arches, abri, tree trunks, arcuate niches, tunnels and small precipitation forms (e.g., spherical nodules) are other features of sandstone meso-and microrelief which may bear an interpretable temporal record.

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Sandstone modellation across climatic zones and lithofacies: The concept of porokarst

Landscapes showing characteristic geomorphology and hydrography bound to porous massive sandstones are usually denoted by the term of "sandstone pseudokarst". This term, however, is not apposite for processes and forms subjected to a non-live component of the sandstone phenomenon. The first, though the least important reason is a degrading prefix pseudo- which indicates a "pinchbeck" of another phenomenon (in this case, karst). However, sandstone meso- and microrelief show peculiar forms, which can be aesthetically fully compared with karst. Major reason lies in the factual inaccuracy of account of relevant processes. The term of karst is an aggregate for territories build of carbonates and other dissolvable rocks and adjacent typical underground and surface forms and characteristic hydrography. A subordinate term parakarst is used for features in non-carbonate rocks formed by solution; it is subdivided, among others, to bradykarst (quartzites and other silicious rocks) and tachykarst (evaporites). The term pseudokarst is reserved for features that originated at the same time as the host rock (e.g., cavities left by gases in lavas), and again for forms made by tectonic effects, mechanic disintegration and/or water, ice, and wind erosion. Versatility of forms of sandstone phenomenon is, however, caused mostly by numerous combinations and successions of the two following phenomena: 1, salt erosion made by salt solutions within the rock massive; 2, precipitation in the vicinity of the rock surface, which tends to the case hardening (i.e., origin of a rock crust of various thickness, shape and durability). The mass of the secondary cement comes from within the rock massive, but in contrast to karst, it precipitates only inside the substrate. Neither the first process, nor the second one fall to the definition of karst, parakarst or pseudokarst; they thereby require an additional term. Because the porosity of the substrate (specific in size of capillary space) is one of the key factors of hydrography of the sandstone phenomenon, the term of porokarst is designed herein. The porokarst can be defined by the presence of the two above-mentioned processes. Likewise karst and other related phenomena, also demarcation of porokarst is fuzzy. Across the climatic zones, poor conditions for the origin of porokarst are in arctic zone (e.g., East Greenland) because of weak vaporization and strong mechanic (i.e. pseudokarst) effects. Moderately humid temperate zone (e.g., Czech Republic and Germany) is the optimum. Towards subtropical and tropic arid areas, aeolian erosion dominates (e.g., Namibia Desert) but porokarst effects will probably be also locally important. Conditions of humid tropical zone bring to sandstone areas significant solution and therefore a dominance of parakarst processes (Tepuys, Venezuela). Across the lithofacies, medium-grained quartzose sandstones represent an optimum for porokarst. Effects of both main porokarst principles decline with decreasing or increasing of grain size (e.g., salt erosion and case hardening are not of use in conglomerates) as well as with increasing of amount of carbonate or clay cement.

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Distribution patterns and conservation status of endangered bryophytes in Saxonian Switzerland

The Saxonian Switzerland is an area very rich in bryophytes. 457 bryophyte species have been reported in the area. 389 species occur here at present.
The species richness is especially high in narrow sandstone ravines because of it's special climatic conditions (high humidity; reducing and delaying effect on temperature fluctuations: during cold fronts, the bottoms of the ravines are warmer than the plateaus and reefs, during warm fronts, they are colder than the plateaus and reefs).
For the distribution of bryophytes in the ravines, the climate, among other factors (e.g. soil, relief, competition, humidity), is of great importance. In the ravines, the share of boreo-montane, coldness and humidity loving species is much higher than on the plateaus. Dryness resistent species are more common on the plateaus.
Remarkable montane, boreal, subalpine und subarctic elements of the bryophyte flora of the Saxonian Switzerland are e.g. Anastrophyllum michauxii, Cephalozia leucantha, Dicranodontium asperulum, Fissidens osmundoides, Hygrobiella laxifolia, Mylia taylorii.
Remarkable atlantic elements are e.g. Campylopus fragilis und Porella pinnata (extinct).
There are 200 endangered species (species of the red lists of Saxony or Germany) among the bryophytes discovered in the area, of which 137 species have been found recently. The percentage of rare and endangered species is much higher for bryophytes than for phanerogams.
Especially remarkable endangered species of the area are the following species critically endangered in Saxony: Anastrophyllum michauxii, Drepanocladus cossonii, Fissidens osmundoides, Fissidens rufulus, Frullania dilatata, Geocalyx graveolens, Hookeria lucens, Leiocolea alpestris, Leucodon sciuroides, Neckera crispa, Riccardia latifrons, Scapania cuspiduligera, Sphagnum contortum, Sphagnum warnstorfii.
Important substrates for endangered bryophytes in the Saxonion Switzerland are acidophytic sandstone rocks and boulders, calcareous sandstone rocks, oligotrophic and base-rich swamps, sandstone walls, boulders in streams and brooks, the bark of trees, dead wood, the forest floor of coniferous forests, basalt boulders and springs in forests.
The nature conservation status of the bryophytes in the national park sector of the Saxonion Switzerland is good. Otherwise a high percentage of endangered species is also found in the landscape reserve area. Here, five species of the highest red list category (critically endangered) occur which are not present in the national park sector. For the protection of these endangered species, stronger conservation measurements are necessary.

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Quantitative hydrological model of the Ploučnice catchment using neural networks

An application deals with calibration of neural model and Fourier series model for Ploučnice catchment. This approach has an advantage, that network choice is not dependent on other example's parameters. Each networks, and their variants (different units and hidden layers number) can be connected in as a "black box" and tested independently. A Stuttgart neural simulator SNNS is used for testing. A perceptron network has been constructed, which was trained by back propagation method improved with a momentum term. The network is capable of an accurate forecast of next day runoff on the base of runoff and rainfall values from previous data.

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The lichen flora of the National Park České Švýcarsko

A detailed lichenological exploration of the National Park České Švýcarsko started in 2000. Approximately 190 species were recorded so far (sparse literature data included), which represents about 10% of the total lichen flora of the Czech Republic. Eight lichen species recorded in the area were not published from the Czech Republic so far (Caloplaca chrysodeta, Gyalideopsis anastomosans, Lepraria elobata, Micarea pycnidiophora, M. viridileprosa, Phaeographis inusta, Vezdaea cobria). Several findings represent second records for the country (Chromatochlamys vezdae, Enterographa hutchinsiae, Micarea bauschiana).Two epiphytes listed as extinct in Red-data book for the Northern Bohemia were refound (Graphis scripta, Thelotrema lepadinum). Still many other lichens, however, seem to be extinct now in all the area of the National Park (e.g Bunodophoron melanocarpum).
Epiphytic lichen flora is relatively poor and very unevenly distributed. Only several species dominate on single trees. The reason might be also rather recent stochastic recolonizations via dispersal events by wind (both from long distances and local residual population sources) after abrupt decline of industrial immisions in last decades. Only three epiphytic macrolichens were scored regularly in the area (Hypogymnia physodes, Parmelia saxatilis, Parmeliopsis ambigua), while the others are rare and shrubby lichens like Evernia prunastri, Usnea or Bryoria sp. div. were not recorded so far at all. Microlichen species like Japewia subaurifera, Ropalospora viridis, Micarea peliocarpa, M. viridileprosa may sometimes cover large parts of trunks, while under normal conditions they produce smaller thalli intermingled among other lichen species. The richest epiphytic lichen flora is developed in the protected valley of the rivulet Kamenice where many suboceanic elements grow. E.g., the valley forms European easternmost distributional limit for two microlichens (Micarea pycnidiophora, Phaeographis inusta).They and other pecularities represent probably relics of formerly much richer epiphytic lichenflora.
Sandstones - due to their faster weathering, larger water sorption capacity, as well as favourable microclimatic conditions - host many species primarily occupying epiphytic, epixylic or epigaeic niches: e.g. Hypocenomyce caradocensis, H. scalaris, Phlyctis argena, Trapeliopsis glaucolepidea, but also lichens more-less specific for this kind of substrate (Pertusaria ocellata).Crustose lichens e.g. Caloplaca chrysodeta, Gyalecta jenensis or Lecidella stigmatea belong to reliable indicators of higher lime content in sandstone.
Terricolous lichens are omnipresent in the area, well developed especially in man-made/influenced habitats like road-ditches, heaths etc. Prospering autochtonous terricolous lichen communities are well developed mainly in thin relic pine forests on open sandstone plateaus. They are potentionally endangered by spreading of invasive Pinus strobus.
Taking into account lichenological viewpoint, the area of National Park belongs, despite seeming monotony, to totally singular areas within the Czech Republic. Undoubtedly it deserves, besides systematic and targeted conservation, further research and attention not only from the part of lichenologists but also from experts in other biological fields.

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Ground water hydrochemical composition dependence on hydrogeological position in Bohemian Switzerland National Park

Bohemian Switzerland National Park territory is representing area with full hydrogeological cycle. Excellent porous conductivity is increased with intensive tectonic dislocation. For eastern part of National Park is typical infiltration of surface water-course, as a result some water-courses completely infuse itself into the rock massive at hydrological minimum time (e.g. Vlčí stream or Doubický stream). On contrary in western part of National Park takes place dark groundwater drainage into the water-course or on spring form. Most intensive drainage takes in places, where a deep valley and canyon interrupted across groundwater level. Groundwater transport from infiltration area by drainage area takes on order of thousands years. Long-time groundwater and rock massive interaction during transport may effect on groundwater hydrochemical composition.
By basic series of sandstone rocks it can be allocate areas with different geological structure and with different groundwater hydrochemical composition. In the north-east part intervene into the National Park granitic rocks of Lužický pluton. In the whole area is frequent incidence of tertiary volcanic rocks. Along Lužická tectonic breakdown is unique on surface situated Permian rocks and Jurassic limestone. Groundwater hydrochemical composition therefore may be important indicator of geological structure.

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Earthworm (Lumbricidae) distribution in Bohemian Switzerland - present state of knowledge

In this contribution, the data are summarized on the occurrence of earthworms at the territory of the Bohemian Switzerland National Park and the Elbe Sandstones Protected Landscape Area. In total, almost 4000 earthworms were collected at 47 sites, representing the most frequent types of ecosystems, in 1980-2000. 29 species and subspecies were identified, i.e. 56 % of the Czech earthworm fauna. Of those, euryecious earthworms Dendrobaena octaedra, Dendrodrilus rubidus, Lumbricus rubellus, Aporrectodea rosea and A. caliginosa were most common, however, individual sites differed largely in spectra of scarce species.
Acidophilous spruce and beech forests, and dry pine forests and bogs on sandstone bedrock were inhabited by poor assemblages composed of only two to five epigeic or subcorticolous earthworms. On the other hand, wet beech forests and eutrophic water sources on basalt bedrock, and other wetlands possessed earthworm assemblages much richer in species (site species richness 9-17), composed of representatives of all three main ecological groups of earthworms. Within the sandstone area, similarly rich assemblages were only found on stream banks in narrow valleys, where mountain species Lumbricus baicalensis and Octodrilus argoviensis were recorded.
Quantitative parameters of earthworm assemblages were studied at selected model sites. The highest density and biomass of earthworms were respectively found in wet meadow soils of the Stará Oleška (486 ind.m^{-2} and 48.5 g.m^{-2}) and Arba Nature Reserves (221 ind.m^{-2} and 21.7 g.m^{-2}), while the lowest ones (6 ind.m^{-2} and 0.2 g.m^{-2}, and 3 ind.m^{-2} and 0.1 g.m^{-2}, respectively) in acid beech forest at the Děčínský Sněžník foothill and in sandy soil under white pine (Pinus strobus) east of the Jetřichovice village.
Based on 29 taxa recorded, Bohemian Switzerland is among those with the highest diversity of earthworms in Central Europe. Variety of geomorphological, pedological, botanical and microclimatic conditions throughout the territory resulted in a number of very specific earthworm communities. The role of Bohemian Switzerland as a refuge and/or migration corridor for several worm species is discussed.

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Dimension stones from the "sandstone" areas in the Czech Republic

Sandstones are understood as any clastic sedimentary rock in technical practice. These rocks of Palaeozoic to tertiary age occupy more than 1/4 of the territory of the Czech Republic. The extensive exploitation of sandstones since medieval times (probably Gothic) significantly influenced Czech architecture and sculpture and, for sure, sandstone landscapes as well.
This contribution gives overview of important "sandstone" areas in the Czech Republic. The basic properties and uses of selected stone types are presented together with their perspective application. The influence of sandstone exploitation on landscape evolution is discussed mainly in the case of the Bohemian Cretaceous Basin.

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Erosion of wealden sandstone outcrops by visitors

Sandstone cliffs developed in Lower Cretaceous sandstones in southeast England are popular visitor attractions and suffer considerable recreational use and damage. The cliffs first became popular attractions in the nineteenth century, especially in the vicinity of the Spa town of Tunbridge Wells. 'Pleasure grounds' were developed, most notably at High Rocks, where walkways were constructed to give access to the base and tops of the cliffs, and tearooms built to provide refreshments. Other cliffs were incorporated into 'romantic' landscaped gardens developed by rich landowners and surrounded with exotic temperate shrubs and trees. Many of these gardens remain very private but others are now open to the fee-paying public. In the early twentieth century the cliffs became popular for rock climbing, and some of the cliffs are now among the most heavily used in England.
Southeast England is the most populous part of England with great recreational pressure on the open countryside. The cliffs mostly lie in an Area of Outstanding Natural Beauty (ANOB) which gives planning bodies special powers to control commercial development. In recognition of their geological, geomorphological and botanical importance several sites have been designated Sites of Special Scientific Interest (SSSI) but this gives little or no protection from recreational pressures. One site has been bought and is managed by the Sussex Wildlife Trust
Although it forms impressive cliffs the sandstone is weakly cemented and is very susceptible to abrasion, especially if the protective surface crust is broken or removed. As a consequence, there are a number of ways in which visitors cause damage to the geomorphological value of the cliffs. Walking and scrambling over the cliffs damages the surface crust and associated weathering features. In extreme cases the entire form of the sandstone surface is 'remodelled' by footstep abrasion. Climbing poses particular problems with the cliff face suffering abrasion by hands, feet and bodies and, unless preventative action is taken, climbing ropes rub against the surface and abrade deep gouges into the sandstone. Many cliffs have also been disfigured by graffiti cut into the surface of the rock, some of it several centuries old. The ground surface below heavily visited cliffs is undergoing significant lowering and the passage of visitors through the widened joints or 'gulls' that dissect the cliff faces is causing considerable erosion of their infill.

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Climate, colonisation and celibacy: Phylogeography and population structure in Trichomanes speciosum (Pteridophyta)

The Killarney fern Trichomanes speciosum Willd. (Hymenophyllaceae) was first discovered in central Europe in 1993. The species is unique in possessing both extensive sexual (both generations present) and asexual (gametophytes only present) ranges. T. speciosum is represented in this area by its perennial, vegetatively propagating gametophyte generation. Genetic diversity (allozymes and cpDNA sequencing) has been investigated from throughout the known distribution, including all Macaronesian archipelagos, the western Atlantic fringe and Central Europe. Chloroplast DNA sequencing revealed a clear partinioning of diversity and suggests different refugia and subsequent colonisation routes of the taxon during the Pleistocene.
For Central Europe the pattern of allozyme diversity suggests that colonisation was not solely of a "stepping stone" or "leading edge" type. We suggest that during a climatically favourable period, probably the Atlantic hypsithermal, there may have been an explosive colonisation by long distance dispersal from glacial refugia. This was followed by a short period during which sporophyte production, sexual reproduction and local spread was possible. With climatic change and the consequent loss of the sporophyte generation individual genets resulting from this process became fixed within small, favourable but scattered sites. The possibility that some central European sites north of the Alps, especially sandstone massifs such as the Elbsandsteingebirge, acted as peri-glacial refugia cannot be discounted, but would appear less likely than (re-)colonisation from the Atlantic fringe.

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Spiders on sandstone rocks in České Švýcarsko National Park

Spiders on sun-exposed and shaded rock walls in České Švýcarsko NP were collected using hanging board traps. A total of 174 spider specimens belonging to 39 species were collected. A half of species collected were found exclusively on sun-exposed rocks, a second half exclusively on shaded rocks. The assemblage of sun-exposed rocks is characterised by presence of species with usual or preferential occurrence in Thermophyticum and in very dry habitats (Xerolycosa nemoralis, Drassodes lapidosus, Zelotes puritanus, Zelotes petrensis, Aelurillus v-insignitus, Zodarion germanicum, Episinus truncatus). The assemblage of shaded rocks is characterised by presence of species with usual or preferential occurrence in Mesophyticum and in semi-humid habitats (Nesticus cellulanus, Hahnia pusilla, Amaurobius fenestralis, Callobius claustrarius, Harpactea lepida, Cicurina cicur, Histopona torpida).
Lepthyphantes pulcher is an exclusive inhabitant of rocks. Zelotes puritanus occurs rare on rocks, rock margins and adjacent rock steppes and forest steppes. Records in České Švýcarsko NP and Klíč Mt. in north Bohemia extends its distribution behind borders of Thermophyticum.
Sandstone rocks are characterised by marked contrast between forested plateau and bare vertical rock wall. The edge with sporadic herb and shrub vegetation is very narrow, but is the case of sun-exposed rocks, is able to harbour specific assemblage of spiders with numerous thermophilous species.

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Meloderma desmazieressii is destroying the white pine (Pinus strobus) stands in the České Švýcarsko National Park

The most frequent and the most important fungal pathogen of white pine in the territory of the České Švýcarsko National Park is the needle-cast Meloderma desmazieressii. It infests trees of all age stages. It causes dying not only of the infested needles but also of the whole shoots. When the infection repeats in a few subsequent years the trees may even die. The needle-cast is most damaging in the localities with stabile air moisture, i.e. in the bottoms of valleys and canyons.
Of other important fungal pests of white pine, the rust Cronartium ribicola can be observed in the territory of the national park. This pathogen, which is most important for white pine elsewhere, is not too much frequent here, probably since the most common second host of this rust – the black currant (Ribes nigrum) - occurs rarely in this territory.
Quite often there occur trees died after infection by wood-destroying fungi in the territory of the park. They attack the root system of white pines. The most frequent in this role are root rots of the genus Armillaria – first of all Armillaria ostoyae, less often some other wood-destroying fungi (Heterobasidion annosum, Phaeolus schweinitzii).
Occurrence and harmfulness of other fungi on white pine is more or less negligible.

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Salt weathering of Cretaceous sandstones in acidified areas: predictions and reality

Formation of salt crusts on sandstones is common in conditions of chemical weathering. The diagnosis of the salt source and process of its formation is complicated in nature and related to physical-chemical conditions of the system in the contact with water and atmosphere. At first, the thermodynamic factors should be taken into account. In our study, we have used typical composition of the acid rainwater collected in polluted regions of N and NW Bohemia (data of Czech Hydrometeorological Institute) to calculate the saturation indexes using MINEQL and PHREEQC software, alternatively. We have found that gypsum is theoretically the most perspective secondary phase. The results of direct evaporation tests showed that gypsum usually occurs as main crystalline mineral in the precipitate. Gypsum is usually present in crusts even on calcium-depleted sandstones with clay matrix; the support of calcium from the rainwater is sufficient.

As we have found earlier, the mineralogical composition of the crusts on Cretaceous quartz sandstone of N and NW Bohemia is quite similar in all studied samples; gypsum and ammonium and/or potassium-rich alums are predominant phases in most of samples. Except of aluminium, occurrence of all the main compounds forming the crusts (SO_4^{2-}, Ca^{2+}, NH_4^{+}) is in good correlation with a typical composition of acid rain; while evaporating, gypsum is preferentially crystallized; ammonium alums are preferentially contaminated by potassium. The low pH values of penetrating solutions cause the dissolution of aluminium-bearing minerals and these conditions are suitable for the rise of Al-SO_4 minerals as typical products of acid-sulphate alterations. The problem is that thermodynamically the most perspective phase – alunite – frequently mentioned in the literature, has not been found in any of about 200 samples of sandstone weathering crusts. Instead of that fairly soluble alums usually appear. It clearly demonstrates the importance of kinetic factors of mineral precipitation and dynamic effects of water movement within the porous media (wetting/drying alterations), which probably significantly affect the relative stability of these mineral forms during the chemical weathering.

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The Ishalo – the gem of Madagascar

The Ishalo Massif lies in the south-western part of Madagascar. It covers about 1000 square kilometres, and most of its area is protected as a National Park. Ishalo is one of the earliest National Parks on the island, which protects the unique landscape of a sandstone massif dissected by a labyrinth of deep canyons and a jumble of ruiniform contours of strange appearance. The Ishalo Massif represents a part of the earliest sedimentary layers of the Permo-Trias karroo series, which was formed on the bottom of the old, Permian Sea once covering part of the Gondwana continent (Battistini 1972). The climate is hot and rather dry. The annual mean temperature equals about 25^{o}C, and the precipitation is about 1500 mm per month, but falling almost entirely in the hot season. The dry season may extend to several months (Donque 1972). In the phytogeographical divisions of Madagascar the area is comprised within the Centre Area (Koechlin 1972), which includes the central plateau region, above the average height of 800 m a.s.l.
For a long period of time (about 1000 years) the Ishalo area has been under extensive anthropopressure due to grazing, clearing and burning of forest, although stable settlements do not occur here.
At present the area is covered by various type of vegetation. They include the relic (or secondary) formations of sclerophyllous forest with domination of Tapia sp. (Capparidaceae), Asteropeia sp. (Theaceae), Uapaca bojeri (Euphorbiaceae), Cussonia bojeri (Araliaceae) and other species. Another type are the lax, forest formations with many gaps, where the many shrubs and herbaceous plants occurs. The most common of these are Maesa lanceolata (Myrsinaceae), Aphloia theaeformis (Flaccourtiaceae) and many endemic species of Helichrysum (Asteraceae), Catharanthus and Pachypodium (Apocynaceae) or Xerophyta sp. (belonging to the endemic family Veloziaceae). Rock crevices harbour not only grasses and herbs, but also small endemic trees of Ficus and many succulent species of Aloe, Kalanchoë, Cynanchum and Euphorbia. There is also a wide area of pseudo-steppes with Aristidia rufescens, Trachypogon sp., Heteropogon sp.and Imperata sp. here, which represents a relic of the old, grazing and burning, type of Ishalo management.

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Geobotanical analysis of the Stołowe Mts. (Poland, the Sudetes Mts.)

The Stołowe Mts. is the largest Jurassic-cretaceous sandstone massif in Poland. It is a part of the Middle Sudetes, stretching in the western part of the Kłodzko Region, on the border of Poland and the Czech Republic. The lowest section of the Stołowe Mts. is the valley of the Bystrzyca Dusznicka River (355 m), the highest peaks reaching 927 m a.s.l. (Mt. Szczeliniec) and 908 m a.s.l. (Mt. Skalniak). Those peaks are typical table mounts, the only ones of this type in Poland. And thus the area is very important for Polish nature protection – the Stołowe Mts. National Park was established here in 1993, and it will certainly be comprised within the Natura 2000, a system of the European ecological network.
The flora of the Stołowe Mts. contains about 1050 taxa. During my investigations (1992-1998) 885 taxa were discovered, rediscovered or confirmed; between them 12 species of plants listed in the Polish Red List and 44 protected by law in Poland. Also, not fewer than 72 mountain taxa, 42 xerothermic plants and 53 archeophyts occur here.
There are 6 main phytogeographical divisions in the Stołowe Mts. The submontane level contains three of them. These are the Grodzic Massif (central part of the level), Obniżenie Kudowskie depression (western part) and the south-eastern piedmont division between Batorów and Polanica. The flora of the submontane level is of lowland character, and comprises many common lowland species such as Stellaria holostea, Carpinus betulus, Tilia cordata, Corydalis intermedia, Hedera helix, Hepatica nobilis, Lonicera xylosteum, Chamaecytisus supinus, Genista germanica, Orobanche elatior and others.
The montane level comprises two divisions: Stoliwo (central part of the Stołowe Mts.) and the Lewińskie Hills. The first one is the best preserved area in the region and protects very interesting and rich flora, both within limestone and sandstone habitats. Many rare and vulnerable species in Poland (e.g. Gentianella praecox, Traunsteinera globosa, Dactylorhiza fuchsii, Orchis mascula, Arnica montana, Drosera rotundifolia, Carex lasiocarpa, Ledum palustre) occur exclusively in this division. Saxifraga decipiens has its sole locality in Poland in this level, close to the peak of Rogowa Kopa.
The highest peaks of the Stołowe Mts. (from 850 to 927 m a.s.l.) have many both nature and landscape values, which makes them very different from the montane and submontane level. Some of high-mountainous communities (Plagiothecio-Piceetum, community of alliance Rhododendro-Vaccinion) occur here, and the relict populations of Pinus sylvestris, Pinus mugo (the second natural locality in the Sudetes Mts.) and Betula pubescens ssp. carpatica grow in this layer, too.

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Terrestrial arthropods (Oniscidea, Diplopoda, Chilopoda) of the sandstone and adjacent habitats in Bohemian Switzerland National Park

Up to the end of the twentieth century, only several scarce data about the faunas of terrestrial isopods, millipedes and centipedes of the Elbe sandstone area and surrounding territories were known. Only general information about the centipedes, except for Geophilus flavus, was published by Rosický (1876) and Folkmanová (1928). More detail analysis of the millipede fauna of North Bohemia and the neighbouring Saxonia proposed Verhoeff (1910) and the list of terrestrial isopods has been summarised by Flasarová (1995).
In 1996, hand sorting, soil sampling and pitfall trapping were used for the faunistic as well as cenological research on these three groups of soil macrofauna. Further sampling in another localities including the alluvium of the Elbe River later on completed extended material, collected during this year. The main results based on this research have been already subsequently published (Tajovský, 1998, 2001).
The centipede species Schendyla montana and Lithobius tenebrosus fennoscandius were noted here for the first time for the Czech Republic. The record of Unciger transsilvanicus in the Arba Nature Reserve represents the north-westernmost occurrence of this species in Europe. The highest numbers of millipede and centipede species were found in beech forests (Melico-Fagetum) covering basalt summits (Růžák National Nature Reserve, Mlýny, Purkartický les). Acidophilous beech forests and deep sandstone passes were poor in millipede and partly in isopod faunas, but usually not in centipede assemblages. Wet meadows and forests of open valleys were the richest ones in population densities of isopods (970-1030 ind.m^{-2}) and centipedes (up to 522 ind.m^{-2}). The narrow alluvium along the Elbe River is characterized by presence of some species typical for wetland habitats (e.g. the millipede Julus scanicus, the centipede Lamyctes emarginatus). The Elbe River valley represents a possible corridor between the central and west European (atlantic) areas, as confirmed for example the occurrence of the millipede Polydesmus angustus and Craspedosoma germanicum.
Together with literary data, 14 species of terrestrial isopods, 31 species of millipedes and 28 species of centipedes are known today for this whole area. Based on this data, the territory of the sandstone and adjacent habitats in Bohemian Switzerland represents on of the richest area not only in the Czech Republic, but also in the whole Central Europe.

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Dendroclimatic comparison of invasive Pinus strobus and native Pinus sylvestris growing in the Czech Republic on ecological and geographical gradient

Introduction

Alien white pine (Pinus strobus) was introduced from North America to the plantations in the Czech Republic at the end of the 18th century, with intensive planting beginning in the twentieth century. At present white pine reproduces naturally and suppresses the native vegetation by forming dense monocultural stands and a thick layer of needle litter in some regions of the country, especially in sandstone rock areas.

One of the studies presented compares the responses to temperature and precipitation levels of the native Scots pine and the invasive white pine growing in the Elbe River Sandstone Mountains (National Park) as a region heavily affected by spontaneous regeneration of Pinus strobus. On a transect across a river valley we selected sites with contrasting environmental variables including differences in direct solar radiation, soil depth and water availability.

The second study was focused on dendroclimatology of these two species in three regions of the Czech Republic differing in their abiotic characteristics and a degree of Pinus strobus regeneration in the plantations and spreading into the forests of other species.

Material and methods

In the transect across a valley, standard dendroclimatological methods were used for the comparison; these included application of a response function model and partial correlation of monthly average temperatures and monthly precipitation with tree-ring widths. A transect was chosen for the study area across a narrow valley in the plateau of the Elbe Sandstone at altitudes between 200-250 m a.s.l. Three sites were included in the transect: shaded position near the bottom of the valley with relatively deep soil with high water availability and two positions on the rim of the valley, both with southern and northern exposition, with almost no soil and higher potential direct solar radiation.

The response function analysis, the moving response function analysis and the pointer years analysis were used in the comparison of tree regions with old plantations of Pinus strobus and native or planted Pinus sylvestris forests:

1) the Elbe Sandstone Mountains in the North of the Czech Republic, with massive invasion of white pine;
2) the Elbe River Lowland in the centre, with regeneration of white pine increasing in recent years;
3) the Jindrichuv Hradec region in the South, with almost no spontaneous regeneration of white pine.

Results and discussion

The response function analysis of the trees from the transect showed that both species were positively sensitive to June-July precipitation in all the chosen habitats, although Scots pine was less sensitive near the bottom of the valley. Both species were also found to be positively sensitive to higher February-March temperatures, due to the possibility of late-winter frost damage. Scots pine reacted strongly in all habitats while white pine reacted weakly high above the bottom of the valley on the edges of the sandstone plateau, but strongly near the bottom of the valley where there is a risk of inversion frosts. The two pine species differed in their reaction to temperatures in the September of the preceding tree-ring growth season. The most striking finding is that white pine reacted negatively to high temperatures while Scots pine showed no reaction. This could be due to the negative influence of high temperatures on bud development which takes place in white pine later than in Scots pine. The temperature reaction in white pine is weak near the bottom of the valley where direct solar radiation in September is reduced by shading from the valley rim.

The basic features of response of both species described above occured at all the plots in three study areas on the geographical gradient. There were differences in the intensities of the reaction and several uncommon further reactions: the most important were positive influence of high precipitation in previous summer to both species in the Jindrichuv Hradec region.

The pointer years analysis showed a strong common response of both species in all study areas to extremely dry summer in 1976. Other pointer years were different for each area and species.

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The Killarney Fern (Trichomanes speciosum) in sandstone regions of the Czech Republic

The Killarney fern (Trichomanes speciosum) is a vascular plant species, hidden-living in some parts of its distribution range. In Central Europe, the species develops only fibrous gametophyt (sexual phase of life). Colonies of the species have round, oval or irregular shape and size from several millimeters to several decimeters. The height of the colonies is usually 2-5 mm. The gametophyt looks like a green mould and has special habitat requirements. In the Czech Republic, it has been found only in blocky sandstones of the Bohemian Cretaceous Basin. It prefers deeper, tight and small caves or it grows in rocky slots and combs with special microclimate, i.e. high humidity and good temperature. Slot orifices are usually covered by moss and algae and the colonies of the fern are usually situated only deep, where there is nearly no light.
The first locality in the Czech Republic was found by Vogel and Jessen in Suchá Kamenice in 1993 (VOGEL, JESSEN, GIBBY, JERMY & ELLIS 1993). In May 2001, another important site was discovered by K. Horn in the Břehyně–Pecopala National Nature Reserve (the Liberec region). In that year, the Agency for Nature Conservation and Landscape Protection of the Czech Republic, as a national coordinator of NATURA 2000, has started the research and mapping of species with the help of foreign and Czech botanists (Trichomanes speciosum belongs among twelve vascular plants listed in Annex II of the Habitats Directive 92/43/EEC and occurring in the CR). At present, about one hundred sites of occurrence of Trichomanes speciosum are known in Bohemia. The most important region for this species is the Kokořínsko Protected Landscape Area (Central Bohemia). The soft sandstones of Kokořínsko that disintegrate into rich combs, many small caves and horizontal deep slots are a very suitable habitat for the species. Moreover, the largest colonies of Trichomanes occur in the Kokořínsko PLA and we suppose that more then a hundred sites will be found there. Most sites are situated in northern Bohemia: České Švýcarsko, Labské pískovce, Hradčanské stěny, sandstones near Hamr, Sloup v Čechách, Břehyně (the Břehyně-Pecopala National Nature Reserve), Česká Lípa (the Peklo National Nature Monument), Kolné, Staré Splavy. A smaller number of sites have been found in eastern Bohemia: Český ráj, Prachovské skály. The last one is easternmost site in the world. Concerning altitude, the lowest site in the Czech Republic is situated near Kamenice - 130 m above s.l. (JESSEN 2001), while the highest site is near Sloup v Čechách - 420 m above s.l.
The fern has not been discovered yet in the sandstones of Adršpašsko-Teplické skály and Broumovské stěny. They are situated in higher altitude with only a very few small caves and slots and have much colder climate. Neither the survey in Toulcovy Maštale and Pivnice near Bor u Skutče has been successful. The sandstone is too soft there and erosion goes too fast. Such conditions are not suitable for the species.
Considering the special ecology and habitat requirements of the species, a question arises whether the fern is threatened at its sites. Čeřovský says in the Red Data Book (ČEŘOVSKÝ, FERÁKOVÁ, HOLUB, MAGLOCKÝ & PROCHÁZKA 1999) that survival of the relict could be endangered by changes of rock gorge microclimate, for example as a result of forest damage. We suppose that regular cutting, esp. clear-cutting on large areas, also has negative impact on the species. Trichomanes speciosum does not thrive also in caves that are occasionally used by tramps who make fire there. Most of the species' sites are protected as nature reserves, the species itself is included in the Red List of the Czech Republic as a critically endangered taxon (HOLUB, PROCHÁZKA 2000) and is included also among the especially protected species of the newly prepared regulation.

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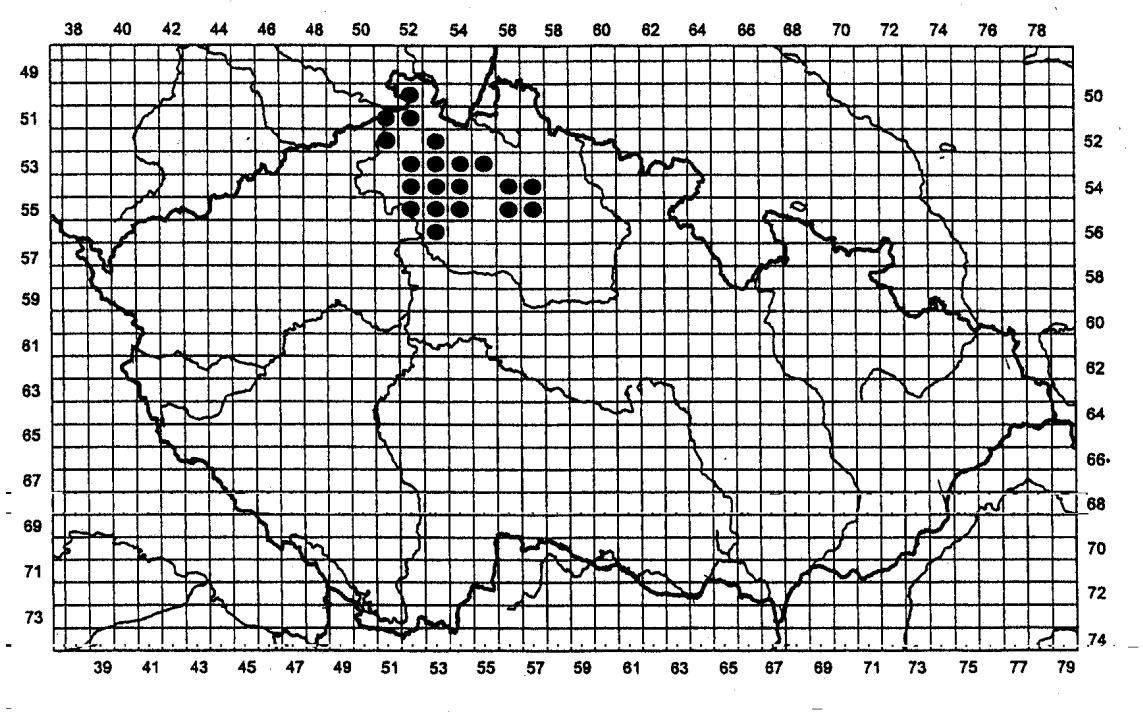
Annnex: Map of distribution of Trichomanes speciosum in the Czech Republic



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Ferruginization in sandstones of the Bohemian Switzerland National Park, Czech Republic

A typical feature of sandstones both in the Bohemian Switzerland National Park and elsewhere in the Bohemian Cretaceous Basin is Fe-mineralization. Owing to its higher resistance to weathering and deflation, it acts as a resistant element in the sandstone relief, often creating unique and bizarre forms on the rock walls, thus increasing the aesthetic value of the landscape. Ferruginization can be found throughout almost the whole area of the National Park. It mostly forms subvertical planar tabular bodies along contacts of basaltic dykes with the host sandstone and fillings of open joints and faults - Type 1 and irregular, thin undulating parallel crusts, circles or linear concentric tubes in the rock massif - Type 2, whose genesis is explained by the Liesegang phenomena. Type 3, represented by strata-bound subhorizontal bodies, follows conglomerate beds or strata-parallel fracture zones.
The character of ferruginization in sandstones and its relation to basaltic bodies, geological and tectonic conditions was studied by means of field mapping at classical localities. The viewpoint of "Rudolfův kámen" is a typical and possibly the most frequently visited locality of ferruginous sandstones, where all three defined types of Fe-mineralization can be found. The following sites are important for the occurrence of ferruginization: Baldurova jehla, Čínská zeď, pod Pravčickou bránou, Kyjovské údolí (Type 1); Temný důl, Nad jeskyní Peklo, Tetřeví kout (Type 2), and the rock formation called "Tři stoly" with a subhorizontal body of Fe-oxyhydroxides (Type 3) that gives rise to mushroom rocks. The measured orientations (mostly NE–SW to E–W) of encrustations lining joints and of ferruginous tube axes generally corresponds to the directions given by Seifert (1939). However, ferruginization is more extensive at localities on the Czech side of the protected area, than indicated on the Seifert's map.
Spatial relationships between intrusive bodies and individual ferruginization types were confirmed by the study of Adamovič (2001). Accumulations of iron oxide and hydroxide (goethite, less often hematite) probably formed during the main volcanic phase in the Late Oligocene and Early Miocene owing to transport of Fe^{2+} through the mediation of hot mineralizing post-magmatic fluids. Their main source in the National Park is probably represented by the Tertiary basaltic rocks: olivine basalt, limburgite, tephrite etc. - Slunečný vrch, Sokolí vrch, Koliště, Kitzenberg, Mlýny, Zámecký vrch, Růžovský vrch, Groβer Winterberg, and also the occurrences of basaltic rocks documented only on the basis of traces after their quarrying.

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Geomorphology of the Bohemian Switzerland National Park, Czech Republic

Bohemian Switzerland National Park constitutes an integral and unique geological and morphological unit, protecting an area of outstanding sandstone scenery. The main objects of protection are the so-called 'rock cities' developed in the sandstone, with their unique geomorphology, weathering features and related biodiversity.
Sandstone relief in such areas resulted from the combination of several basic genetic factors. Geological, and particularly tectonic, conditions decisively influenced the macrostructure of the terrain - e.g., by the formation of plateaus, valley networks and block disintegration of the sandstones. Lithological factors, assisted by selective weathering, participated in the formation of the sandstone pseudokarst landforms. Climatic/microclimatic factors defined the extent of capillary water transport to a considerable extent, being one of the most important causes of sandstone degradation. In the same way, biological factors - in particular bioerosion - also contributed to the creation of various perforations and rock bowls. A leading role in the geomorphic history in this area was played by two main antagonistic processes: surface hardening (rock crusts mostly caused by silica and ferruginous impregnation) and salt weathering.
The high vertical relief of the National Park area was produced by intensive fluvial erosion at the end of the Tertiary and during the Quaternary, which dissected the originally flat-topped sandstone massif. In this process, less resistant rocks were removed and a wide spectrum of characteristic landforms was created. Large morphological forms (macroforms) include rock plateaus and canyons of the Kamenice and Křinice rivers, rock walls as high as 150 m (even 250 m in the area of the Pravčická brána Arch) and rock cities or rock labyrinths. Medium-sized forms (mesoforms) are represented by the renowned Pravčická brána Rock Arch. This structure, now the symbol of the National Park, originated due to lateral erosion of a narrow sandstone rib. Its dimensions (16 m in height, almost 27 m in length) make it the largest sandstone arch in Europe. Rock ledges, shelters and chimney rocks are also abundant. Rock pillars, mushroom rocks and rock windows occur rarely. Smaller relief forms on the surface (microforms) are represented mainly by abundant honeycombs, pits and rock cavities. Pseudokarst karren ca. 0.7 m deep often cover the rims of the plateaus and cliffs.

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Bryophyte diversity of České Švýcarsko (Bohemian Switzerland) National Park

The area pattern of České Švýcarsko (Bohemian Switzerland) conditions two different views of bryophyte species diversity. On the one hand species low rich communities occur there frequently which is related to the occurence of nutrient-poor soils on sandstones. Apart from this there occur species which are connected with unique microhabitats (e.g. rock fissures) related to strong and specific broken topography. Together there are found species the occurence of which is determined by climate of the inversion sites (ravines) and also by generally oceanic-suboceanic pattern of this area. Thanks to these unique climatic conditions this area amounts to the one of the most richest sandstone areas in the Czech Republic as far as bryophyte species are concerned. From the standpoint of phytogeography mostly temperate species are represented (26%), more than one fourth of species is boreal-montane, almost 10% of species is oceanic-suboceanic.

Tetraphis pellucida, Calypogeia integristipula, Lepidozia reptans, Dicranella cerviculata, Dicranella heteromalla, Dicranodontium denudatum, Mylia taylorii and Pellia epiphylla are representatives of the most common sandstone rocks communities.

Many species are not too frequevent in the area. These species are dependent on habitats with specific micro-mesoclimate or unique substrate:

In vertical rock rifts or under shaded rock ledges Tetrodontium brownianum occurs.

Of many species characteristic of the inversion sites of this area subarctic-alpine species Lophozia grandiretis, Dicranodontium asperulum and Hygrohypnum ochraceum, subarctic-subalpine mosses Oligotrichum hercynicum, Polytrichum alpinum and Tetrodontium repandum, a subalpine liverwort Anastrophyllum michauxii and montane liverworts Pellia neesiana and Tritomaria execta can be mentioned.

Frequent occurence of suboceanic-oceanic bryophytes supports oceanic area pattern, among them e.g. Kurzia sylvatica, Cephalozia connivens, Campylopus fragilis, Plagiothecium undulatum, Rhabdoweisia crispata or Rhytidiadelphus loreus.

On calcareous sandstones basiphilic bryophytes e.g. Pedinophyllum interruptum, Lophozia bantriensis, Fissidens gracilifolius or Neckera crispa occur.

On decayed wood very rare and endangered species Cephalozia leucantha, Riccardia chamaedryfolia a R. latifrons occur among the other.

On secondary habitats rare and endangered mosses Syntrichia latifolia and Didymodon spadiceus are found.

Markedly Orthodontium lineare invasion shows in the whole area. On some localities occurence of another invasive species Campylopus introflexus has been observed.

More than 270 species of bryophytes (30% liverworts, 70% mosses) have been recorded in the area of National Park České Švýcarsko, out of which „Preliminary lists of threatened bryophytes in the Czech Republic“ include 34 species, e.g. Anastrophyllum michauxii, Jamesoniella autumnalis, Lophozia grandiretis, Pedinophyllum interruptum, Riccardia chamaedryfolia, R. latifrons, Atrichum tenellum, Campylopus fragilis, Didymodon spadiceus, Fissidens gracilifolius, F. rufulus , Rhynchostegium confertum or Tetrodontium brownianum. Some of these threatened species e.g. Geocalyx graveolens, Harpanthus flotowianus, H. scutatus, Jungermannia caespiticia or Nowellia curvifolia are only historical data, recently their occurence hasn´t been corroborated yet.

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An overview of cardinal aspects of South Africa's sandstone regions

There are many regions in South Africa where sandstone forms a prominent feature of the landscape and the presentation will provide an overview of cardinal aspects of select sandstone regions in South Africa. This will be done in order to elucidate possible resemblances between South Africa's, Europe's and other sandstone regions of the world. Aspects that will be discussed during the presentation include:
Bioweathering and erosion of Clarens sandstone.
Endolithic lichen species are the dominant colonisers of sandstone outcrops in many regions of South Africa. These lichens contribute significantly to weathering of the sandstone and soil formation, in addition to natural physical and chemical weathering processes.
Significant erosion of the weathered sandstone occurs through an association between insect larvae and the endolithic lichens, in addition to natural erosion processes.
Economic importance of sandstone.
Sandstone was extensively used as construction material in South Africa during the early part of the twentieth century. These buildings and monuments form part of South Africa's cultural heritage, with consequent tourism potential. However, endolithic lichens cause extensive damage to many of these sites.
Several National, Provincial and Municipal Parks and private enterprises (game farms and lodges) exploit specific characteristics of sandstone regions of South Africa for economic gain through tourism.
Agricultural activities in sandstone regions.
The climate and vegetation of the different sandstone regions have compelled settlers in these regions to adopt distinct farming practices.
Ecological importance.
Sandstones act as water reservoirs with perceived implications for the vegetation associated with these regions in South Africa.
Such sandstone outcrops are colonised by cryptoendolithic cyanobacterial communities, which represent unique micro-ecosystems.
The role of sandstone as ecological islands has particularly been neglected as a field of study in South Africa.
Sandstone regions as cultural and natural heritage repositories.
Sandstone caves have been used by Stone Age and more recently by the San peoples as settlement areas. The San have left irreplaceable rock paintings, which are nowadays exploited by the tourism industry.
Africans on the other hand use some of these caves as ancestral worship and communication sites.
As in other parts of the world, sandstone regions in South Africa are well known for their animal and plant fossil records, which are also exploited as tourist attractions.
Limited scientific research has been undertaken on many of the aforementioned aspects. Such shortcomings will be highlighted during the presentation, as it is anticipated that they may provide focus points for future collaborative research.

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Geomorphology of sandstone cliffs in Southeast England

Ardingly Sandstone of Early Cretaceous age outcrops around the margins of the High Weald of Sussex and Kent. Poorly cemented and friable, it is usually concealed by soil and surface deposits, but at some locations it forms cliffs, especially on steep valley sides. These cliffs can be as much as 15 m high and can extend for distances of 0.5 km or more. Whereas some cliffs appear to be still developing, others seem to be fossil features, perhaps created by periglacial processes, and may be being slowly destroyed by present-day weathering and erosion.

Although the Ardingly Sandstone gives rise to cliffs on hillslopes above streams and rivers, it only rarely forms waterfalls. Laboratory and field studies suggest that the rock has relatively little resistance to abrasion, and cannot long survive fluvial erosion.

Many of the cliffs have rounded or flattened tops. The vertical sides are frequently undercut at the base. On some steep valley sides, vertical joints intersecting the cliff faces have become opened up as a result of movement of the joint blocks, in places creating a network of narrow passageways. The blocks may have moved apart under periglacial conditions, perhaps when permafrost melted, rendering the valley sides unstable.

Exposed rock surfaces usually develop a protective crust or rind as a result of the deposition of additional silica cement. Honeycomb or alveolar weathering is commonly developed on vertical rock surfaces, while some cliff tops and boulders at the base of the cliffs exhibit tortoise shell weathering or polygonal cracking. The origin of these and other micro-weathering features is not well understood.

The cliffs of Ardingly Sandstone show many interesting morphological contrasts with cliffs developed in older sandstones in other parts of Britain. One reason is that the cliffs have never been glaciated, another that the sandstone is particularly weakly cemented. Rock basins are rarely developed and flutes are absent, whereas on the Millstone Grit cliffs in Derbyshire and Yorkshire both basins and flutes are quite common. Honeycombing and polygonal cracking are better developed than on many of the harder sandstones. Cliff foot deposits consist mainly of loose sand with small sandstone clasts and only occasionally large boulders, not angular talus, which is found beneath sandstone cliffs in some other areas of Britain.

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Nature friendly management of rock fall danger: 22 years of safety monitoring on sandstone rockslopes in Labe canyon

Picturesque landscape evolved on Cretaceous Sandstones in Bohemian Switzerland National Park and in Labe Sandstone Preserved Natural Landscape brings us - besides an aesthetic joy, also a constant thread of repeating rock falls from steep, from 40 to 100 m high sandstone walls. A historical statistics for the Labe-river Canyon, which has started in the year 1780, revealed that recurrence intervals of catastrophic rock falls with volumes in order 10^2 and 10^3 m^3 lay mainly within the interval from three to ten years. Smaller falls occur practically every year.

Already in 1980, a systematic monitoring of rock walls and stability interpretation of data gained were chosen as the main tool to control actual probability degree of rock fall occurrence, and hence to minimize rockfall danger for society, and, in the same time, to satisfy strong demands for nature protection in the areas of the Labe–river Canyon and of Hřensko village. Sources of risk – unstable and potentially unstable rock walls and objects, were localized in a sequence of rock fall risk zoning maps.

The idea backing the application of Safety Monitoring is simple. A catastrophic rock fall is the ultimate but no the inevitable end of much more longer (tens or even hundreds of years) lasting process of activity of slope movements within an unstable slope. Therefore, if there is any probability of further long-time development of the failure in the case in question, the monitoring can be used as a full-worth equivalent to technical remedial works. The inevitable cases requiring such technical remedy are only the ones, for which the danger of rock fall, declared according the results of some type of numeric stability analysis, could have been proved by monitoring data. That is, which exhibits precursors of danger of rock fall occurrence within the short time intervals from months to 2 years.

At present time, the regional net consists of more then 600 monitoring sites in 3 sub-nets along 16 km of sandstone rock walls in the area of Labe-river canyon, on the main rock walls just above block of flats in Děčín town, and on the walls of valley sides of Kamenice-river canyon in the area of Hřensko village. During 21 years of service of the net, 16 cases of immediate rock fall danger have been indicated in sufficient advance to take inevitable precautions – four-times for rock objects with volumes in the order of 10^3 m^3, eleven-times for volumes of 10^2 m^3. The last 5 cases took their place in Hřensko village just in spring of 2002.

The monitoring know-how is now being passed to the Group for Rock Walls Monitoring & Maintaining established in the frame of the Bohemian Switzerland National Park, and five new sub-nets are under construction along the routes with highest tourist traffic in the area of rock walls and rock towns of this Natural Park.

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Nonlinear science a new tool for study of risky geodynamical processes: An example of rockfalls from sandstone rock walls

New paradigm nonlinearity and complexity of natural systems is gaining growing credit in all fields of science. The reason is it enables us to better grasp patterns of real natural processes and systems instead to restrict us to their simplified, laboratory models. Such systems are very complex; their items interplay each with other giving to emerge new, sometimes rather surprising, quality. Moreover, such systems can be considered to be causal or random in the same time, according only on the spatio-temporal scale of our study.

Facing such systems, mathematics of the "classical", linear physics fails in "the holly aim" of all hard science – be able, knowing initial (actual) conditions within the system in question, to predict precisely its future behaviour. Moreover, the classical, linear paradigm fails even in the prerequisite task – to describe actual behaviour of the system.

Nevertheless, the new way is also not free of difficulties. Results gained on research frontiers of nonlinear mathematics in the last 40 years are not always directly applicable to real geodynamical processes, which are too "dirty and noisy". So, methods should be thoroughly chosen from a toolkit provided by nonlinear science, and, after it, to be sharpened regarding specific aims of their use.

The paper describes the actual state reached in a challenge to establish a new methodical basis for better insight into the process of gravitational failure of rock slopes. The project of non-linear analysis of monitoring data from rock slopes has started in the year 2000. In retrospect, we were both right on the money and hopelessly naïve at the start of the project.

On the money, because we correctly appreciated that the use of new methods will give us additional power. Complexly structured fluctuation patterns of time series from slope monitoring possess non-linear features and bear the stamp of chaos. Therefore part of information had been hidden to methods, of common linear analysis, because in their outputs it seemed to be only an irrelevant noise. Our finding has also profound, provoking theoretic implications to the matter of outer influences and triggering-effects, as well as to the possibility of prediction. Also new tools to improve displaying and characterisation of monitoring time-series has been found.

Naïve because we grossly underestimated the quality and quantity of data required to make a plausible case for chaotic determinism. Our main problem is the noisy, polygenetic nature of monitoring time series, which is – in addition, mostly gained by irregular sampling. The data set in question consists of coexisting dynamics by different processes. Various forms of "unpredictable noise" (e.g. climate), and external dynamical disturbances (e.g. vibrations by traffic) coexist within the signal with the features produced by our process in question and with the features by their potentially complex interactions. Facing these two problems, we spent lot of time in search for convenient analytical tools.

In spite of the difficulties, the method of phase portrait of embedded of monitoring signal was already successfully used in practice to indicate dangerous shifts in dynamics of process of rock fall preparation. It also provided us with the basis for simple algorithmisation of medium- and long-time, multi-aspect automatic monitoring data evaluation, the goal impossible to reach by classical, linear tools.