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3 Mohelno Serpentinite Steppe

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Introduction

The Mohelno Serpentinite Steppe (*Mohelenská hadcová step*) is situated in south-western Moravia near the small town of Mohelno, about 30 km west of Brno, in the low-altitudinal marginal area of the Bohemian-Moravian Highlands. The steppe occupies the south-facing slopes of the Jihlava River Valley which dissects a gently undulating landscape.



The upper part of the south-facing slopes of the Mohelno Serpentinite Steppe with a dry grassland of *Stipa dasyphylla* in the foreground and open *Pinus sylvestris* woodland in the background. Photo P. Daněk.

Geology, soils and climate

The area is built of metamorphic rocks (mainly granulite, gneiss and amphibolite) which are locally overlaid by loess. An important feature of this region is the occurrence of serpentinite. This ultrabasic metamorphic rock can also be found in other parts of the Bohemian Massif (e.g. the Slavkovský les Mountains in western Bohemia, the Bohemian Forest foothills in south-western Bohemia and other parts of the Bohemian-Moravian Highlands), though in south-western Moravia, and particularly near Mohelno, the serpentinite effect on vegetation is magnified by the location of its outcrops in a deep river valley. While the gentle slopes allow an accumulation of a soil layer deep enough to suppress the effects of the serpentinite bedrock on vegetation to some extent, the steep slopes of the Jihlava River Valley are being permanently eroded, for which reason the serpentinite bedrock has a stronger influence on the associated flora and fauna.

Serpentinite is an ultrabasic rock characterized by a high magnesium content combined with a relatively low calcium content. Serpentinite soils are usually deficient in nutrients (nitrogen, phosphorus and potassium) and contain large amounts of heavy metals (cobalt, nickel and chromium). In addition to the chemical properties of serpentinite, its physical characteristics are also important.



The Mohelno Serpentinite Steppe with a meander of the Jihlava River in the 1920s and in 2014. The forest has expanded considerably due to the abandonment of grazing. Photo archive of the Department of Botany and Zoology, Masaryk University, and J. Chytrý.

The dark colour and low thermal conductivity of the rock lead to its strong heating during the summer when surface temperatures can reach 50 °C, exceeding the air temperature by more than 20 °C (Hrudička 1937). Although some of these properties are also characteristic of other rock types, their unique combination on serpentinites constitutes stress conditions under which only some species can survive.

In contrast to the sunny south-facing serpentinite slopes with shallow leptosols which host mainly steppic vegetation and pine forests, the opposite north-facing slopes are mostly formed of granulite and are covered by broad-leaved deciduous forests on cambisols.

The climate is relatively warm and dry with mean annual temperatures slightly above 8 °C and the annual precipitation sum of approximately 550 mm.

History of botanical research and nature conservation

The local botanist Carl Roemer found Mohelno's most famous plant species, the fern *Notholaena marantae*, in 1858. In the early 20th century, the flora of the Mohelno serpentinites was studied by Josef Podpěra who drafted the first proposal for the establishment of a nature reserve in 1914. In the 1920s, his work was continued by Jindřich Suza who studied the relationship between bedrock and vegetation and gave a detailed description of local plant communities (Suza 1928). In 1933, a nature reserve was finally established on an area of 50 ha to prevent the steppe from being destroyed by stone mining. Intensive research continued in the reserve, resulting in a series of seven edited volumes published between 1934 and 1948 presenting knowledge in several fields (geology, soil science, climatology, botany and zoology; Veselý 2002).

The nature reserve was re-established in 1952. Its previously ambiguous borders were newly delineated and the steppe was no longer allowed to be used as pasture. Sheep and goat grazing had been a traditional form of management and its abandonment led to successional changes of steppic vegetation towards pine forests. While only 13% of the reserve's area was covered by forests in 1950, this proportion had increased to 62% by the late 1980s (Čechová et al. 1997). Following expert discussion, a decision was taken to cut much of the overabundant pine as well as some alien tree species (*Robinia pseudoacacia* and *Pinus banksiana*). The main phase of the reduction of tree stands took about ten years and was followed by the restoration of sheep and goat grazing in 1997. This traditional form of management has been practiced ever since (Čech 2005).

Construction of the nearby Dukovany Nuclear Power Station and associated Dalešice and Mohelno dams had a significant impact on the local landscape and led to flooding of a 30-km-long section of the Jihlava Valley in 1978. The Mohelno dam, which serves as a reservoir of process water for the nuclear power plant, borders the western part of the Mohelno Serpentinite Steppe. The large amount of water contained in the reservoir affects the mesoclimate of the valley by lowering daily temperature amplitudes and increasing air humidity (Quitt 1996) which might affect vegetation, particularly in the lower parts of the slopes.

Intensive research into the steppe and its surroundings resulted in several botanical studies in the 1990s. Chytrý & Vicherek (1996) described the natural and semi-natural vegetation of the Oslava, Jihlava and Rokytná River Valleys including the unique plant communities of the Mohelno Serpentinite Steppe and other serpentinite outcrops in the Jihlava Valley. Unar (1996) produced a flora inventory of the Mohelno Steppe and Koblížek et al. (1998) characterized the flora of selected localities in the region. The area of the reserve was extended to approximately 110 ha in 2012.

Vegetation and flora

There are several phytogeographically distinct species growing on the steppe. The aforementioned *Notholaena marantae*, a southern European fern, reaches its northern distribution limit here at an isolated site. *Stipa dasyphylla* is a continental Eurasian grass also known from some other southern Moravian localities, but all these occurrences are isolated from the species' continuous distribution range. *Scorzonera austriaca*, a species from the Asteraceae family, reaches its north-western distribution limit here.

The upper part of the steppe and the adjacent plateau are covered by dry grasslands (alliance *Festucion valesiacae*) dominated mainly by narrow-leaved tussocky fescues (*Festuca rupicola*, *F. valesiaca*) and feather grasses (*Stipa capillata*, *S. dasyphylla*, *S. pulcherrima*) accompanied by other drought-adapted species (*Carex humilis*, *Dorycnium germanicum*, *Dianthus carthusianorum* agg.,

Seseli hippomarathrum, *Thymus praecox* and *Veronica spicata*). The plateau between the river valley and the town of Mohelno is grazed by sheep. Patches of specific grassland vegetation type dominated by *Festuca pulchra* with the occurrence of the serpentinite specialist *Armeria elongata* subsp. *serpentini* can be found here.

Plants tend to grow much smaller than usual in this part of the steppe, and much attention has been paid to this phenomenon in the past. Rudolf Dvořák described 279 of these 'nanisms' in 170 plant species and attributed them to the low availability of nutrients and water on serpentinite soils (Dvořák 1935). However, since the abandonment of pasture these ecomorphoses have largely disappeared and it is currently believed that they were mainly caused by grazing (Kolář & Vít 2008).

The lower slopes are steep with numerous gullies and serpentinite outcrops. In this part of the reserve, the vegetation of dry grasslands changes to rocky steppes (alliance *Alyso-Festucion pallentis*) with dominant *Festuca pallens* and an admixture of other plants capable of growing on shallow stony soils (*Allium flavum*, *Alyssum montanum*, *Euphorbia seguieriana*, *Linaria genistifolia*, *Melica ciliata*, *Pilosella echioides* and *Seseli osseum*). In late summer, this vegetation is dominated in places by the grass *Bothriochloa ischaemum*.

The serpentinite rock outcrops are a habitat of *Notholaena marantae* which grows together with another fern, the serpentinite specialist *Asplenium cuneifolium* (Vicherek 1970). Along with other species confined to rock crevices (*A. ruta-muraria*, *A. trichomanes*, *Sedum album*) they form the association *Notholaena marantae-Sempervivum hirti* (alliance *Asplenion cuneifolii*) which can only be found here and on a few serpentinite sites in Austria. Scattered individuals of Scots pine (*Pinus sylvestris*) are common all over the steppe, while some shrubs (*Berberis vulgaris*, *Prunus mahaleb*) form patches of dense scrub.

The eastern part of the reserve is covered by forests. Most of them consist of *Pinus sylvestris* which expanded here after the abandonment of pasture, so the herb layer composition is similar to that of the steppe, though usually less diverse. The potential natural vegetation here is supposed to be a deciduous oak forest dominated by *Quercus petraea* with pine restricted mainly to rock outcrops. These oak forests on serpentinite can still be found elsewhere in the Jihlava Valley and were described as an endemic association *Asplenio cuneifolii-Quercetum petraeae* (Chytrý & Horák 1997), a specific type related to the broad association *Sorbo torminalis-Quercetum* (alliance *Quercion petraeae*). In some places with deeper soils (mostly close to the valley bottom), stands with an admixture or dominance of broad-leaved species (*Acer campestre*, *Carpinus betulus*, *Quercus petraea*, *Tilia cordata*) occur and these forests can be classified as oak-hornbeam forests (association *Galio sylvatici-Carpinetum betuli*, alliance *Carpinion betuli*) if their understorey contains mesophilous forest species (e.g. *Actaea spicata*, *Asarum europaeum*, *Campanula persicifolia*, *Galium odoratum*, *Hepatica nobilis*, *Pulmonaria officinalis* agg.). On the valley floor, close to the river, remnants of floodplain forests of the association *Stellario nemorum-Alnetum glutinosae* (alliance *Alnion incanae*) can be found. These forests are rich in vernal species that flower before tree-leaf flushing (e.g. *Adoxa moschatellina*, *Corydalis solida*, *Ficaria verna* and *Gagea lutea*).

The riverbanks are lined with discontinuous vegetation dominated by the grass *Phalaris arundinacea* accompanied by other hygrophilous species such as *Carex buekii* and *Scrophularia umbrosa* (alliance *Phalaridion arundinaceae*).

Kozének Nature Reserve

Located about 4 km east of the town of Mohelno, the Kozének Nature Reserve provides ecological contrasts to the serpentinite steppe. Its gentle slopes on granulite and gneiss are occupied mainly by dry acidophilous grasslands of the alliance *Koelerio-Phleion phleoidis*. This vegetation is dominated by grasses (e.g. *Festuca ovina*, *F. rupicola*, *Helictochloa pratensis* and *Phleum phleoides*) and hosts several endangered species (e.g. *Orchis morio*, *Pulsatilla grandis* and *Saxifraga bulbifera*). In some places thermophilous species are less abundant and the grasslands have different dominants (e.g. *Briza media*, *Carex pallescens*, *Danthonia decumbens* and *Nardus stricta*) characteristic of the nutrient-poor acidophilous *Nardus* grasslands of the alliance *Violion caninae*. These grasslands were historically used as pasture, similarly to the Mohelno Steppe, evidence of which is provided by scattered old individuals of shrubby juniper (*Juniperus communis*). The outer parts of the reserve are covered by hay meadows of the alliance *Arrhenatherion elatioris* dominated by grasses (*Agrostis capillaris*, *Anthoxanthum odoratum*, *Arrhenatherum elatius*, *Festuca rubra*) and including several mesophilous herb species (e.g. *Centaurea jacea*, *Ranunculus acris* and *Rhinanthus minor*).



The Mohelno Serpentinite Steppe in the Jihlava River Valley south of the town of Mohelno.



Acidophilous dry grassland in the Kozének Nature Reserve. Photo D. Zelený.

Appendix 3 Selected species of vascular plants of the Mohelno Serpentinite Steppe.

Species of dry grasslands and rock outcrops

<i>Achillea collina</i>	<i>Centaurea scabiosa</i>	<i>Hieracium schmidtii</i>
<i>Acinos arvensis</i>	<i>Centaurea stoebe</i>	<i>Holosteum umbellatum</i>
<i>Agrimonia eupatoria</i>	<i>Centaurea triumfetti</i>	<i>Hylotelephium maximum</i>
<i>Agrostis capillaris</i>	<i>Cerastium arvense</i>	<i>Hypericum perforatum</i>
<i>Agrostis vinealis</i>	<i>Cerastium holosteoides</i>	<i>Inula conyzae</i>
<i>Ajuga genevensis</i>	<i>Cerastium pumilum</i>	<i>Juniperus communis</i>
<i>Allium flavum</i>	<i>Chamaecytisus ratisbonensis</i>	<i>Knautia arvensis</i>
<i>Alyssum alyssoides</i>	<i>Chenopodium album</i>	<i>Koeleria macrantha</i>
<i>Alyssum montanum</i>	<i>Chondrilla juncea</i>	<i>Koeleria pyramidata</i>
<i>Anchusa officinalis</i>	<i>Cichorium intybus</i>	<i>Lactuca serriola</i>
<i>Antennaria dioica</i>	<i>Cirsium arvense</i>	<i>Leontodon hispidus</i>
<i>Anthericum ramosum</i>	<i>Cirsium vulgare</i>	<i>Lepidium campestre</i>
<i>Anthoxanthum odoratum</i>	<i>Clinopodium vulgare</i>	<i>Leucanthemum vulgare</i>
<i>Anthyllis vulneraria</i>	<i>Convolvulus arvensis</i>	<i>Ligustrum vulgare</i>
<i>Arabidopsis thaliana</i>	<i>Coryza canadensis</i> (neo)	<i>Linaria genistifolia</i>
<i>Arabis hirsuta</i>	<i>Cotoneaster integerrimus</i>	<i>Lotus corniculatus</i>
<i>Arenaria serpyllifolia</i> agg.	<i>Cuscuta epithymum</i>	<i>Luzula campestris</i>
<i>Armeria elongata</i>	<i>Cynodon dactylon</i>	<i>Medicago falcata</i>
subsp. <i>serpentini</i>	<i>Cynoglossum officinale</i>	<i>Melica ciliata</i>
<i>Arrhenatherum elatius</i>	<i>Cystopteris fragilis</i>	<i>Melica transsilvanica</i>
<i>Artemisia campestris</i>	<i>Cytisus nigricans</i>	<i>Melilotus officinalis</i>
<i>Artemisia vulgaris</i>	<i>Dactylis glomerata</i>	<i>Muscari comosum</i>
<i>Asperula cynanchica</i>	<i>Danthonia decumbens</i>	<i>Myosotis arvensis</i>
<i>Asplenium cuneifolium</i>	<i>Descurainia sophia</i>	<i>Myosotis ramosissima</i>
<i>Asplenium ruta-muraria</i>	<i>Dianthus carthusianorum</i> agg.	<i>Myosotis stricta</i>
<i>Asplenium trichomanes</i>	<i>Dorycnium germanicum</i>	<i>Noccaea caerulea</i>
<i>Aster amellus</i>	<i>Echium vulgare</i>	<i>Nonea pulla</i>
<i>Astragalus glycyphyllos</i>	<i>Elymus hispidus</i>	<i>Notholaena marantae</i>
<i>Atriplex patula</i>	<i>Erigeron acris</i>	<i>Odontites vernus</i> subsp. <i>serotinus</i>
<i>Ballota nigra</i>	<i>Erophila verna</i>	<i>Oenothera moravica</i> (neo)
<i>Berberis vulgaris</i>	<i>Eryngium campestre</i>	<i>Opuntia phaeacantha</i> (neo)
<i>Berteroa incana</i>	<i>Euphorbia cyparissias</i>	<i>Orchis morio</i>
<i>Biscutella laevigata</i> subsp. <i>varia</i>	<i>Euphorbia epithymoides</i>	<i>Origanum vulgare</i>
<i>Bothriochloa ischaemum</i>	<i>Euphorbia seguieriana</i>	<i>Orobanche alba</i>
<i>Brachypodium pinnatum</i>	<i>Falcaria vulgaris</i>	<i>Orobanche coerulescens</i>
<i>Briza media</i>	<i>Festuca ovina</i>	<i>Phelipanche arenaria</i>
<i>Bromus erectus</i>	<i>Festuca pallens</i>	<i>Phelipanche purpurea</i>
<i>Bromus hordeaceus</i>	<i>Festuca pulchra</i>	<i>Phleum phleoides</i>
<i>Bromus japonicus</i>	<i>Festuca rubra</i>	<i>Picris hieracioides</i>
<i>Bupleurum falcatum</i>	<i>Festuca rupicola</i>	<i>Pilosella echioides</i>
<i>Calamagrostis epigejos</i>	<i>Festuca valesiaca</i>	<i>Pilosella officinarum</i>
<i>Calluna vulgaris</i>	<i>Filago arvensis</i>	<i>Pimpinella saxifraga</i>
<i>Campanula patula</i>	<i>Filipendula vulgaris</i>	<i>Pinus sylvestris</i>
<i>Campanula rotundifolia</i> agg.	<i>Fragaria viridis</i>	<i>Plantago lanceolata</i>
<i>Capsella bursa-pastoris</i>	<i>Frangula alnus</i>	<i>Plantago media</i>
<i>Carduus acanthoides</i>	<i>Gagea bohemica</i>	<i>Poa bulbosa</i>
<i>Carduus nutans</i>	<i>Gagea lutea</i>	<i>Polypodium vulgare</i>
<i>Carex caryophyllea</i>	<i>Galatella linosyris</i>	<i>Potentilla argentea</i>
<i>Carex humilis</i>	<i>Galeopsis angustifolia</i>	<i>Potentilla heptaphylla</i>
<i>Carex michelii</i>	<i>Galium album</i>	<i>Potentilla incana</i>
<i>Carex muricata</i>	<i>Galium verum</i>	<i>Prunella grandiflora</i>
<i>Carex praecox</i>	<i>Genista pilosa</i>	<i>Prunus fruticosa</i>
<i>Carlina acaulis</i>	<i>Genista tinctoria</i>	<i>Prunus mahaleb</i>
<i>Carlina vulgaris</i>	<i>Geranium pusillum</i>	<i>Prunus spinosa</i>
<i>Carum carvi</i>	<i>Hackelia deflexa</i>	<i>Quercus petraea</i>
<i>Caucalis platycarpus</i>	<i>Helianthemum grandiflorum</i>	<i>Quercus robur</i>
<i>Centaurea jacea</i>	subsp. <i>obscurum</i>	<i>Ranunculus acris</i>
	<i>Helictochloa pratensis</i>	<i>Ranunculus acris</i>
	<i>Herniaria glabra</i>	<i>Ranunculus bulbosus</i>
		<i>Robinia pseudoacacia</i> (neo)



Plate 3 Plants of the Mohelno Serpentinite Steppe: (a) *Pinus sylvestris*, (b) *Seseli hippomarathrum*, (c) *Notholaena marantae*, (d) *Euphorbia seguieriana*, (e) *Berberis vulgaris*, (f) *Senecio erucifolius*, (g) *Scabiosa canescens*, (h) *Stipa capillata*, (i) *Asplenium cuneifolium*, (j) *Prunus mahaleb*, (k) *Bothriochloa ischaemum*, (l) *Thymus praecox*.

Rosa canina
Rumex acetosella
Salvia pratensis
Sanguisorba minor
Saxifraga bulbifera
Scabiosa canescens
Scabiosa ochroleuca
Scleranthus annuus
Scorzonera austriaca
Securigera varia
Sedum acre
Sedum album
Sedum sexangulare
Senecio erucifolius
Senecio jacobaea
Senecio viscosus
Seseli hippomarathrum
Seseli osseum
Silene otites
Silene vulgaris
Sorbus aucuparia
Stachys recta
Stipa capillata
Stipa dasyphylla
Stipa pennata
Stipa pulcherrima
Stipa tirma
Taraxacum sect. *Erythrosperma*
Taraxacum sect. *Taraxacum*
Teucrium chamaedrys
Thymus praecox
Tragopogon orientalis
Trifolium alpestre
Trifolium arvense
Trifolium campestre
Trifolium dubium
Trifolium repens
Verbascum chaixii
 subsp. *austriacum*
Verbascum lychnitis
Verbascum phoeniceum
Verbascum thapsus
Veronica arvensis
Veronica prostrata
Veronica vindobonensis
Veronica spicata
Vicia tenuifolia
Vincetoxicum hirundinaria
Viola rupestris
Viscaria vulgaris

Forest species

Abies alba
Acer campestre
Acer platanoides
Acer pseudoplatanus
Actaea spicata
Adoxa moschatellina
Aegopodium podagraria
Ajuga reptans

Alliaria petiolata
Anemone nemorosa
Angelica sylvestris
Anthriscus sylvestris
Asarum europaeum
Asplenium cuneifolium
Astrantia major
Athyrium filix-femina
Avenella flexuosa
Betula pendula
Brachypodium pinnatum
Brachypodium sylvaticum
Bupleurum falcatum
Calamagrostis arundinacea
Campanula persicifolia
Campanula rapunculoides
Campanula rotundifolia agg.
Campanula trachelium
Cardamine impatiens
Carex digitata
Carex humilis
Carex muricata agg.
Carpinus betulus
Cephalanthera damasonium
Chaerophyllum temulum
Chelidonium majus
Convallaria majalis
Cornus mas
Cornus sanguinea
Corydalis solida
Corylus avellana
Crataegus spp.
Cyclamen purpurascens
Cytisus nigricans
Dactylis polygama
Dryopteris carthusiana
Dryopteris filix-mas
Elymus caninus
Epilobium montanum
Epipactis helleborine
Euonymus europaeus
Euonymus verrucosus
Euphorbia dulcis
Festuca gigantea
Festuca ovina
Ficaria verna subsp. *verna*
Fragaria moschata
Fragaria vesca
Fraxinus excelsior
Galeobdolon montanum
Galium odoratum
Galium sylvaticum
Genista pilosa
Genista tinctoria
Geranium robertianum
Geum urbanum
Hepatica nobilis
Hieracium laevigatum
Hieracium murorum
Hieracium sabaudum

Hypericum montanum
Hypericum perforatum
Impatiens noli-tangere
Impatiens parviflora (neo)
Knautia drymeia
Lactuca viminea
Ligustrum vulgare
Lilium martagon
Lonicera xylosteum
Luzula divulgata
Luzula luzuloides
Melampyrum pratense
Melica nutans
Melica uniflora
Mercurialis perennis
Moehringia trinervia
Monotropa hypophegea
Mycelis muralis
Myosotis sylvatica
Neottia nidus-avis
Noccaea montana
Omphalodes scorpioides
Oxalis acetosella
Phyteuma spicatum
Picea abies
Pilosella officinarum
Pinus sylvestris
Poa angustifolia
Poa nemoralis
Polygonatum multiflorum
Polygonatum odoratum
Polypodium vulgare
Populus tremula
Primula veris
Prunus avium
Pulmonaria obscura
Pulmonaria officinalis
Quercus petraea
Quercus robur
Rhamnus cathartica
Rosa canina
Rubus fruticosus agg.
Sambucus nigra
Scrophularia nodosa
Senecio ovatus
Sesleria caerulea
Silene nutans
Solidago virgaurea
Sorbus aucuparia
Stachys sylvatica
Stellaria holostea
Symphytum tuberosum
Tanacetum corymbosum
Tilia cordata
Tilia platyphyllos
Trifolium alpestre
Ulmus glabra
Urtica dioica
Vaccinium myrtillus
Veronica chamaedrys

Veronica officinalis
Vicia pisiformis
Vincetoxicum hirundinaria

Viola collina
Viola odorata
Viola reichenbachiana

Viola riviniana
Viscaria vulgaris
Viscum album subsp. *austriacum*



Dry grassland with *Carex humilis* and *Dorycnium germanicum* in the canopy openings of a pine woodland in the Mohelno Serpentinite Steppe. Photo P. Daněk.

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4 Krumlov-Rokytná Conglomerates

Pavel Novák

Introduction

The Krumlov-Rokytná Conglomerates (*Krumlovsko-rokytnské slepence*) National Nature Reserve was established in 2005 to protect the dry grasslands, rock outcrops and forests of the Rokytná River Valley north-east of the town of Moravský Krumlov, about 30 km SW of Brno. The reserve is comprised of two parts which in total cover an area of 87 ha at altitudes between 220 and 340 m. It is situated on the north-western edge of the Pannonian Province in southern Moravia and contains various vegetation types with many rare (especially thermophilous) plant species.

The southern part of the reserve surrounds a meander with the historical town of Moravský Krumlov with its picturesque sixteenth-century Renaissance castle, remains of the old town fortification, several churches and the remarkable Baroque pilgrimage Chapel of St. Florian from 1697 situated on the upper edge of the reserve.



Summer view of dry grassland with blooming *Allium senescens* subsp. *montanum*. This vegetation is frequently developed on the red Carboniferous-Permian conglomerate on the steep sunny slopes of the Rokytná Valley above the historical town of Moravský Krumlov. Photo P. Novák.

Geology, soils and climate

The site includes a deep river valley with steep rocky slopes, numerous rock outcrops and small screes. The prevailing bedrock type is the Carboniferous-Permian red conglomerate containing mostly acidic gravel clasts within a matrix of a fine-grained calcareous sediment which has supported the development of mixed acidophilous and basiphilous flora and vegetation. Quaternary alluvial and colluvial sediments occur along the Rokytná River meandering along the valley bottom. Cambisols are the