The saprotrofic food chain in terrestrial ecosystems : Soil

What is soil ? / Co je půda?

V. V. Dokuchaev (1846-1903; founder of the modern pedogenetic school):
"**Soil is the upper, weathered layer of the earth's crust, altered by climatic and chemical effects and by the activity of organisms**. It is a complicated, enlivened (biological) system with peculiar traits and properties."
"Soil is a **product of nature differentiated into genetic horizons**, that originated on the interface of different spheres, more or less easily disintegrated and **enlivened**."
Without organisms, soil is not soil but only dead substrate.
Without live organisms there is no soil creation!

V. V. Dokučajev (1846-1903; zakladatel moderní ruské pedogenetické školy):
„**Půda je svrchní, zvětralá vrstva zemské kůry, pozměněná klimatickými a chemickými vlivy a činností organismů.** Je to komplikovaný oživený systém (biologický útvar) se specifickými znaky a vlastnostmi."
„Půda je **přírodnina diferencovaná v genetické horizonty**, vzniklá **na rozhraní různých sfér**, více nebo měně snadno rozpojitelná a **oživená**."
Bez organismů není půda půdou, jedná se pouze o mrtvý substrát. Bez živých organismů ani žádná půda nevzniká!

The saprotrofic food chain in terrestrial ecosystems : Soil

What is soil ? / Co je půda?

The creation and character of soil is influenced by the
- lithosphere (parent rock),
- hydrosphere
- atmosphere, and
- biosphere.

Soil has no sharp limits as it presents a border phenomenon of the earth's surface – the pedosphere.

Smolíková (1982): Soil is a segment of the pedosphere (???), including all between the two extremes: fresh rock – raw litter.

Na vznik a charakter půdy má vliv litosféra (matečná hornina), hydrosféra, atmosféra a biosféra. Není ostře ohraničená, neboť představuje hraniční fenomén zemského povrchu – pedosféru.

Smolíková (1982): Půda je výřez pedosféry (???), zahrnující vše mezi extrémy: čerstvá hornina – surový opad.

The saprotrofic food chain in terrestrial ecosystems : Soil

What is soil ? / Co je půda?

E. A. Mitscherlich (1905): “Soil is a **mixture of solid particles of fine grain size, water and air**, which carries vegetation as long as its content of plant nutrients is adequate.”

Thus three phases are present

Solid – solid particles (mineral and organic) – larger particles – stones
Liquid – soil water (solution)
Gaseous – soil air

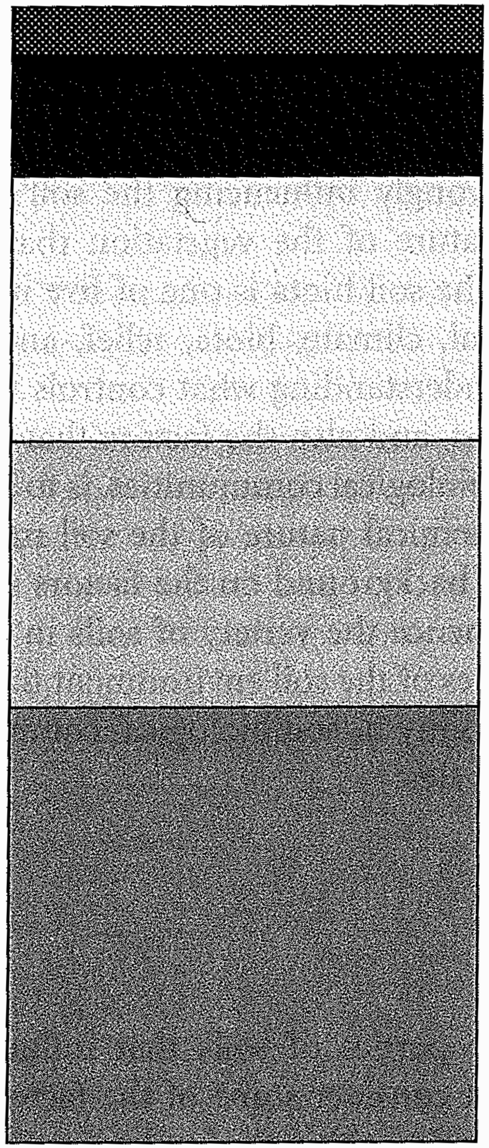
The 2nd and 3rd phase are situated in between the solid particles, in the soil pores. Organisms also dwell in these pores: plant roots and the **edaphon** (soil organisms as a whole)

E. A. Mitscherlich (1905): „Půda je **směsí jemnozrnných pevných částic, vody a vzduchu**, která je při přiměřeném obsahu rostlinných živin nositelem vegetace.“
Jsou tedy přítomny tři fáze (skupenství):
pevná – pevné častice (minerální i organické) – větší částice – kameny tvoří „skelet“
tekutá – půdní voda (roztok)
plynná – půdní vzduch
Druhá a třetí fáze se nachází v prostorech mezi pevnými částicemi, v půdních pórech (průduších). V nich se také nachází organismy: kořeny rostlin a **edafón** (půdní organismy jako celek).

The saprotrofic food chain in terrestrial ecosystems : Soil

Půdní horizonty

Soil horizons



L layer. Fresh litter

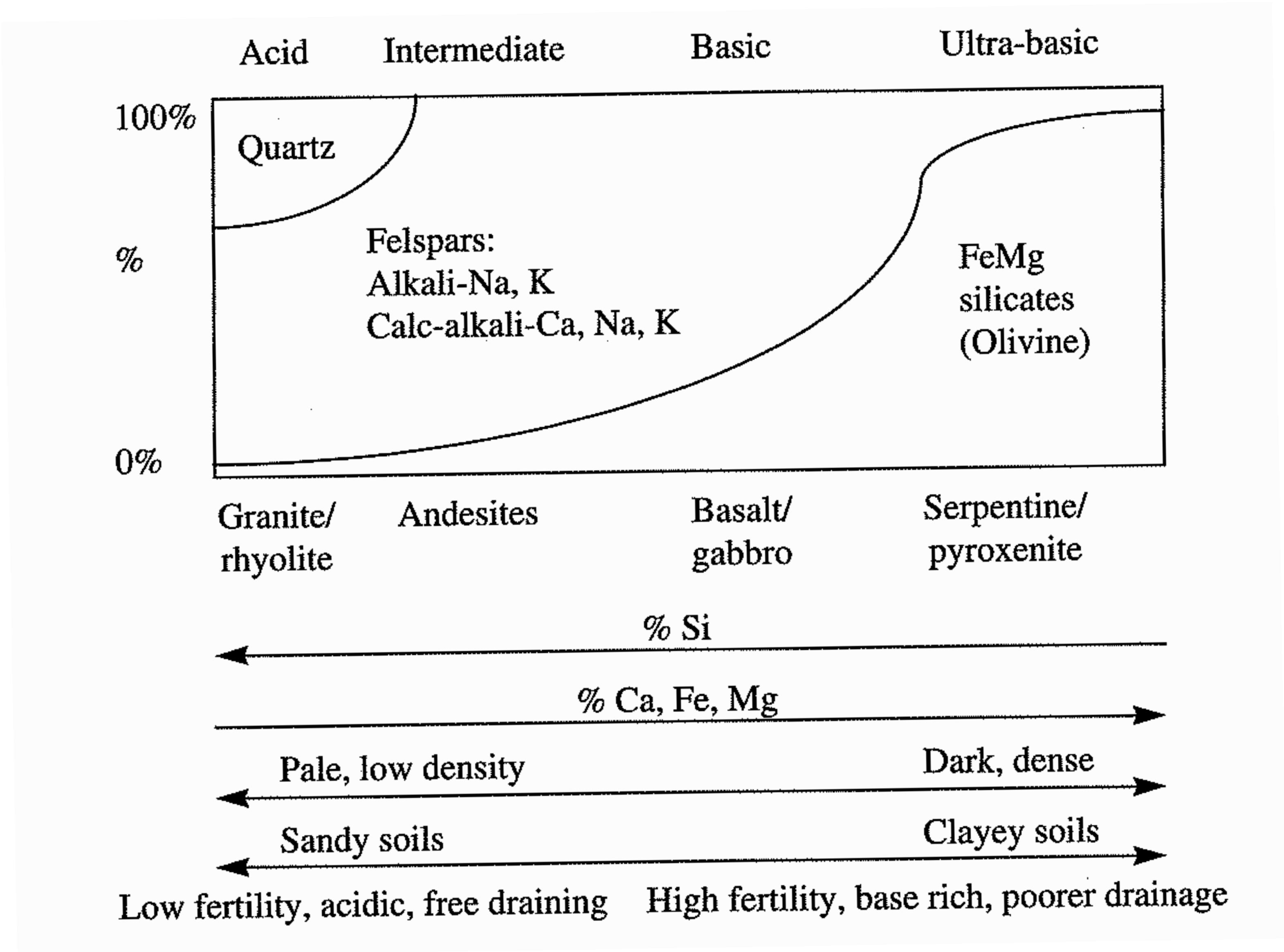
F and H layers. Organic horizons originating from litter deposited or accumulated on the surface

A horizon. Mineral horizon formed at or near the surface, and characterized by the incorporation of humified organic matter. Generally illuvial

B horizon. Mineral subsurface horizon without rock structure, characterized by the accumulation of silicate clays, iron, and aluminium. Generally eluvial

C horizon. Unconsolidated or weakly consolidated mineral horizon that retains rock structure

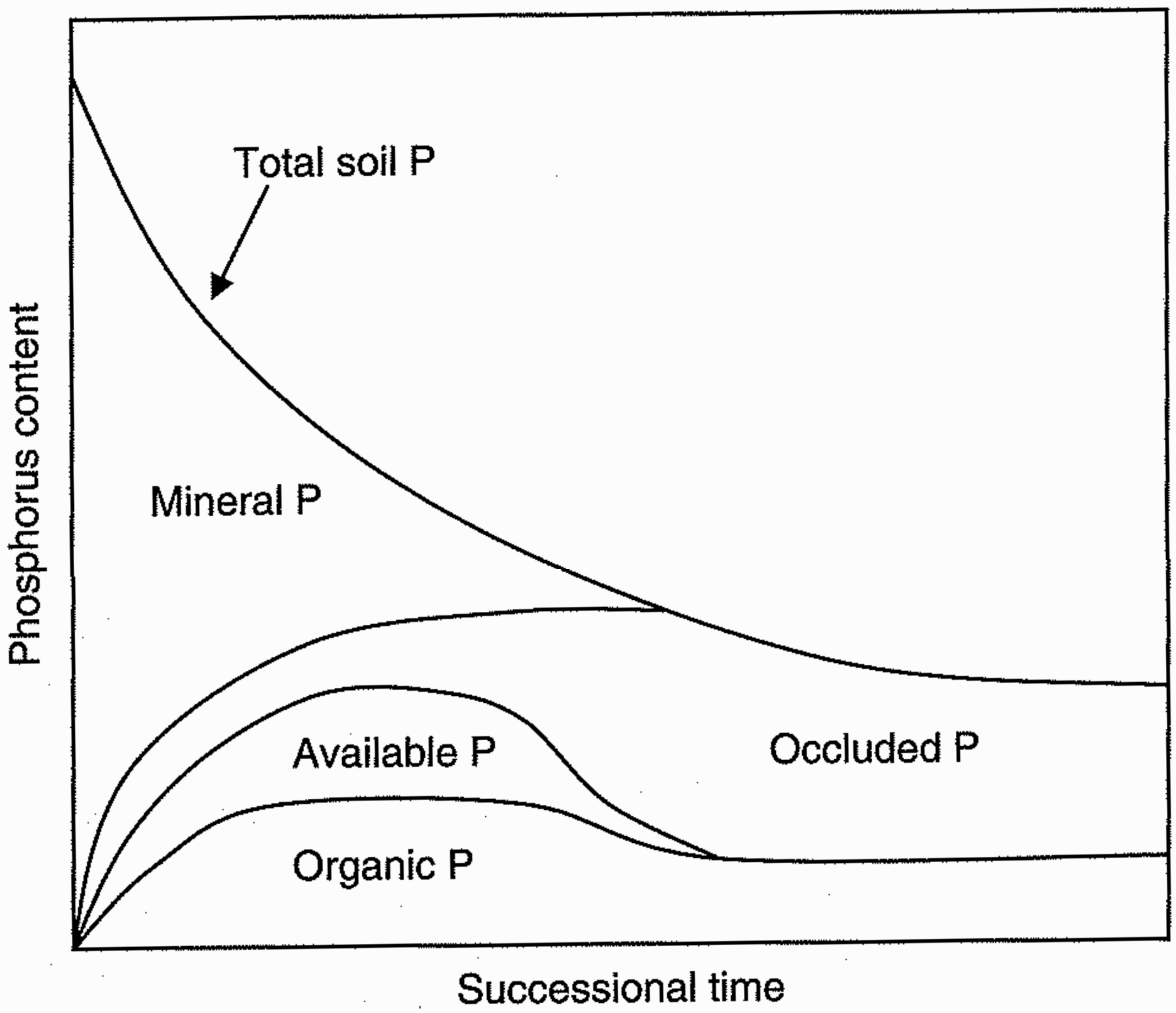
The saprotrofic food chain in terrestrial ecosystems : Soil



Schematic classification of igneous rocks and their resulting soils

Schematická klasifikace vyvřelinových hornin a výsledných půd

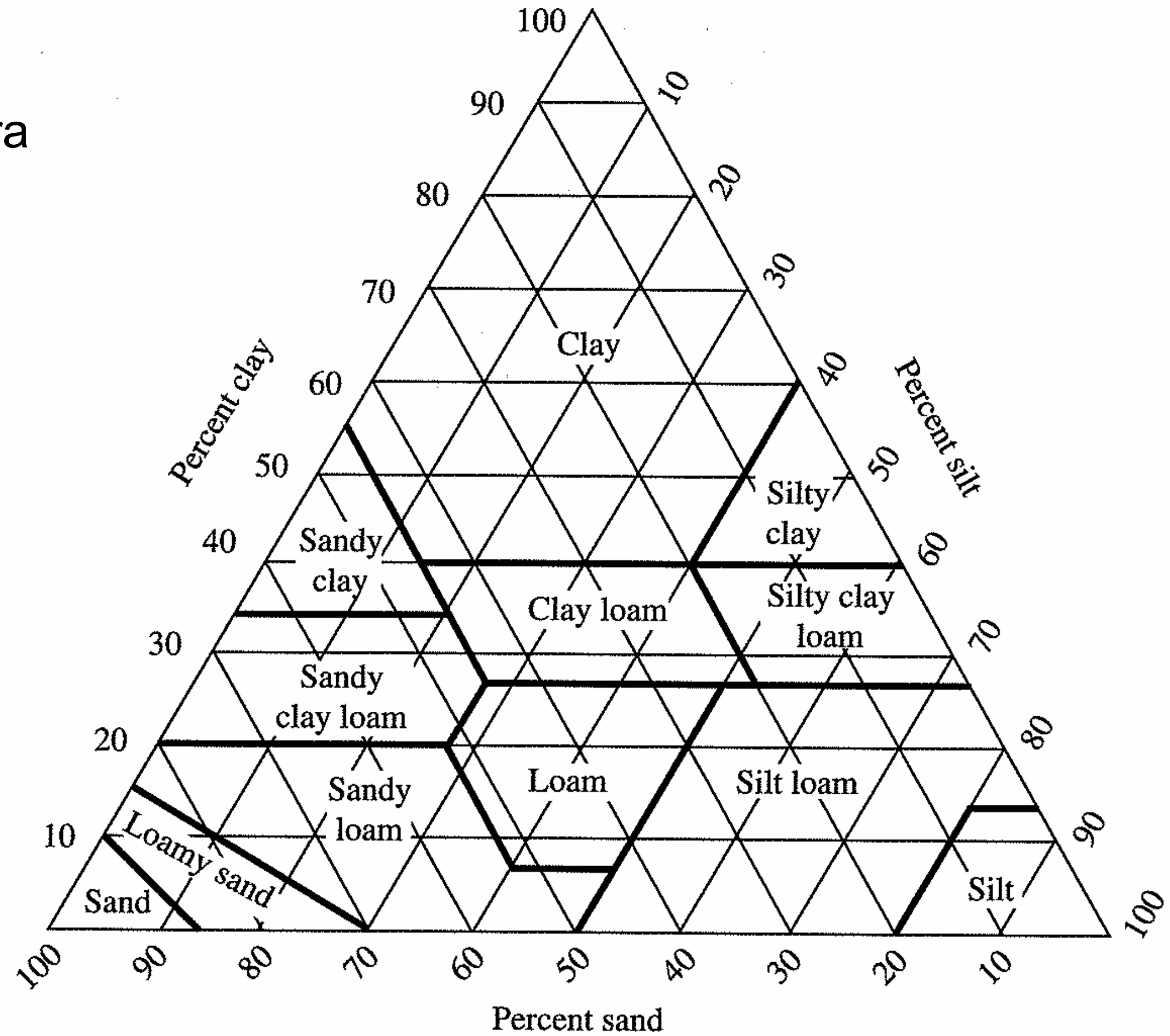
The saprotrofic food chain in terrestrial ecosystems : Soil



Generalized effects of long-term weathering and soil development on the distribution and availability of P in soil (Adapted from Walker and Syers 1976).

The saprotrofic food chain in terrestrial ecosystems : Soil

Soil texture
Půdní textura



Composition of the textural classes of soils based on percentages of sand, silt, and Clay. For example, a soil with 60 % sand, 10 % silt, and 30 % clay is a sandy clay loam.

The saprotrofic food chain in terrestrial ecosystems : Soil

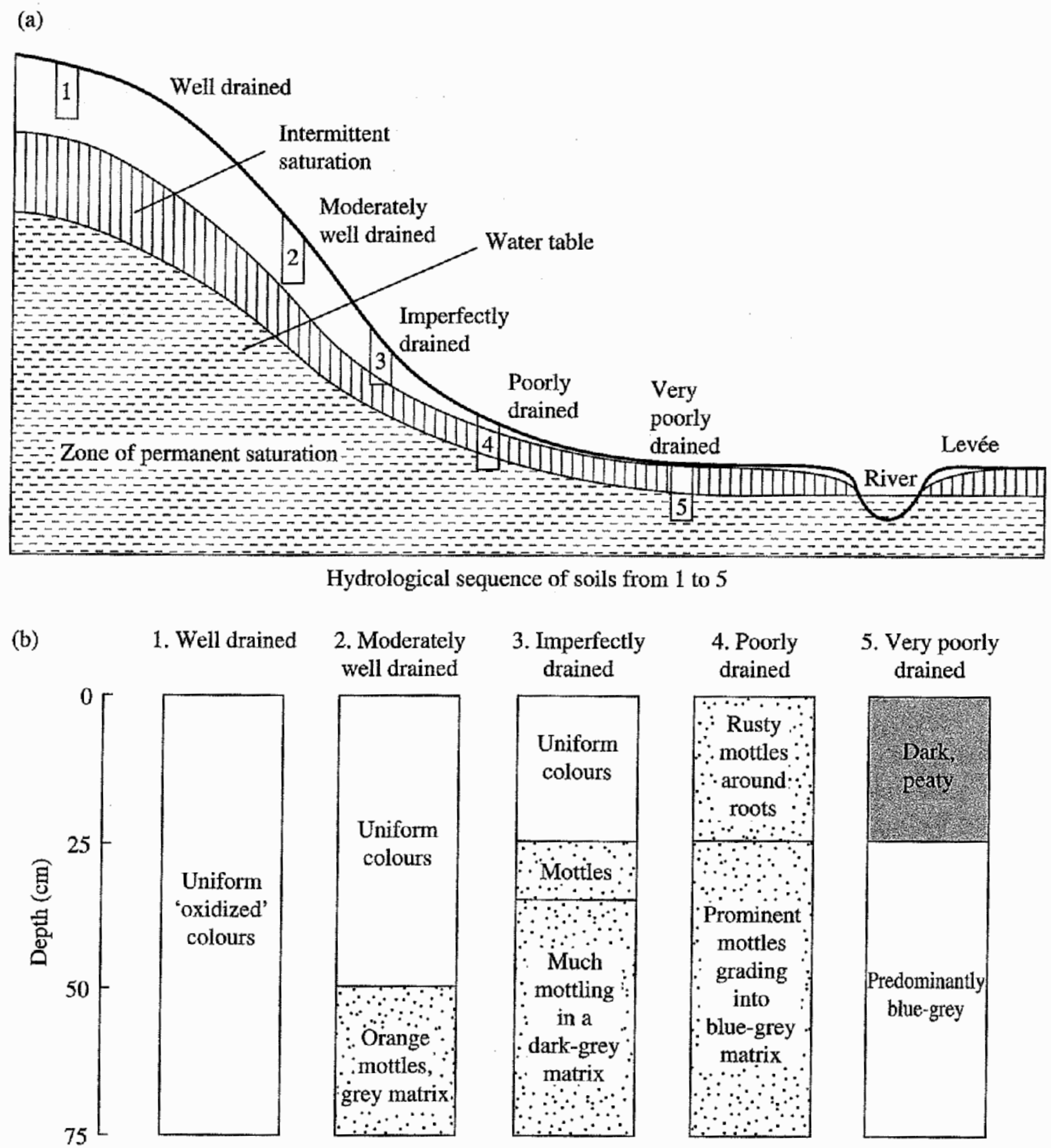
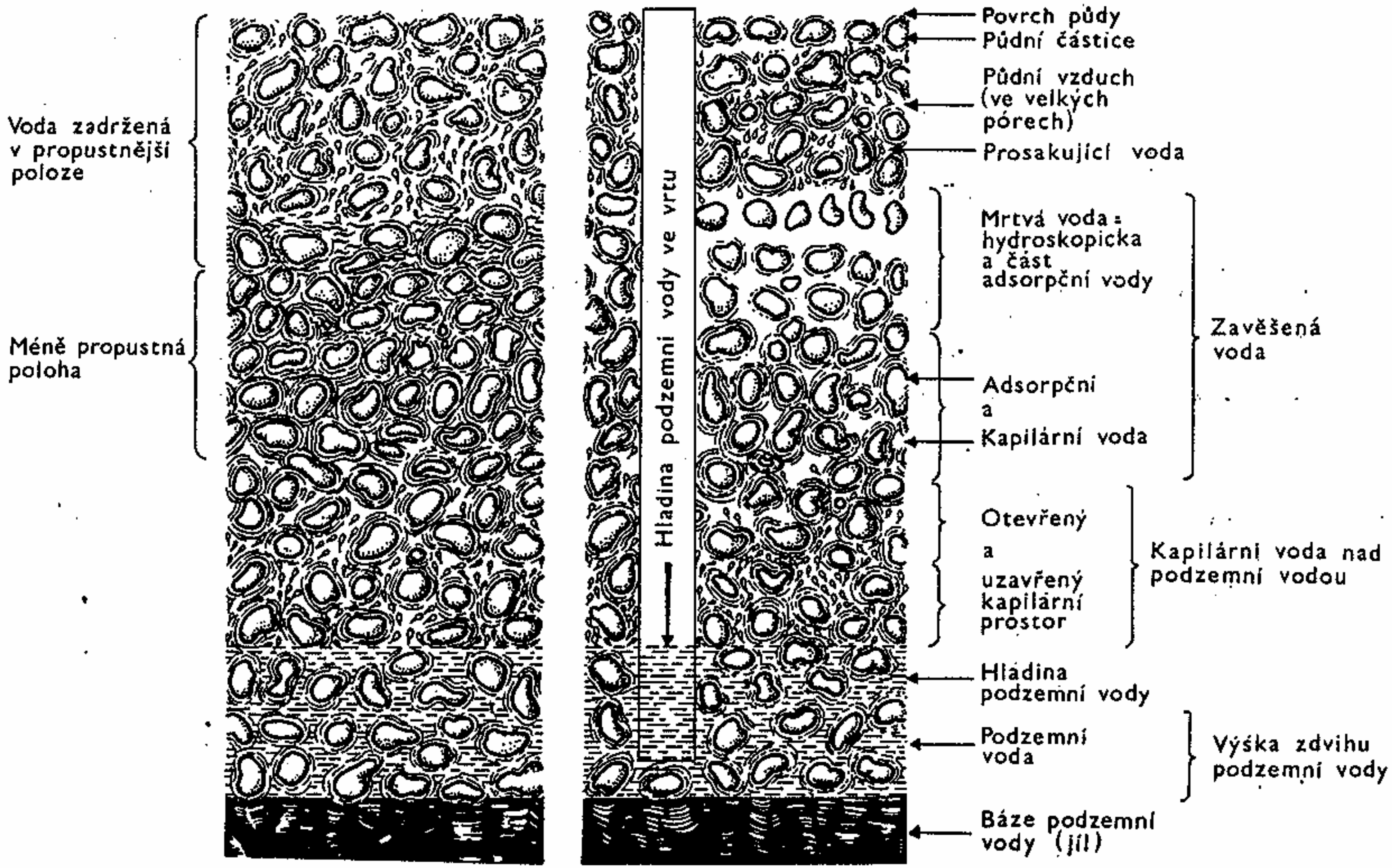


Fig. 1.6 (a) Section of a slope and valley bottom showing a hydrological soil sequence, and (b) changes in soil profile morphology. (Redrawn with permission from Blackwell Science; White 1997)

The saprotrofic food chain in terrestrial ecosystems : Soil



Obr. 19

Nejdůležitější formy vody v půdě. - Podle E. Mückenhausena 1961

The most important sorts of water in soil

The saprotrofic food chain in terrestrial ecosystems : Soil

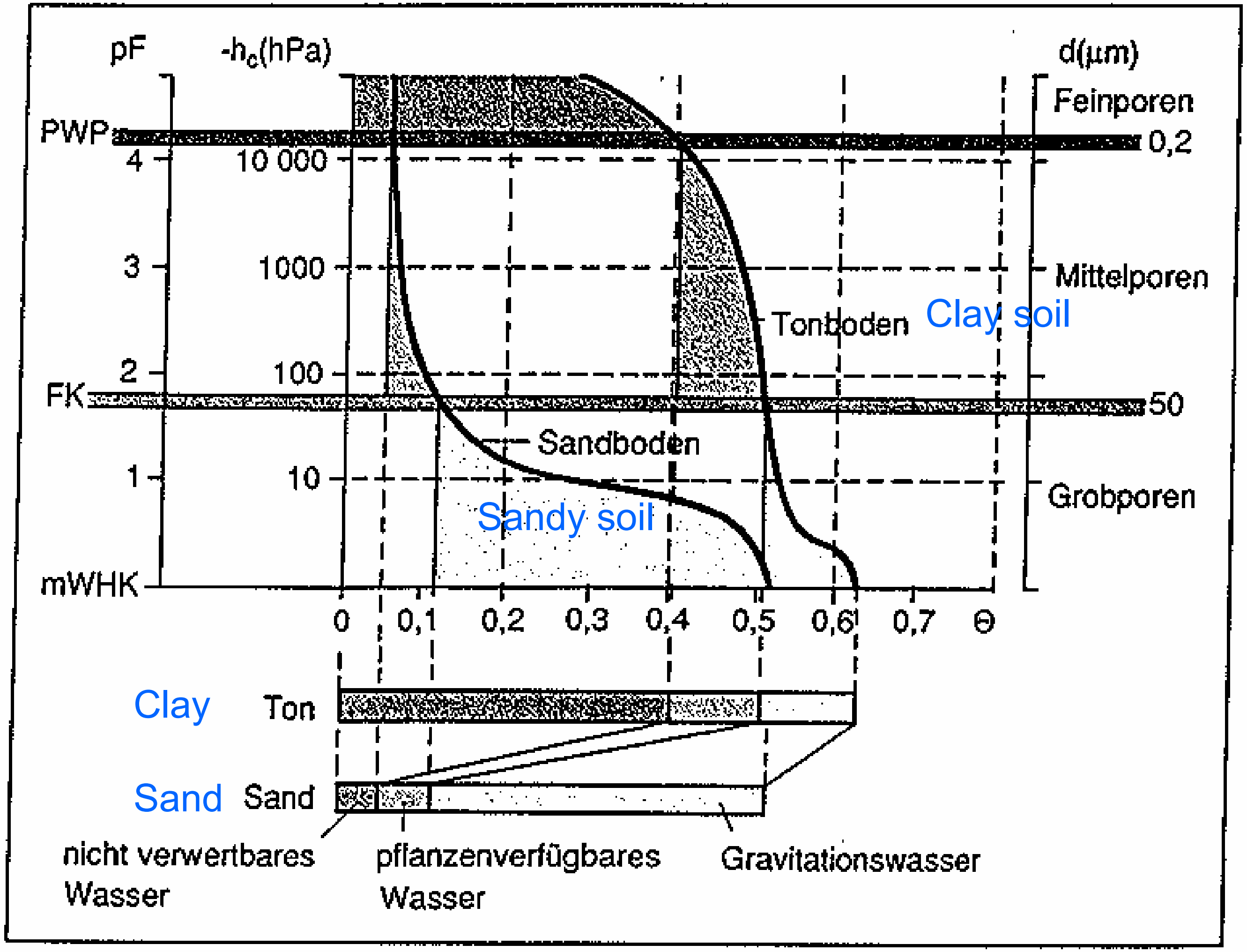


Abb. 2.21 Desorptionskurven eines Sand- und Tonbodens mit dazu gehörenden Wasserverfügbarkeitsbereichen und Porenklassen. Wasserspannung ausgedrückt als pF-Wert oder negative Steighöhe h_c. PWP = permanenter Welkepunkt, FK = Feldkapazität, mWHK = maximale Wasserhaltekapazität

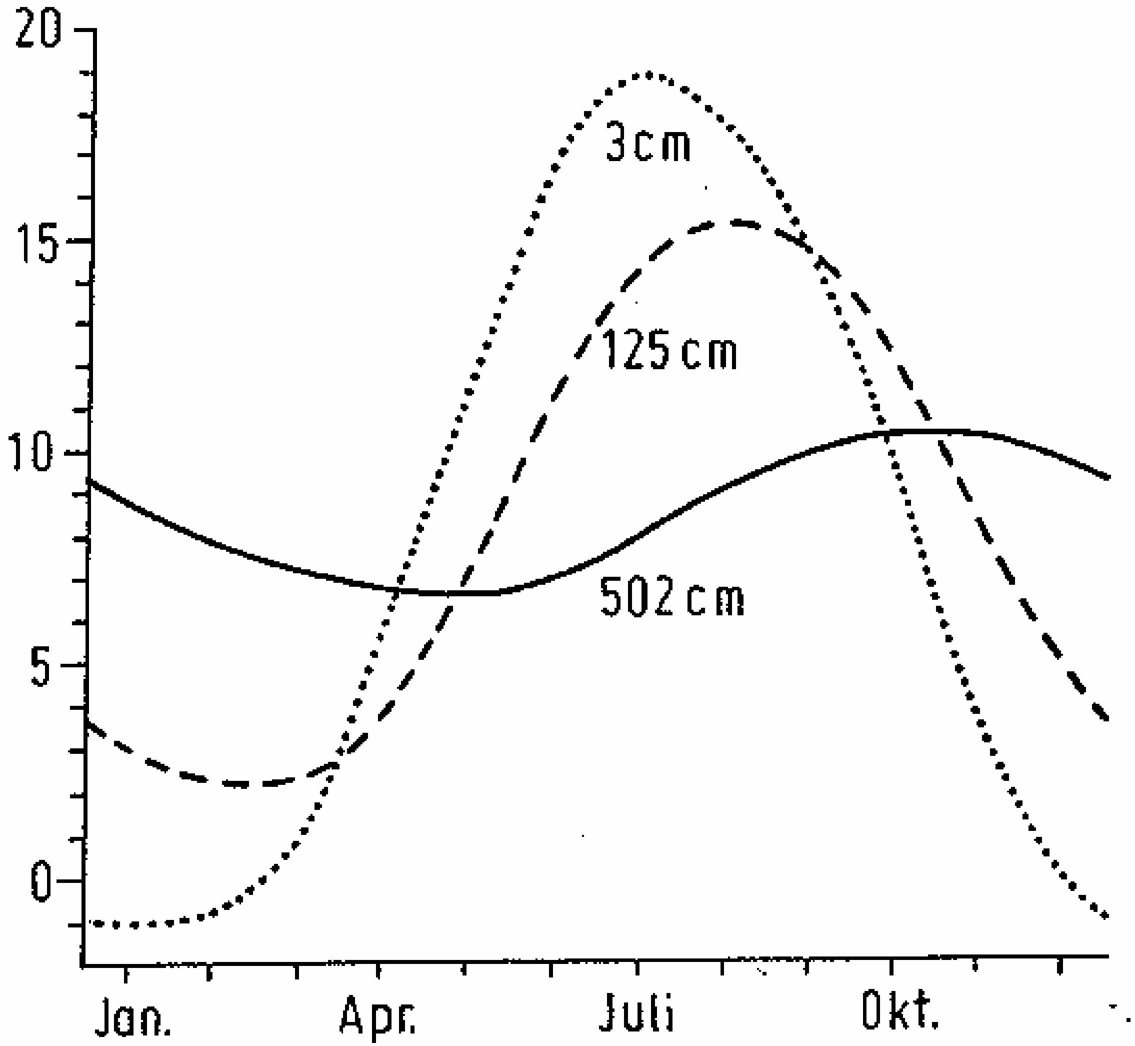
Fine pores

Medium-sized pores

Coarse pores

Desorption curves of a sandy and a clay soil with the associated ranges of water availability and pore classes. Water tension given as pF-Value.
PWP – permanent wilting point,
FK – field capacity,
mWHK – maximal water holding capacity.

The saprotrofic food chain in terrestrial ecosystems : Soil



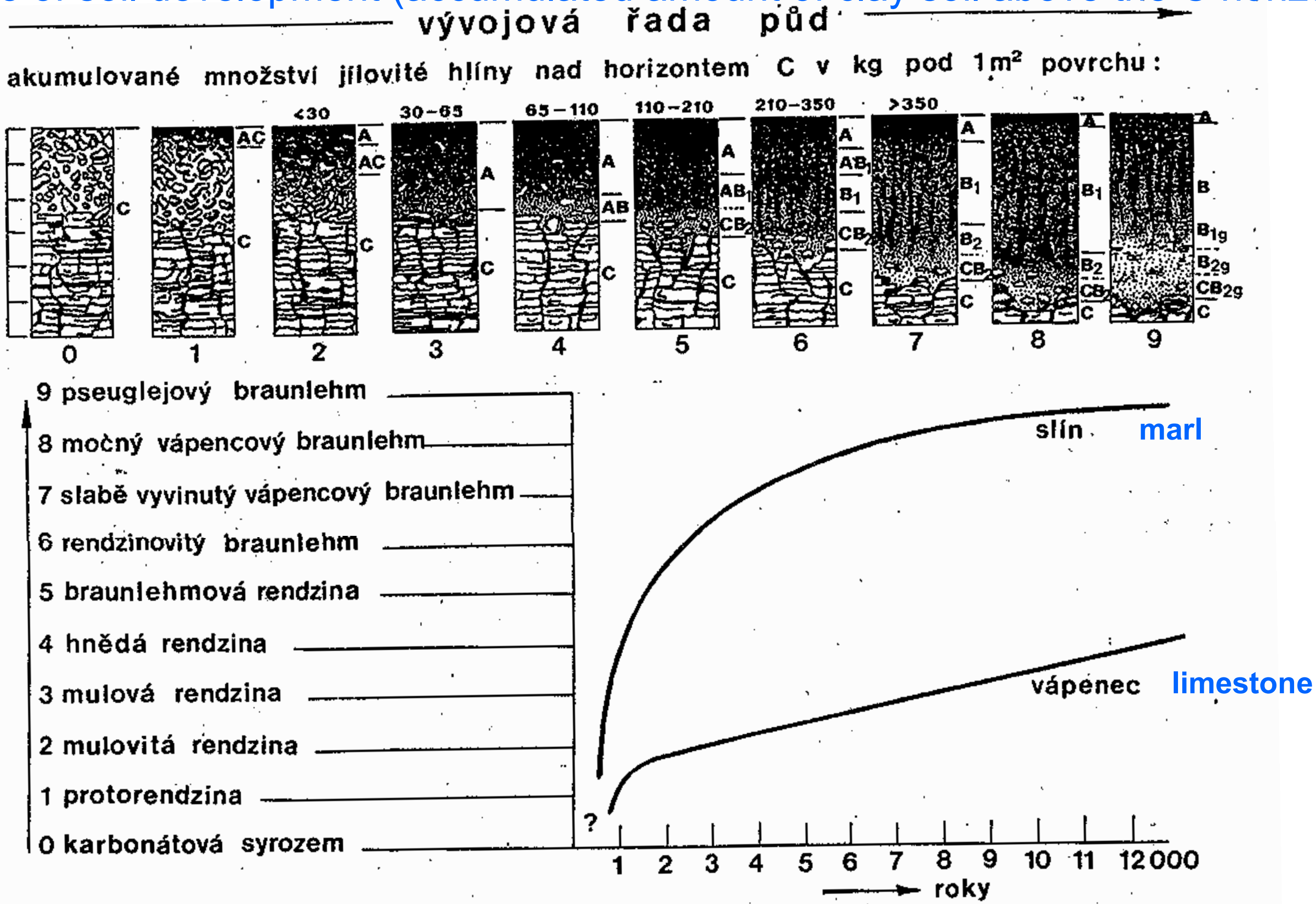
Roční průběh půdních teplot v třech různých hloubkách

Annual course of soil temperatures in three different depths

(zdroj/source:Geiger, 1961 in Brauns, 1968)

The saprotrofic food chain in terrestrial ecosystems : Soil

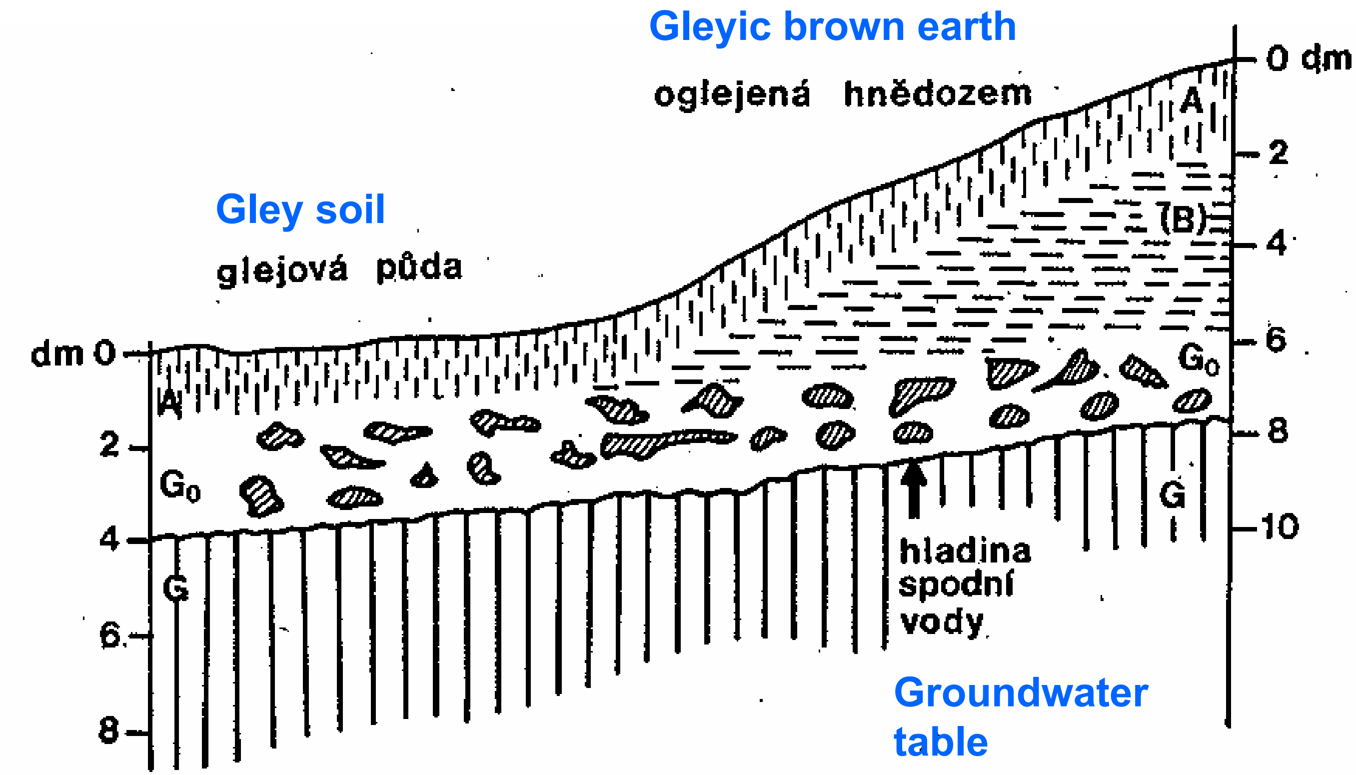
Sequence of soil development (accumulated amount of clay soil above the C horizon in kg/m^2)



Vývojová řada půd z karbonátového substrátu s údaji akumulovaného množství zbytkového jílu v jednotlivých vývojových stadiích. Srovnání vývojových rychlostí v případě slínů a vápenců jako matečného substrátu v oblasti střednotriasového lasturovaného vápence u Göttingen. - Podle H. Rohdenburga a B. Mayera 1963

Sequence of soil development from carbonate substrate giving the remaining clay amount in the individual stages; speed of development on marl and limestone as bedrock (middle triasic shell limestone near Göttingen)

The saprotrofic food chain in terrestrial ecosystems : Soil

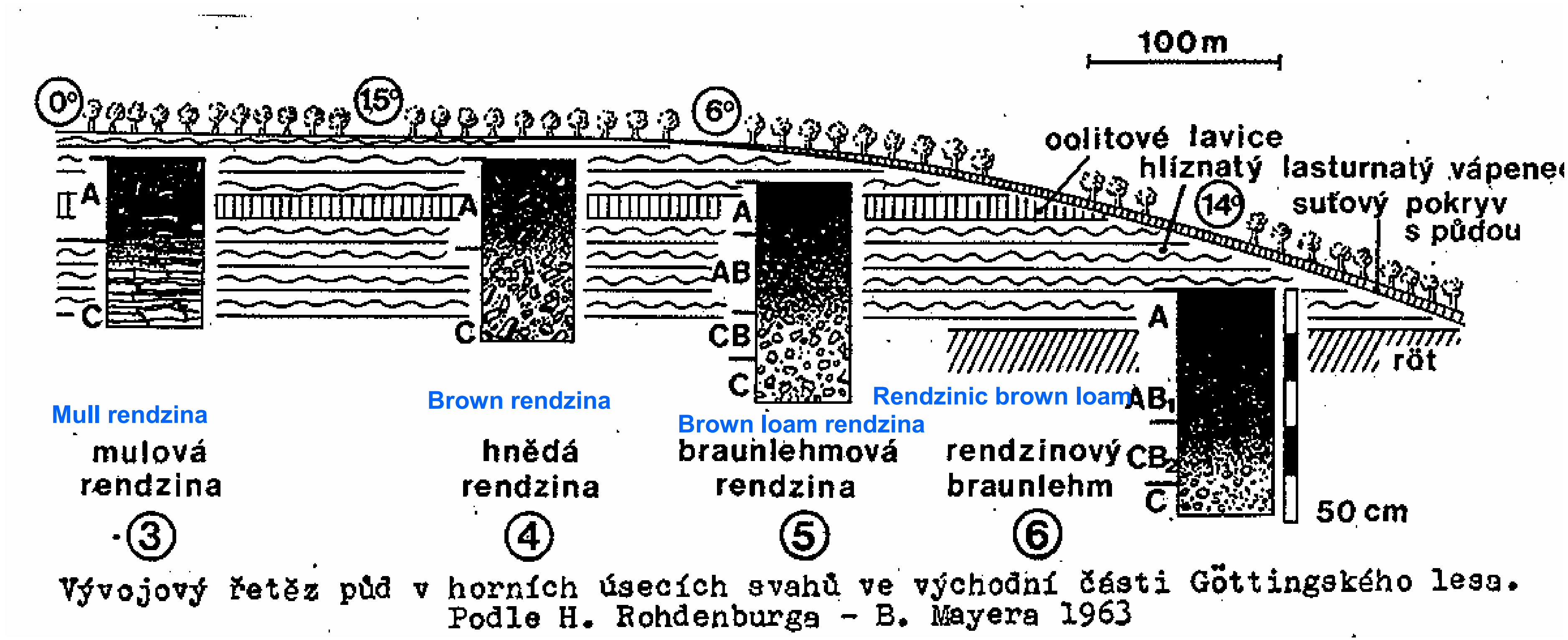


Obr. 13

Schematické znázornění vzniku glejových půd nad mělce pod povrchem ležící hladinou podzemní vody (vlevo). Se vzrůstající mocností nadložních vrstev a tím relativním poklesem hladiny podzemní vody se tvoří již terestrická půda, např. oglejená hnědozem (vpravo). Při dalším stoupání terénu by již následovaly hnědozemě. - Podle E. Mückenhausena 1977

Schematic visualization of the genesis of gley soils above a shallow groundwater table (on the left). With increasing height of soil layers, leading to a relative drop of the groundwater table, the result of pedogenesis are already terrestrial soils, for instance gleyic brown earth (on the right). Further up-slope brown earth would follow. According to Mückenhausen, 1977.

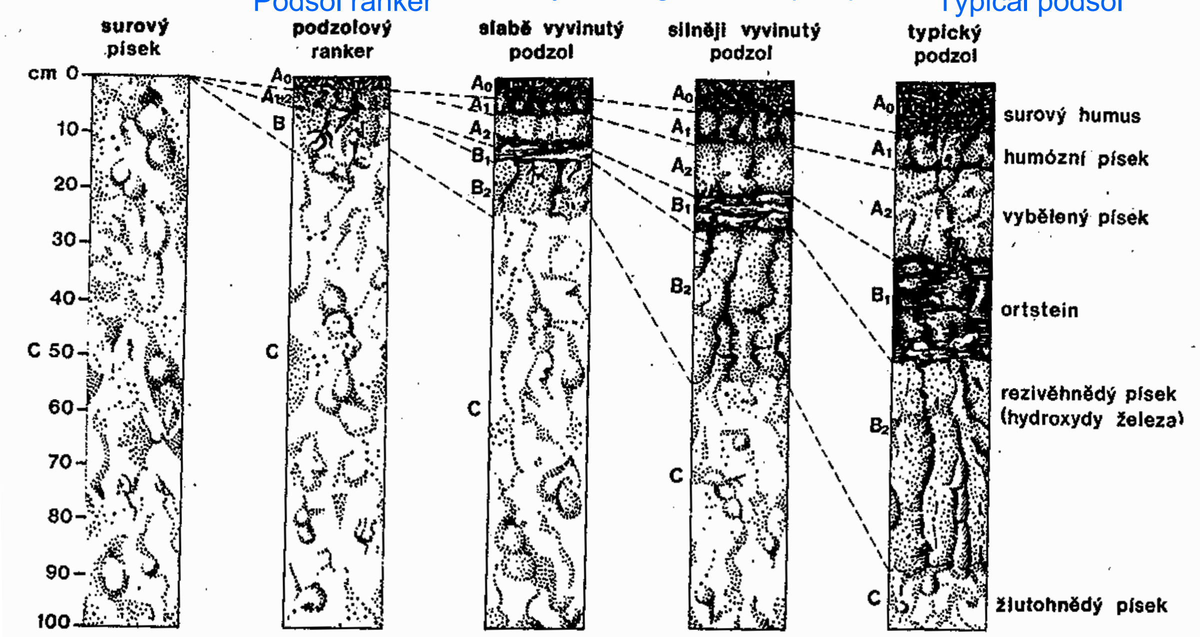
The saprotrofic food chain in terrestrial ecosystems : Soil



Section through the upper parts of the slope in the eastern part of the Göttinger Wald (Göttingen Forest) showing a development sequence of soils (according to Rohdenburg & Mayer, 1963).

The saprotrofic food chain in terrestrial ecosystems : Soil

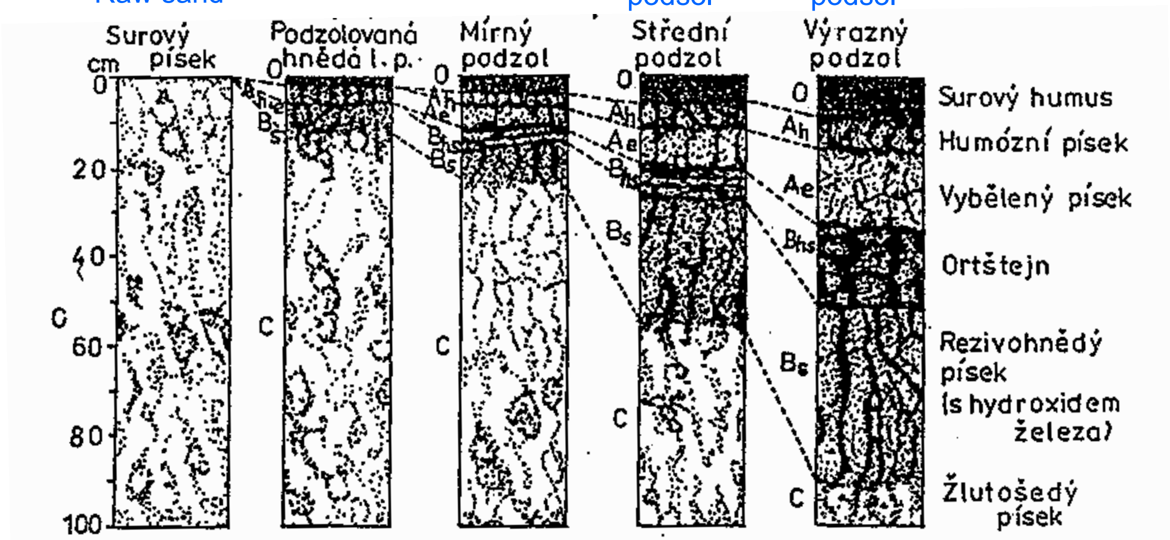
Development of podsol from sand



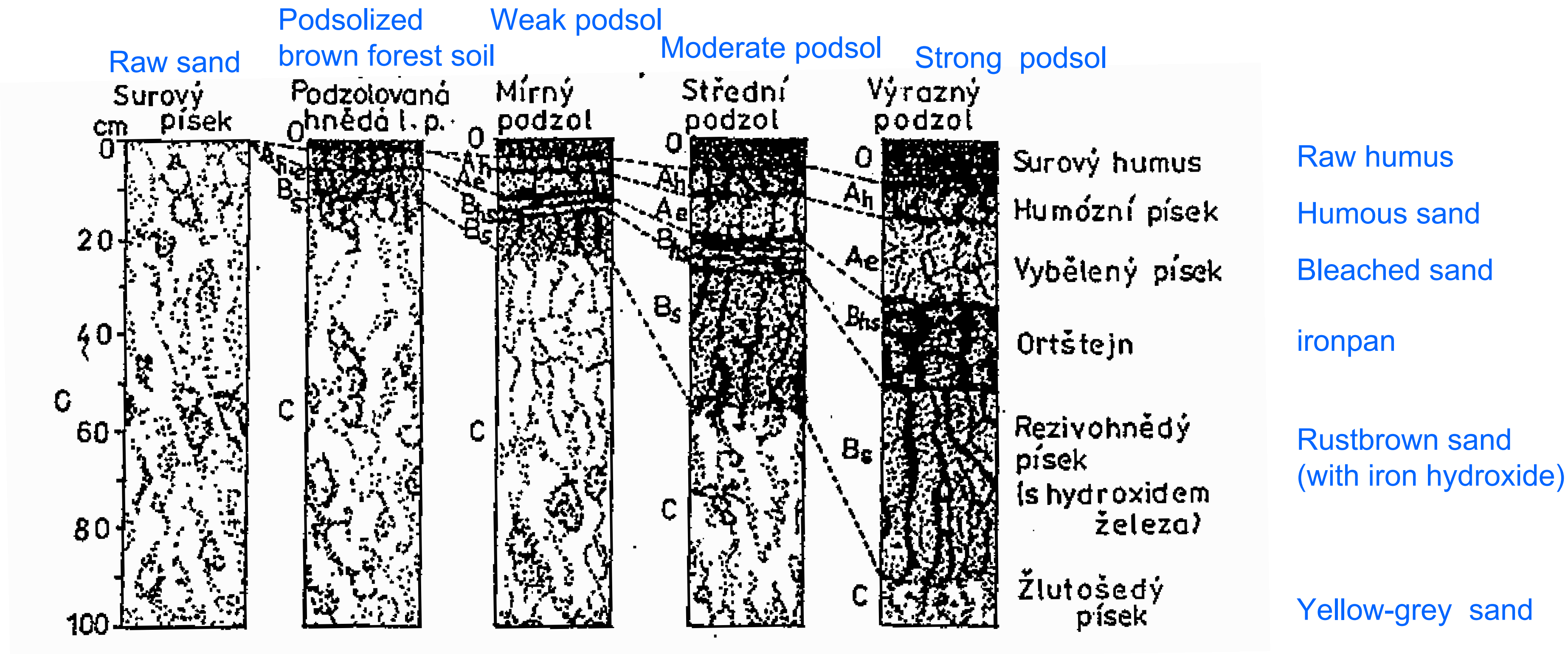
Obr. 11

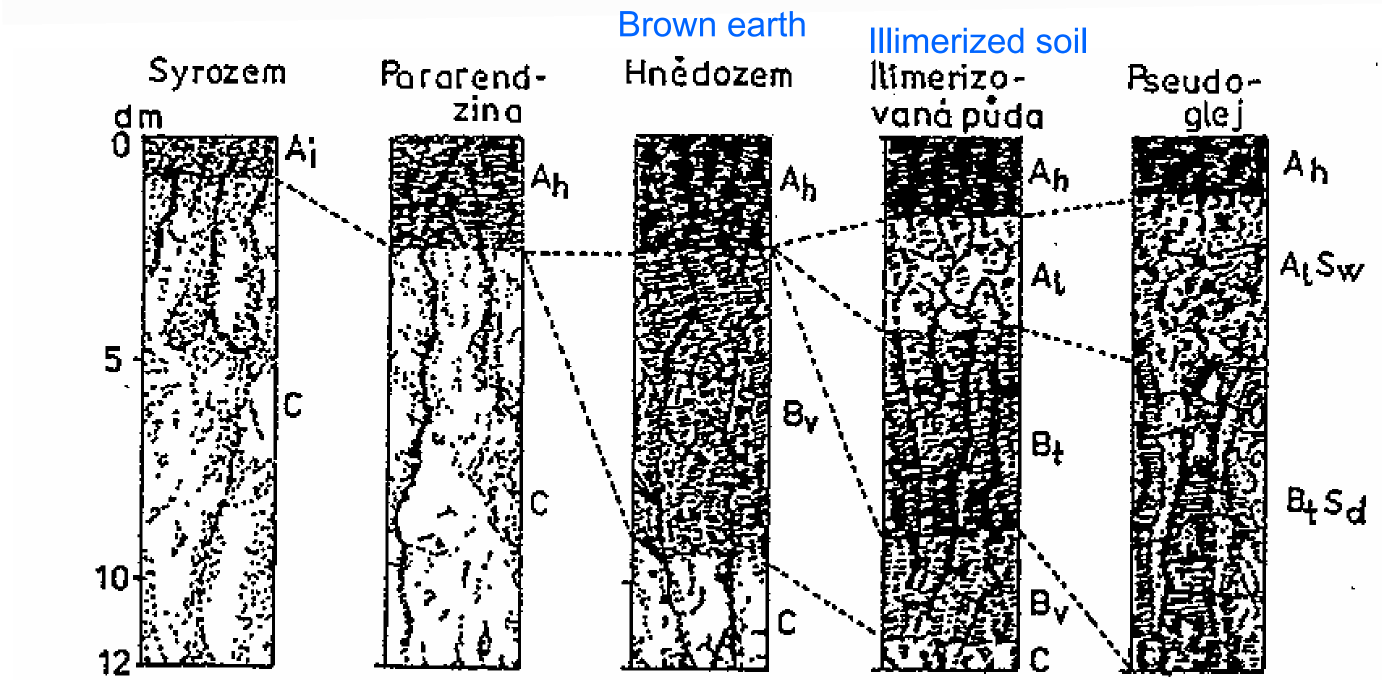
Schematické znázornění vývojových stadií podzolu z písku; tvorba probíhá za stejných podmínek. Jednotlivá stadia jsou pouze funkcí času. - Podle E. Mückenhausena 1977

Same data presented by two authors (above: Smolíková, 1982; below: Klimo, 1996) based on works of Mückenhausen (1977, 1975)



The saprotrofic food chain in terrestrial ecosystems : Soil





Soil development on sand (above) and loess (below) according to Mückenhausen (1975)

Vývoj půdy na písku (nahoře) a spraši (dole) podle Mückenhausena (1975)

The saprotrofic food chain in terrestrial ecosystems : Soil

US Soil Taxonomy (Brady & Weil, 1999 in Bardgett, 2005)

Table 1.1 Soil taxonomy orders

Order	Brief description
Entisols	Recently formed azonal soils with no diagnostic horizons
Vertisols	Soils with swell-shrink clays and high base status
Inceptisols	Slightly developed soils without contrasting horizons
Aridosols	Soils of arid regions
Mollisols	Soils with mull humus
Spodosols	Podzolic soils with iron and humus B horizons
Alfisols	Soils with a clay B horizon and >35% base saturation
Ultisols	Soils with a clay B horizon and <35% base saturation
Oxisols	Sesquioxide-rich, highly weathered soils
Histosols	Organic hydromorphic soils (peats)

The saprotrofic food chain in terrestrial ecosystems : Soil

Processes of soil formation / Půdotvorné procesy

Leaching of salts / ion: occurs when precipitation > evaporation. Soluable components of the soil column are carried away by water washing down through the soil (salts, ions, e.g. calcium, held as exchangeable ions in clay-humus complexes, its substitution by hydrogen ions leads to acidification. The washed out ions either accumulate in deeper layers (B-horizon), where they might precipitate, or reach the groundwater.

Vymývání solí / iontů

Illimerization, lessivation: Soil particles held in suspension, in particular fractions of colloidal and very fine clay (< 0.2 µm) are washed out (**eluviation**) and translocated to lower horizons, where they accumulate (**illuviation**). Clay is translocated in soils where drought and wet periods alternate, and only after $CaCO_3$ has been washed out, at an optimal pH of 5.5 – 6.5. Cracks created during dry spells serve together with root channels and animal burrows as drainage channels for water carrying the clay. The clay forms incrustations of orange-brown to red-brown colour on their walls.

Illimerizace, lessivace, eluviace, illuviace

The saprotrofic food chain in terrestrial ecosystems : Soil

Podsolisation: Occurs in (semi-)humid climate when strongly acid soil solutions ($pH < 5$) cause the breakdown of clay minerals. As a result silica, aluminium and iron form complexes with organic substances in the soil. These minerals are removed from the surface zone of the soil and can accumulate in distinct dark sub-surface layers - very evident on inspection. Upland heaths and moors often contain podsols (typical humus form is raw humus or mor).

Zola / Sola (Russian) = ash – grey colour of the washed out horizons
Podzolizace

Gleying: Occurs where the soil is in (almost) permanent contact with groundwater. In such waterlogged, anaerobic conditions iron compounds are reduced and either removed from the soil, or segregated out as mottles or concretions in the soil. Also manganese - Mn (IV) and Mn (VII) - and polyad sulphur are reduced. Decomposition of soil organic matter is slowed down. Marshy wetlands often contain gleyed soils.
When waterlogging occurs periodically, Fe II (present in compounds) is again oxidized to Fe III – rusty freckles.
When waterlogging is permanent, green alumosilicates (containing Fe (II), bluish phosphates, and grey-black sulphites are created, resulting in a bluish grey G horizon. Rusty freckles (concretions) on interface between oxidation and reduction zones.

Gley (Russian) = sticky, smeary soil
Oglejení

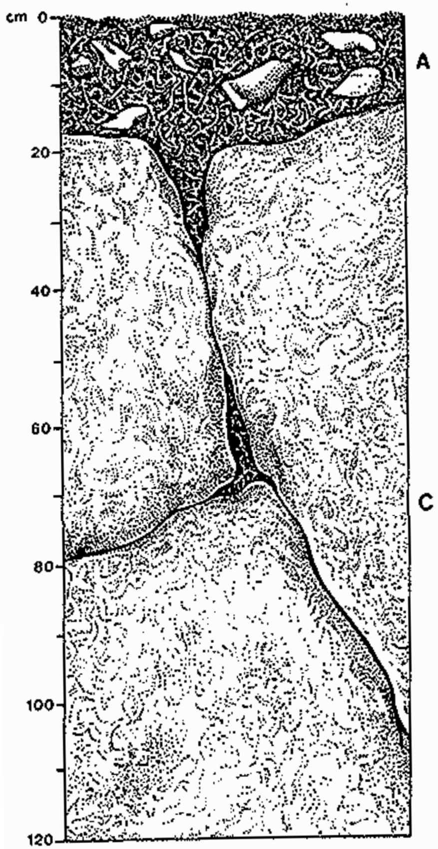
The saprotrofic food chain in terrestrial ecosystems : Soil

Brunification: Occurs in the process of weathering of minerals containing bivalent iron - Fe (II), i.e. iron silicates. Iron is only released in greater extent when pH < 7, i.e. subsequent to the washing out of carbonates if these were present, e.g. in loess). Fe^{2+} ions precipitate as brown hydroxides ($FeOH_2$), which create crusts on soil particles, leading to brown colouration of soil. At the same time clay particles are formed.
Typical of soils of high biotic activity with mull humus (pH 4.5 – 7).

Brunifikace, hnědnutí

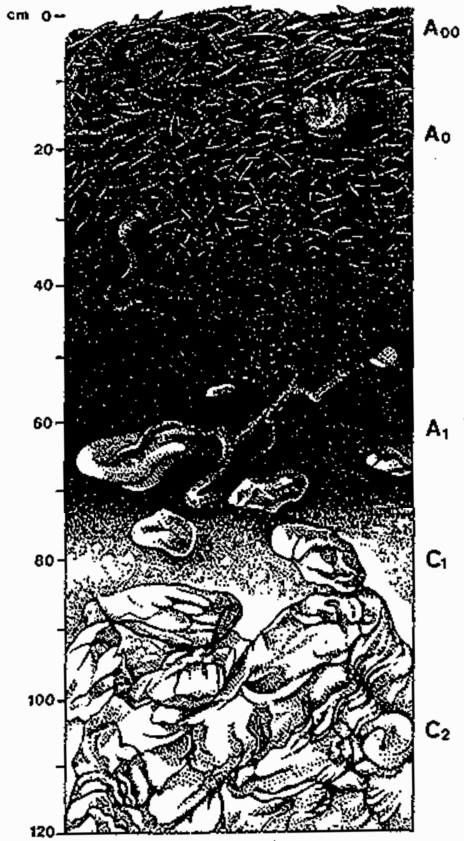
The saprotrofic food chain in terrestrial ecosystems : Soil

Ranker – shallow soils on calcium-poor, silicate bedrock / rankery – mělké silikátové půdy



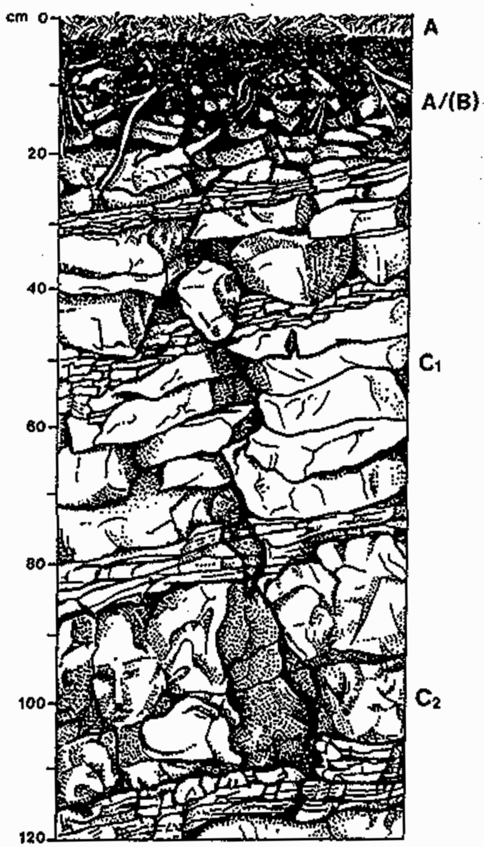
Obr. 43
Protoranker na žule

Protoranker on granite



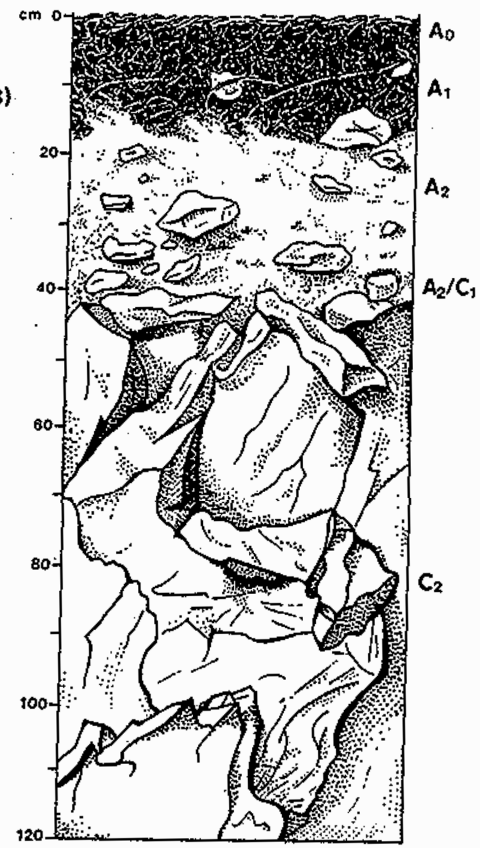
Obr. 44
Tangelový ranker na rule

Tangel ranker on gneiss



Obr. 45
Hnědozemní ranker na vápencích s polohami břidlic

Brown soil ranker on limestone with shale layers

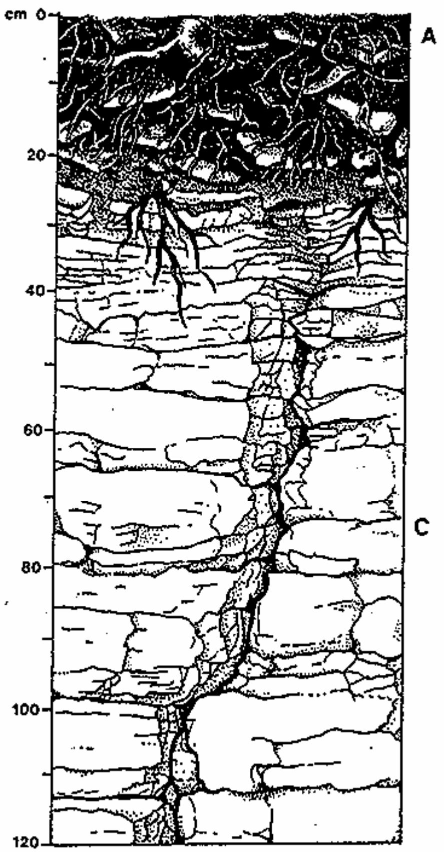


Obr. 46
Podzolový ranker na kvarcitu

Podsol ranker on quartzite

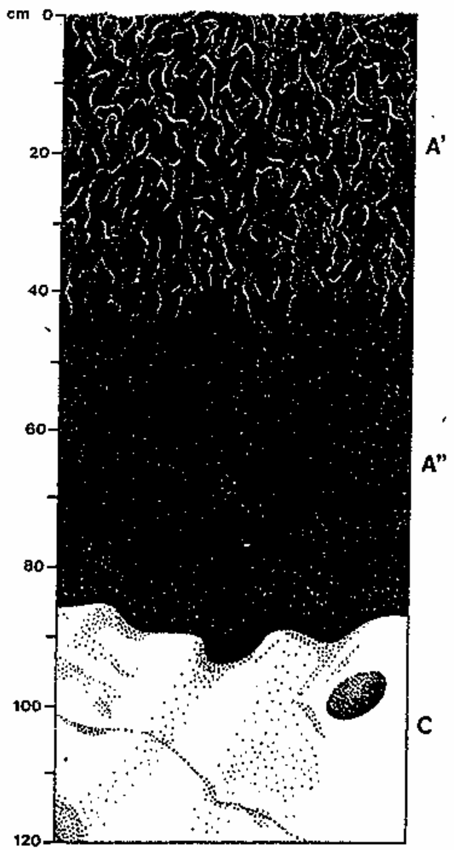
The saprotrofic food chain in terrestrial ecosystems : Soil

Rendzinas – shallow soils on calcium-rich bedrock / rendziny – mělké karbonátové půdy



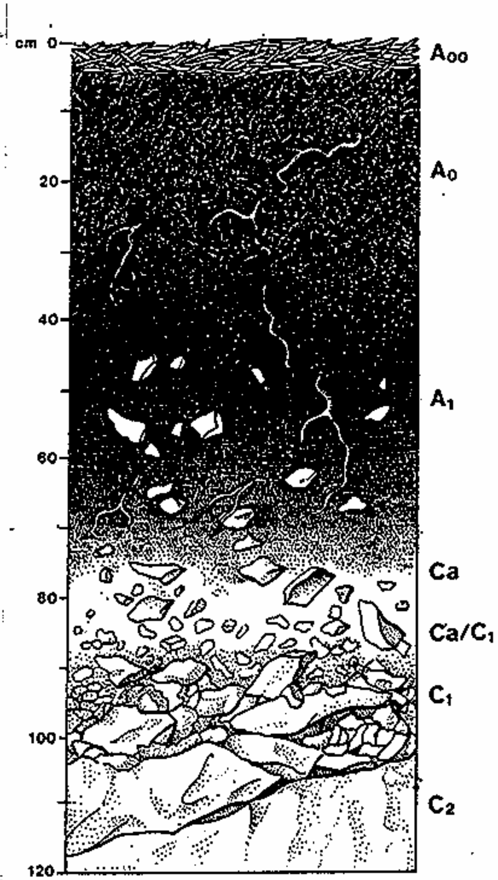
Obr. 47
Protorendzina na vápenci

Protorendzina on limestone



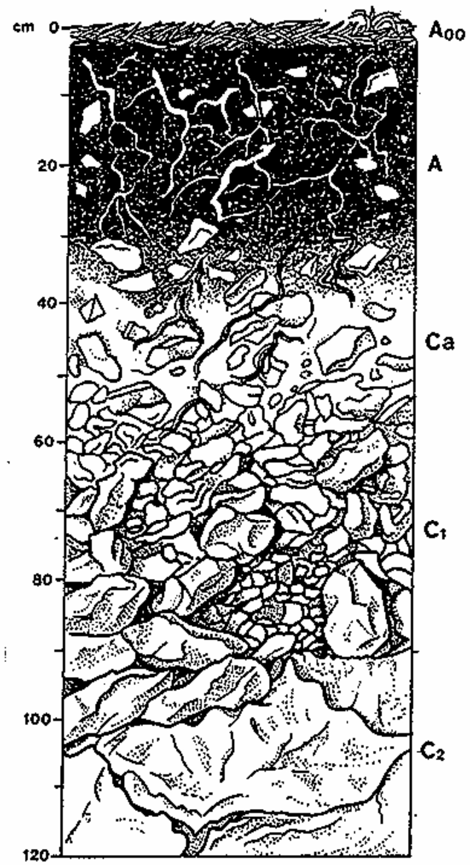
Obr. 48
Velehorská rendzina na vápenci

Alpine rendzina on limestone



Obr. 49
Tangelová rendzina na dolomitu

Tangel rendzina on dolomite

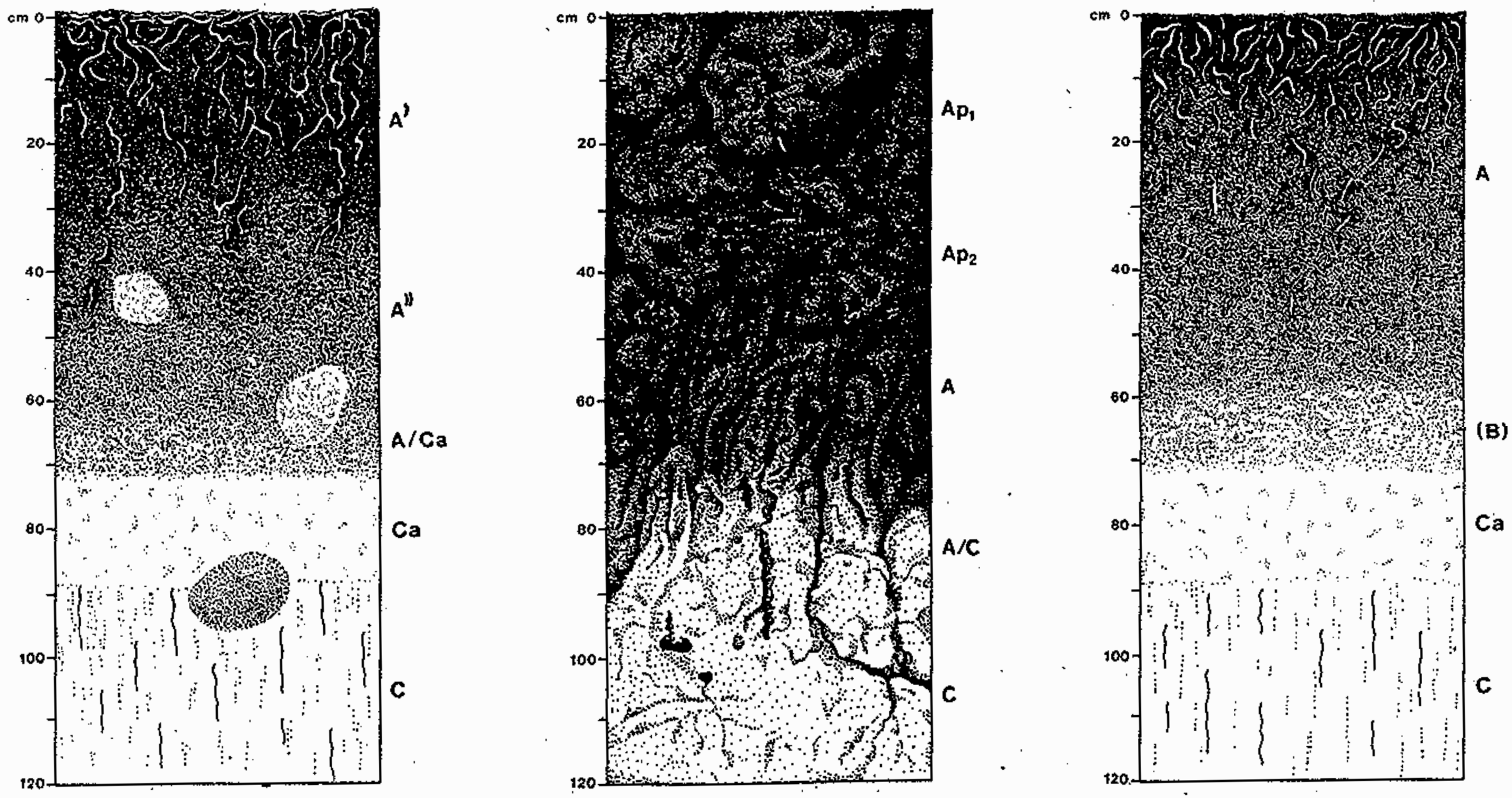


Obr. 50
Mulovitá rendzina na dolomitu

Mull rendzina on dolomite

The saprotrofic food chain in terrestrial ecosystems : Soil

Chernozems – steppe soils / černozemě



Obr. 54
Černozem na spraši

Obr. 55
Slabě degradovaná černozem
na sprašové hlíně

Obr. 56
Degradovaná černozem
na spraši

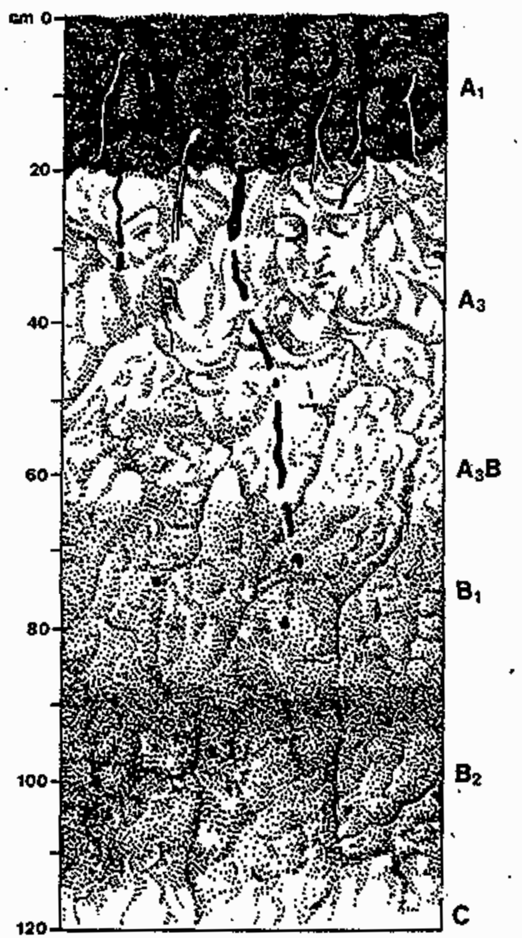
Chernozem on loess

Slightly degraded chernozem on loess loam

Degraded chernozem on loess loam

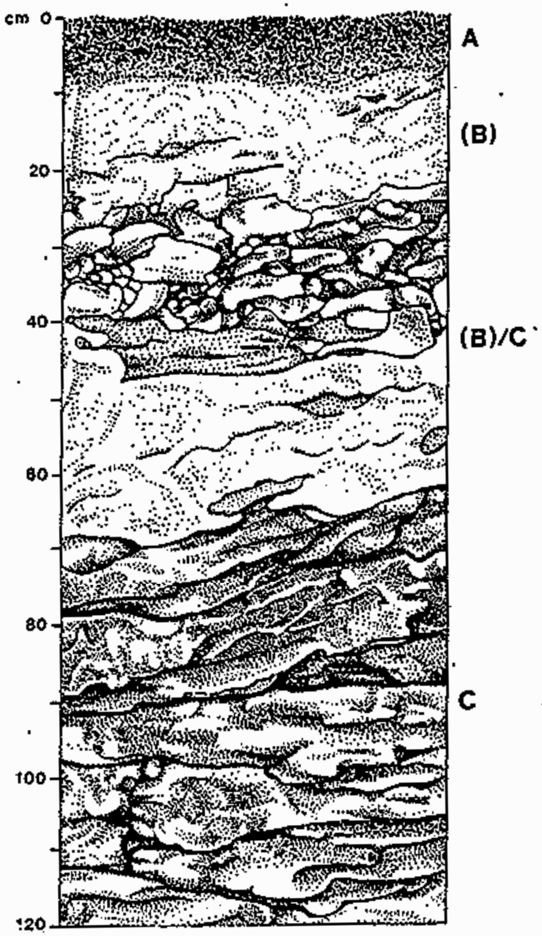
The saprotrofic food chain in terrestrial ecosystems : Soil

Cambisols / Kambisoli, Kambizemě



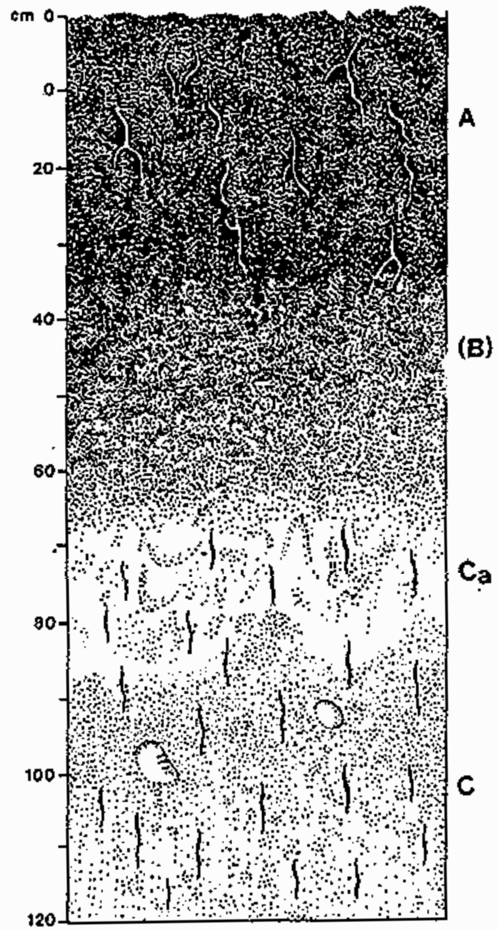
Obr. 60
Parahnědozem na spraši

Para-brown soil on loess



Obr. 58
Oligotrofní hnědozem
na křemitých břidlicích

Oligotrophic brown soil on quartzite shales

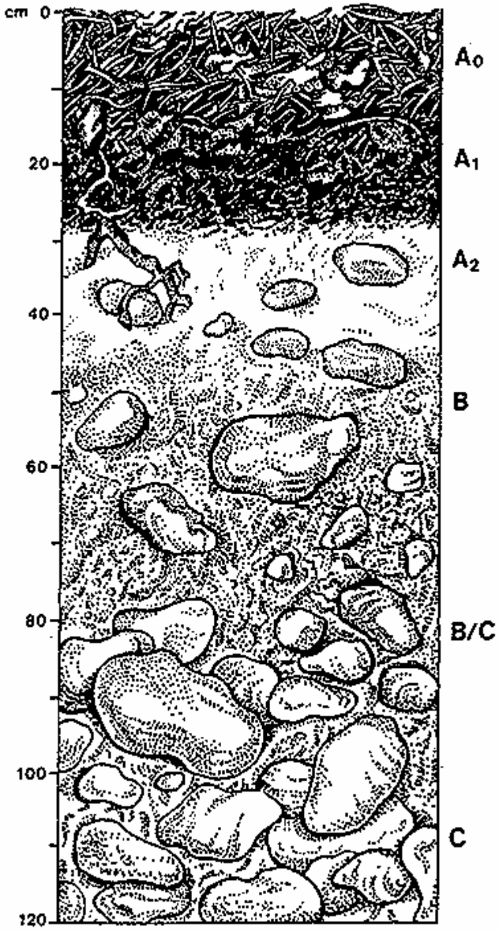


Obr. 59
Vápenatá hnědozem
na spraši

Calcareous brown soil on loess

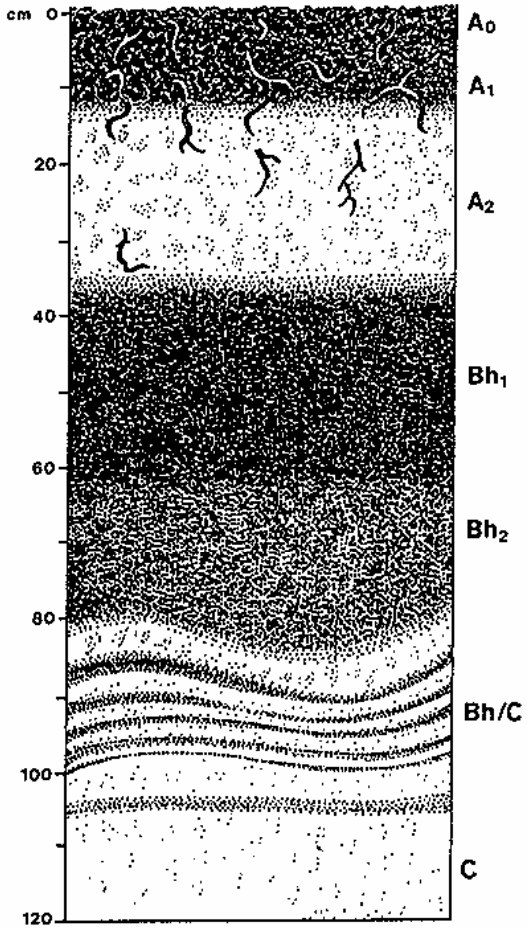
The saprotrofic food chain in terrestrial ecosystems : Soil

Podsols (= Podzols, Spodosols) / Podzoly



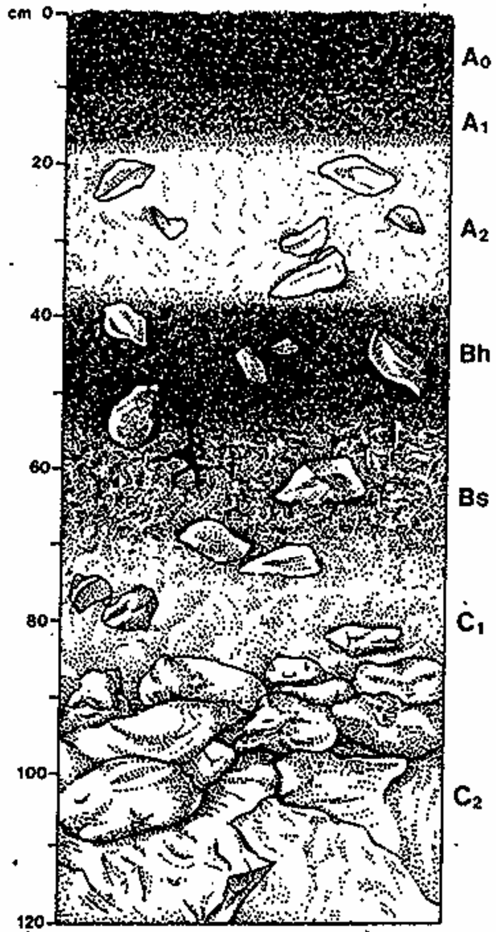
Obr. 63
Podzol na terasových štěrkopíscích

Podsol on terrace gravel-sand sediments



Obr. 64
Humusový podzol na vátých píscích

Humus (humic) podsol on aeolian sand



Obr. 65
Železitohumusový podzol na pískovci

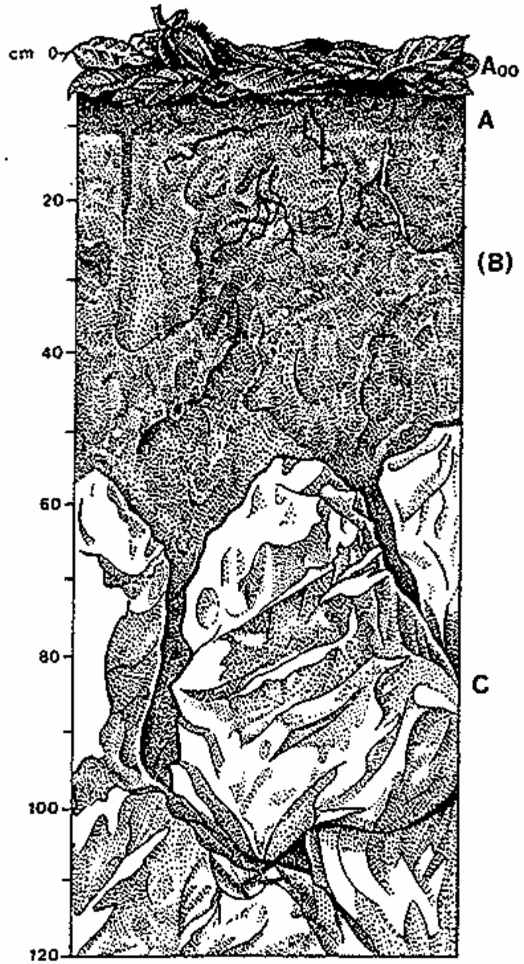
Iron humic podsol on sandstone

The saprotrofic food chain in terrestrial ecosystems : Soil

Stagnopodsol (pseudopodsol)
in upland Wales (UK)

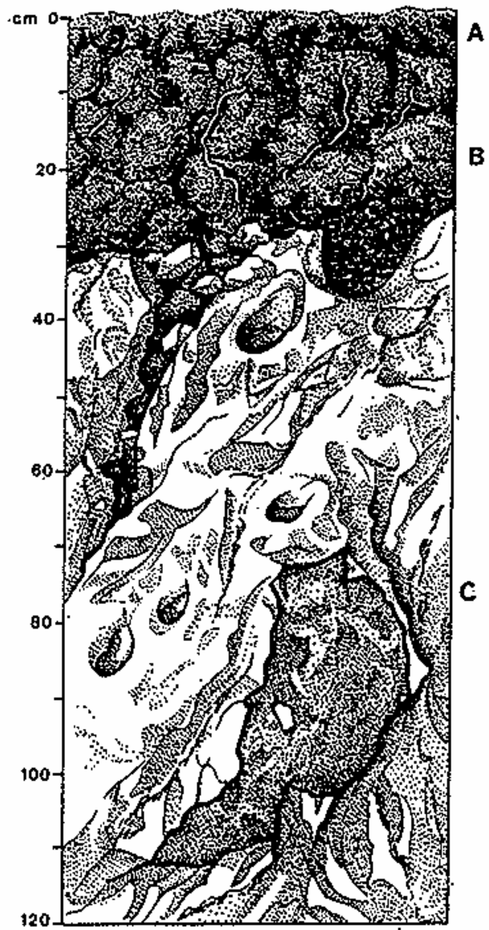
The saprotrofic food chain in terrestrial ecosystems : Soil

Soils of warm climates (incl. fossile soils) / Půdy v teplém klimatu (vč. fosilních půd)



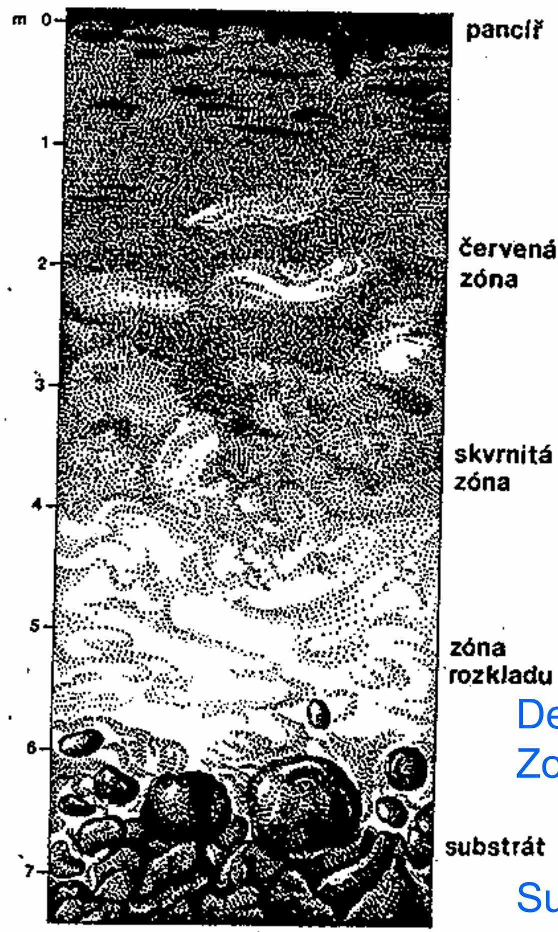
Obr. 66
Terra fusca na vápenci

Terra fusca on limestone



Obr. 67
Terra rossa na vápenci

Terra rosa on limestone



Crust

Red Zone

Freckled Zone

Decomposition Zone

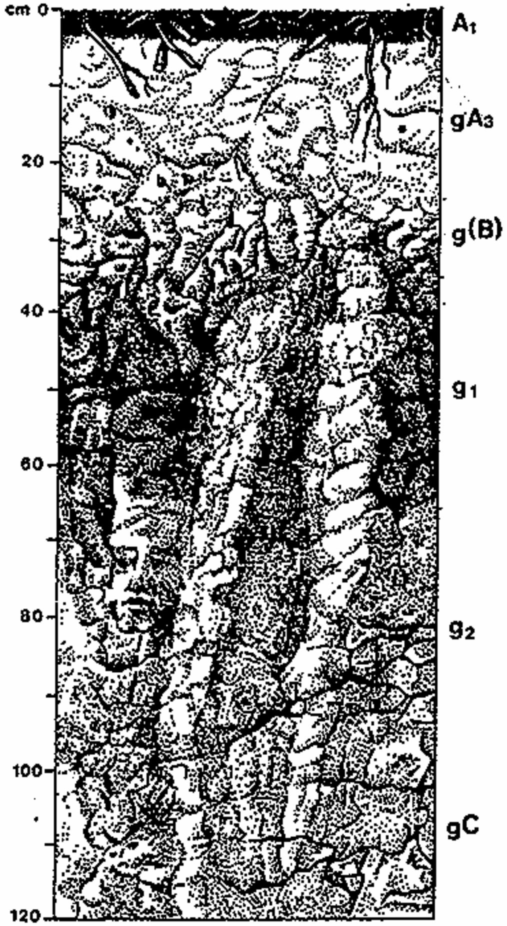
Substrate

Obr. 75
Laterit

Laterite

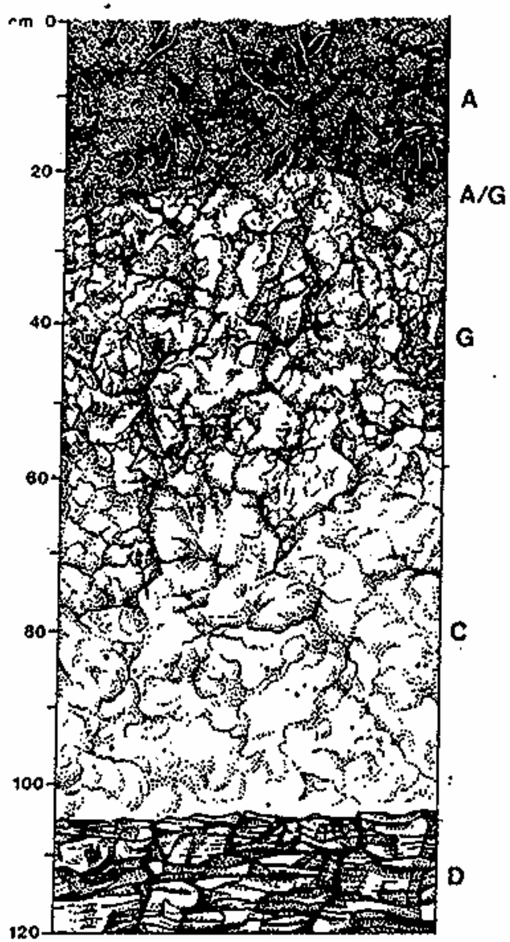
The saprotrofic food chain in terrestrial ecosystems : Soil

Pseudogleys and gleys – (temporary) waterlogged soils / Pseudogleje a gleje



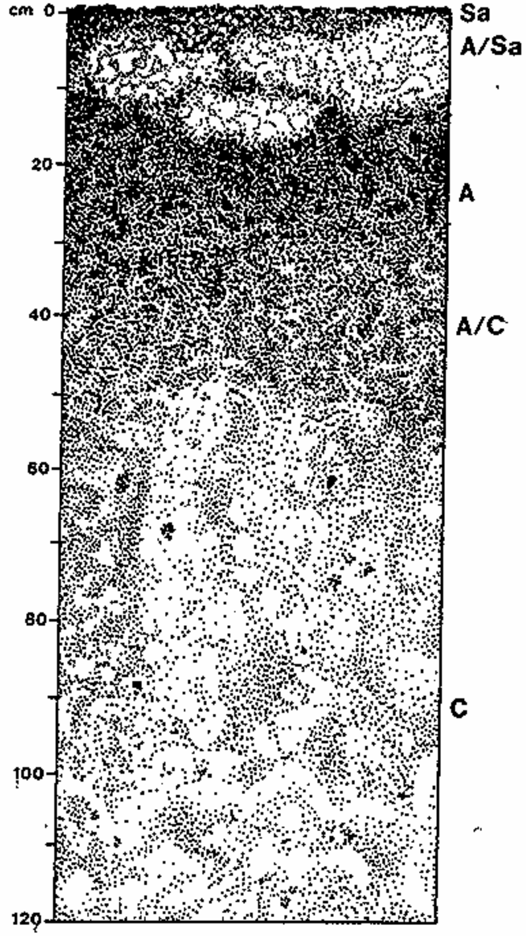
Obr. 62
Pseudoglej na sprašové hlíně

Pseudogley on loess loam



Obr. 82
Glejová půda na svahové hlíně (C) na břidlicích (D)

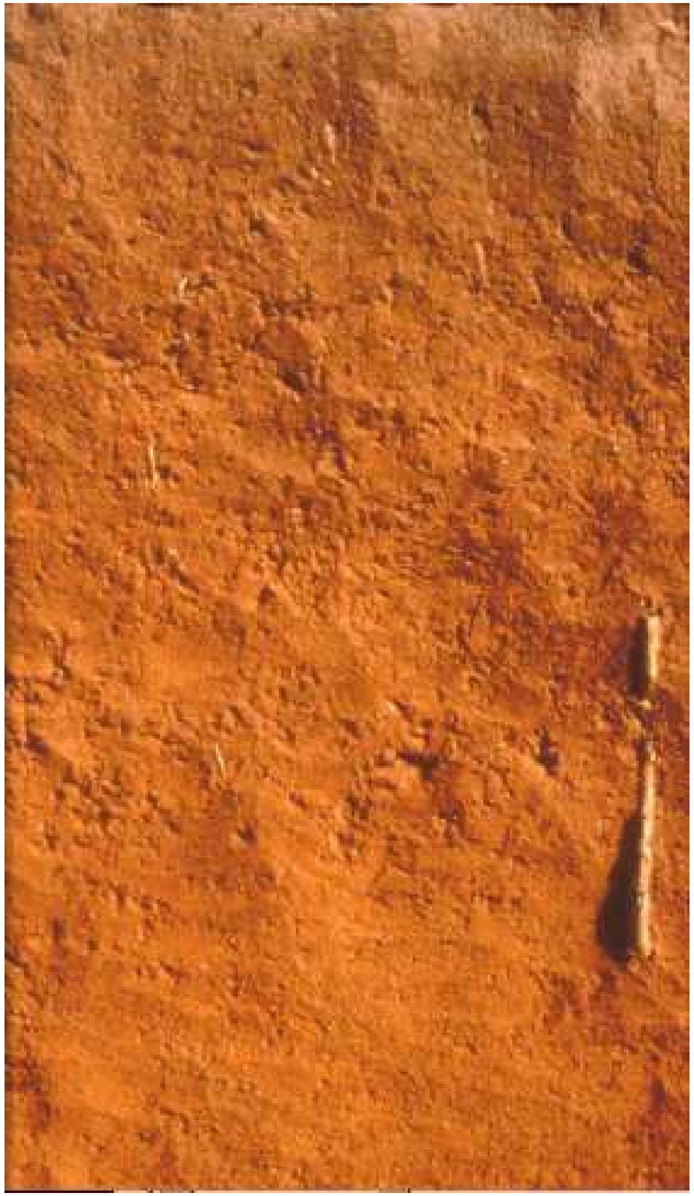
Gley on a slope loam (C) above shale (D)



Obr. 83
Solončak

Solonchak

The saprotrofic food chain in terrestrial ecosystems : Soil



Ferralsols (Oxisols – US soil taxonomy, laterite soils)

Tropical soils

Hard ironstone cover

The saprotrofic food chain in terrestrial ecosystems : Soil

Vertisols – high content of montmorillonite – type of clay that expands and shrinks extremely depending on water content; A/C soils, B-horizon missing due to self-mulching.

Form on basic rocks such as basalt.

Grasslands, grassy woodlands.

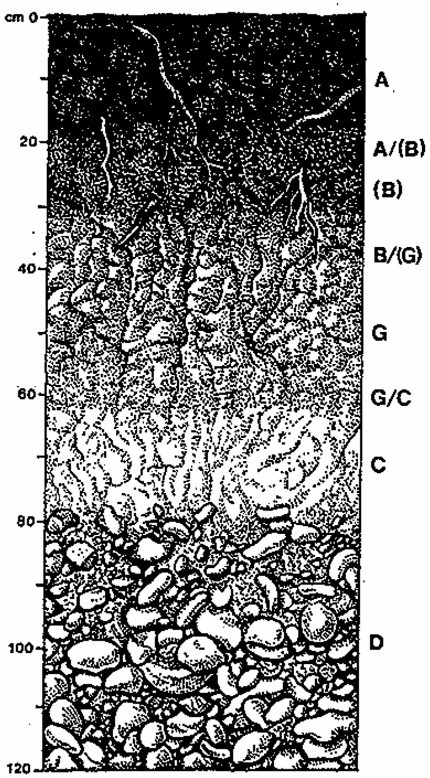
The saprotrofic food chain in terrestrial ecosystems : Soil

Stagnohumic gley soil in upland Wales (UK)

(Pseudogley, surface-water gley)

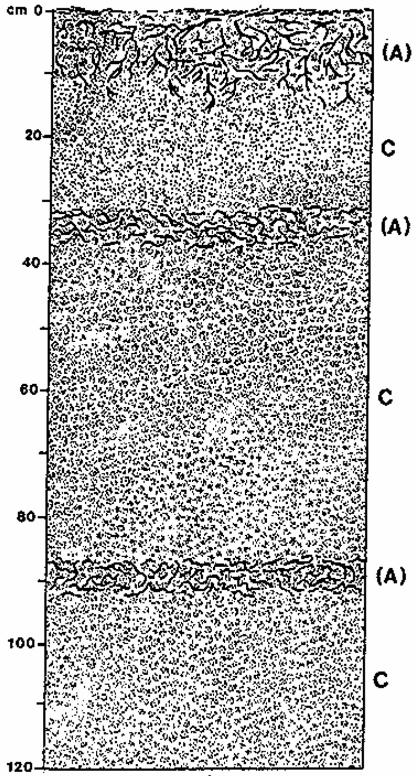
The saprotrofic food chain in terrestrial ecosystems : Soil

Fluvisols - alluvial (floodplain) soils / nivní půdy



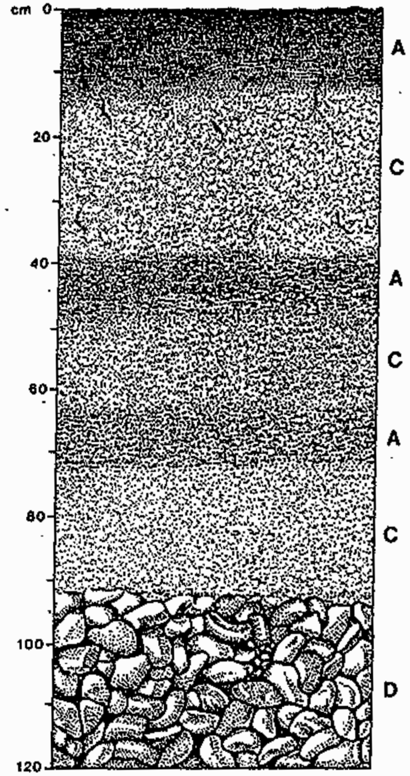
Obr. 31
Profilové schéma nivní půdy na povodňové hlíně (C); v podloží štěrky (horizont D)

Profile of an alluvial Soil on alluvial loam sediments (C) above gravel (D)



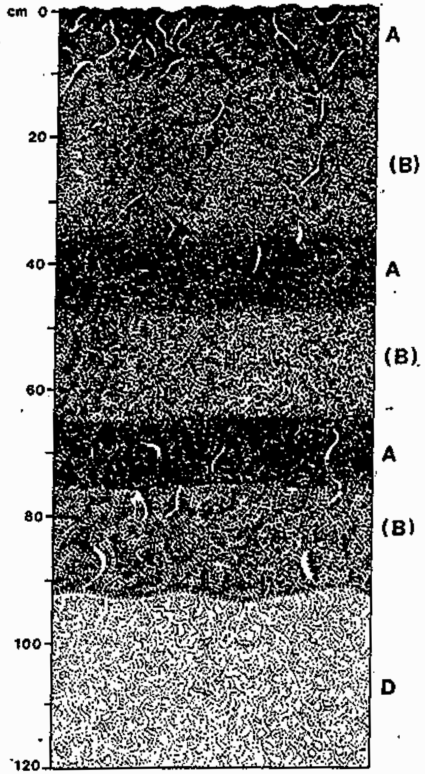
Obr. 77
Rambla na říčním písku

Rambla on alluvial sand



Obr. 78
Paternie na fluviálních sedimentech

Paternia on alluvial sediments



Obr. 79
Alochtonní vega na fluviálních sedimentech

Allochtonnous vega on alluvial sediments

The saprotrofic food chain in terrestrial ecosystems : Soil

Histosols – at least 20 % organic material in upper 40 cm.

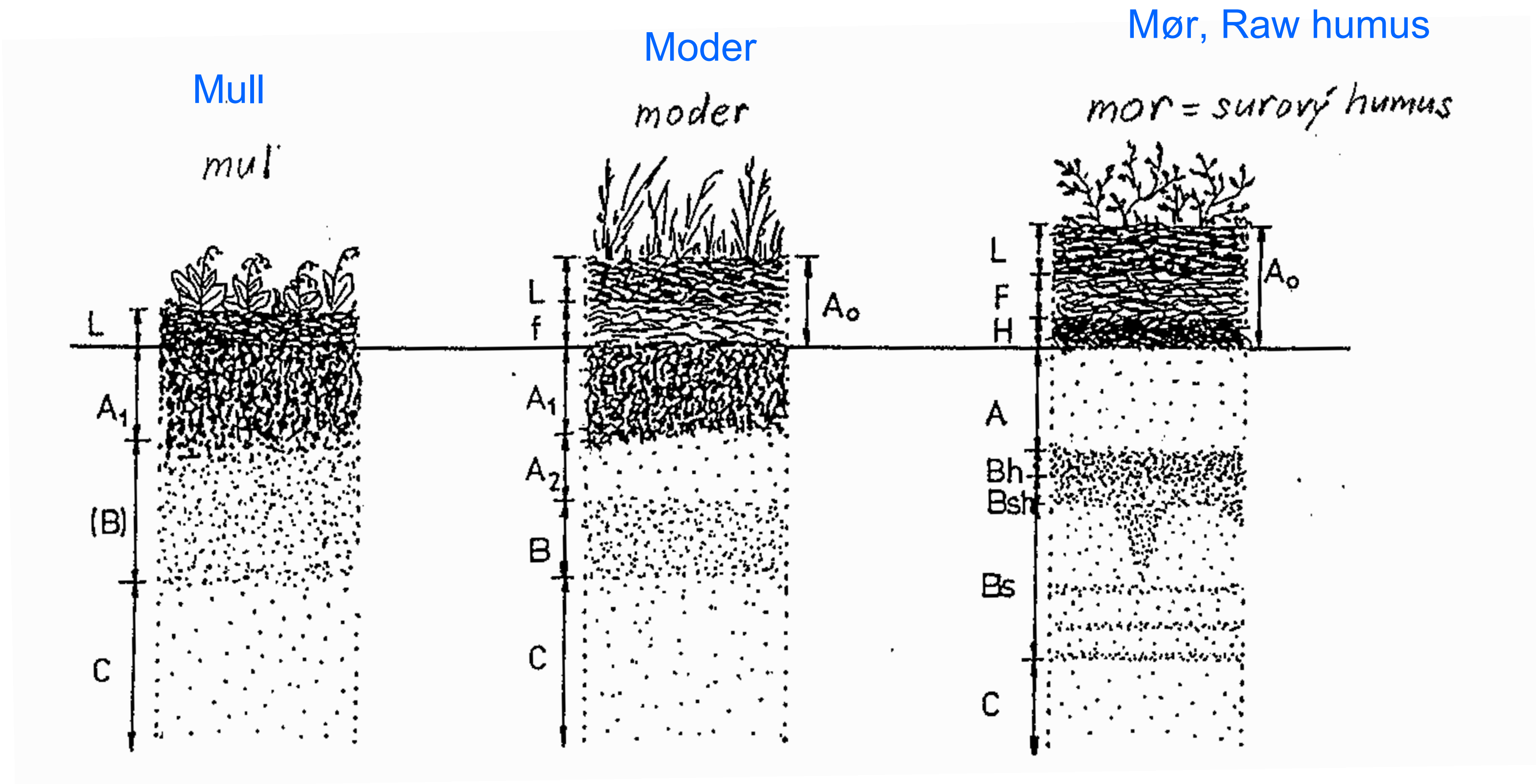
Low bulk density

Poorly drained

Mostly acidic

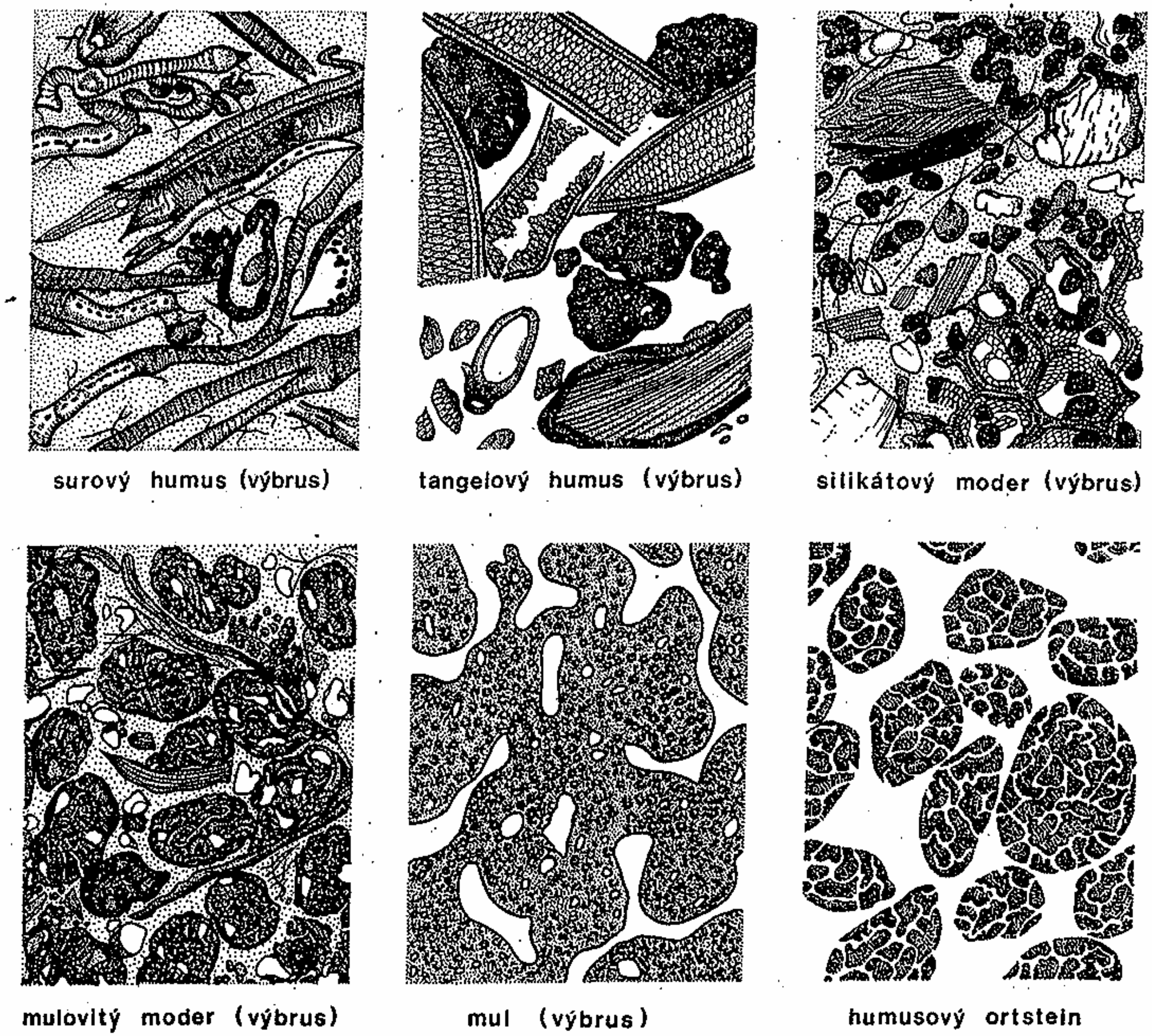
The saprotrofic food chain in terrestrial ecosystems : Soil

Humus forms / Humusové formy



The saprotrofic food chain in terrestrial ecosystems : Soil

Humus forms / Humusové formy



Obr. 14

Hlavní formy terestrického humusu. - Podle W. L. Kubiěny 1953