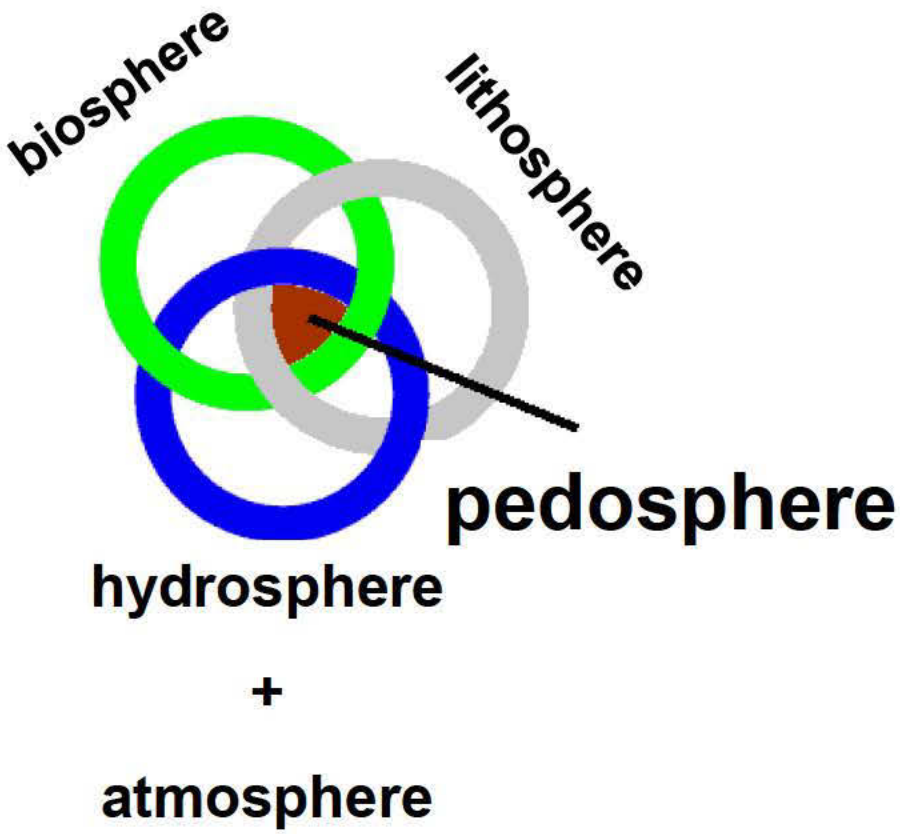
Introduction to Soil Science

Martin Šanda - B673
martin.sanda@fsv.cvut.cz

- importance of soil, soil formation
- soil substances, flow of water in soil
- terminology, classification
- economical evaluation of soils - BPEJ

Soil – interface of systems



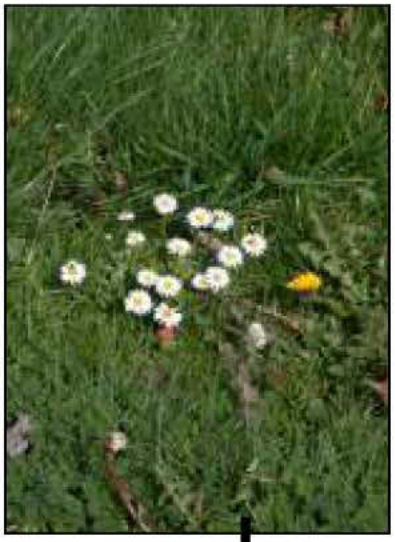
soil is natural unit generated at the interface of lithosphere and atmosphere under mutual process of pedogenetic factors

soil is binding element in between anorganic and organic matter and live organisms on the Earth

soil is desribed according to soil horizons

Atmosphere

Vegetation



Wind
Heat
Rain
Light

CO_2
H_2O

Carbon binding
Roots
Nutrients
Organic matter

Nutrients
Water
pH

pores

loosening

Weathering
Nutrient release
Fertility
Texture
Colour

Soil

Bedrock

Ecological functions of soil

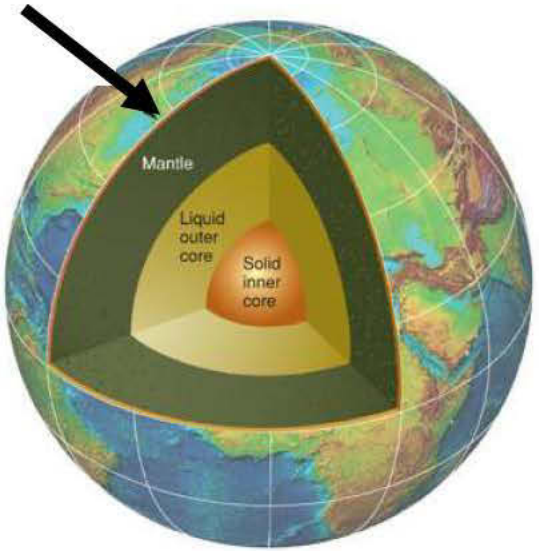
- Supports growth of plants and live of other organisms (phytoedaphon and zooedaphon)
- Recycles nutrients and exhausts
- Governs flow and purity of water
- Serves as building material

Elementary components of soil

Element %	O 49,0	Si 33,0	Al 6,7	Fe 3,2	Ca 2,0	Na 1,1	Mg 0,8
Element %	K 1,8	Ti 0,5	P 0,08	Mn 0,08	S 0,04	C 1,4	N 0,2

(URE a BERROW, 1982)_

- Oxides, hydroxides, organic compounds, soil air
- Silica, silicates, clay minerals
- Clays

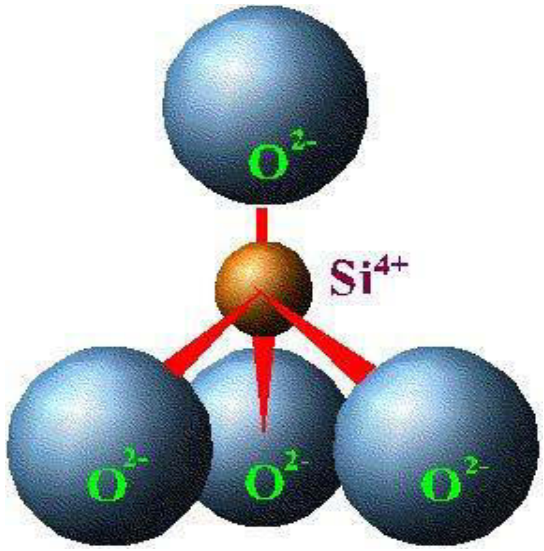


Minerals

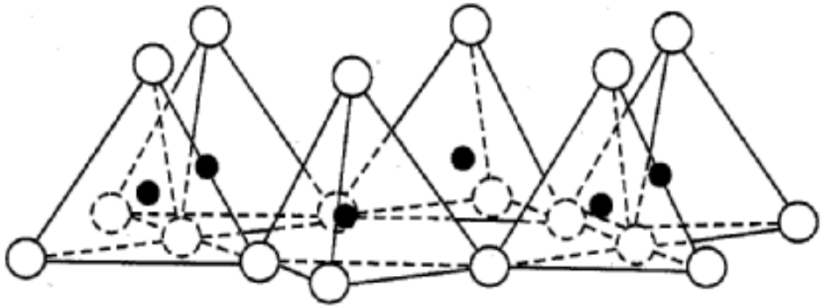
- Up to 50% of soil volume
- Made of particles of different sizes
- Determine chemical reaction
- Originate from bedrock material

Clay minerals

- silica tetrahedron SiO_4
  one atom of Si is surrounded by 4 anions of O^{2-}



- create layer of tetrahedrons sharing O^{2-}

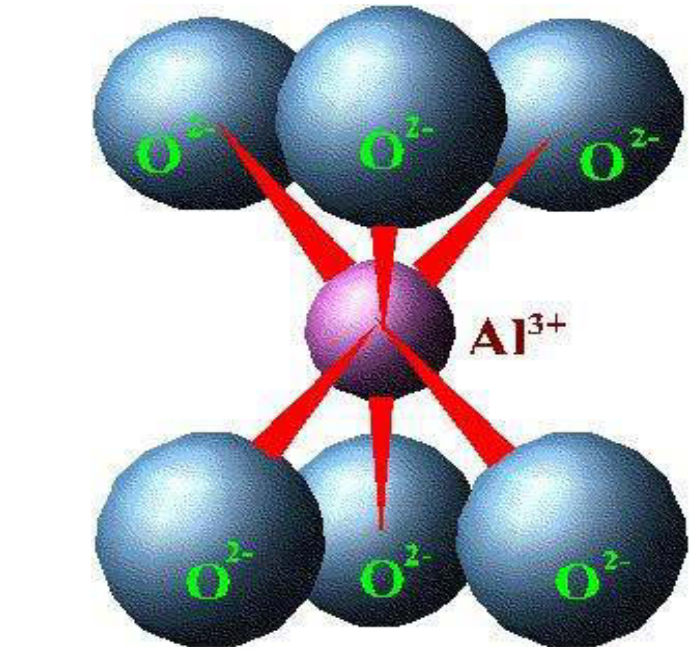


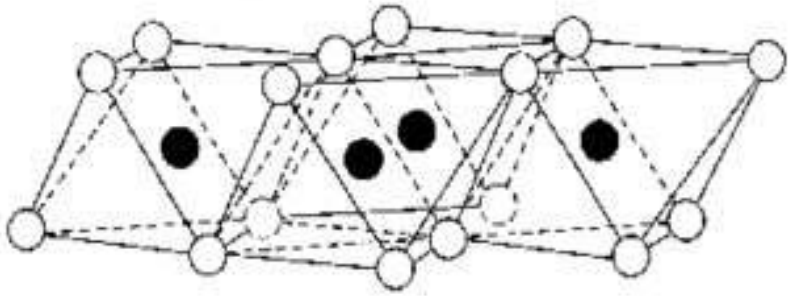
Clay minerals

- aluminium octahedron

  6 oxygens with Al^{3+} atom

- layer of octahedrons bound with shared O^{2-} or OH^-



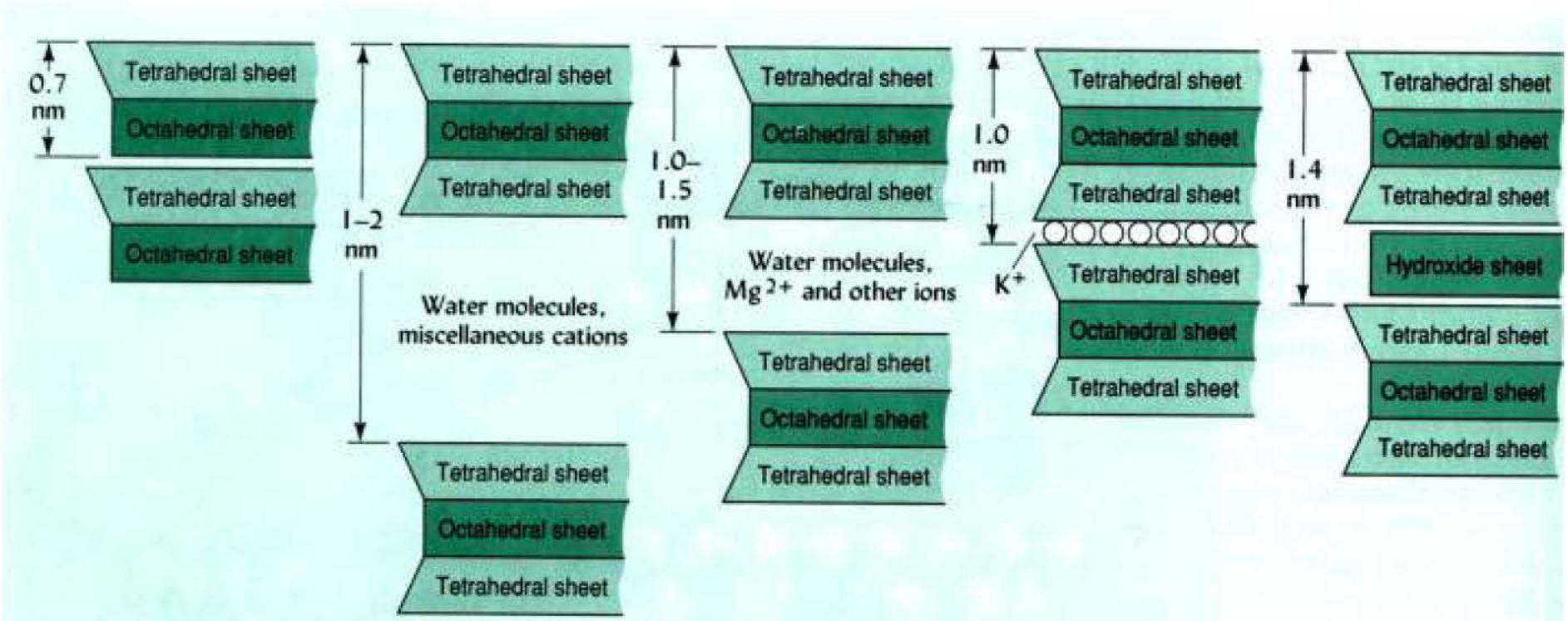


Clay minerals

- Products of **weathering** of rocks (secondary minerals)

- Posses surface charge: attract ions, impact plasticity and adhesion of soil

Types of clay minerals



(Vermiculite (Mica)

Kaolinite 1:1 **Montmorillonite 2:1** **Illite 2:1** **Chlorites 2:1**

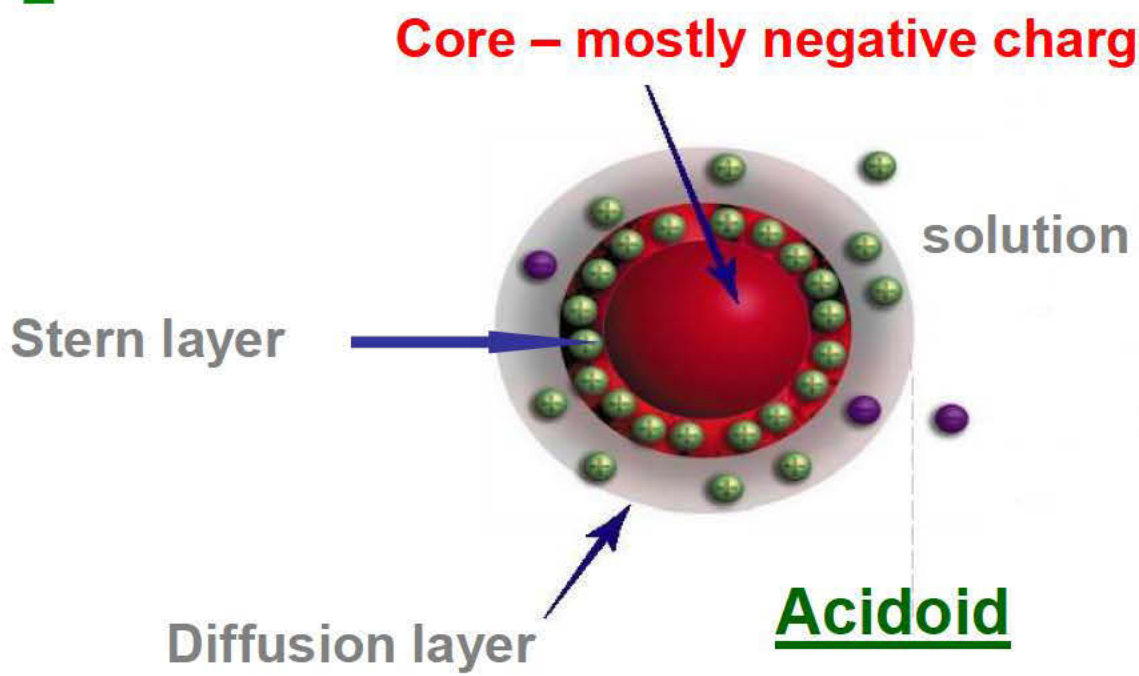
Coloids

Coloids (acc. to charge)

- Acidoids (adsob cations)
- Bazoids (adsorb anions)

Ampholytoids (charge acc. to pH)

- pH ↓ ... bazoids
- pH ↑ ...acidoids



Pedogenetic factors

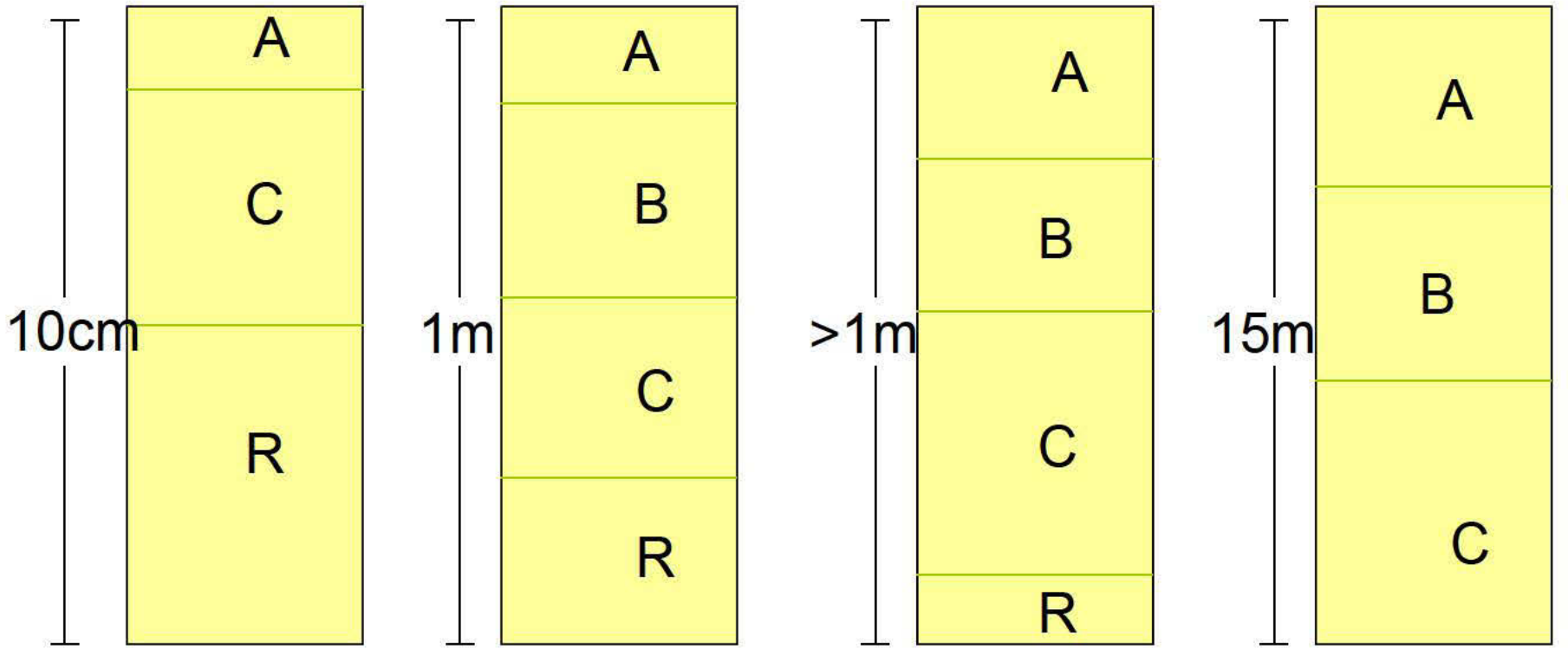
- Bedrock

  (determines properties of soils, important is ability of rock to weather)
- Topography (steepness, orientation, altitude)
- Climate

  (moisture and temperature, precipitation - rainfall)
- Organisms

  (determine creation and existence of soil)
- Time

Impact of climate to soil layering



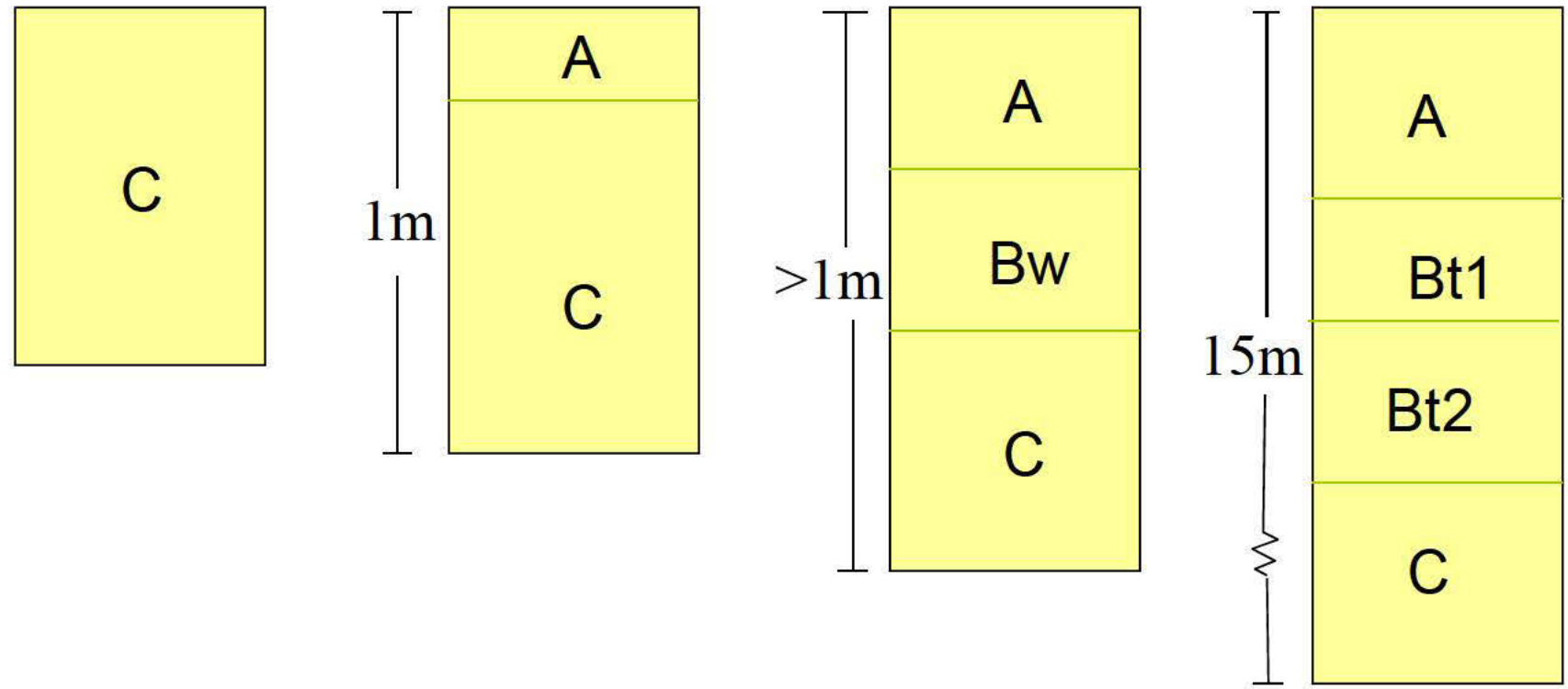
Desert, perma-frost

Arid, semi-arid

warm, wet

rainforest, tropical

Time development of the soil profile



maternal bedrock

"young profile"

"mature profile"

"highly mature profile"

Weathering

physical

1. Frost
2. Irregular heating
3. Swelling - drying
4. Abrasion (water, wind, ice)
5. Root growth

Weathering

Chemical

1. Hydratation
2. Hydrolysis
3. Dissolution
4. Carbonation
5. Complexation
6. Oxidation-reduction

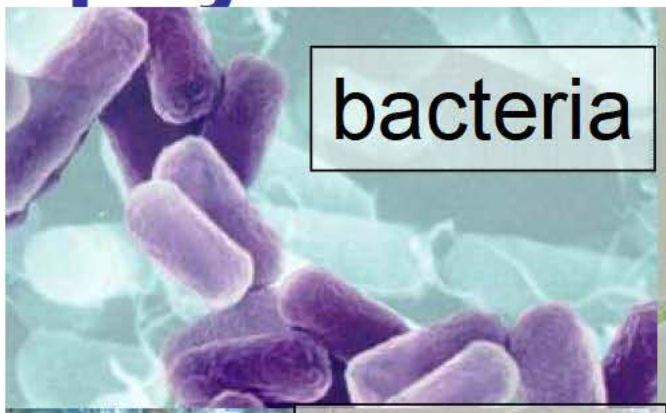
All cases need water!!!

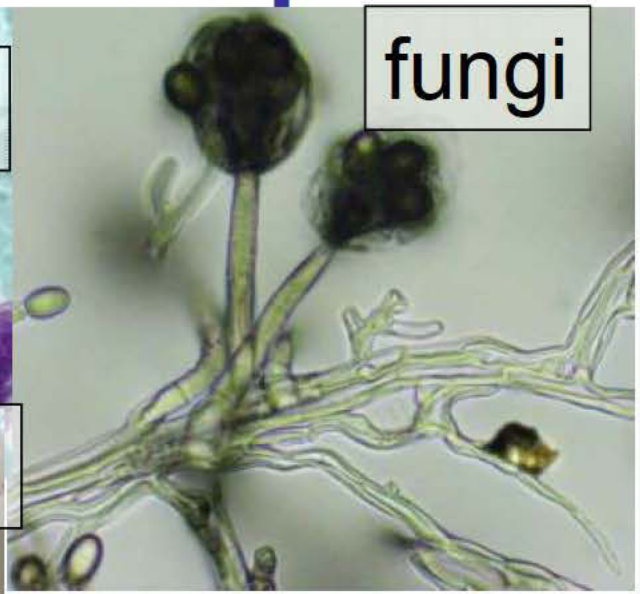
Impact of organisms on the soil formation

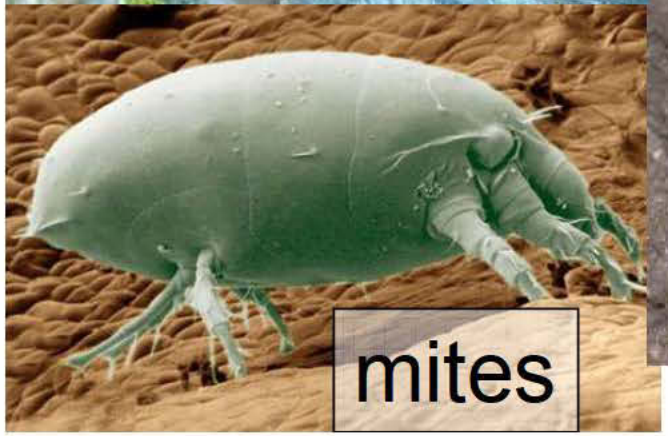
- Vegetation
  - Type of rooting, leaf chemism, amount
- Microbes
  - Decomposition of the organic matter
- Soil animals
  - Building of pathways for water flow
- Humans

  Tillage, compaction, changes of the landscape – drainage, aplication of chemicals, pollution

phyto- a zoo-edaphon - examples







Human impact on soils

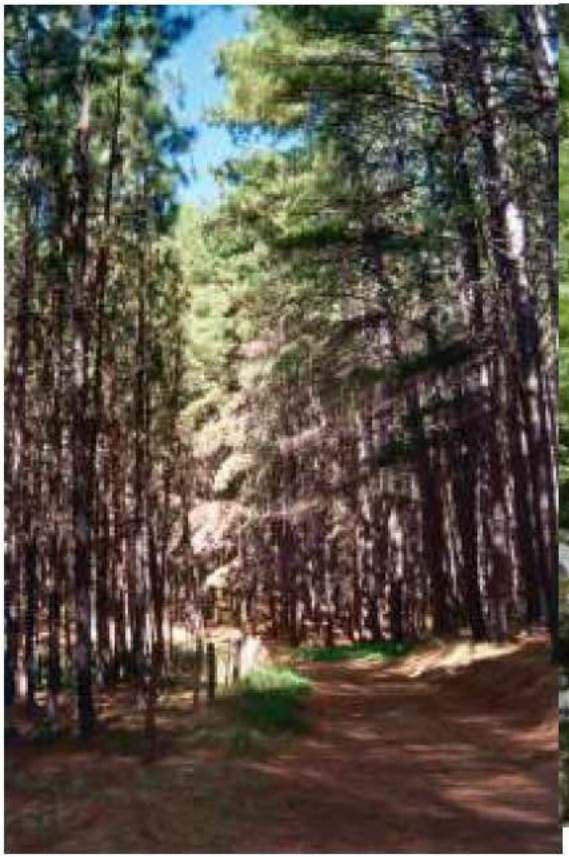
- **intensive agriculture**
  - ✓fertilization
  - ✓pesticides
  - ✓toxic compounds
- **landfills**
- **urbanization**

- **deserti-fication**
- **erosion**
  - ✓forest clear-cutting
  - ✓agriculture

Vegetation

natural plants, agriculture crops:
fields, meadows, pastures, forests

trees – forests, rainforests



Basic nomenclature

Soil horizon designations

layers with properties different from other adjacent layers

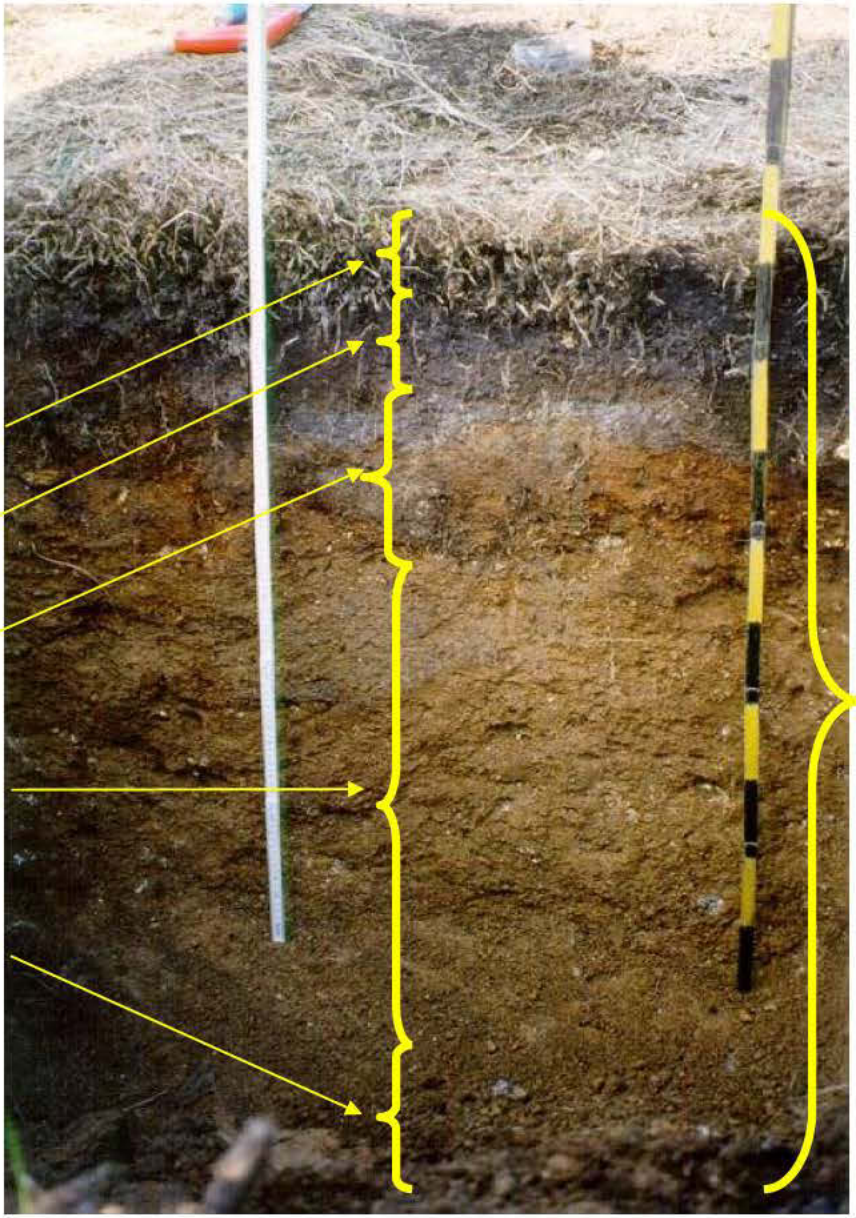
litter layer

A (humus)

B (leached)

C (bedrock substrate)

R (bedrock)

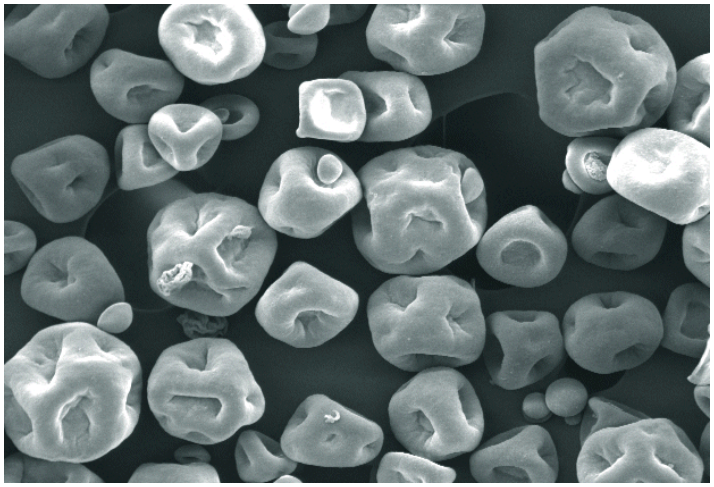


Soil profile – vertical section combining all soil horizons

Soil texture and soil structure

texture – %clay, silt, sand

determined, can not be changed



texture classes

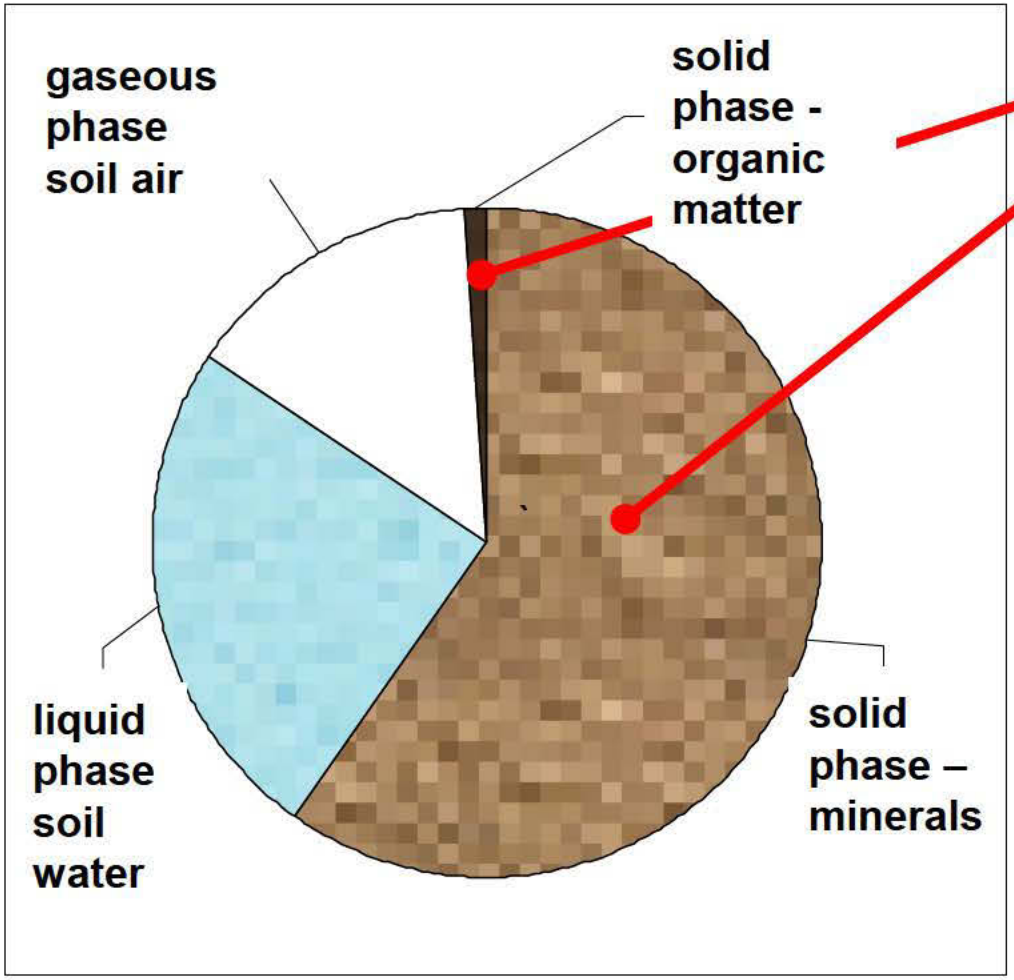
aggregates – spatial composition

chemical bonds of humus units / clay minerals to other grains

can be changed (good/bad)

soil types

Texture and structure are parameters of soil solids



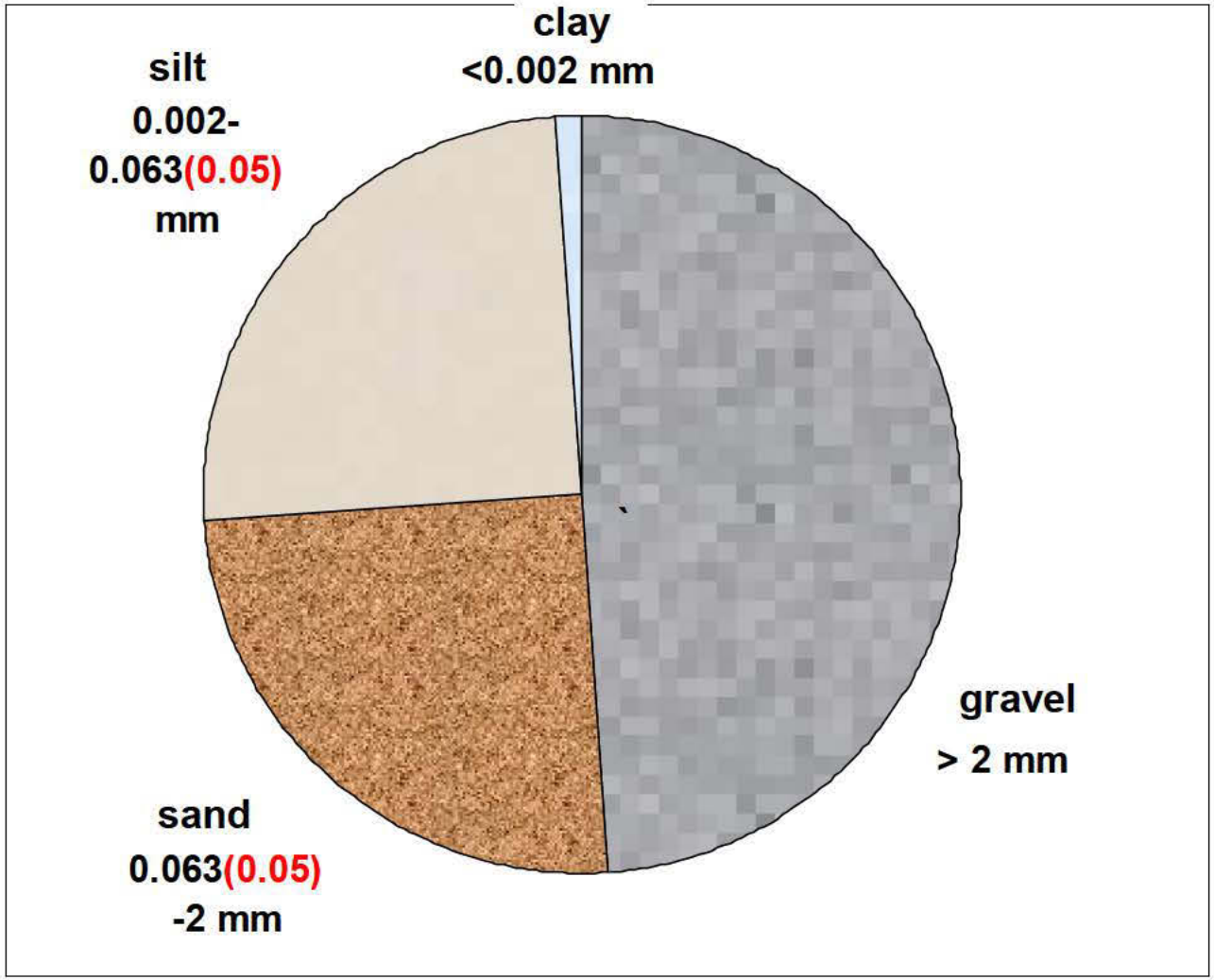
texture relates to **mineral** part of solid phase only

structure is dependent on **mineral** and **organic** part of solid phase

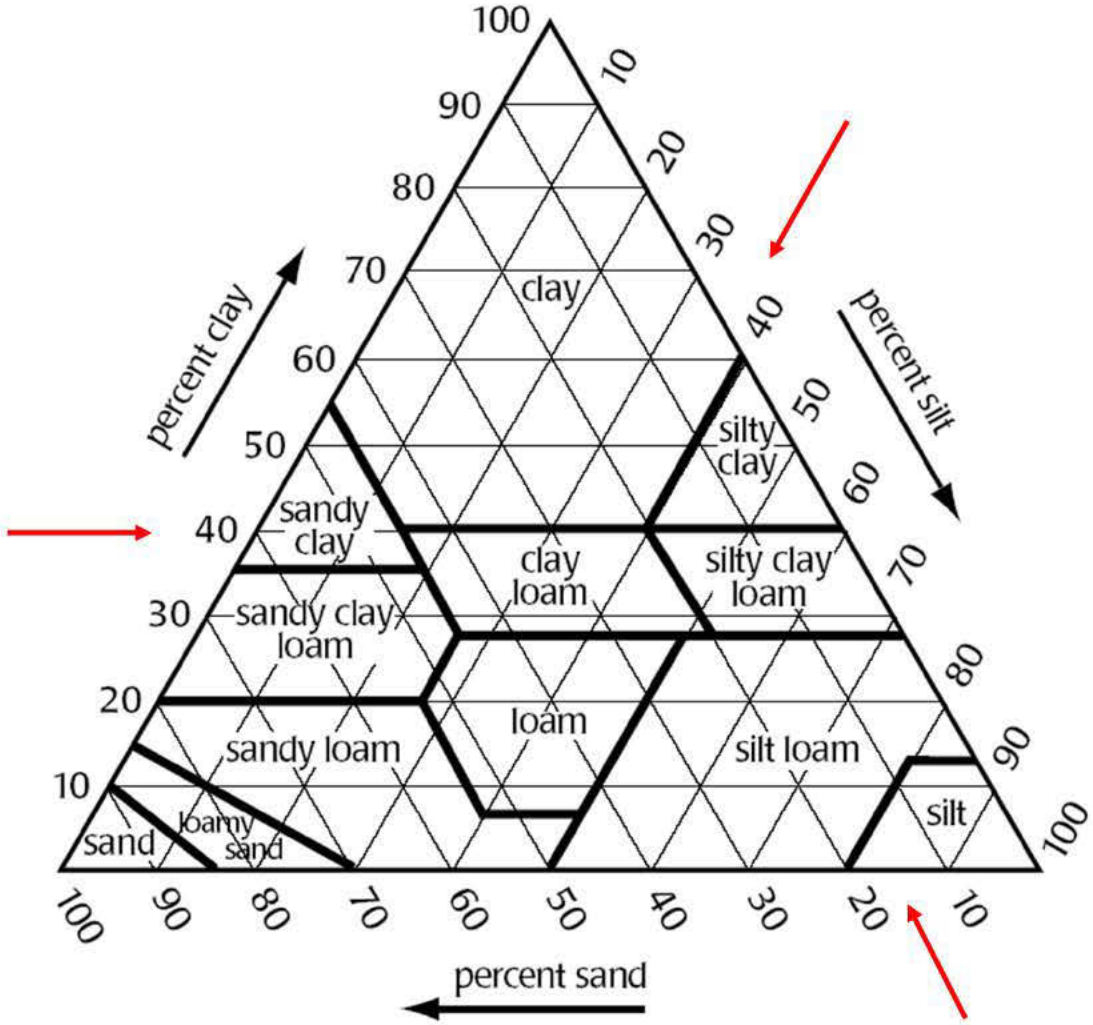
texture categories

gravel, sand, silt, clay

determined as differences % of weights of grain size intervals



Texture classes according to clay, silt, sand



Triangle diagram of soil texture (NRSC USDA)

Soil structure

- primary spatial constellation of soil into clumps called aggregates or pedons
- binding factors are plant root (their excrements), organic matter and clay minerals,
- sandy and rocky soils do not create aggregates
- most important factor of aggregation is organic matter
- stability of aggregate is their endurance towards breakdown under external impacts

Charakteristics of soil structure

- *Type*: Shape of aggregates

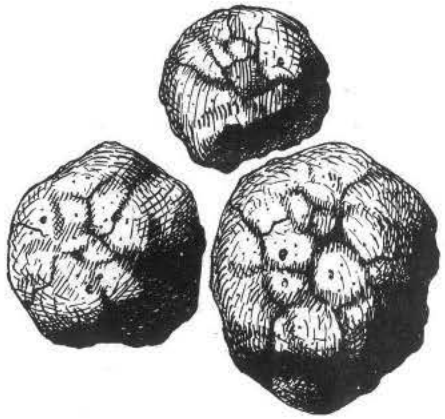
  crumbs, blocky, prizmatic, platy..

- *Size*:
  - fine (microaggregates) <0.25 mm
  - coarse (macroaggregates) >0.25 mm
- *Degree of structure*:
  - without st., weak st., highly developed st.
- *General*
  - **lots of clay→ strong structure, big blocks**
  - **lots of organics→ crumby structure**

impact of roots on soil stability

Sulzman

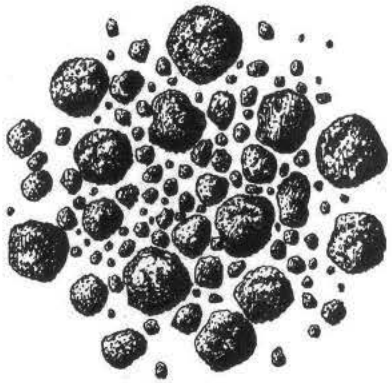
Classes of soil structure



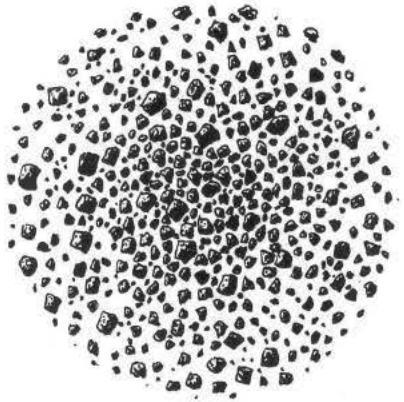
hrudovitá

hrudkovitá

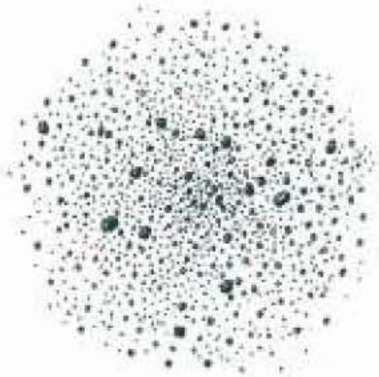
I. crumbs



drobtová (zrnitá)



jemně drobtová (zrnitá)



práškovitá

hrubě polyedrická

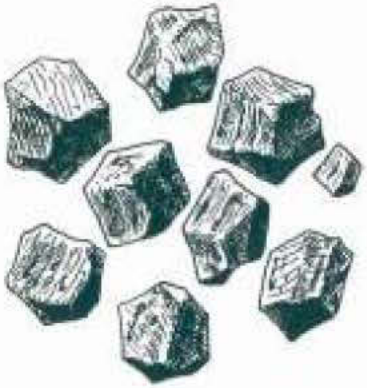
II. polyedric

polyedrická

drobně polyedrická (krupnatá)

Tomášek, M; Atlas půd České Republiky ČGÚ, Praha 1995

Classes of soil structure

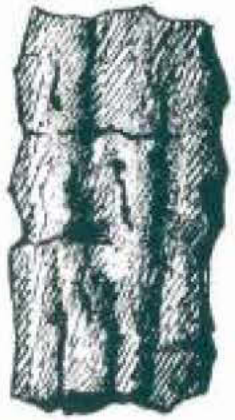


kostková

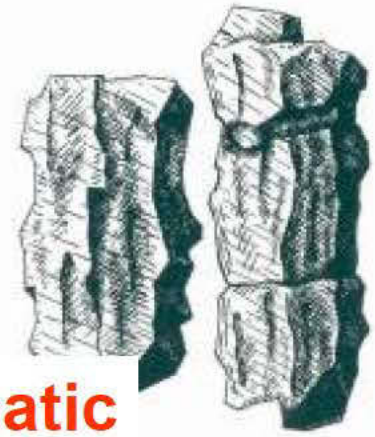
lečková

II.

blocky



hrubě prizmatická

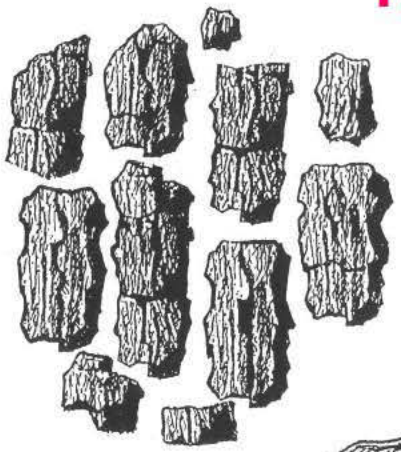


prizmatická

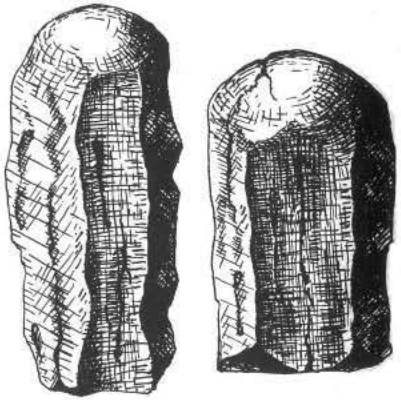
III.

prizmatic

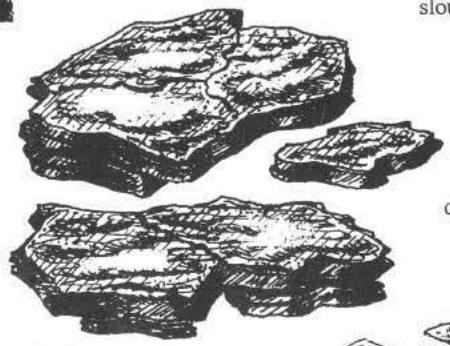
III.



drobně prizmatická



sloupcovitá



deskovitá

destičkovitá

IV.

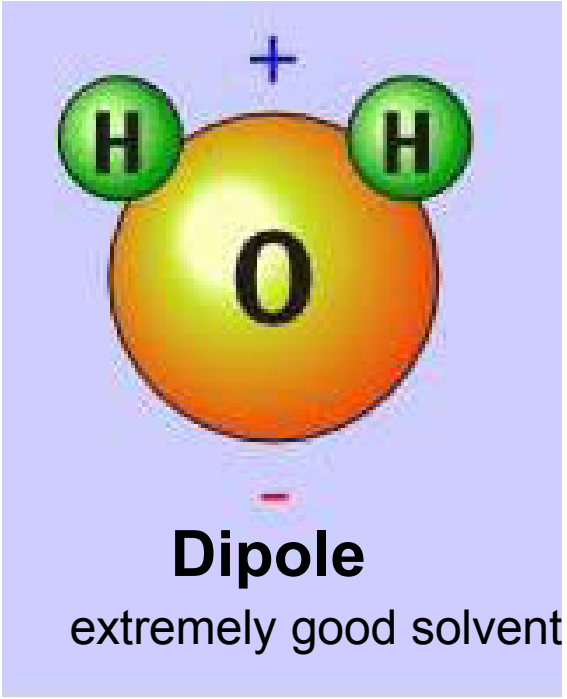
lístkovitá

platy

Tomášek, M; Atlas půd České Republiky ČGÚ, Praha 1995

Soil water

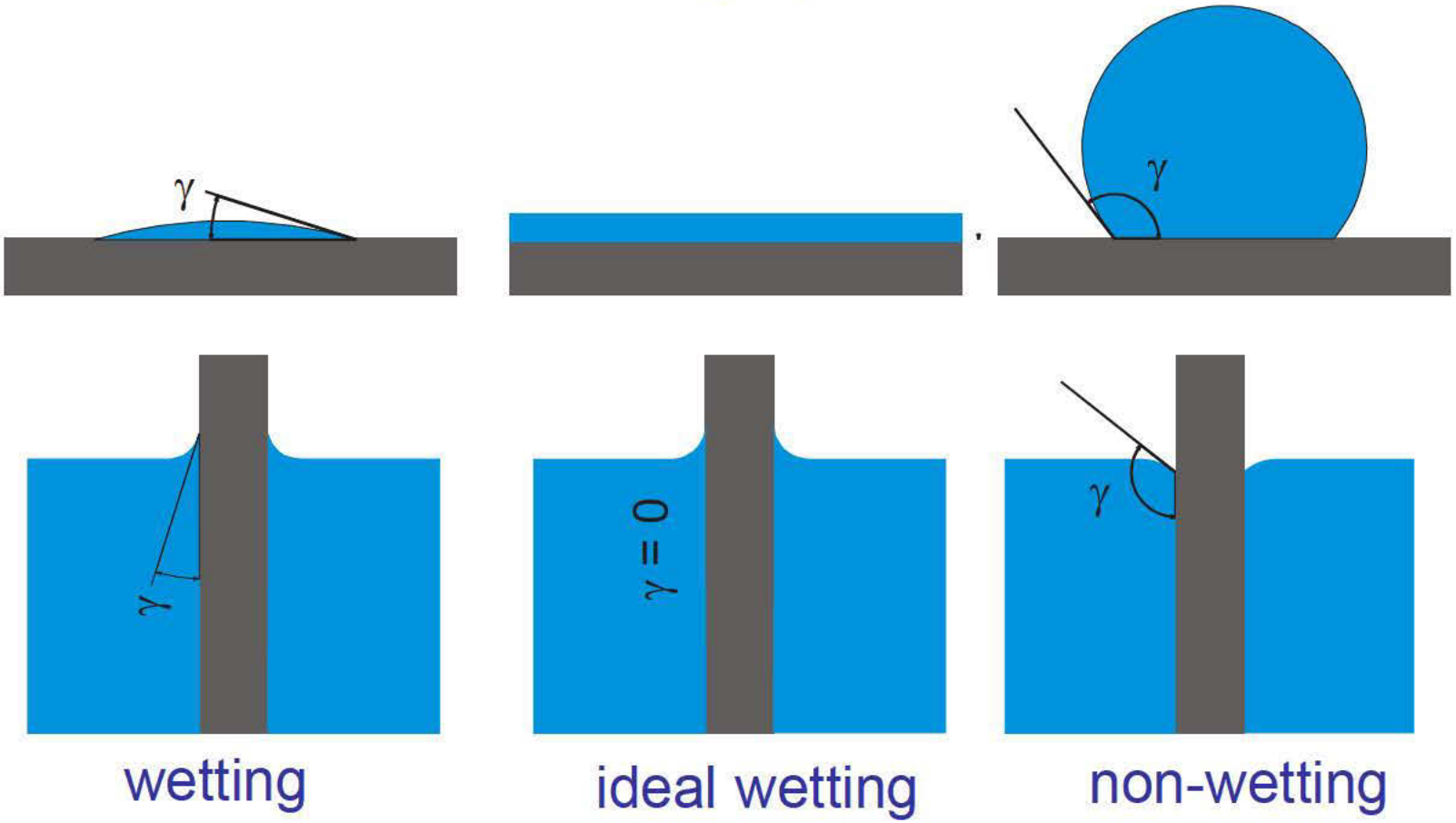
- Necessary for plant growth
- Basic medium for transport of matter
- Necessary for clean up of soil
- Is found in soil as
  - chemically bound and
    hygroscopic (grain wrap),
  - capillary (capillary forces in pores)
  - gravitational (temporal, outflows after cessation of the water source- rain, flood, snowmelt)



Capillarity

At the interace water-gas-solid

contact angle γ occurs

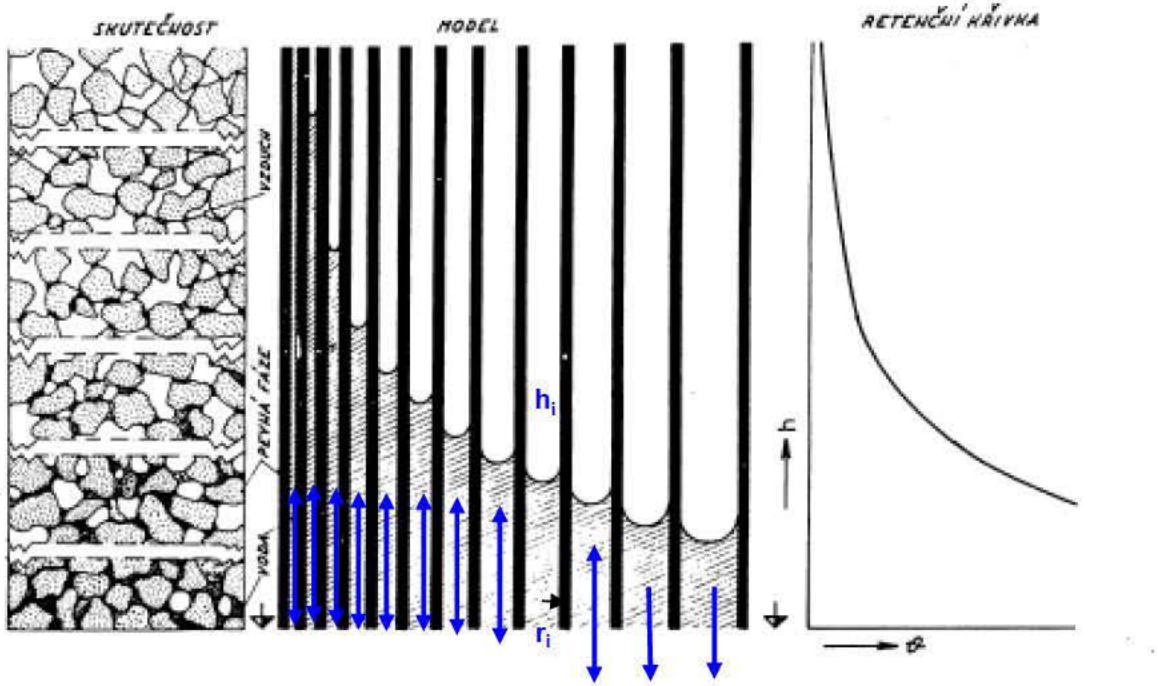


modified from Kutílek a kol. 1994

Retention curve of soil moisture

•soil system of pores can be ideally substituted by the bundle of capillary tubes of different diameters

•applying suction of equivalent suction head h_i all tubes thicker than r_i diameter are drained, thinner than r_i stay filled with water



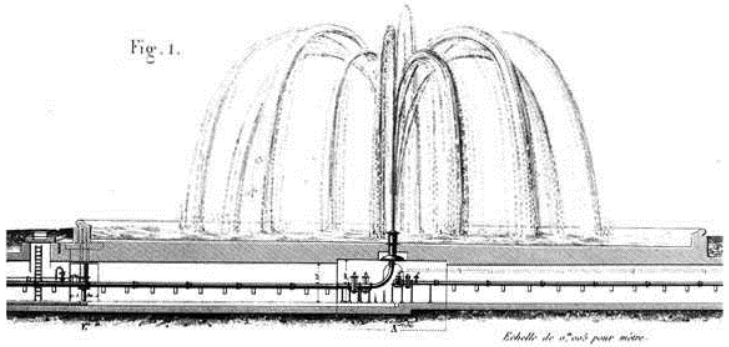
Saturated flow

Henry Darcy

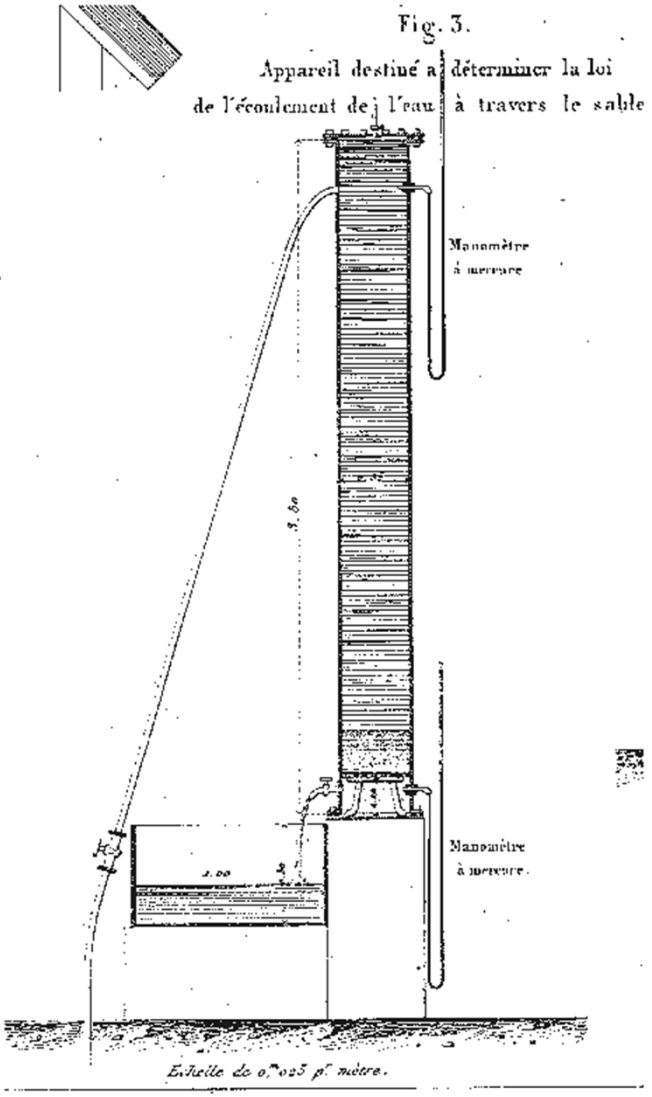
***Henry Darcy (1856)* solved the filtration problem for fountains in Dijon.**

He found that *flow of water* through the column of sand is dependent:

- *proportionally to the difference of hydrostatic pressure at the ends of the column*
- *improportionally to the length of the column*
- *proportionally to the cross-section of the column*
- *depends on the coefficient for the given material*



Darcy, H., 1856. *Les Fountaines de la Ville de Dijon*



Hydraulic conductivity

- is the Darcian coefficient of the material called:

saturated hydraulic conductivity

Darcy law is then

$$\mathbf{v = K_s * i \qquad (m/s)}$$

v – velocity of flow

K_s – saturated hydraulic conductivity (m/s)

i – hydraulic gradient (i = h/L)

Classification of soils:

- aiming to organize knowledge in the relation of soil genesis and soil properties
- World Reference Base - FAO/UNESCO Legend of the Soil Map of the World
  - -diagnostic horizons
  - -diagnostic properties
  - -diagnostic materials
- also each country has its onwn system of soil types

http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/W8594E/W8594E00.htm

FAO – System defines:

Reference soil groups – main pedogenetic process, identification of dominant soil horizon: ending mostly with with –**sol**

HISTOSOLS (HS), CRYOSOLS (CR), ANTHROSOLS (AT), LEPTOSOLS (LP), VERTISOLS (VR), FLUVISOLS (FL), SOLONCHAKS (SC), GLEYSOLS (GL), ANDOSOLS (AN), PODZOLS (PZ), PLINTHOSOLS (PT), FERRALSOLS (FR), SOLONETZ (SN), PLANOSOLS (PL), CHERNOZEMS (CH), KASTANOZEMS (KS), PHAEOZEMS (PH), GYPSISOLS (GY), DURISOLS (DU), CALCISOLS (CL), ALBELUVISOLS (AB), ALISOLS (AL), NITISOLS (NT), ACRISOLS (AC), LUVISOLS (LV), LIXISOLS (LX), UMBRISOLS (UM)
CAMBISOLS (CM), ARENOSOLS (AR), REGOSOLS (RG)

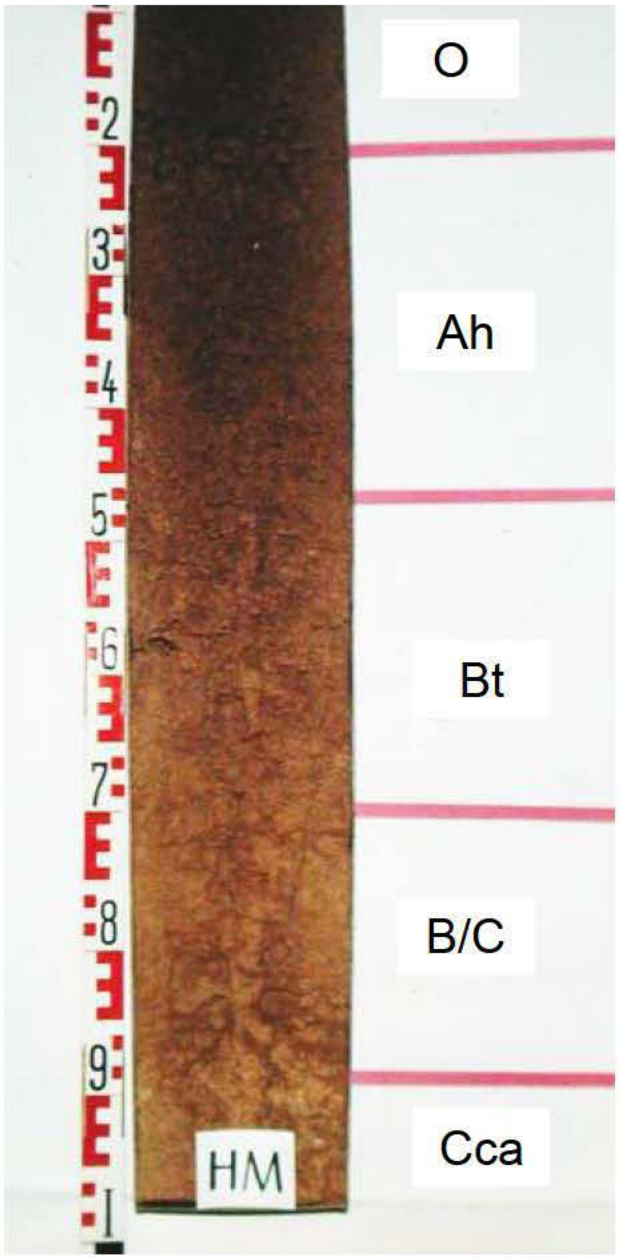
Varietes – adjective codes: identification acc. e.g. to chemical properties

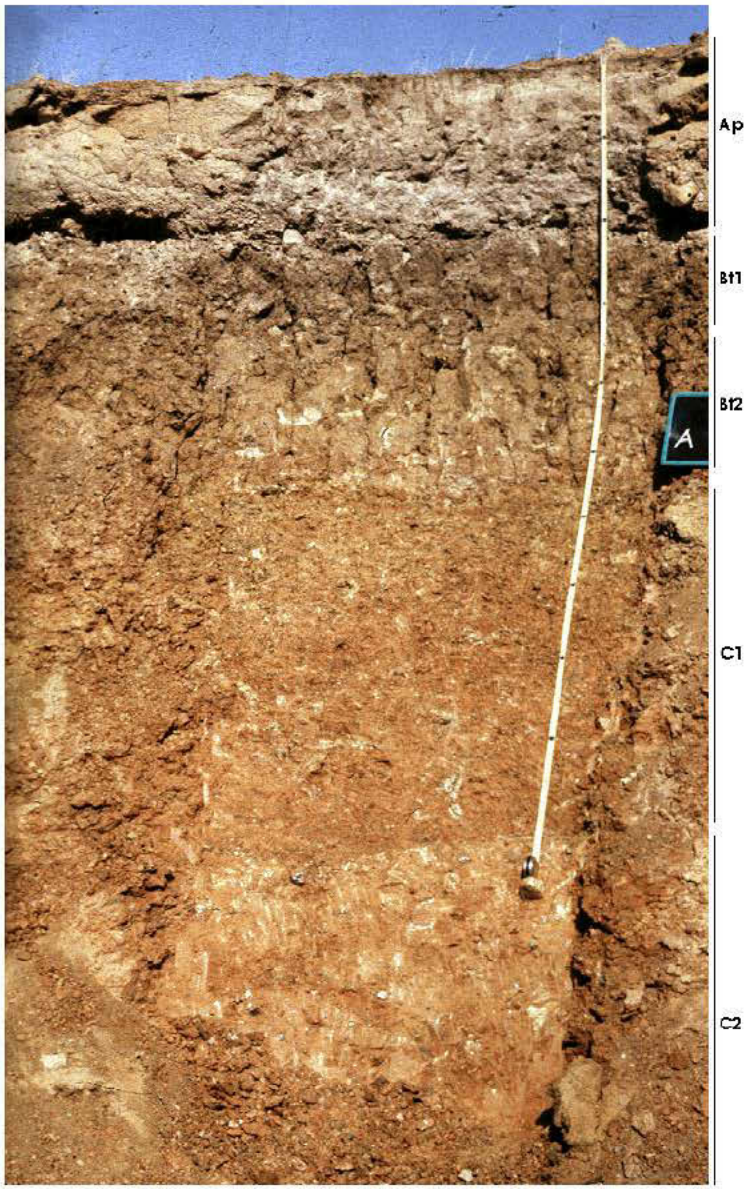
examples:

ab	Albic	cc	Calcic	dy	Dystric
fr	Ferric	gy	Gypsic	hu	Humic
rz	Rendzic	sk	Skeletic	vi	Vitric

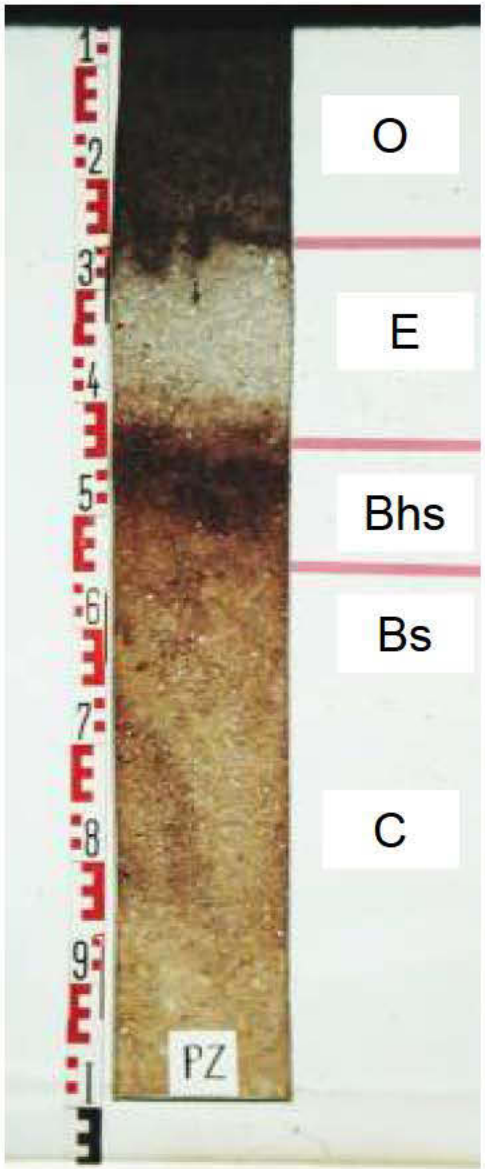
Chernozem

Luvisol





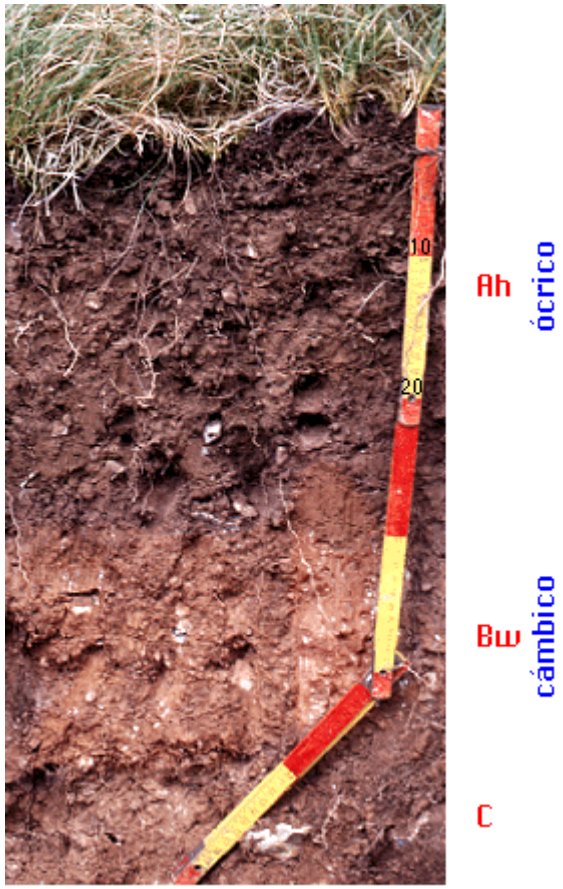
Podzol



Vališ, 1972

http://edafologia.ugr.es/

Cambisol

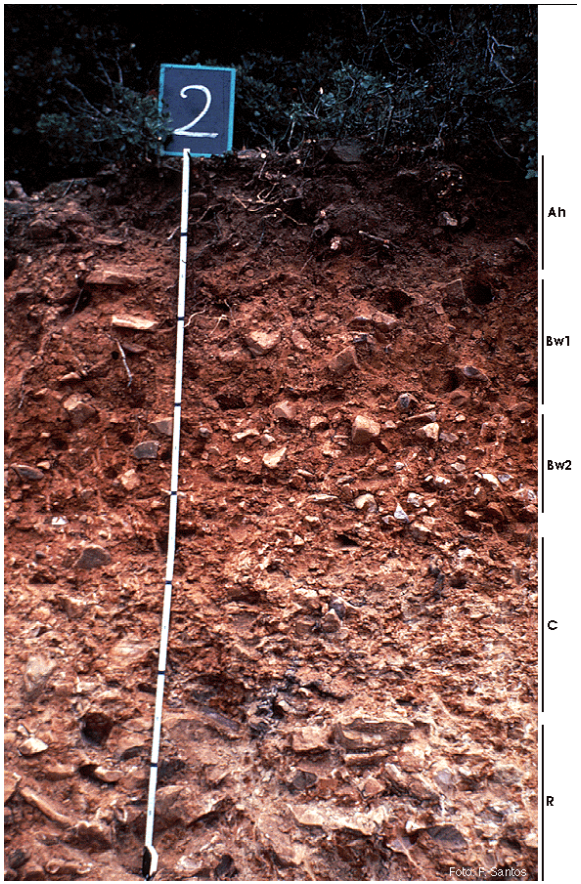


Ah ócrico

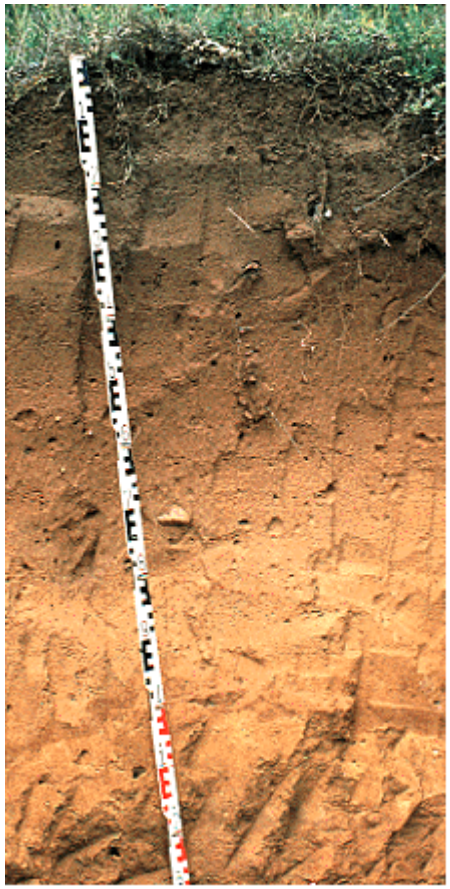
Bw cámbico

C

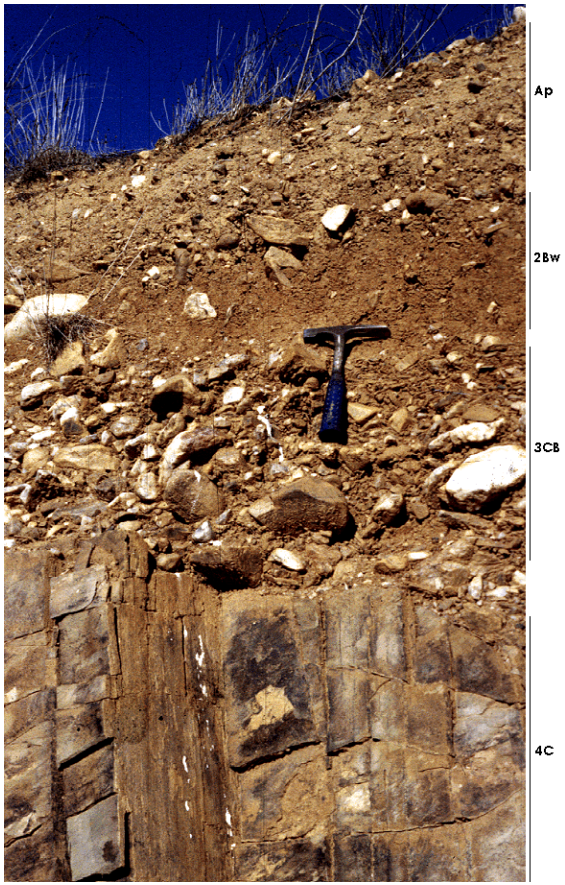
Dystric Cambisol

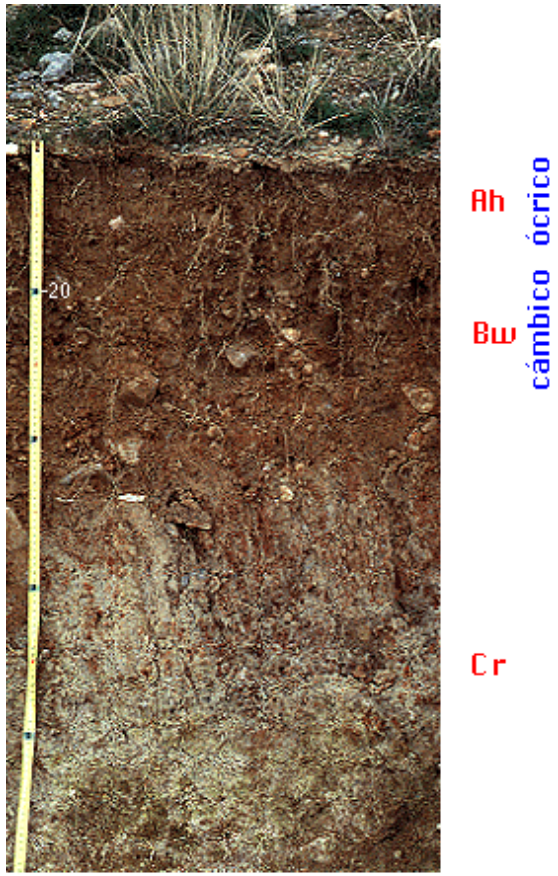


Cambisol



Eutric Cambisol

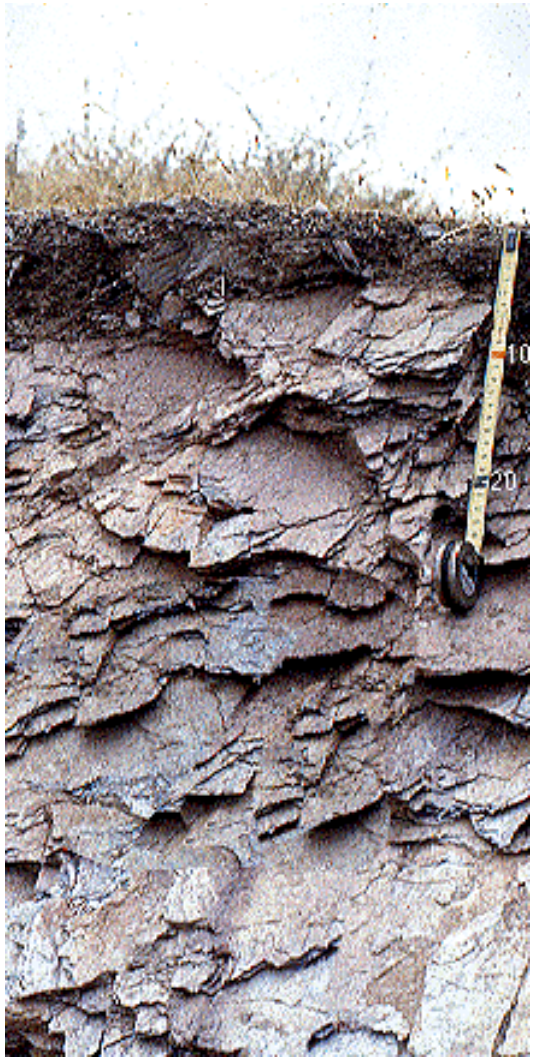




Dystric-Gleyic Cambisol

Gley

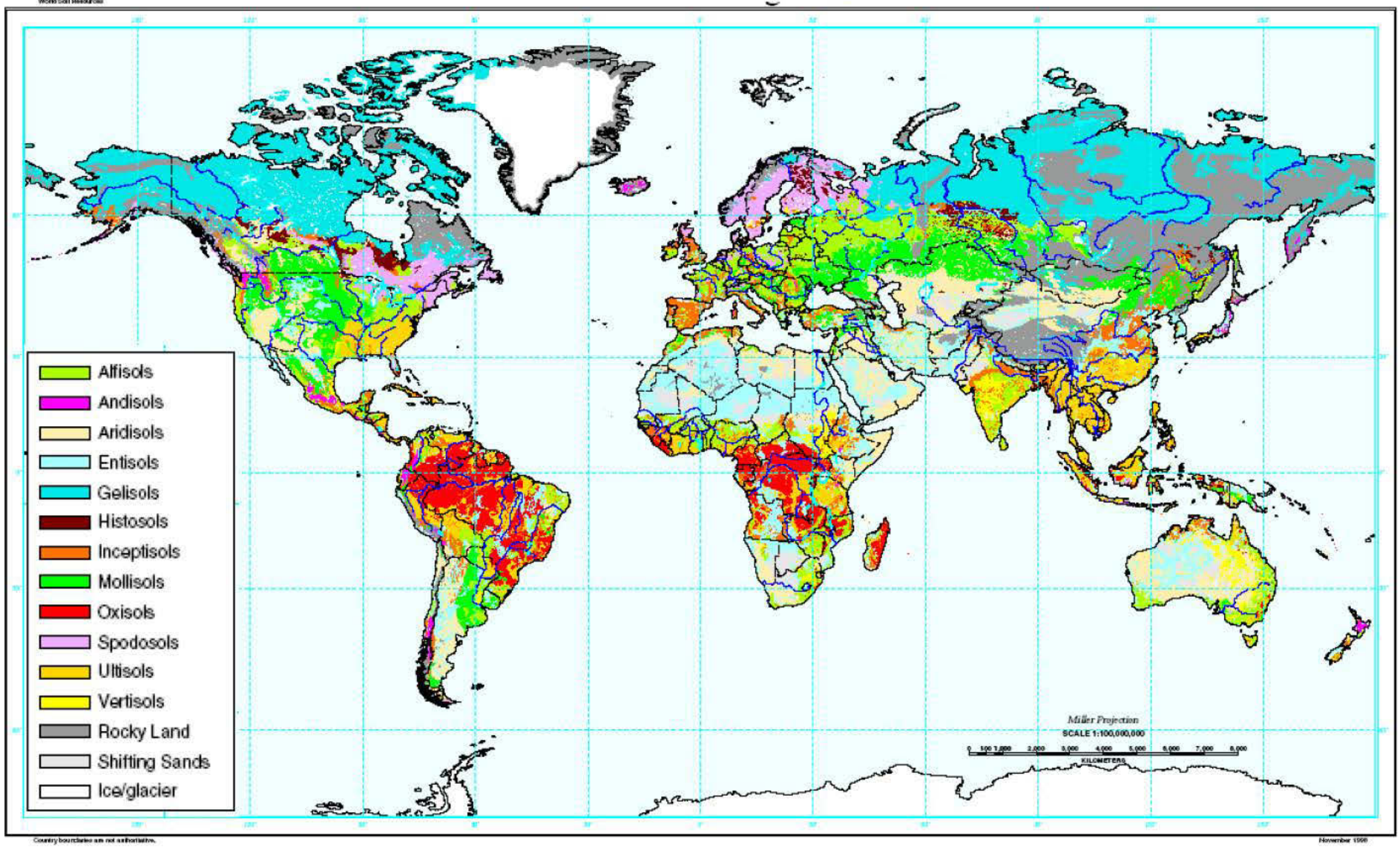
Lithosol



rendzic Lithosol

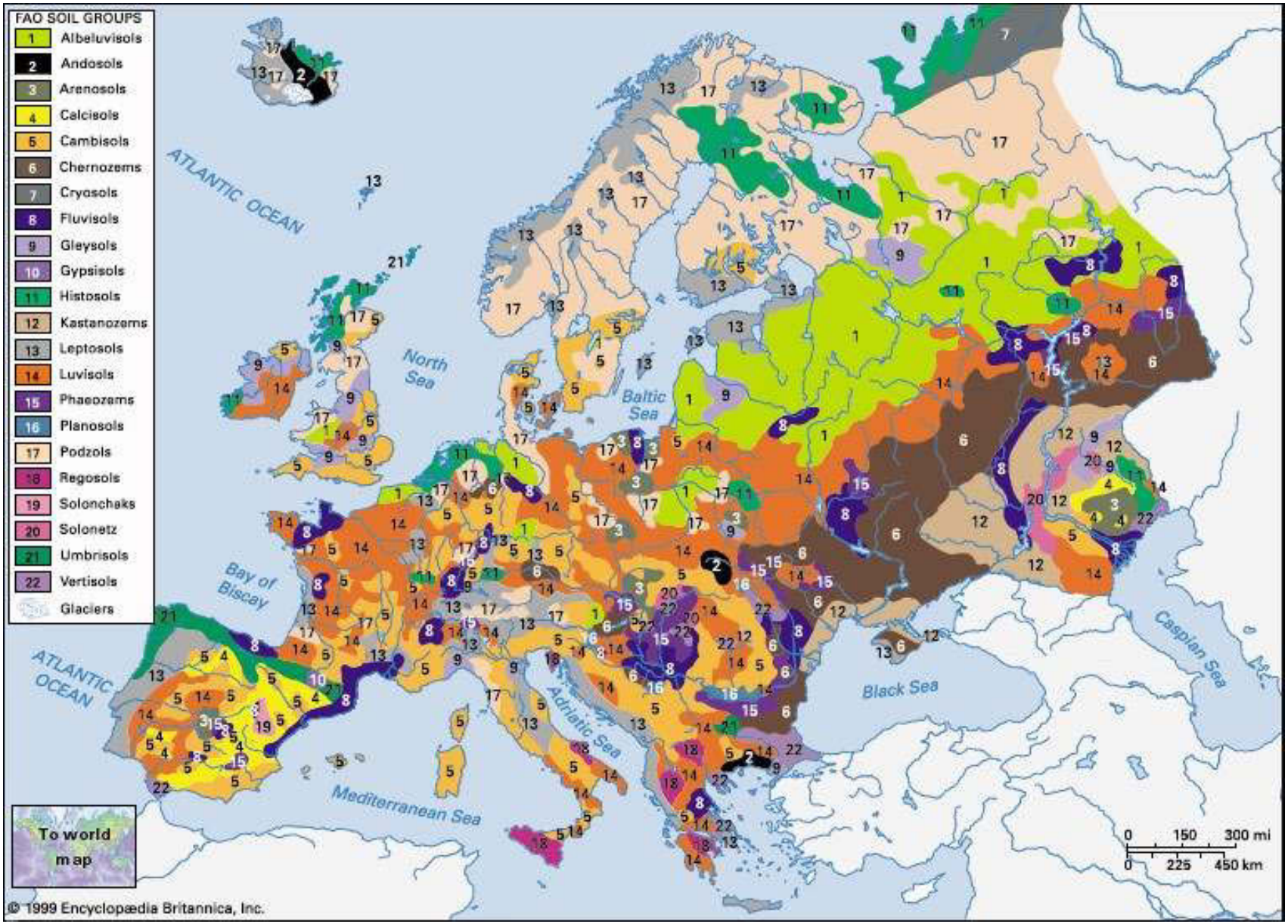
Histosol (peat)

Global soil regions



US –Soil Taxonomy USDA

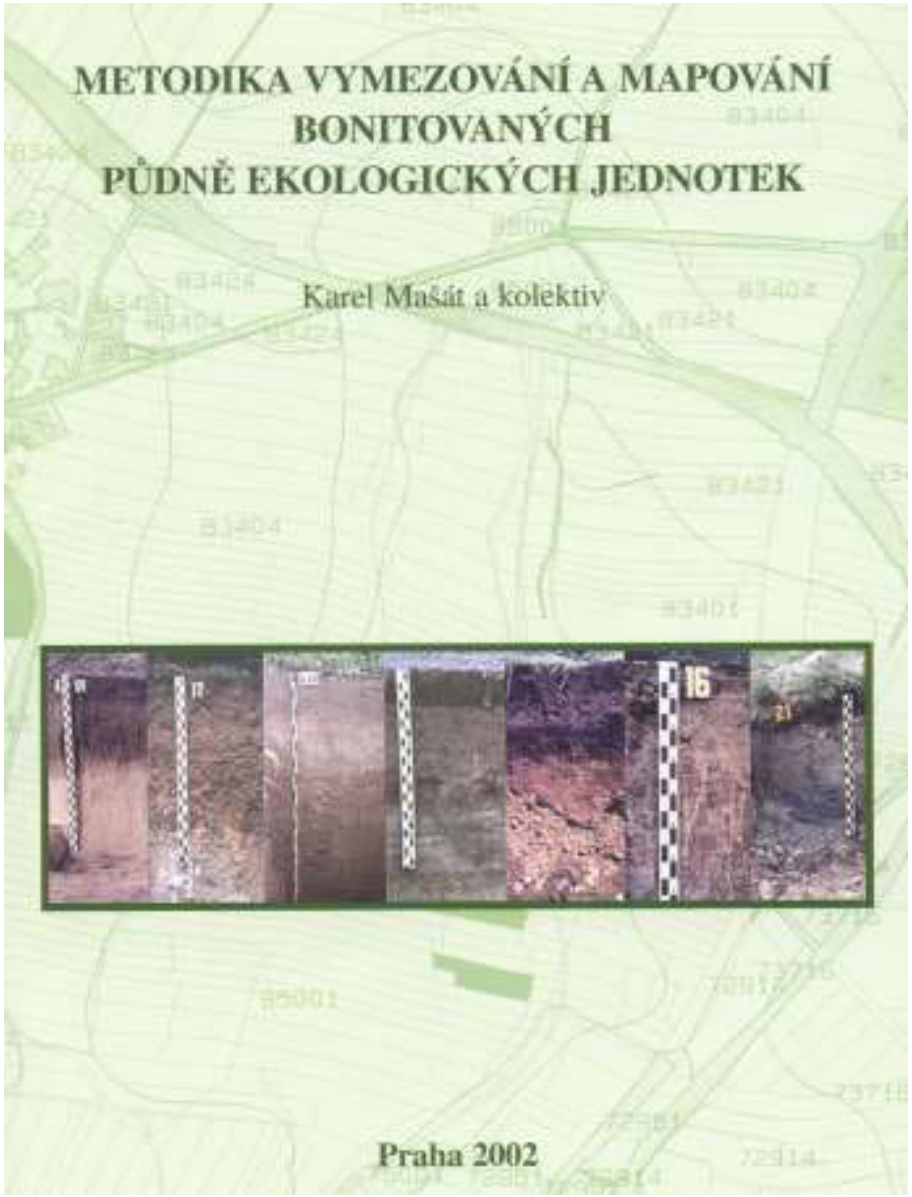
European soil regions



Soil bonity

- classification of soils based of the production ability

- in CR - BPEJ – bonitated soil ecological units



BPEJ

5 digit code

1. digit – characteristics of the climate region

2. a 3. digit – main soil unit reference + soil texture,..

4. digit – combination of decline and expozition

5. digit –combination of the depth and amount of stones

BPEJ

according to the production ability

1) typical arable soils

2) conditionally arable soils and grass fields

3) permanent grass fields

4) soils not suitable for agriculture production

BPEJ Digitized

data in the base

Database Workshop

File Edit Query Help Edit Off

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3	5503	2
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12	5776	2
13	5784	1
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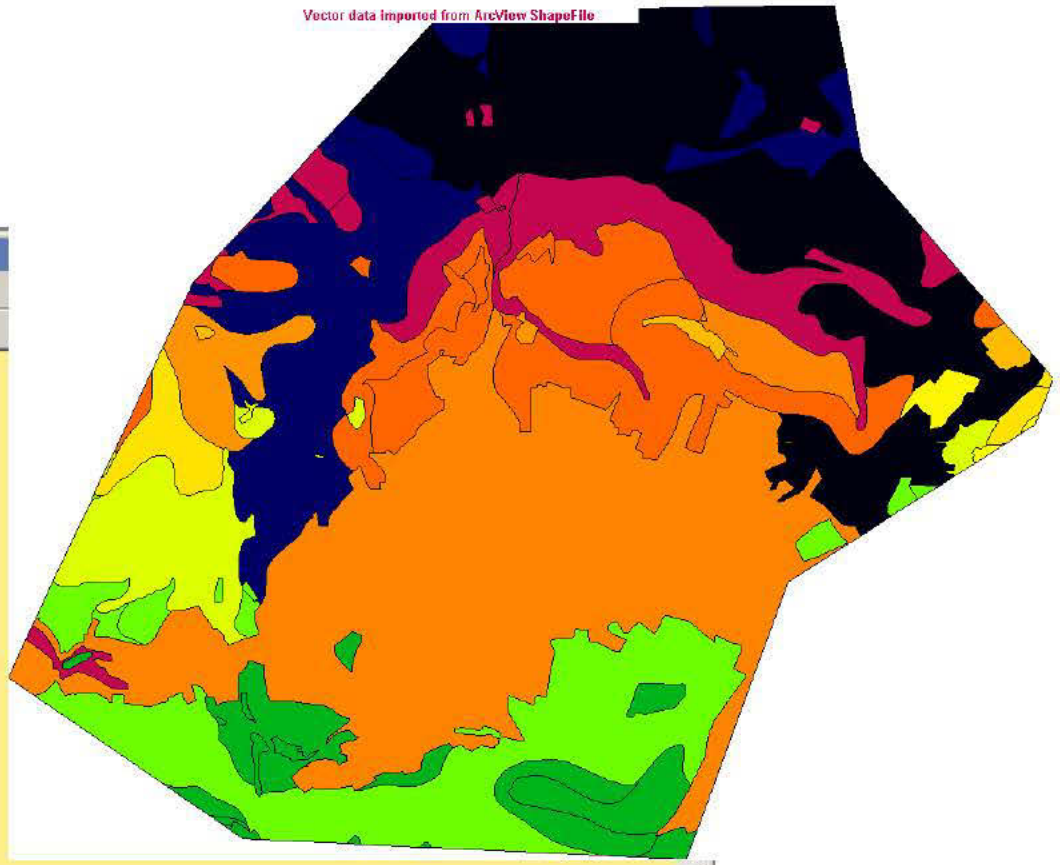

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Request password at martin.sanda@fsv.cvut.cz

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