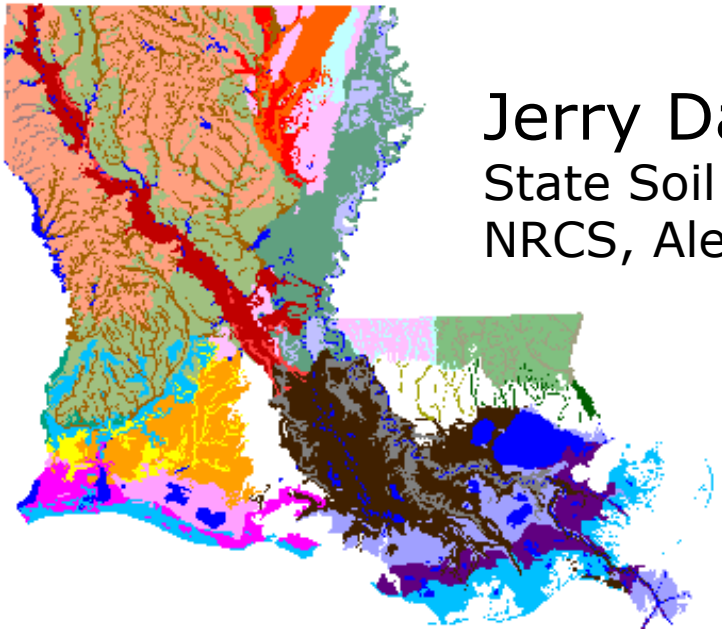
NRCS

Louisiana Soils

Physical and Chemical Characteristics



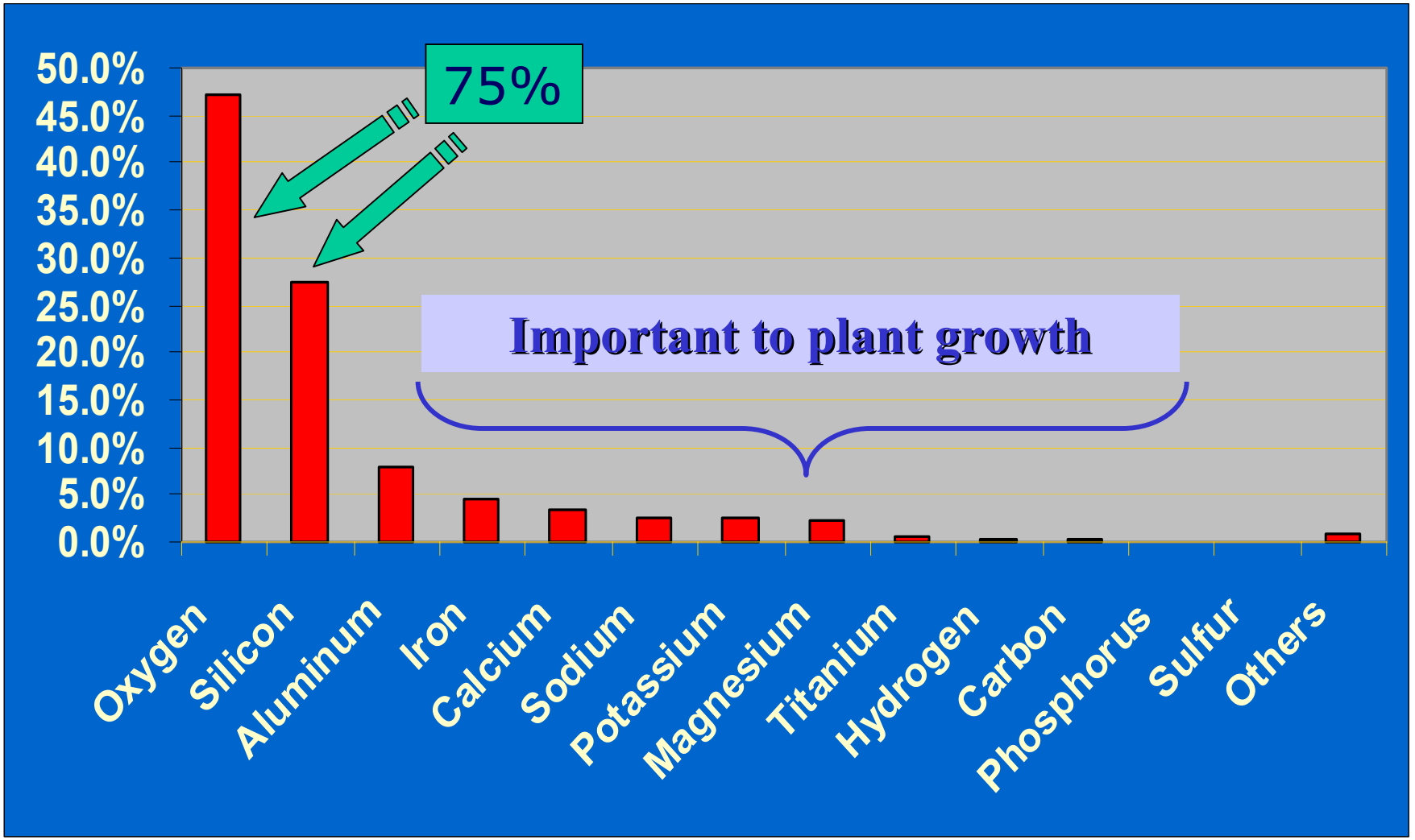
Jerry Daigle
State Soil Scientist
NRCS, Alexandria, LA

USDA
Natural Resources Conservation Service

Chemical and Mineralogical Composition of the Earth's Crust

- About 92 chemical elements are known to exist in the earth's crust
- Various combinations of these elements yields about 2000 minerals
- Relatively few elements and minerals, however, are of real importance in soils

Chemical and Mineralogical Composition of the Earth's Crust



Chemical and Mineralogical Composition of the Earth's Crust

- Most of the elements of the earth's crust exist in combination with one or more others elements to form compounds called *Minerals*
- The minerals generally exist in mixtures to form *Rocks*
- *The breaking up of hard rocks by physical forces exposes new surfaces and facilitates chemical alterations and the formations of Secondary Minerals*

How does soil form?

Factors

- Climate
- Biology
- Parent Material
- Topography
- Time

+

Processes

- Additions
- Removals
- Transfers
- Transformations

- Humans

=

Pedon

- Attributes
- Soil Type
- Qualities
- Suitability

Modified from MacEwan (1997)

Chemical and Mineralogical Composition of the Earth's Crust

Processes

- Oxidation – addition of Oxygen
- Reduction – removal of Oxygen
- Hydration – union with water
- Hydrolysis – Replacement of mineral ions with "H^+"
- Carbonation – Combination with CO_2
- Solution – joint action of CO_2 and H_2O or other weak acids (HNO_2, HNO_3, H_2PO_4, H_2SO_4)

The Soil Profile

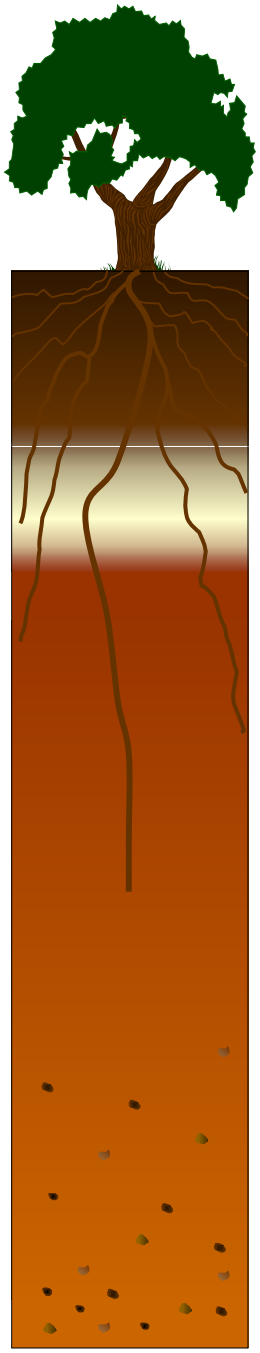
A Surface/Topsoil

E Subsurface

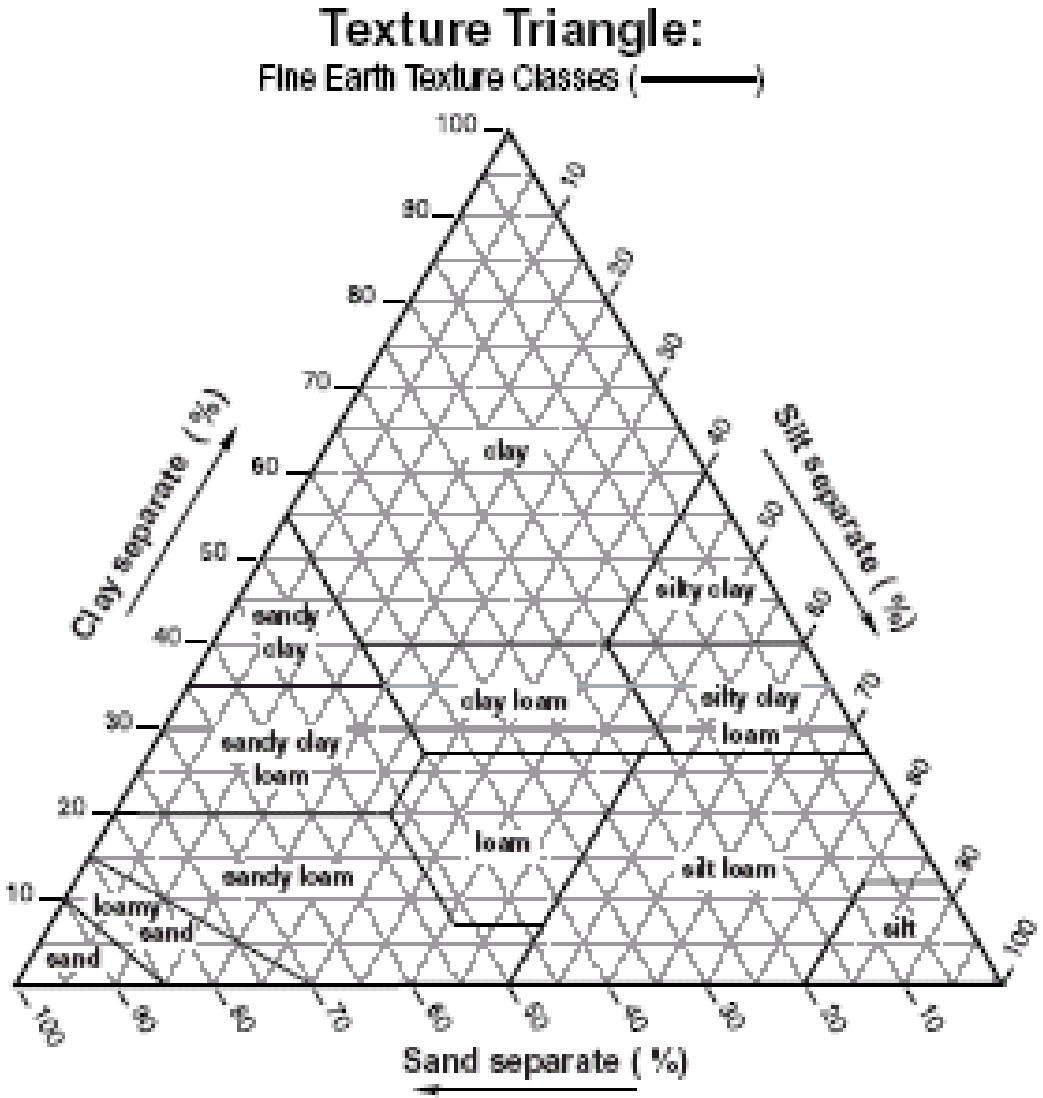
B Subsoil

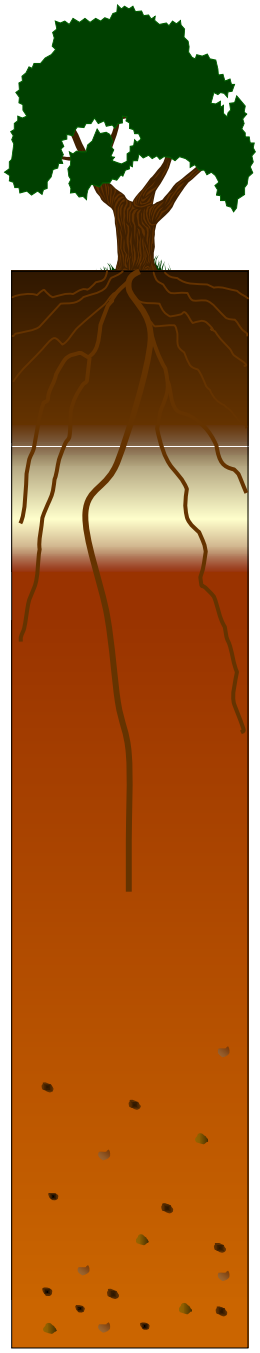
C Parent Material

R Bedrock



Soil Texture

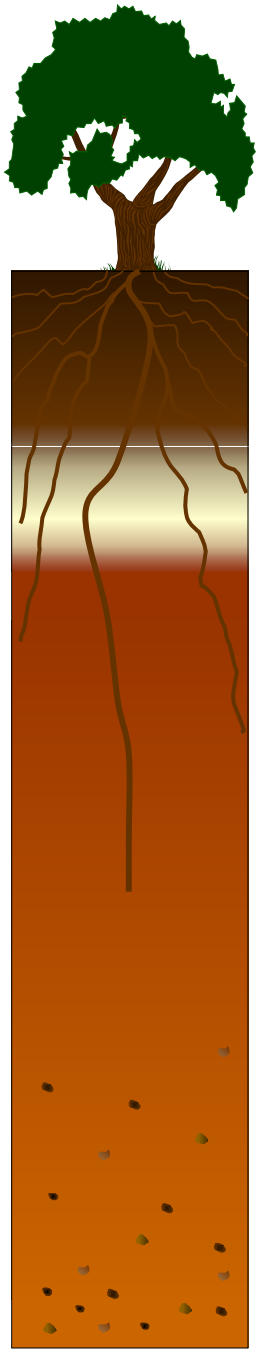




Soil Texture

Sand and Silt Fractions

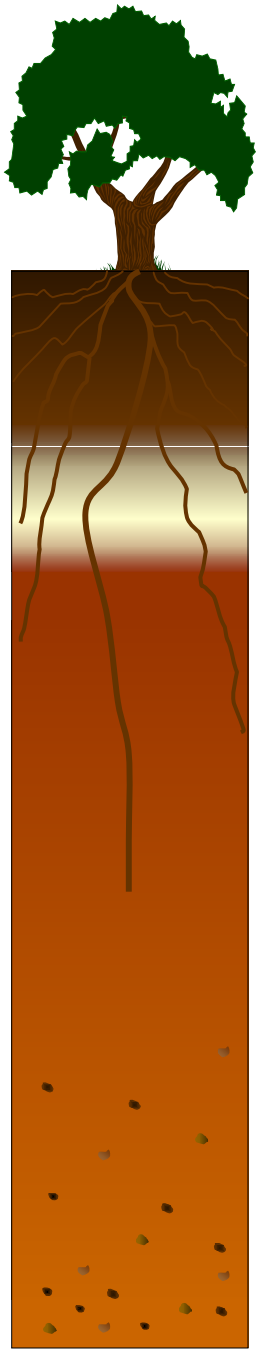
- Quartz
- Feldspars
- Micas
- Ferromagnesian Minerals
- Certain clay minerals



Soil Texture

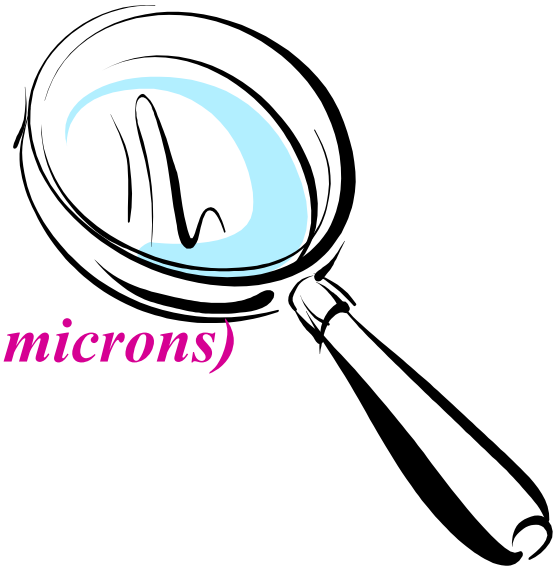
Clay Fraction

Differentiated mineralogically from the silt fraction by being composed predominantly of minerals which are formed as products of weathering and which are not found in unweathered rocks



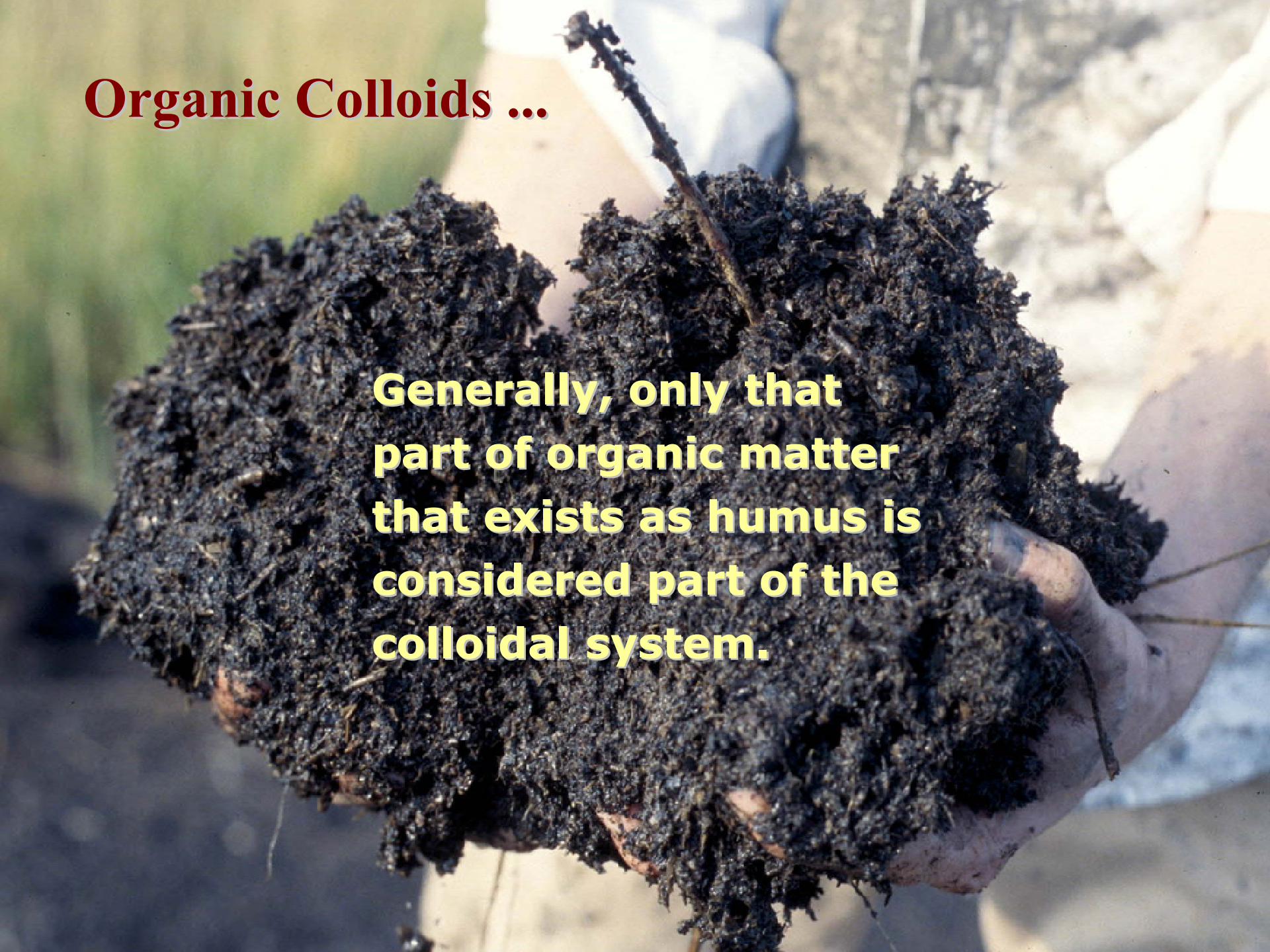
Colloidal Constituents ...

Colloidal constituents of the soil are the seat of most of the chemical and physical reactions taking place in the soil.

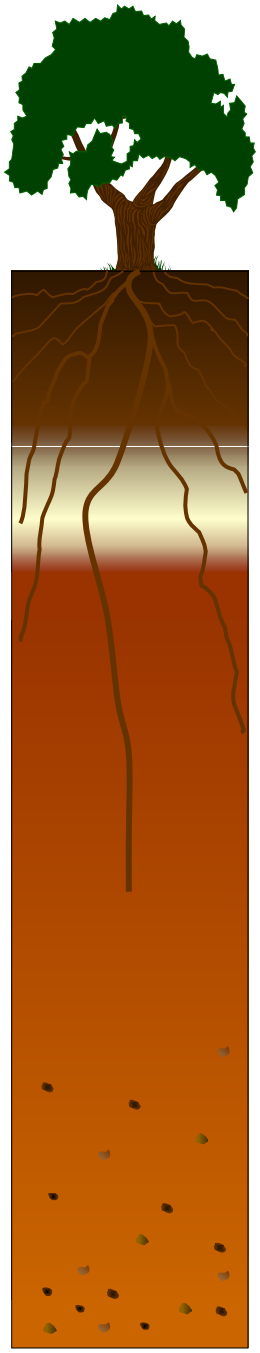


(< 2 microns)

Organic Colloids ...



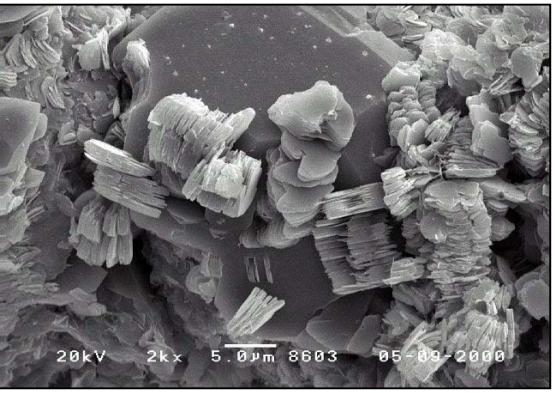
Generally, only that part of organic matter that exists as humus is considered part of the colloidal system.



Mineral Colloids ...

Mineral colloids consist of:

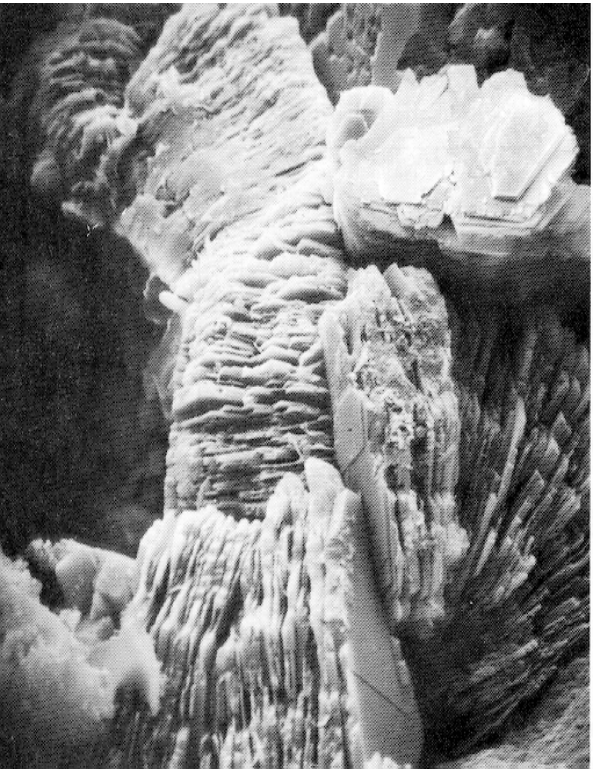
- **oxides of iron and aluminum**
- **silicon in various stages of hydration**
- **group of crystalline compounds known as clay minerals**

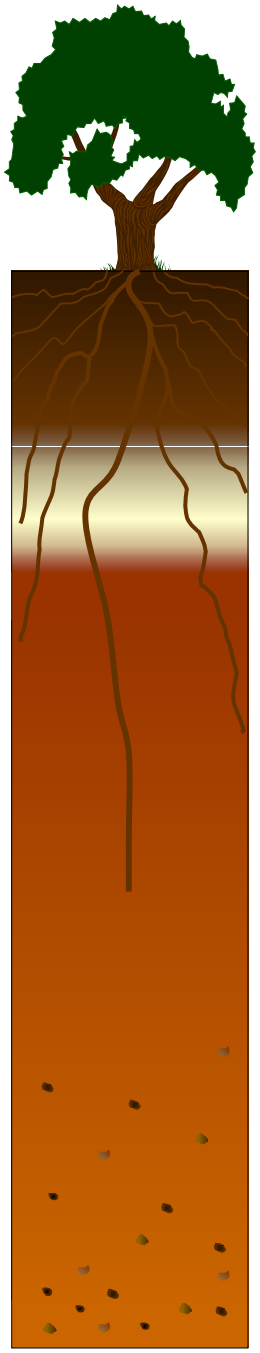


Clay Minerals ...

- Exist as very small and thin, plate-like crystals.

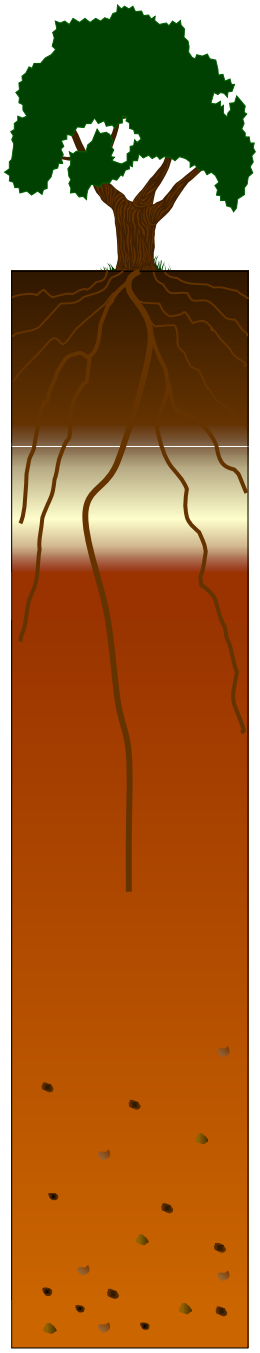
- There size and shape results in the exposure of an extremely large amount of surface for a given weight of colloid.





Clay Minerals ...

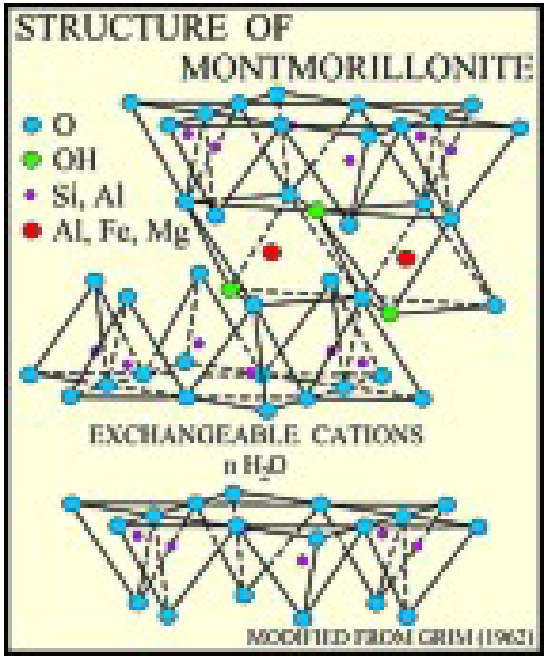
The crystals of clay minerals are made up of layers of aluminum oxide and silicon dioxide, in which the fundamental units of the crystal are chemically bound together by the sharing of certain oxygen atoms between aluminum and silicon atoms (ions)

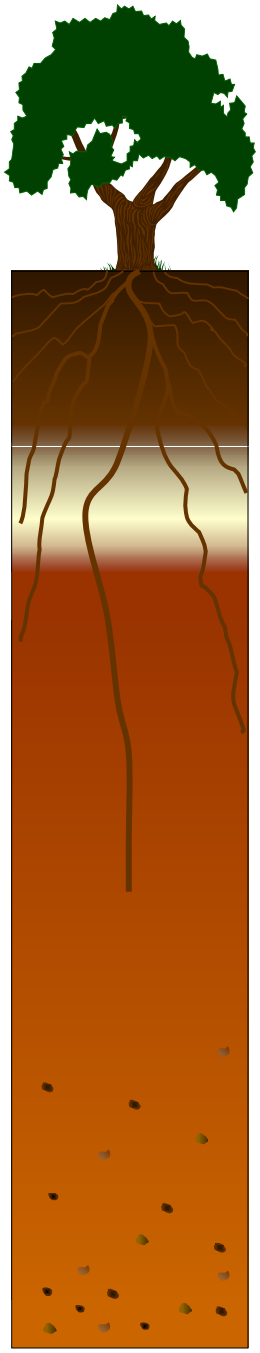


Clay Minerals ...

Some minerals contain two layers of silica with a layer of aluminum oxide between:

- **Montmorillonite**
- **Illite**

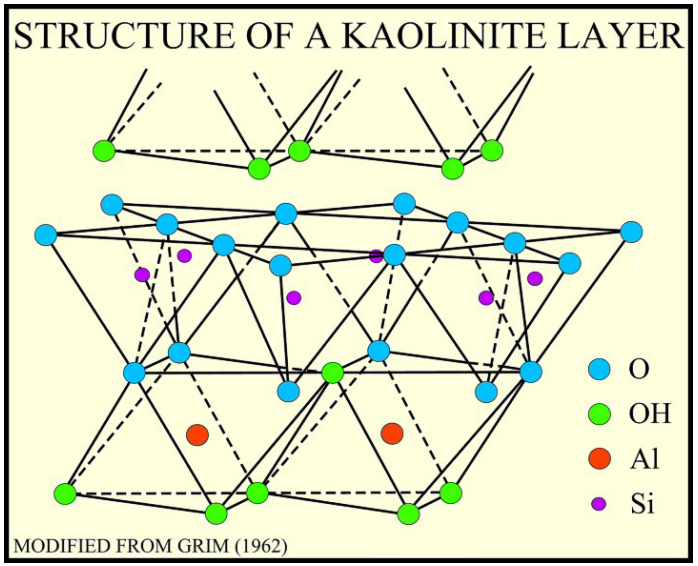




Clay Minerals ...

Other minerals contain one layer of silica to each layer of aluminum oxide:

- **Kaolinite**
- **Halloysite**

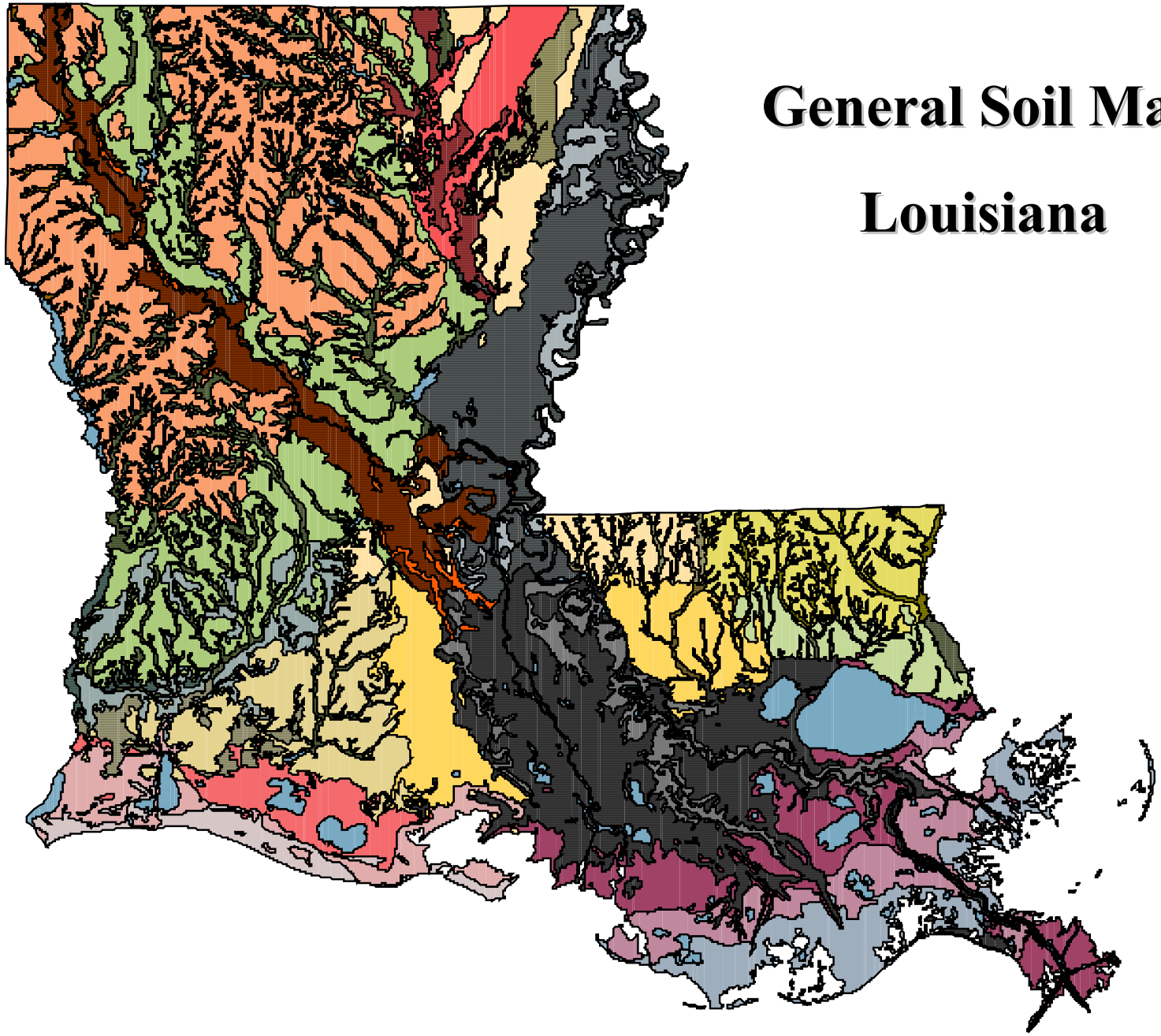


Clay Minerals ...

Mineral	Ratio of Tetrahedra to Octahedra Layers	Relative Particle Size	Cation Exchange Capacity (m.e./100g)	Isomorphous Substitution
Kaolinite	1:1	Large	8	Little or None
Illite	2:1	Medium	30	Al for Si in tetrahedral layer
Montmorillonite	2:1	Small	100	Mg for Al in octahedral layer

General Soil Map

Louisiana



Tertiary Uplands

Minerology:

Sacul
Mixed...
Kaolinite (3),
Vermiculite-Chlorite (2),
Quartz (1)

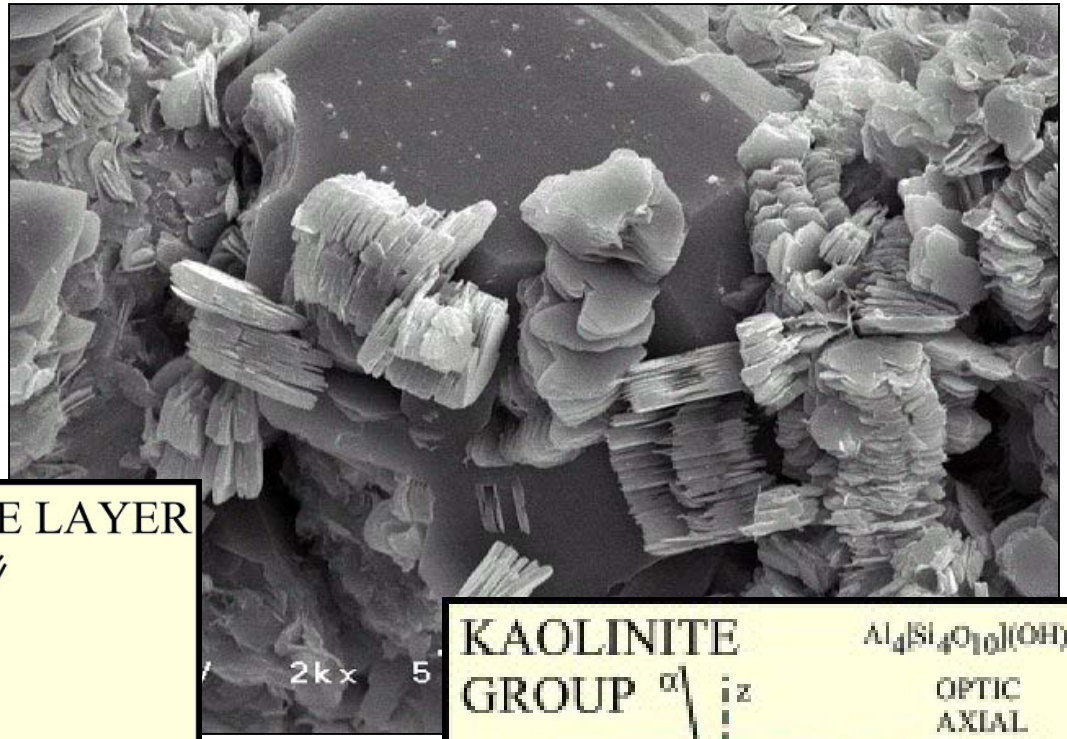
Darley
Kaolinitic…
Kaolinite (3),
Montmorillonite (3),
Mica (2)
Goethite (1)
Quartz (1)

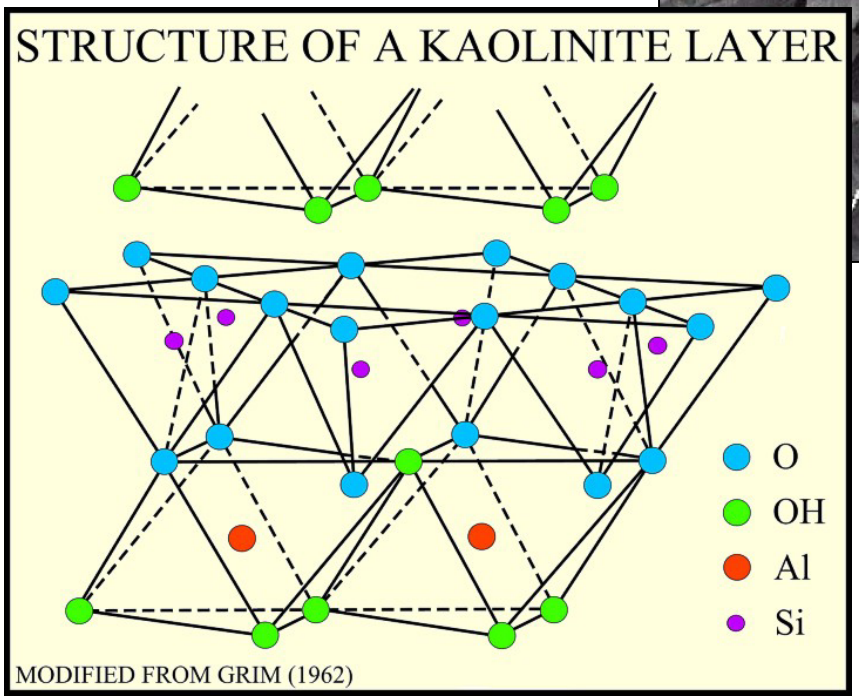
Kaolinite

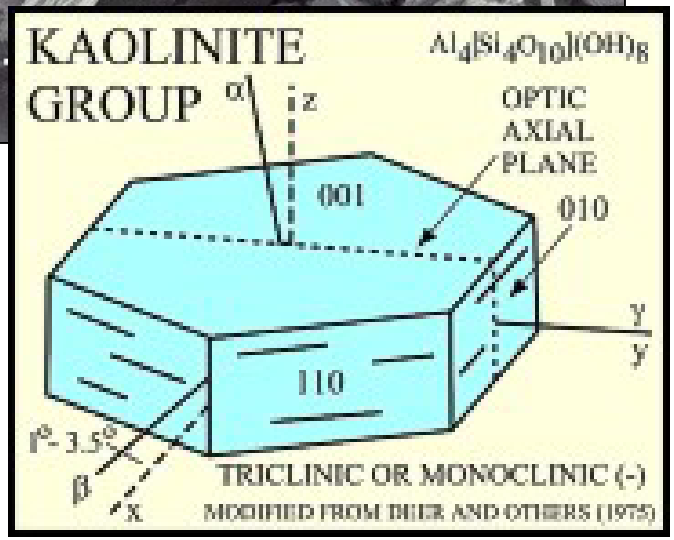
Minerology:

Sacul
Mixed...
Kaolinite (3),
Vermiculite-Chlorite (2),
Quartz (1)

Darley
Kaolinitic…
Kaolinite (3),
Montmorillonite (3),
Mica (2)
Goethite (1)
Quartz (1)







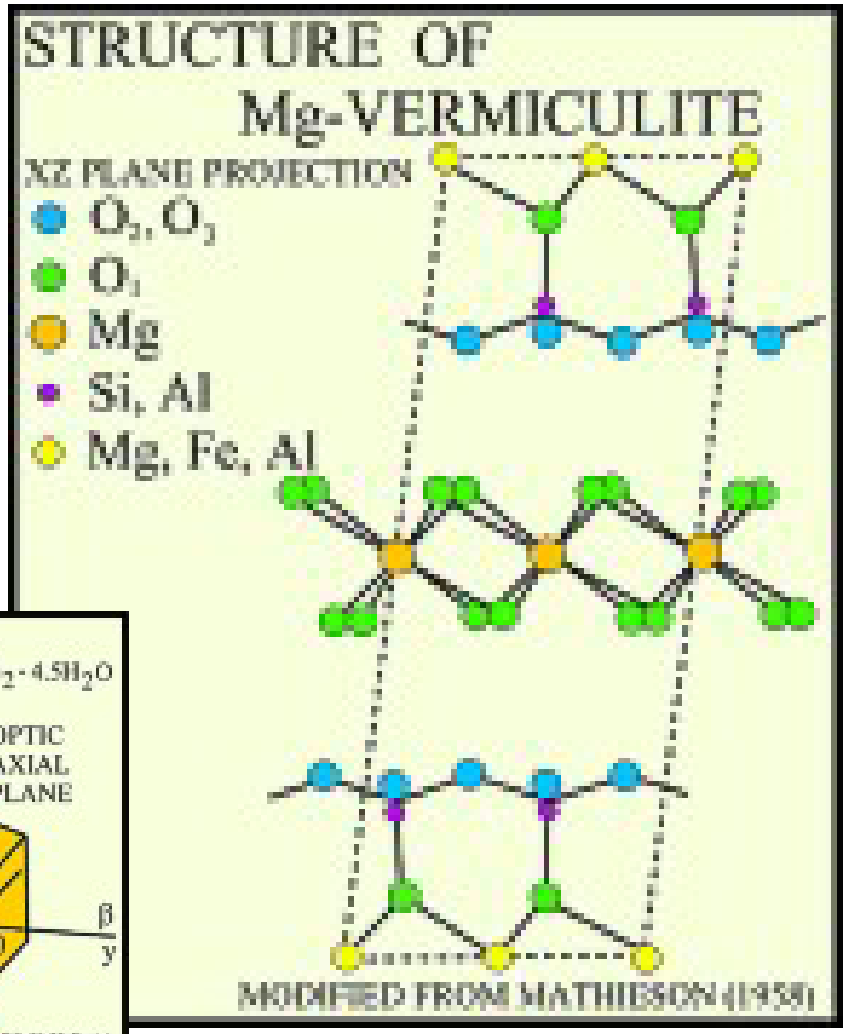
Quaternary Uplands

Minerology:

Rustin
Siliceous...
Kaolinite (3),
Vermiculite (2),
Mica (1)

Malbis
Siliceous...
Hallosite (3)
Vermiculite (2)
Quartz (1)
Geothite (1)

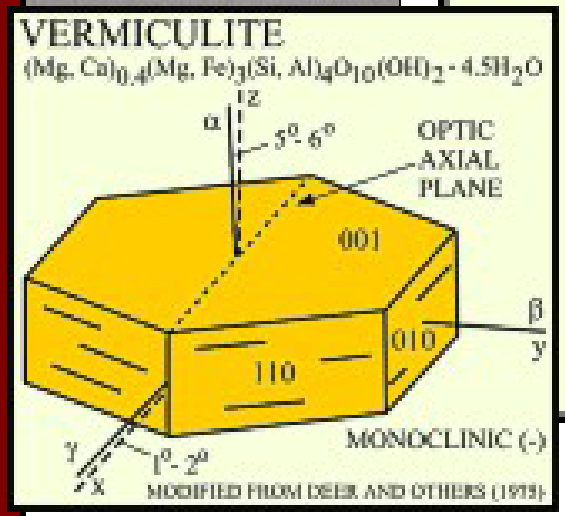
Vermiculite



Minerology:

Rustin
- **Siliceous...**
  - **Kaolinite (3),**
  - **Vermiculite (2),**
  - **Mica (1)**

Malbis
- **Siliceous...**
  - **Hallosite (3)**
  - **Vermiculite (2)**
  - **Quartz (1)**
  - **Geothite (1)**



Flatwoods

Minerology:

Messer
Siliceous…
Kaolinite (2)
Vermiculite (2)

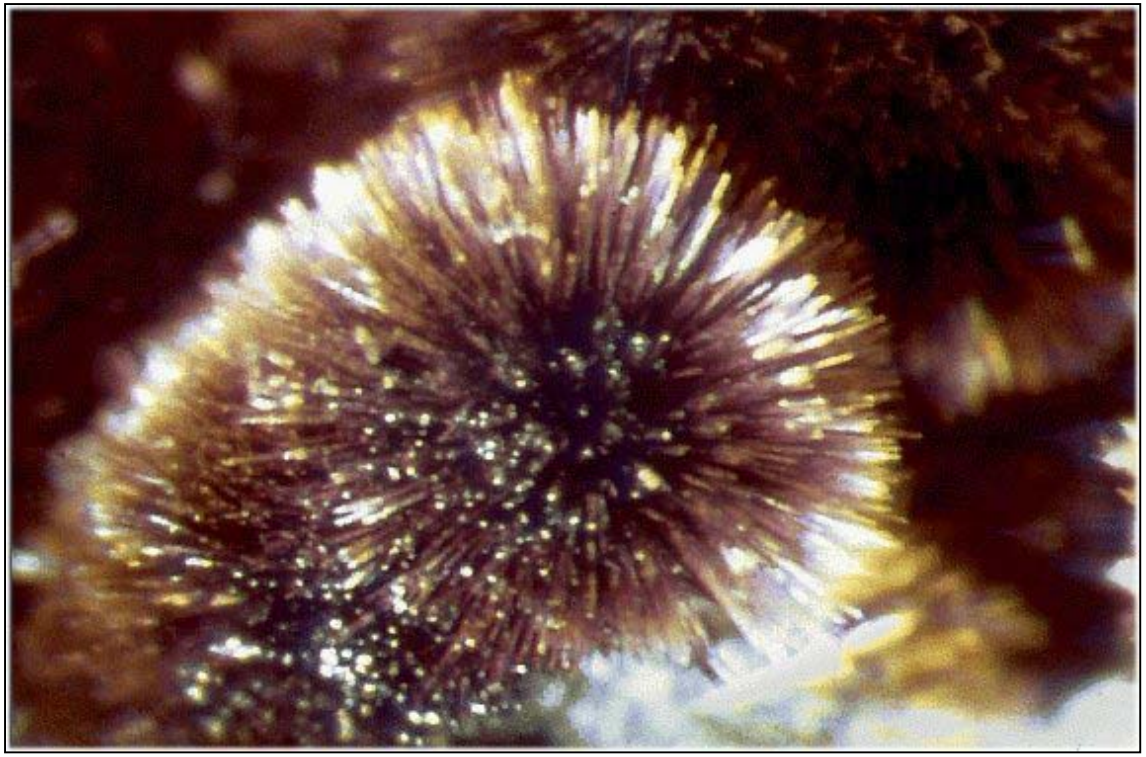
Kinder
Siliceous...
Kaolinite (5),
Vermiculite (2),
Geothite (2)

Minerology:

Messer
- **Siliceous…**
  - **Kaolinite (2)**
  - **Vermiculite (2)**

Kinder
- **Siliceous...**
  - **Kaolinite (5),**
  - **Vermiculite (2),**
  - **Geothite (2)**

Geothite Crystals



Stellate crystalline aggregates of acicular goethite crystals

Silty Uplands (Loess)

Minerology:

Memphis
Mixed...
Vermiculite (3)
Mica (2)
Kaolinite (1),

Patoutville
Mixed...
Vermiculite (2)
Kaolinite (2)
Mica (1)
Quartz (1)

Mica - Biotita

Minerology:

Memphis
Mixed...
Vermiculite (3)
Mica (2)
Kaolinite (1),

Patoutville
Mixed...
Vermiculite (2)
Kaolinite (2)
Mica (1)
Quartz (1)

Gulf Coast Prairie

Minerology:

Crowley
- Montmorillonitic...
  - Montmorillonite (3)
  - Kaolinite (3)
  - Mica (2)
  - Quartz (1)
  - Vermiculite (1)
  - Gibbsite (1)

Acadia
- Mixed...
  - Kaolinite (5)
  - Vermiculite (3)
  - Geothite (2)
  - Mica (2)
  - Vermiculite-Chlorite (1)

Gibbsite

Minerology:

Crowley
- **Montmorillonitic...**
  - **Montmorillonite (3)**
  - **Kaolinite (3)**
  - **Mica (2)**
  - **Quartz (1)**
  - **Vermiculite (1)**
  - **Gibbsite (1)**

Acadia
- **Mixed...**
  - **Kaolinite (5)**
  - **Vermiculite (3)**
  - **Geothite (2)**
  - **Mica (2)**
  - **Vermiculite-Chlorite (1)**

Mississippi River Alluvial Plain

Minerology:

Sharkey
- **Smectitic...**
  - **Montmorillonite (4)**
  - **Mica (3)**
  - **Kaolinite (2)**
  - **Quartz (1)**

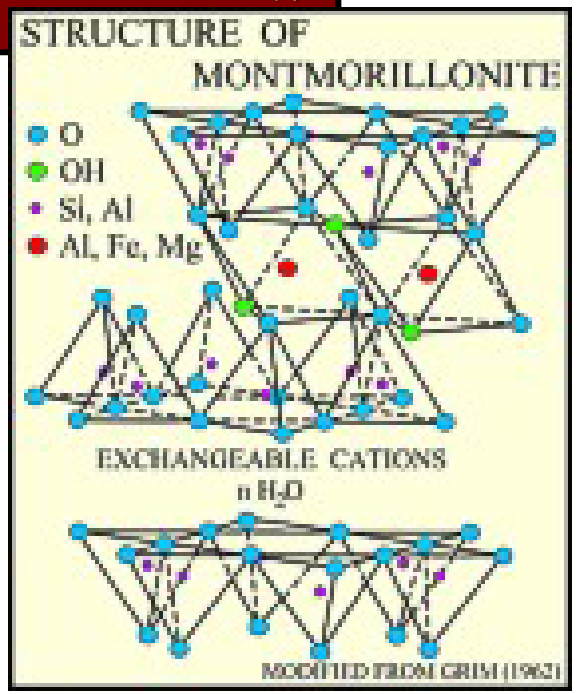
Commerce
- **Mixed...**
  - **Montmorillonite (4)**
  - **Mica (3)**
  - **Kaolinite (2)**
  - **Quartz (1)**
  - **Montmorillonite-Mica (1)**

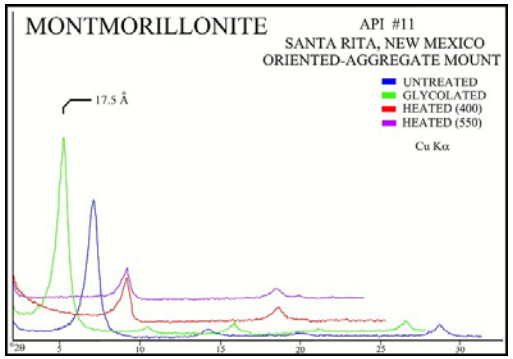
Montmorillonite - Smectite

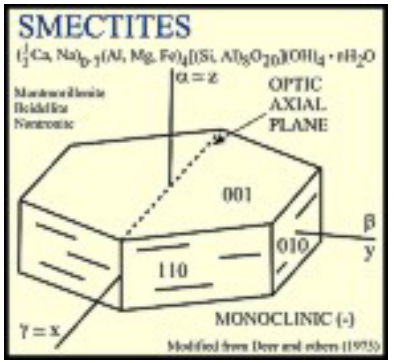
Minerology:

Sharkey
- **Smectitic...**
  - **Montmorillonite (4)**
  - **Mica (3)**
  - **Kaolinite (2)**
  - **Quartz (1)**

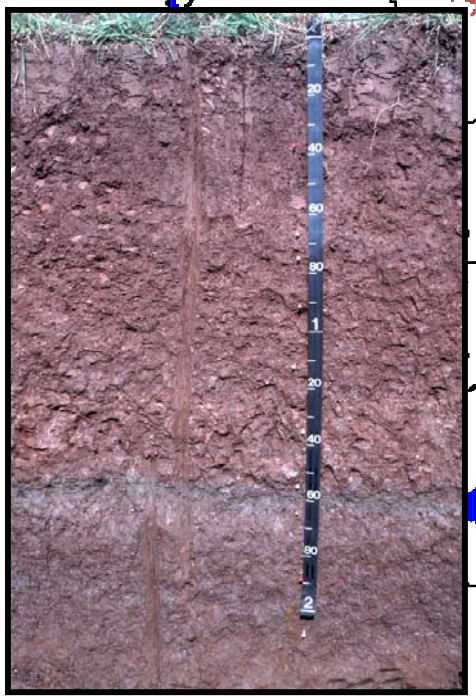
Commerce
- **Mixed...**
  - **Montmorillonite (4)**
  - **Mica (3)**
  - **Kaolinite (2)**
  - **Quartz (1)**
  - **Montmorillonite-Mica (1)**







Red & Ouachita River Alluvial Plain



Minerology:

Moreland
- **Smectitic...**
  - **Montmorillonite (3)**
  - **Mica (3)**
  - **Kaolinite (3)**
  - **Montmorillonite-Chlorite (2)**
  - **Hematite (1)**

Hebert
- **Mixed...**
  - **Montmorillonite (3)**
  - **Mica (3)**
  - **Kaolinite (3)**
  - **Vermiculite (2)**
  - **Lepidocrocite (1)**

Minerology:

Moreland
Smectitic...
Montmorillonite (3)
Mica (3)
Kaolinite (3)
Montmorillonite-Chlorite (2)
Hematite (1)

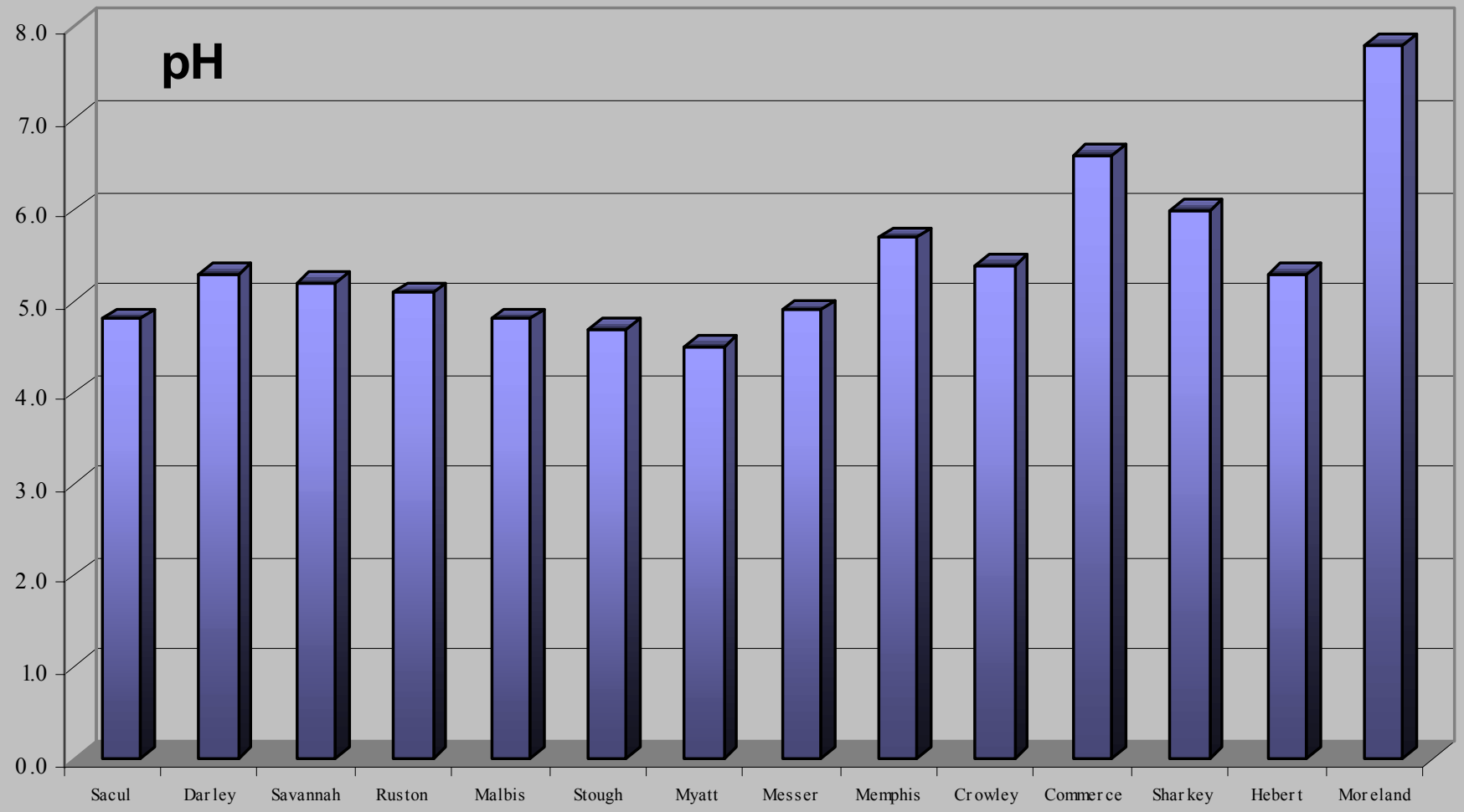
Hebert
Mixed...
Montmorillonite (3)
Mica (3)
Kaolinite (3)
Vermiculite (2)
Lepidocrocite (1)

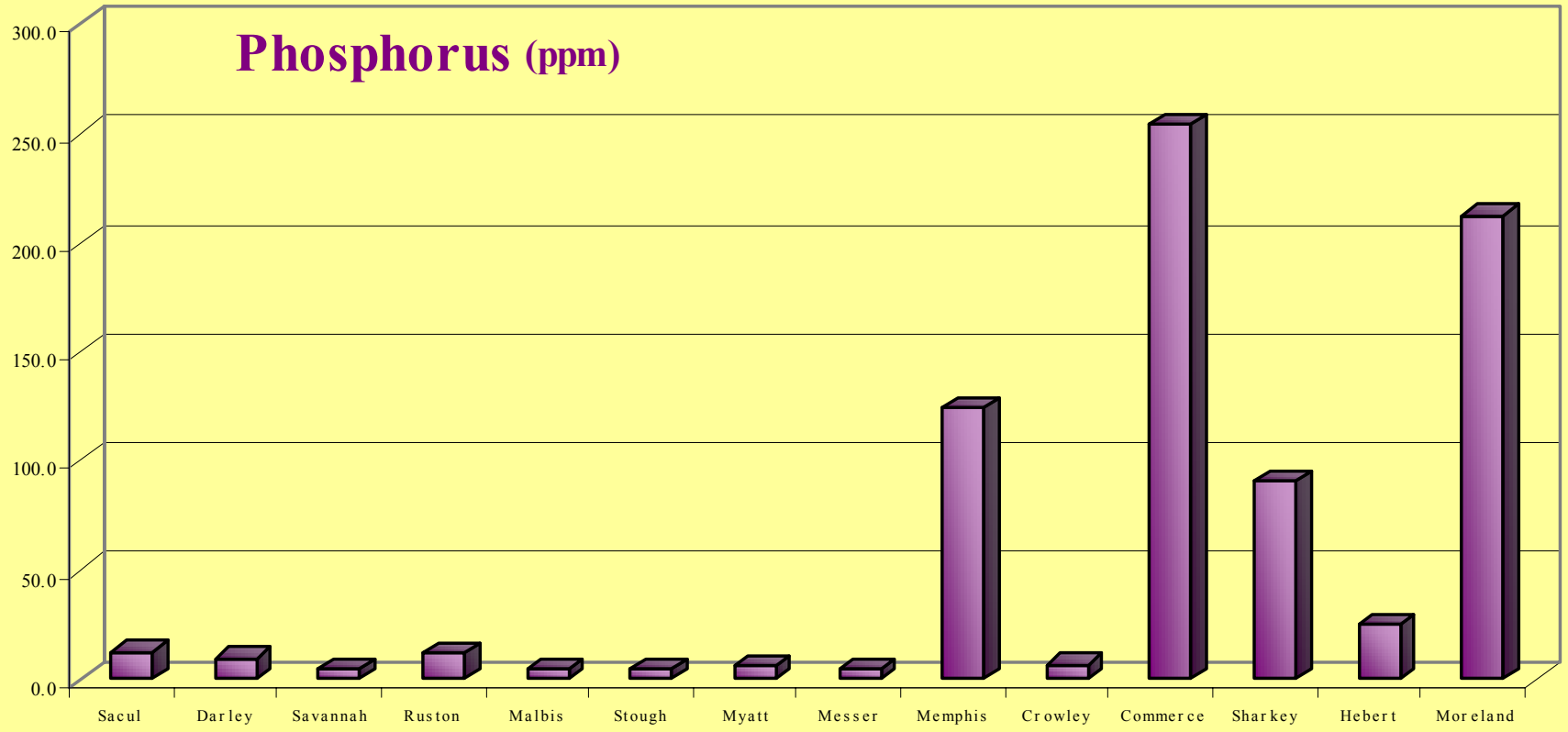
Hematite

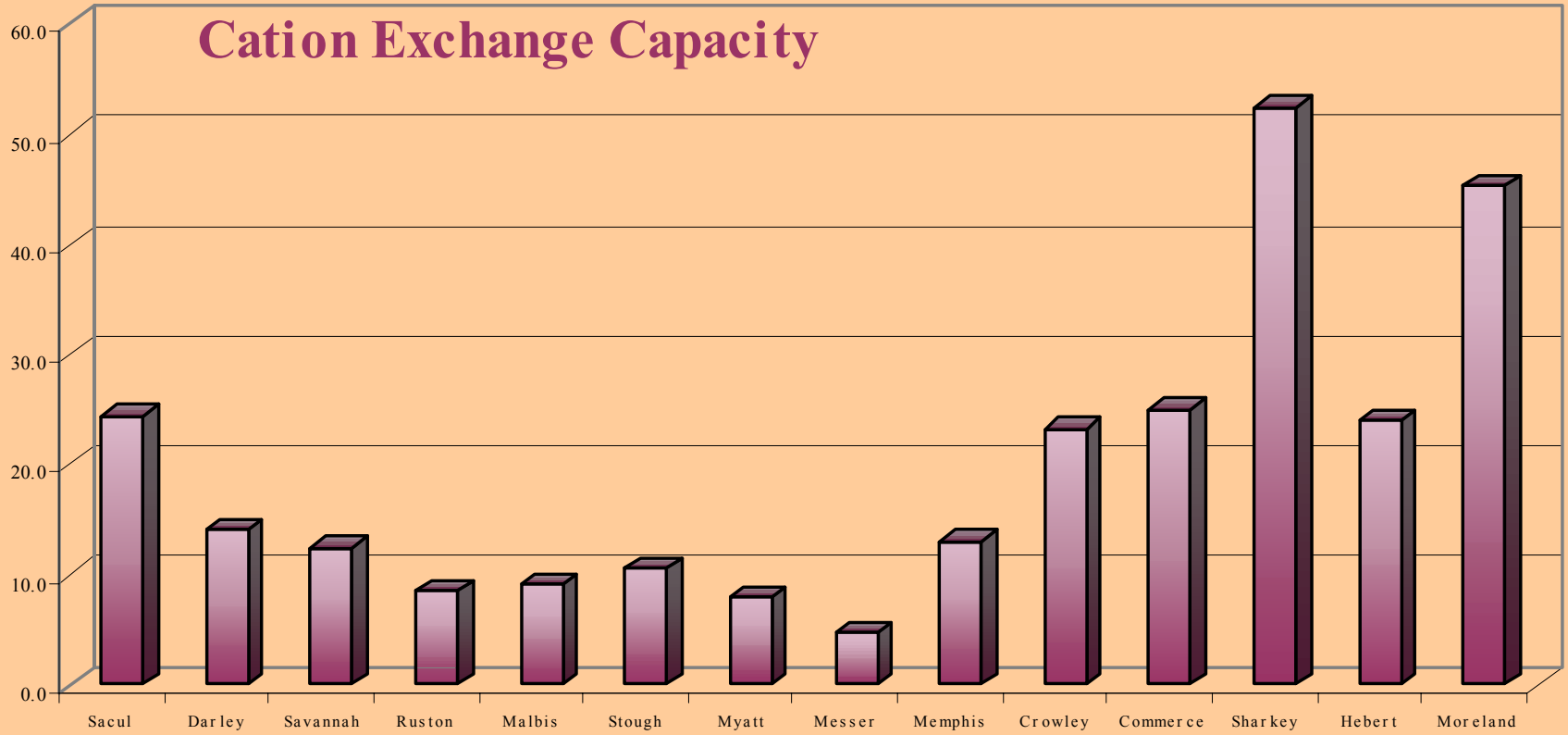
Hematite, Lepidocrocite

Translucent, red-brown crystals of lepidocrocite lining cavities in gossan matrix

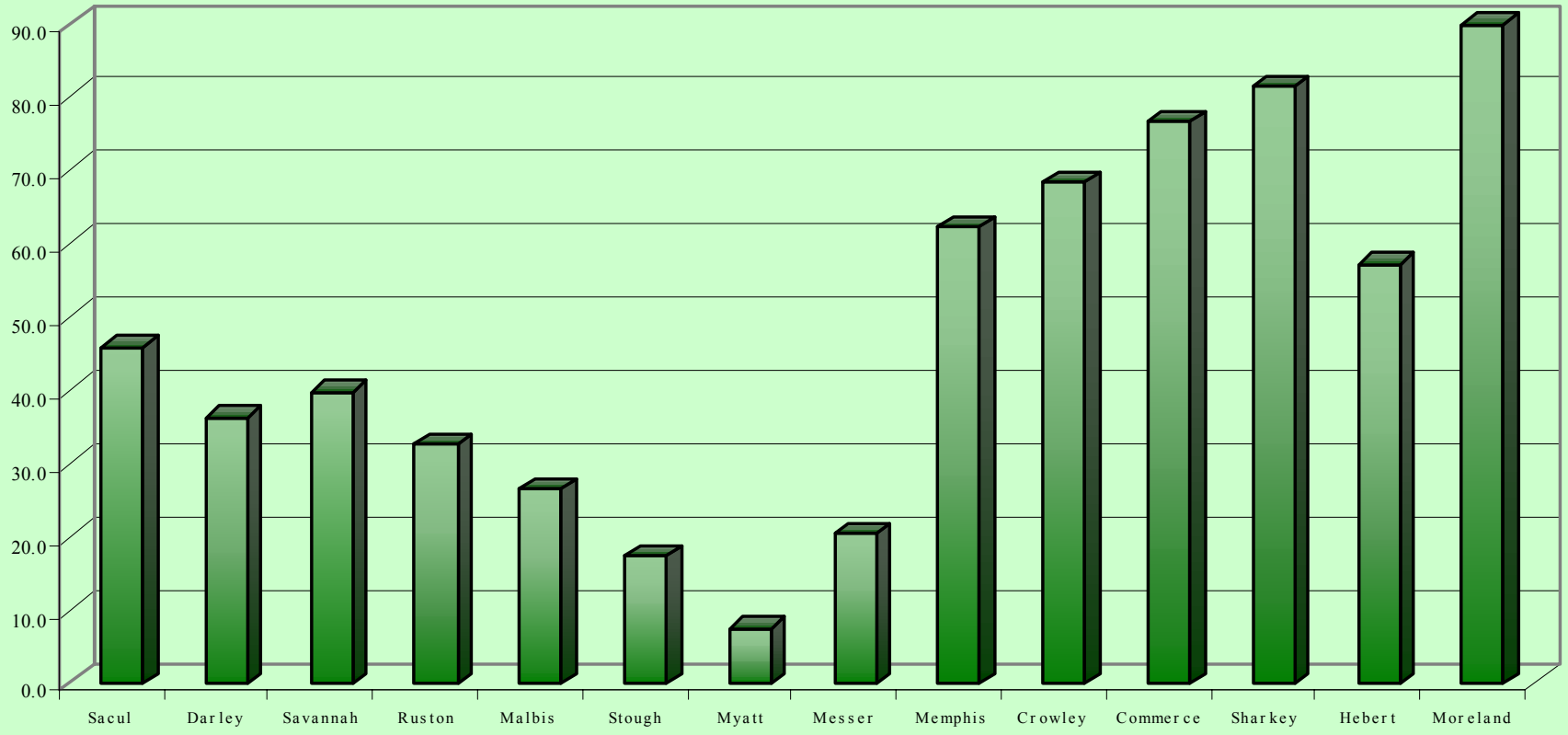
Chenier & Deltaic Marshes


pH
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Sacul
Darley
Savannah
Ruston
Malbis
Stough
Myatt
Messer
Memphis
Crowley
Commerce
Sharkey
Hebert
Moreland

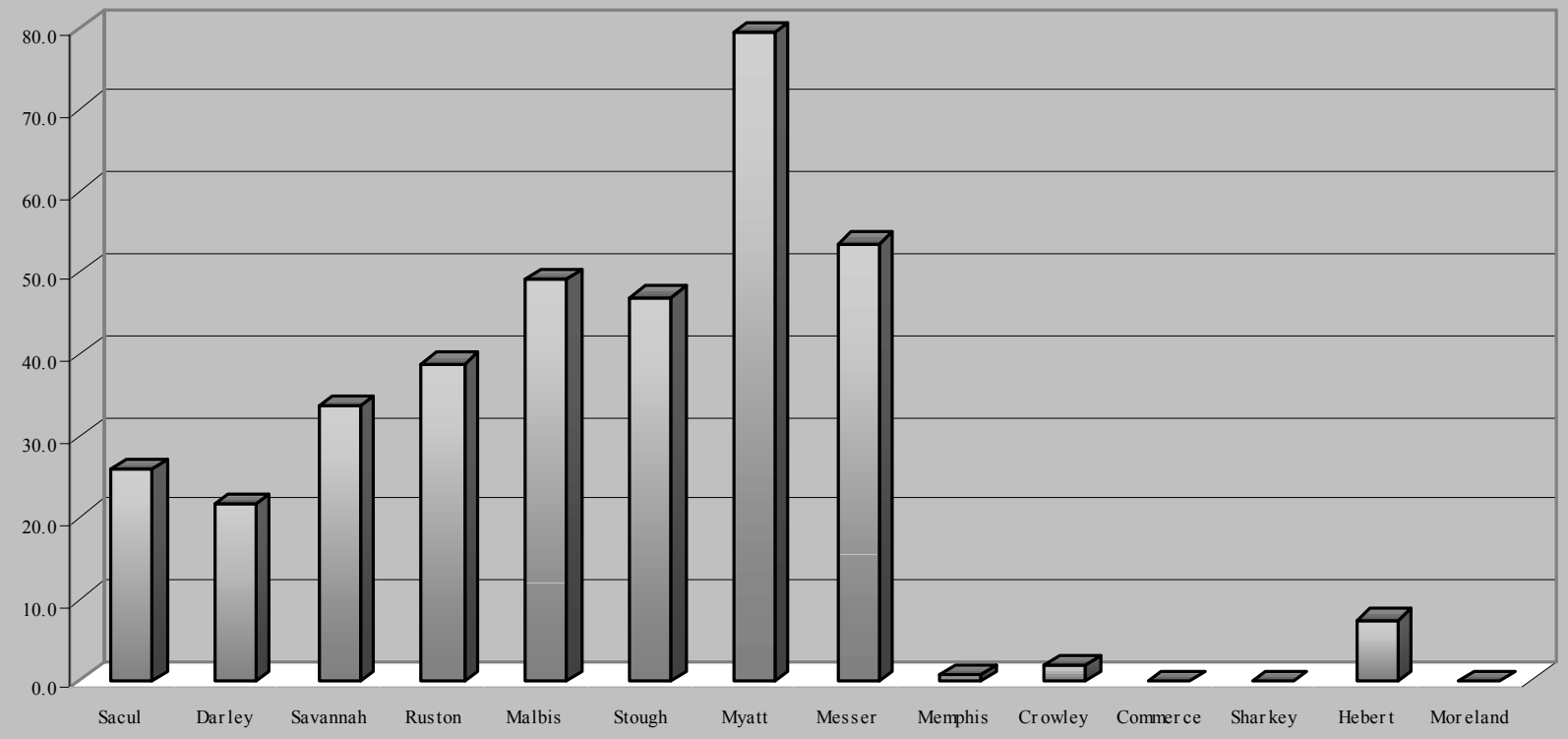

Phosphorus (ppm)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Sacul
Darley
Savannah
Ruston
Malbis
Stough
Myatt
Messer
Memphis
Crowley
Commerce
Sharkey
Hebert
Moreland

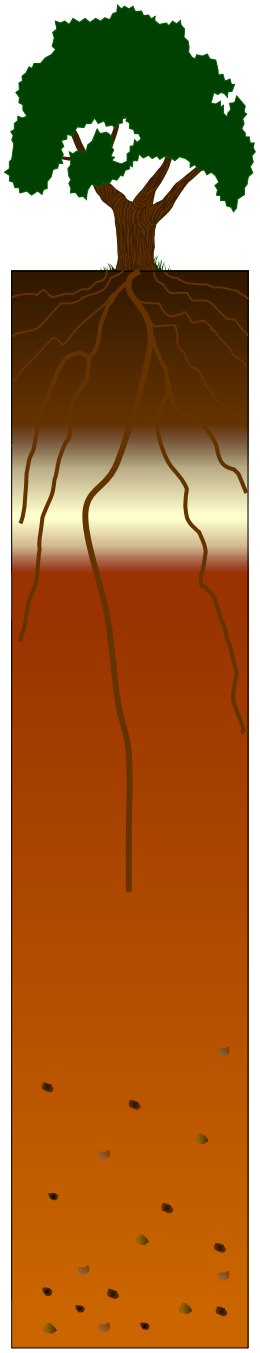

Cation Exchange Capacity
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Sacul
Darley
Savannah
Ruston
Malbis
Stough
Myatt
Messer
Memphis
Crowley
Commerce
Sharkey
Hebert
Moreland

Base Saturation (sum of bases)



Percent Aluminum Saturation



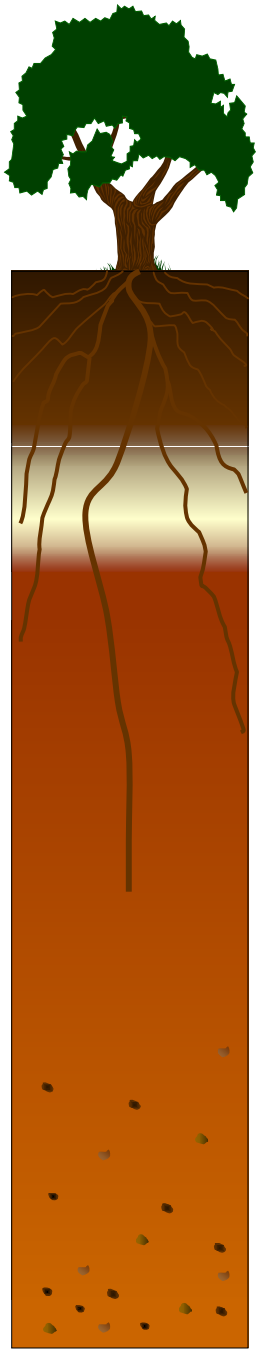


The Primary Nutrients

Nitrogen (N)

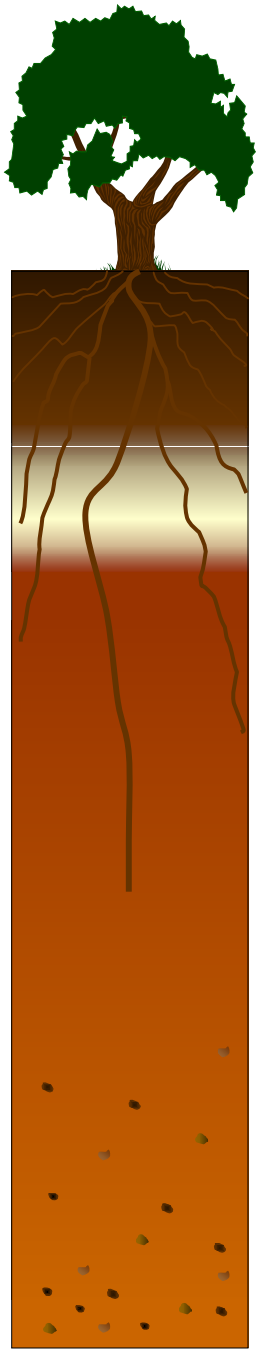
Phosphorus (P)

Potassium (K)



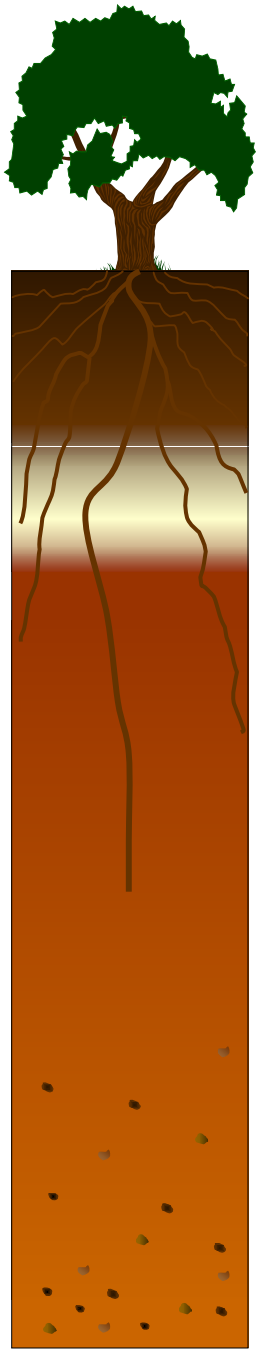
Nitrogen

- Essential for plant growth
- Part of every living cell
- Necessary for chlorophyll synthesis
- Involved in photosynthesis
- Important in water use efficiency



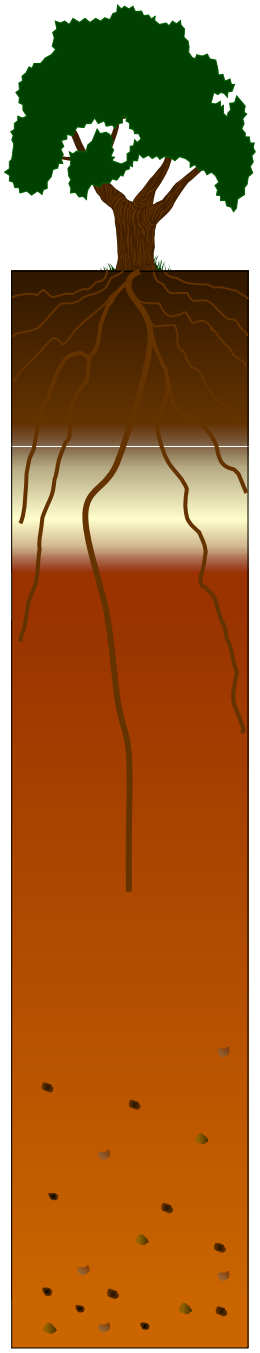
Nitrogen

- Amounts of available (inorganic) form is very small
- Amounts of unavailable (organic) form is high (~97-98% of total N in soil)
- Process by which unavailable organic forms are converted to available forms is called "mineralization"
- Mineralization occurs as microorganisms decompose organic materials for their energy supply



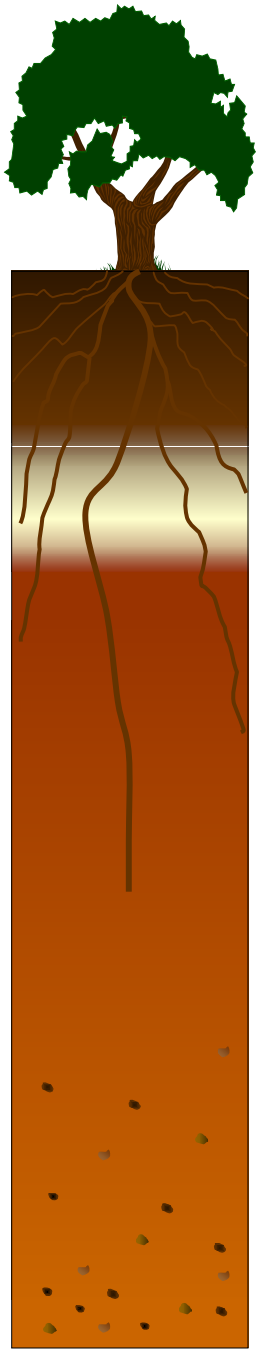
Nitrogen

- Nitrogen can be converted from inorganic to organic forms – "immobilization"
- Immobilization occurs when crop residues high in carbon and low in nitrogen content are incorporated into the soil
- Mineralization and Immobilization occur simultaneously in the soil dependent on the C:N Ratio
- C:N Ratio >30:1 favors immobilization
  < 20:1 favors mineralization
  20:1 – 30:1 about equal



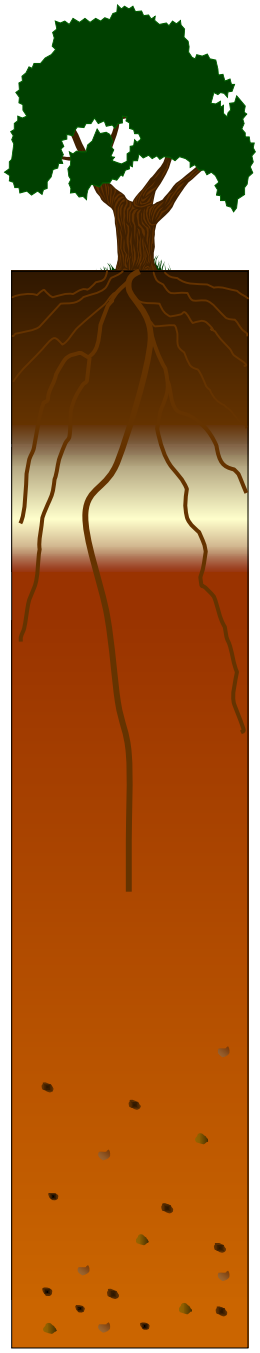
Nitrogen

- Nitrates are readily available for crops
- Nitrates are mobile in the soil
- Nitrates can be lost through denitrification
- Nitrogen fixation must occur before N can be used by plants
- Harvested crops remove considerable amounts of N from the soil
- Most forms of N tend to increase soil acidity



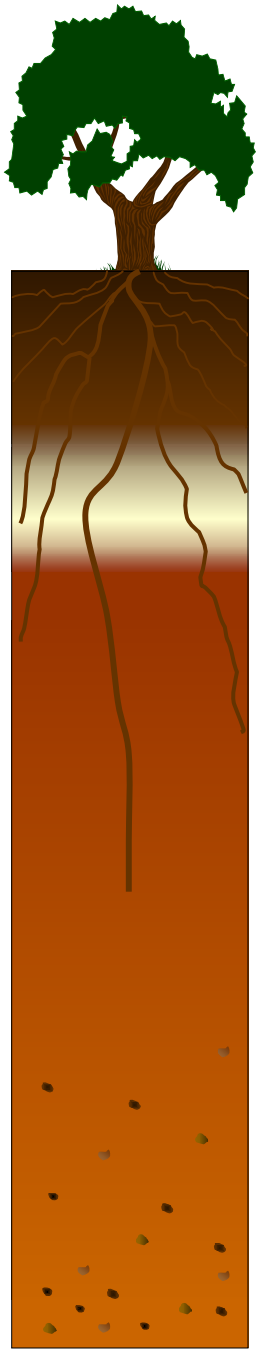
Phosphorus

- Essential for normal growth and maturity of plants
- Plays a role in photosynthesis, respiration, energy storage and transfer, cell division, cell enlargement, several other processes
- helps roots and seedlings develop more rapidly
- Increases water use efficiency and hastens maturity
- Soil P comes largely from the weathering of Apatite, a mineral containing P, Calcium, and other elements



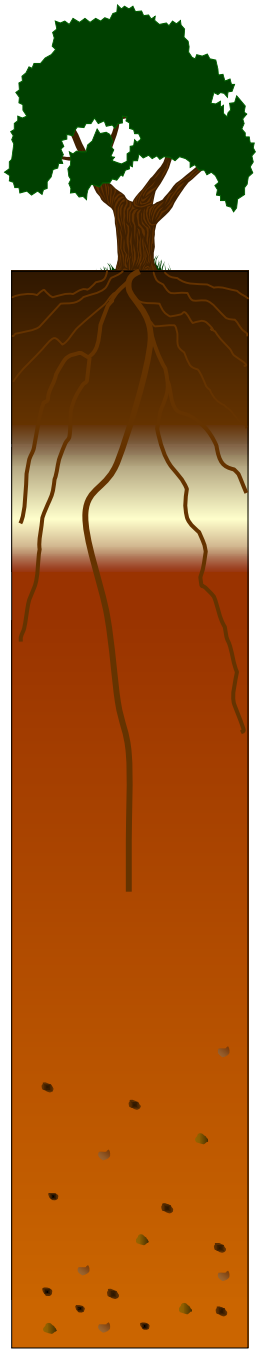
Phosphorus

- Availability affected by:
  - amount and type of clay
  - time of application
  - temperature
  - several other conditions
- Absorbed by plants mostly as the primary orthophosphate ion ($H_2PO_4^-$)
- Smaller amounts absorbed as the secondary orthophosphate ion ($H_2PO_4^{2-}$)



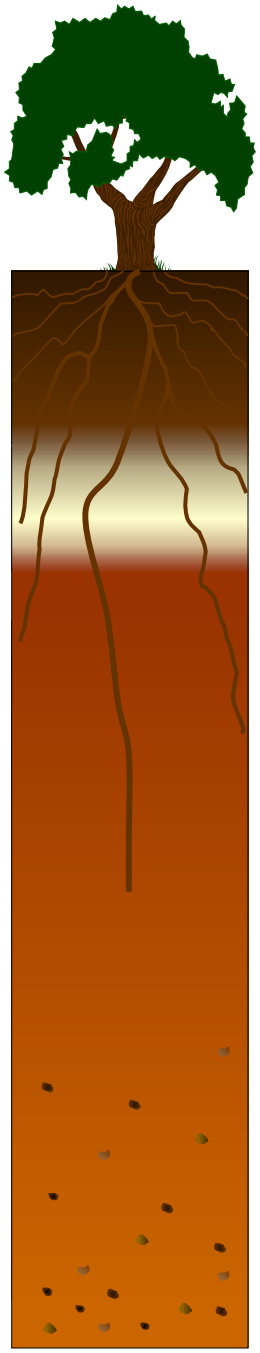
Phosphorus

- Clay minerals containing hydroxyl groups, such as kaolinite, absorb the phosphate ion readily
- Phosphate ion also combines readily with iron and aluminum
- The amount of P in the soil solution is always small
- residual P is greatest in neutral soils, somewhat less in alkaline soils, and least in acid soils
- P moves very little in most soils, mostly by diffusion, dependant on moisture and temperature



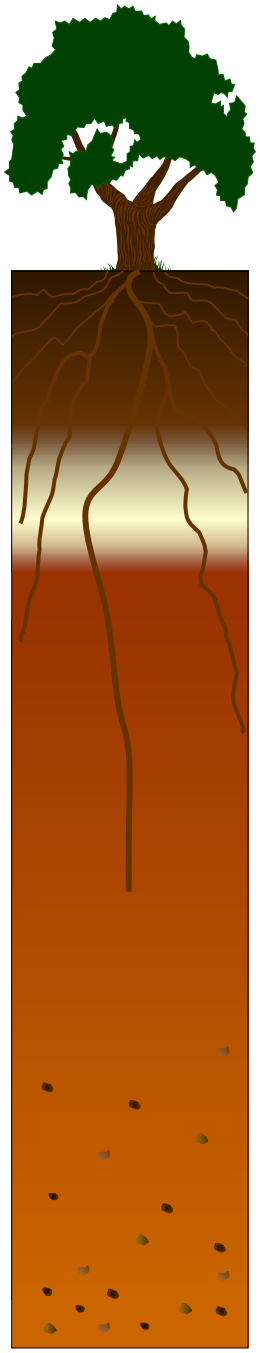
Potassium

- Vital to photosynthesis
- Important to protein synthesis
- Important to breakdown of carbohydrates, providing energy for plant growth
- Absorbed in ionic form – K^+
- Primary function is related to ionic strength of solutions inside plant cells



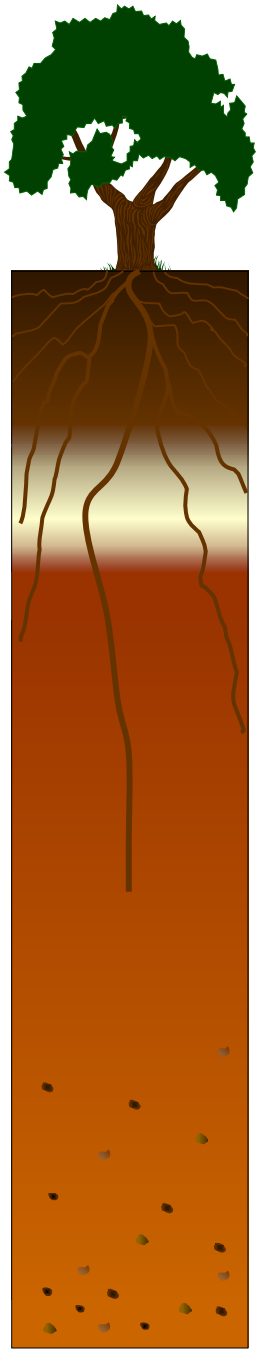
Potassium

- Strengthens plant stalks
- Unlike N & P, does not form organic compounds in the plant
- Has great impact on crop quality
- Increases winter hardiness
- Provides turgor… K deficient plants wilt more easily



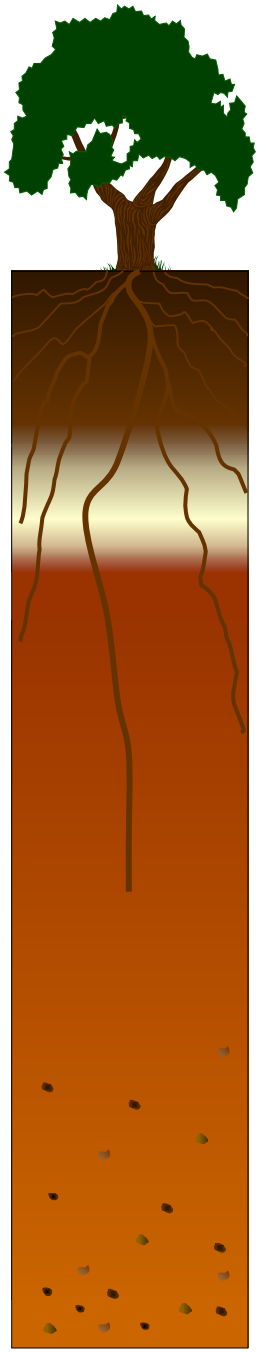
Potassium

- Soils contain huge amounts of K, but just a small amount is available (<2%)
- Three forms:
- Unavailable – released very slowly from minerals (rocks); so slowly as to be unavailable to growing plants in a particular crop year.
- Slowly available – "fixed" or trapped between layers of certain soil clays
- Available – K found in the soil solution plus K held in exchangeable form by organic matter and clay



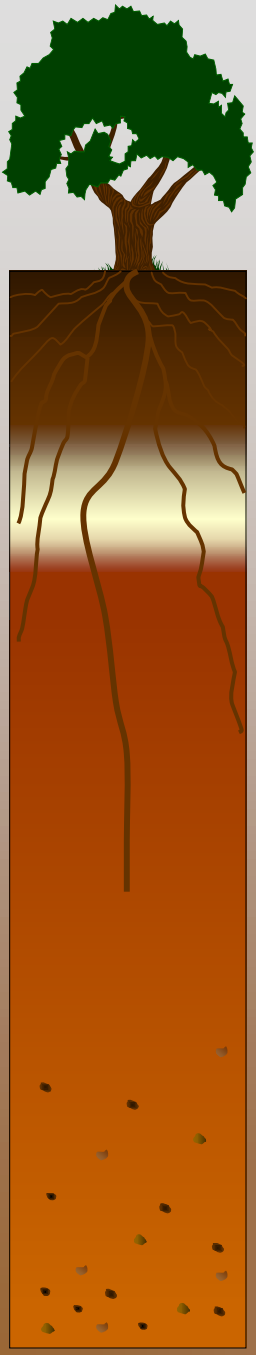
Potassium

- K is relatively immobile in the soil, reaching plant roots by diffusion
- pH value of the soil solution does not appear to influence intake of K
- Reaction, however, plays a part in the depressing effect of other cations on K utilization
- K carrying minerals weather readily into clay
- So, soil w/ high clay have above average K

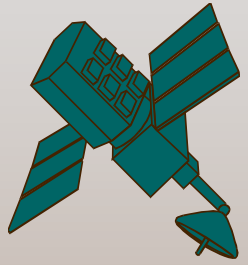


Although soil fertility is vital to a productive soil…

a fertile soil is not necessarily productive



Where Is Information About Soils?



http://www.nrcs.usda.gov

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http://websoilsurvey.nrcs.usda.gov