Soil!
What it is and how it works.

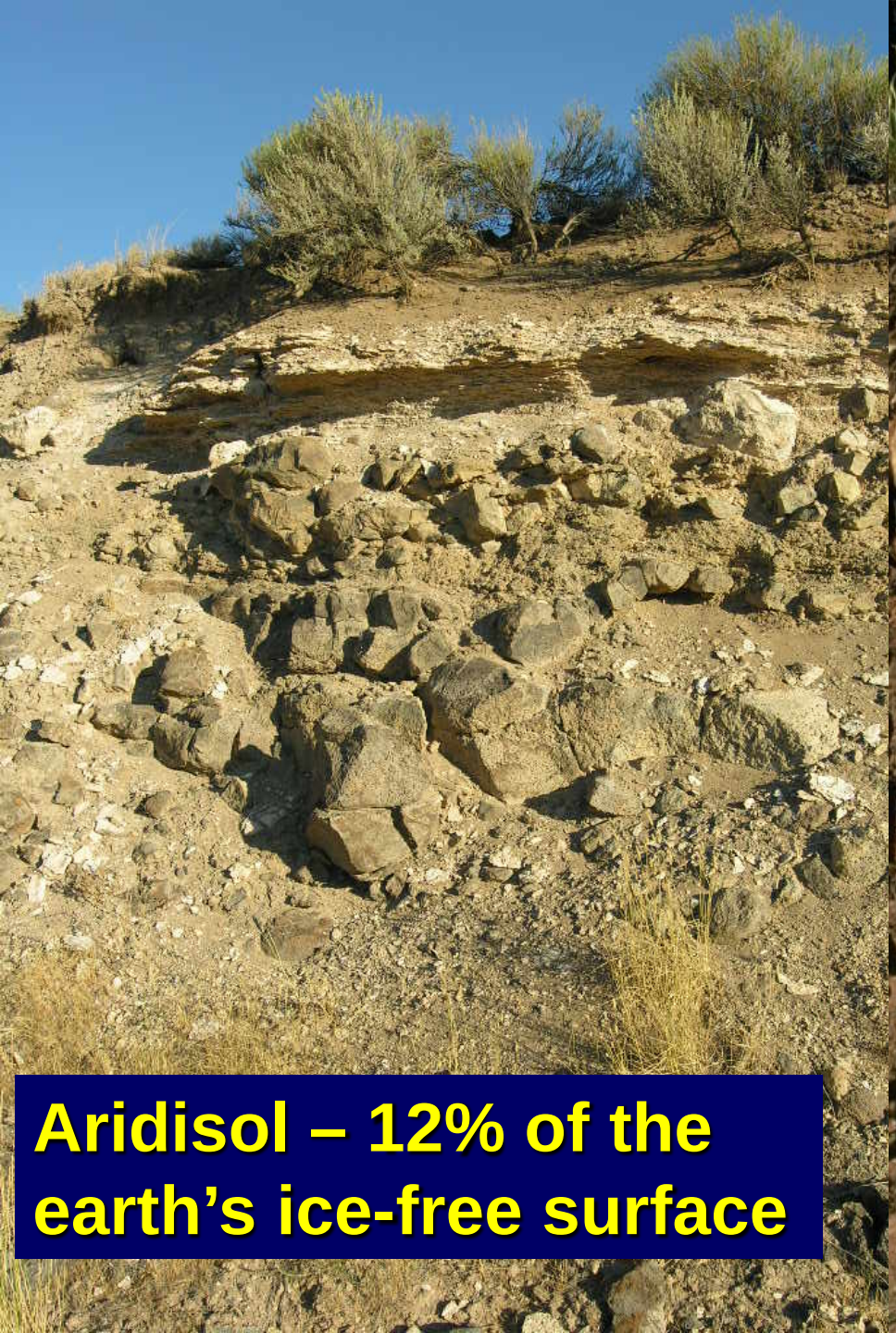
James Cassidy – Oregon State University, Soil Science
President Oregon Society of Soil Scientists
Soilforward.org

Soil!

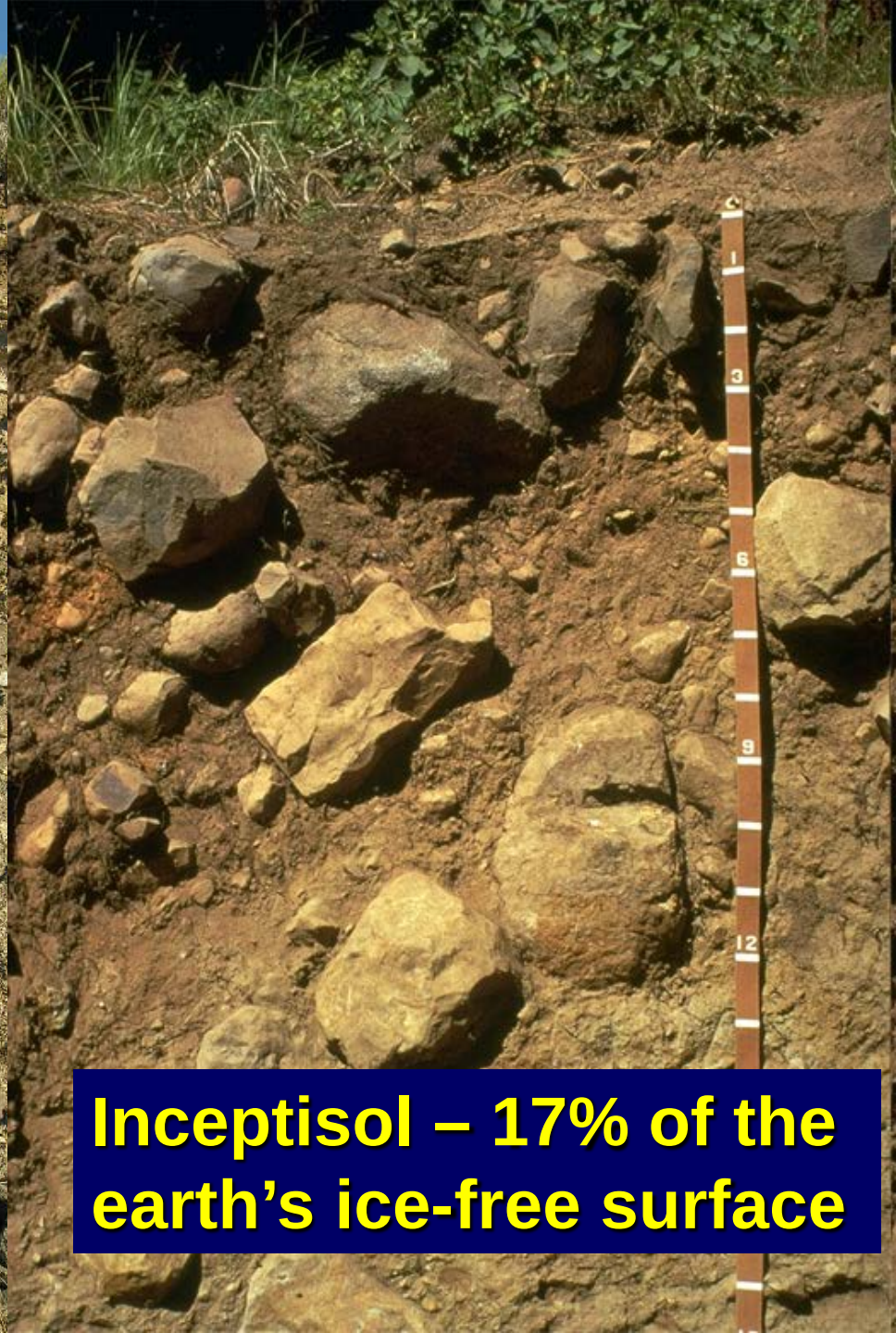
2 of the 12 Soil Orders

Aridisol

Mollisol

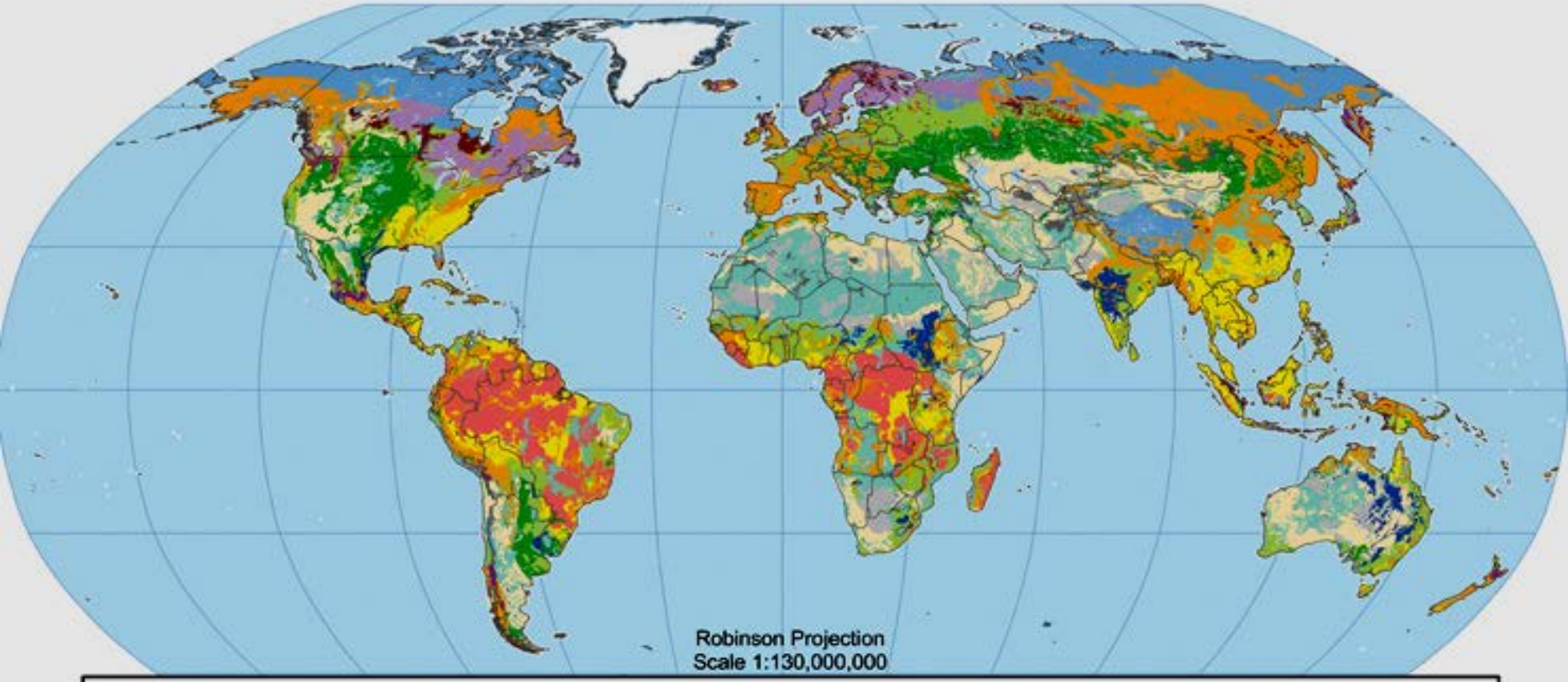


Aridisol – 12% of the earth's ice-free surface



Inceptisol – 17% of the earth's ice-free surface

Global Soil Regions



Soil Orders

Alfisols	Entisols	Inceptisols	Spodosols	Rocky Land
Andisols	Gelisols	Mollisols	Ultisols	Shifting Sand
Aridisols	Histosols	Oxisols	Vertisols	Ice/Glacier

USDA NRCS US Department of Agriculture
Natural Resources
Conservation Service

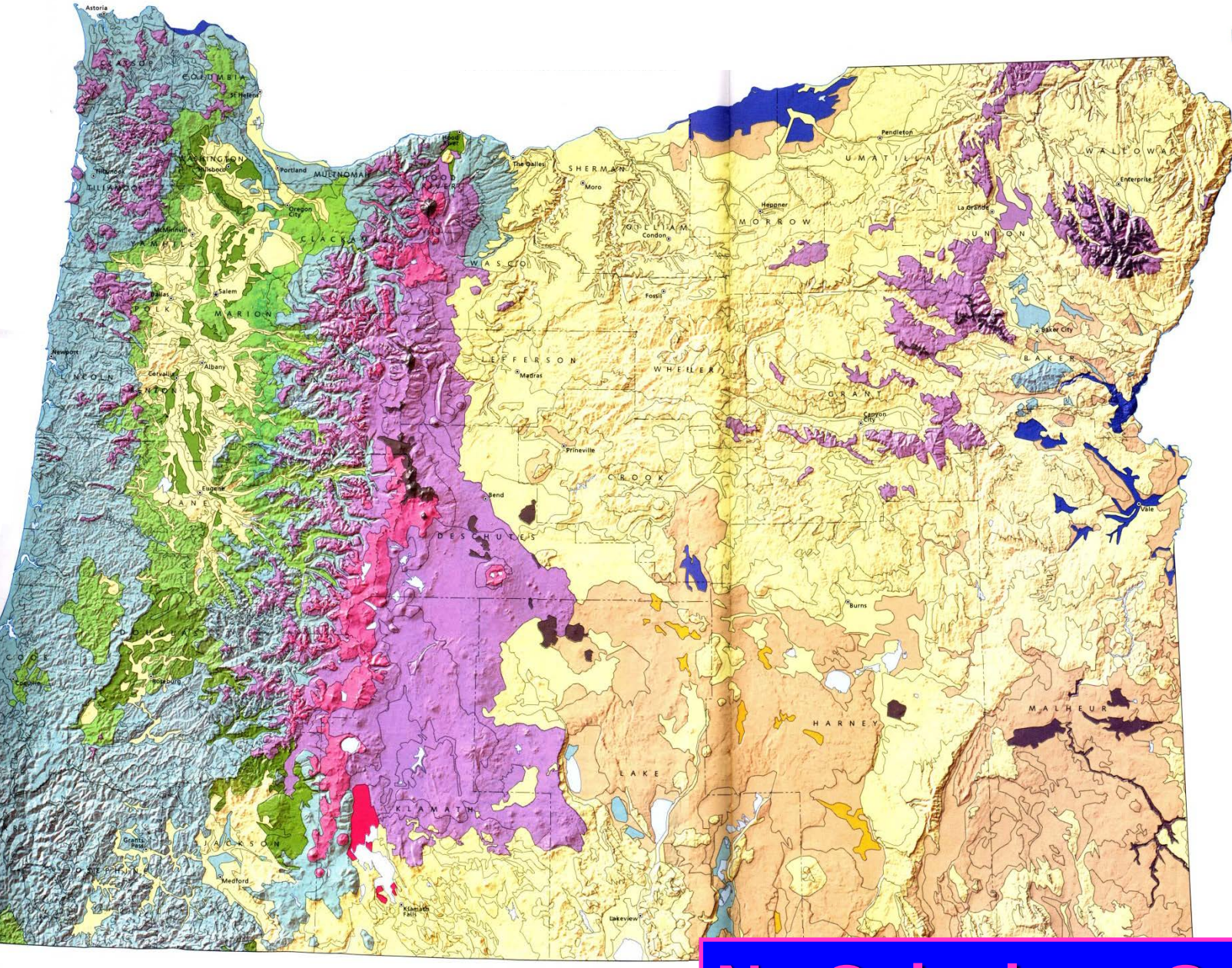
Soil Survey Division
World Soil Resources
soils.usda.gov/use/worldsoils

November 2005

Oxisols

Very-fine, kaolinitic, isohyperthermic Typic Eutrotorrox

Plate 34 Molokai Oxisol growing sugarcane on Oahu, Hawaii. (A. R. Southard)



Soil Descriptions

Inceptisols
ils that are beginning to form and have weakly developed il profiles. Inceptisols are most common in the Coast Range, here they have dark surface horizons (or layers, as when ewed in cross-section) enriched with organic matter and bsoils in which only brighter colors and better structures fferentiate the soil from the parent material. Inceptisols in e Klamath Mountains are similar, but have thinner surface rizons that are lower in organic matter.

Ultisols
d soils with strongly developed subsoil horizons of clay cumulation. Oregon Ultisols are mostly paleosols (old soils) at formed long ago when the climate was warmer and etter. Ultisols are prominent in the foothills on both sides of e Willamette Valley and also occur on foothills in Douglas, sephine and Jackson Counties. They are widely used to oduce grapes, Christmas trees, grass seed and timber.

Alfisols
ils that have thin surface horizons enriched with organic atter and subsoil horizons of clay accumulation. Alfisols cur mainly in Western and southern Oregon. Typical examples clude the reddish brown Willakenzie soils in the foothills of e Willamette Valley and the reddish brown Abegg and Ruch ils on old terraces in Jackson County.

Andisols
ils developed in materials of volcanic origin. Coast Range ndisols are black, light-weight soils developed from basalt der cool, humid conditions. Cascade Range Andisols develop m mixed ash and weathered andesite. Andisols from Crater ke northeastward to Newberry Crater are developed mainly m pumice. Andisols in northeastern Oregon are formed in blanket of white ash mainly from the eruption of Mount lazama.

Spodosols
ils with white near-surface horizons over iron-rich subsoils rmed in sandy materials under pine or spruce in cool, humid eas. Spodosols are the dominant soil at high elevations along e crest of the Cascades, but they are also prominent mponents of the landscape along the Coast from Newport Brookings. Many coastal Spodosols in Coos and Curry unties are intensively used for cranberry production.

Histosols
ighly organic soils, composed almost entirely of the decayed mains of plants that grew in marshy environments. Histosols e dominant only in the vicinity of Upper Klamath Lake, but ey are perhaps better known in the small, finger-like areas f Lake Labish just north of Salem, where the Semiahmoo eries is used intensively to produce Spanish onions.

Aridisols
oils found in the driest parts of southeastern Oregon, mainly old playas and lake basins and on surrounding uplands in ake, Harney and Malheur Counties. Surface horizons for ese soils are light in color and low in organic matter. Many ridisols have subsoil horizons enriched with clay. Some have ccumulations of free lime in the subsoil. A few, where the easonal water table is close to the surface, are salty. Many ridisols are underlain at shallow depth by either volcanic edrock or by a soil-formed hardpan.

Mollisols
oils formed mainly in association with grassland vegetation. Mollisols have relatively thick, dark surface horizons rich in rganic matter under which are subsoils that are either weakly eveloped or enriched in clay or carbonates. More than 650 regon soil series are Mollisols—this order occupies the largest rea of any soil order in the state. On the main floor of the Willamette Valley they are deep, dark, fertile soils. In Eastern regon they have lower amounts of organic matter and are nore likely to be associated with carbonate accumulations, ardpans, or shallow bedrock.

Vertisols
Clay soils that shrink and swell appreciably upon wetting and rying. Vertisols are dominant soils only in small areas of south-entral Oregon, but they form important components of the oil landscape on low foothills and in tributary valleys of the Willamette Valley (Bashaw series), Douglas County (Curtin eries) and Jackson County (Carney and Coker series).

Entisols
oils found mainly in recently deposited parent materials that re too young to have developed soil horizons. The largest rea dominated by Entisols is the Columbia Basin in Morrow nd Umatilla Counties. Irrigation with Columbia River water as made these sandy soils agriculturally productive. Other ntisols occur in small areas on floodplains of rivers and treams, where frequent flooding continually adds new ediments to the land surface.

Rock **Water**

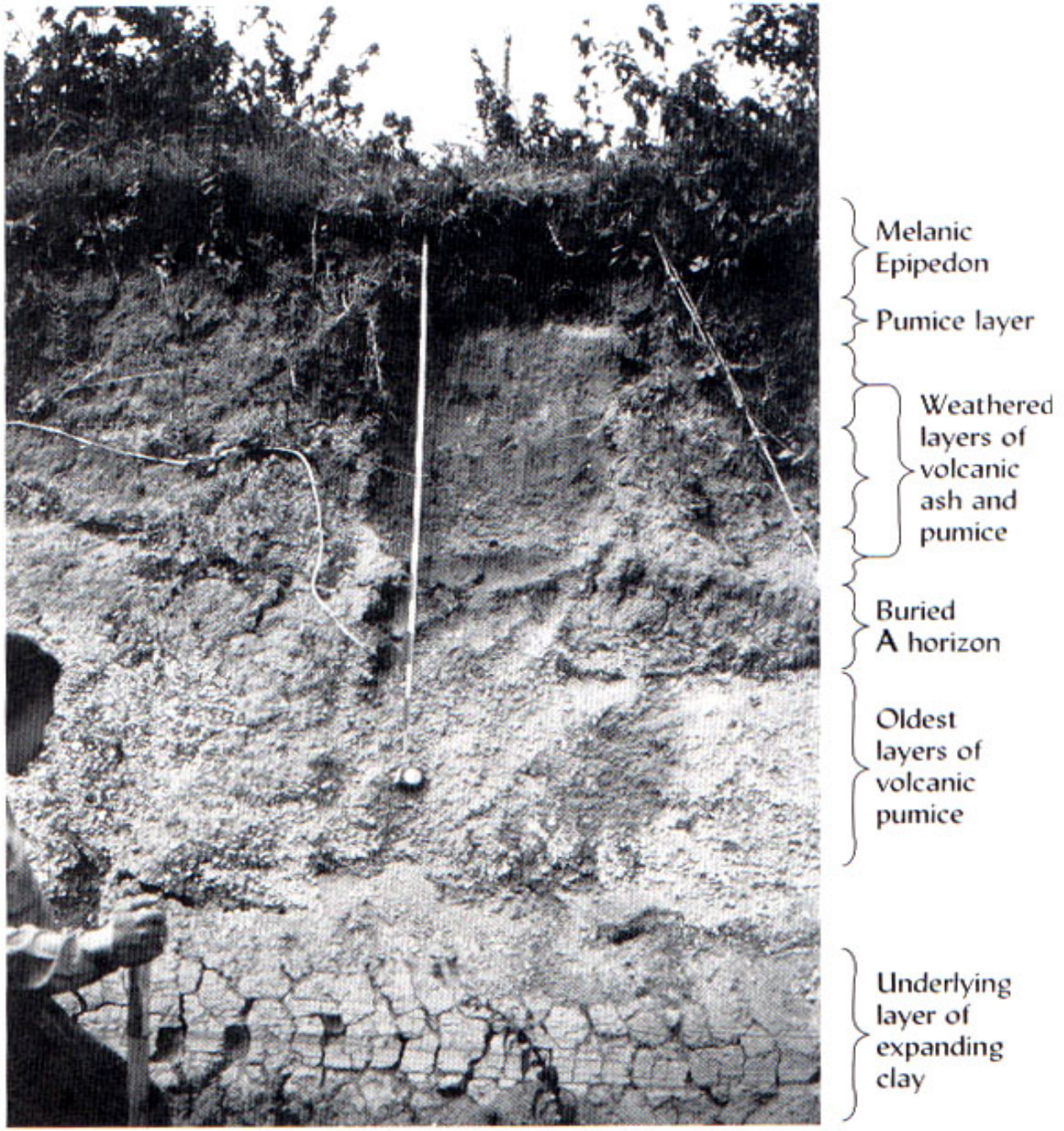
ote: Gray lines within soil orders are boundaries of suborders shown n the following two pages.

No Oxisols or Gelisols!


Spodosol
Oregon Coast

Andisols

Central Africa



Entisols

PLATE 4 Entisols—a Typic Quartzipsamment from eastern Texas. Scale in feet.

Inceptisols

A 0 –5 cm

AB 5- 18

Bw1 18 - 33

Bw2 33 - 55

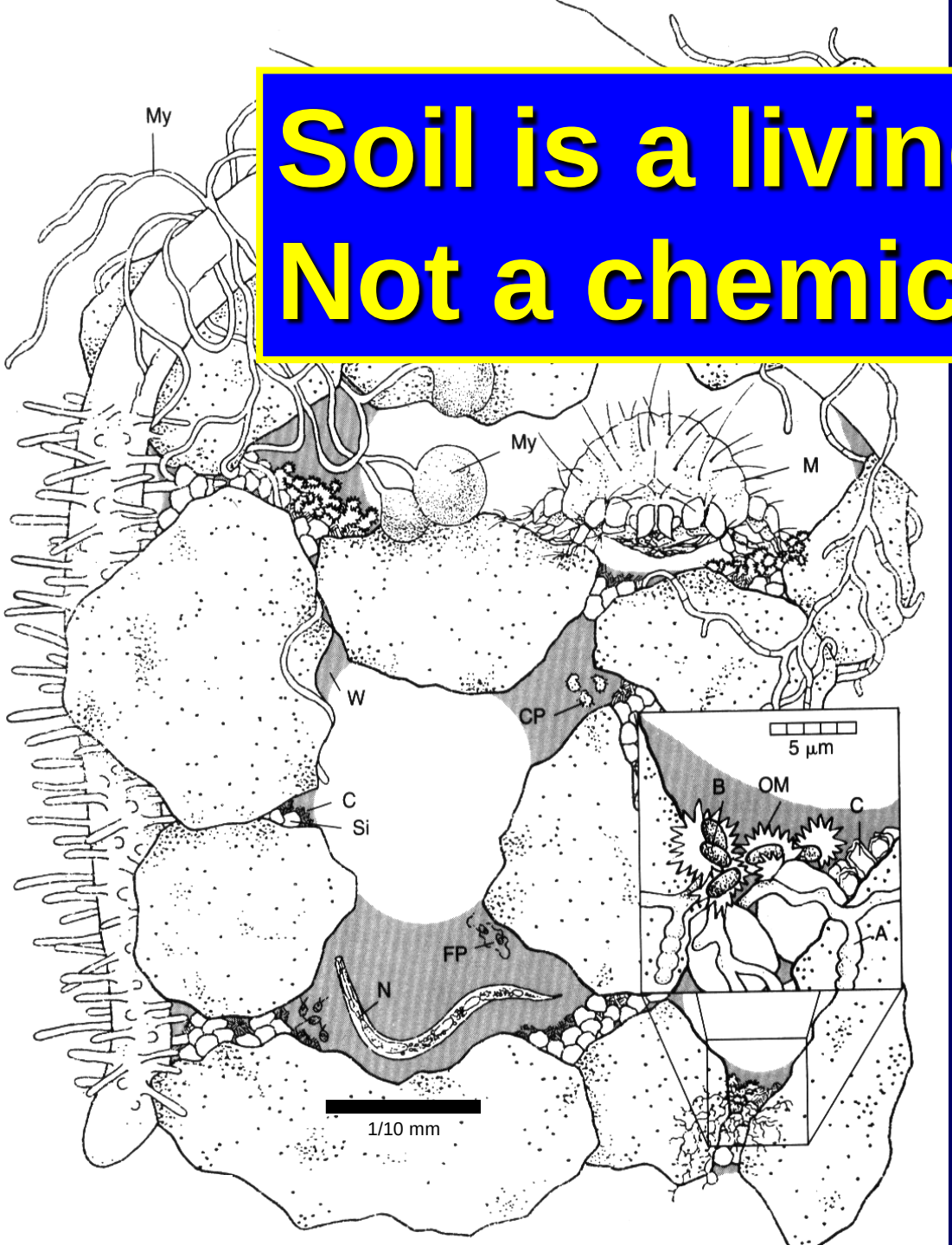
BC 55 - 76

C 76 – 100+

GEORGIA COARSE-LOAMY, MIXED, SEMIACTIVE, MESIC AQUIC DYSTRIC EUTRUDEPTS


Soil is habitat!

Soil is a living thing!
Not a chemical sponge!



B – Bacteria
A – Actinomycetes
My – Mycorrhizae
H – Saprophitic fungus
N – Nematode
CP – Ciliate protozoa
FP – Flagellate protozoa
M – Mite

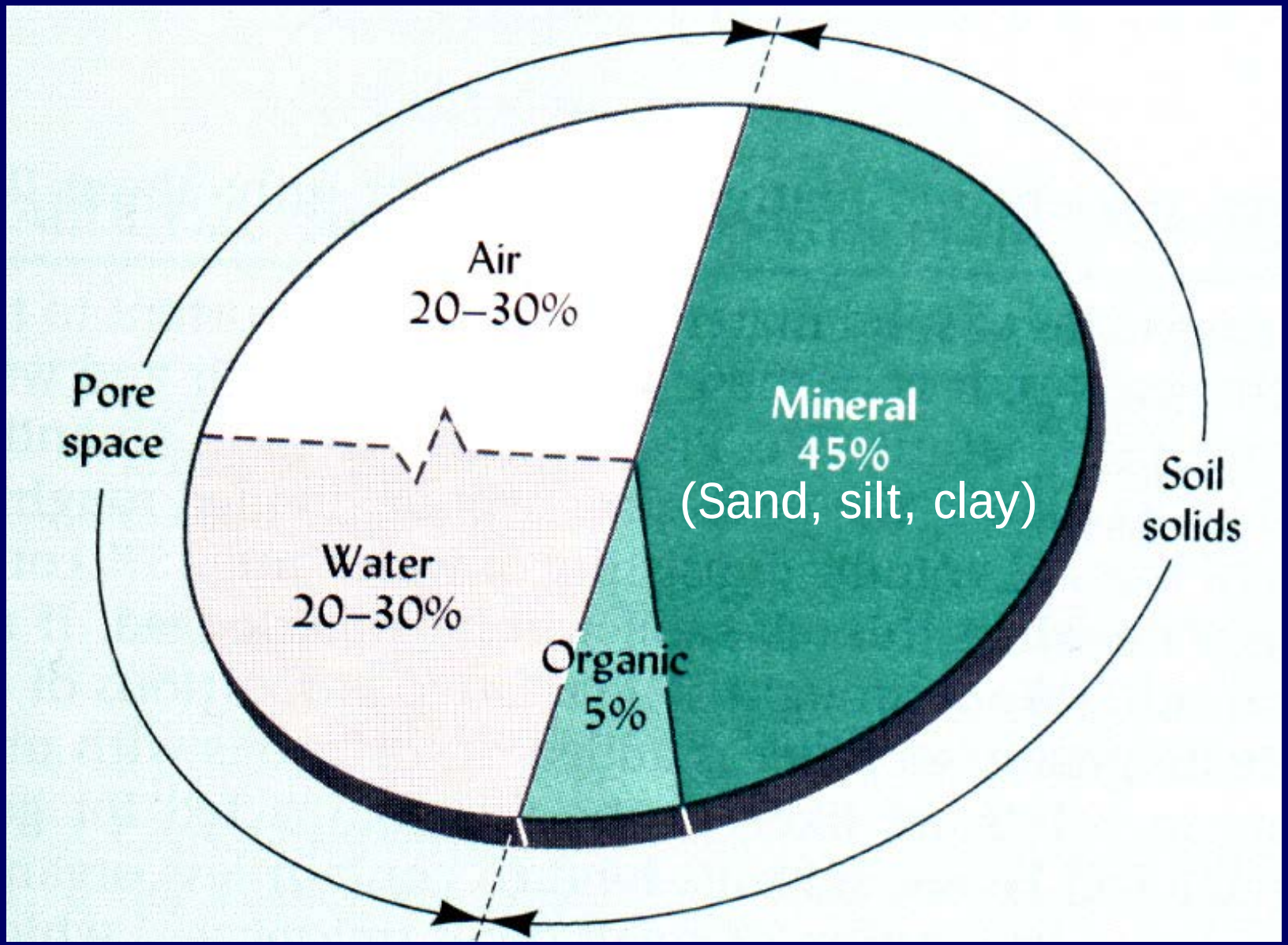
< 1mm

What is Soil?

Soil is:

- **“Rotted” Rock**
- **Decomposed Organic Matter**

The four components of soil:

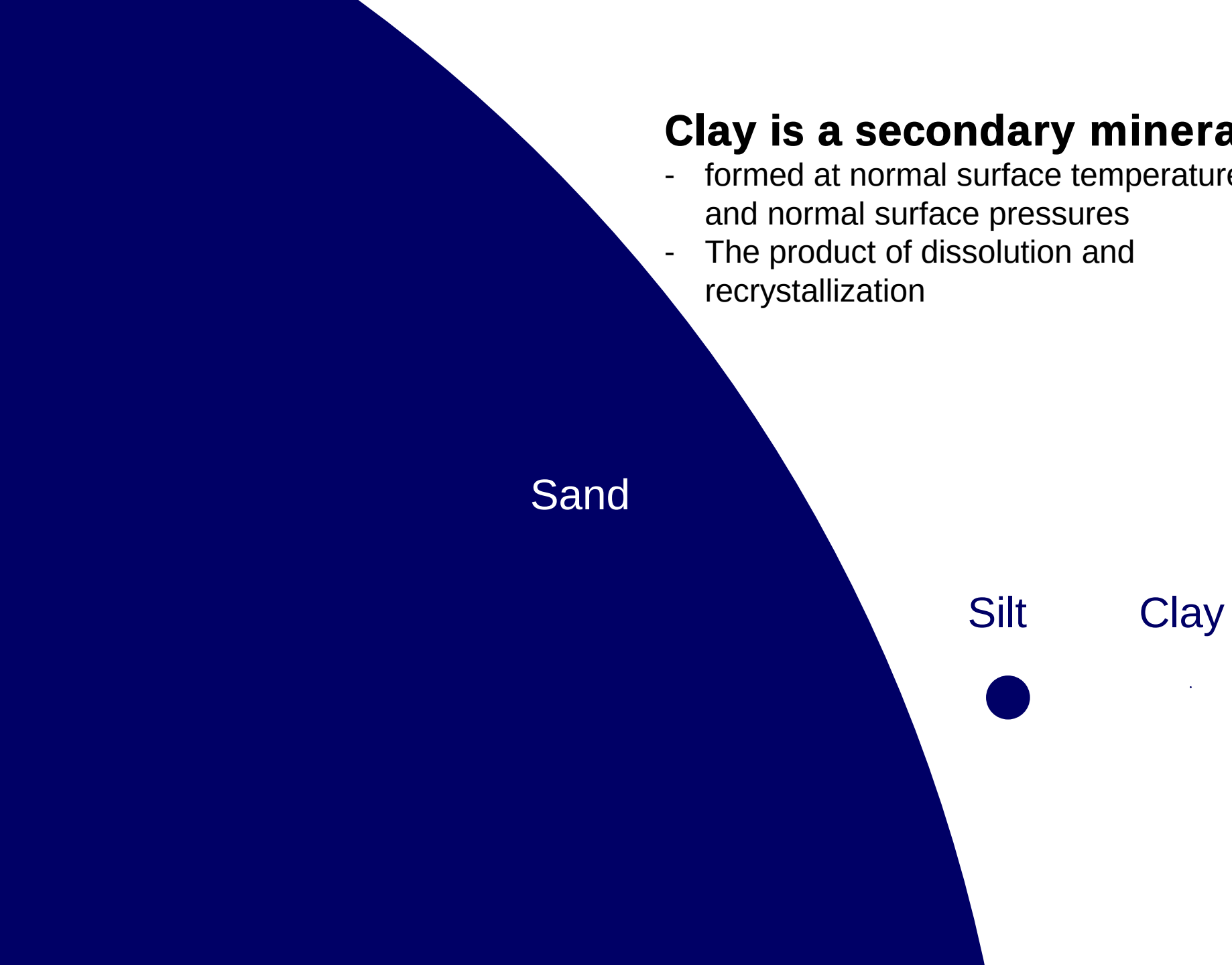


Rock – primary mineral

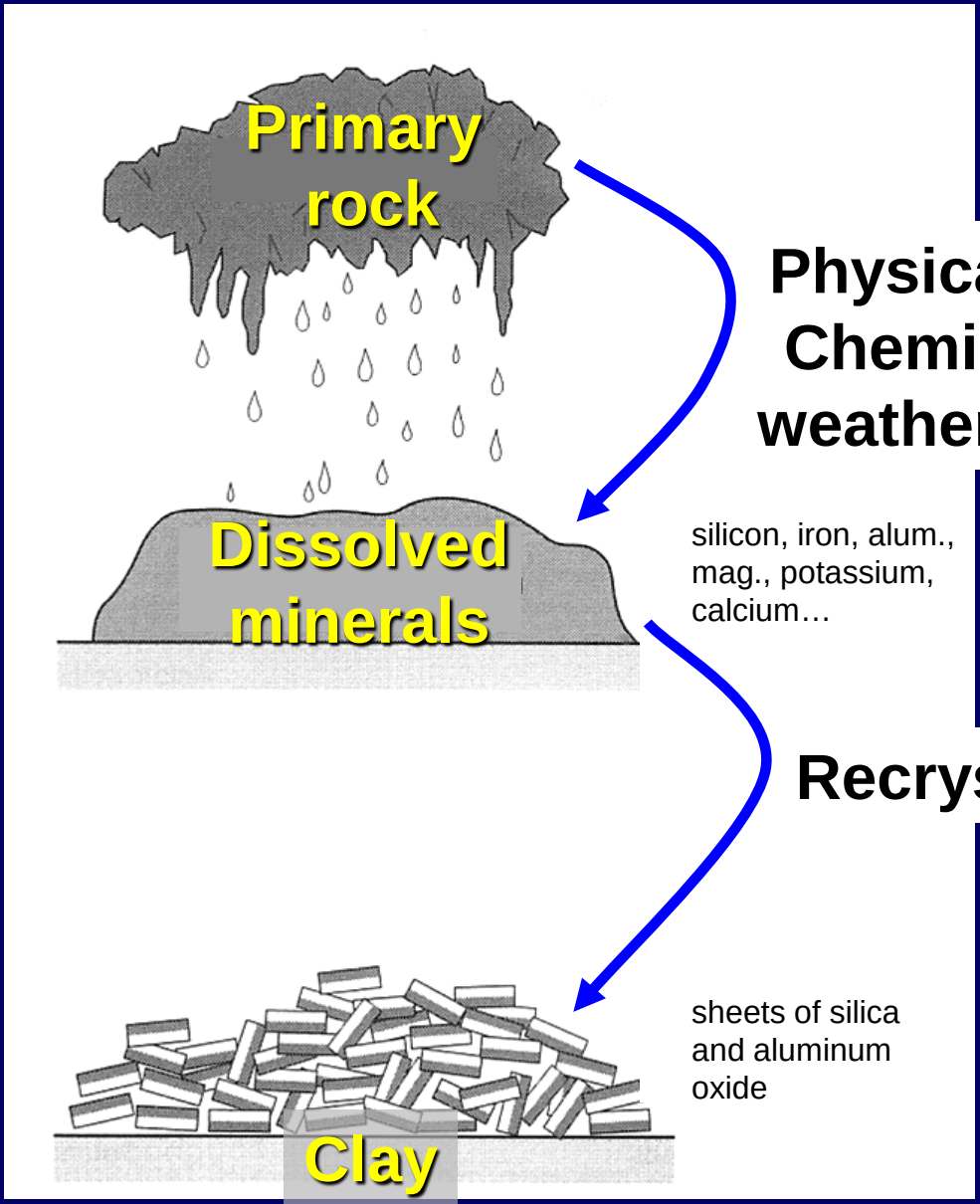
Granite

Clay is a secondary mineral

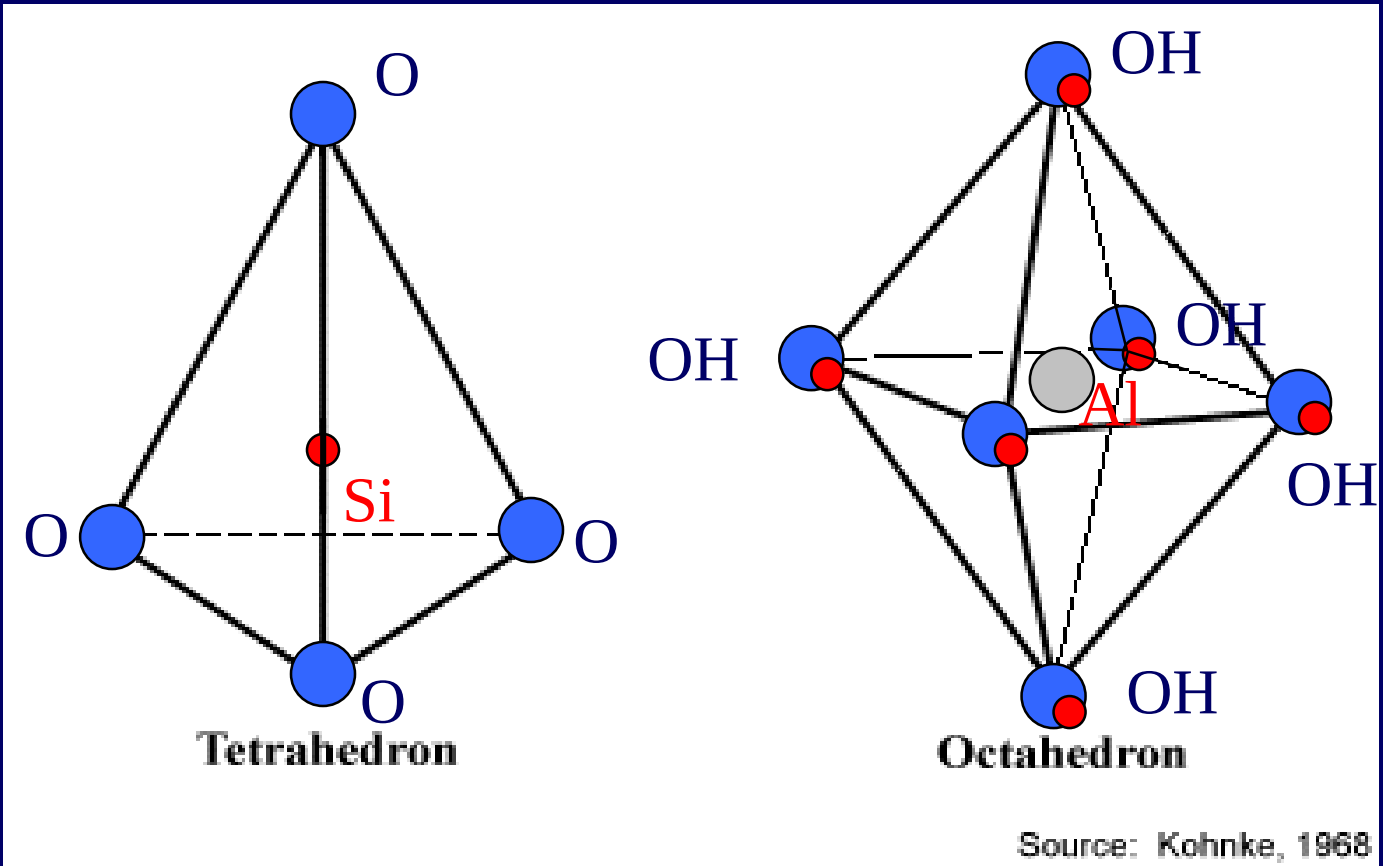
- formed at normal surface temperatures and normal surface pressures
- The product of dissolution and recrystallization



Rocks dissolve and recrystallize



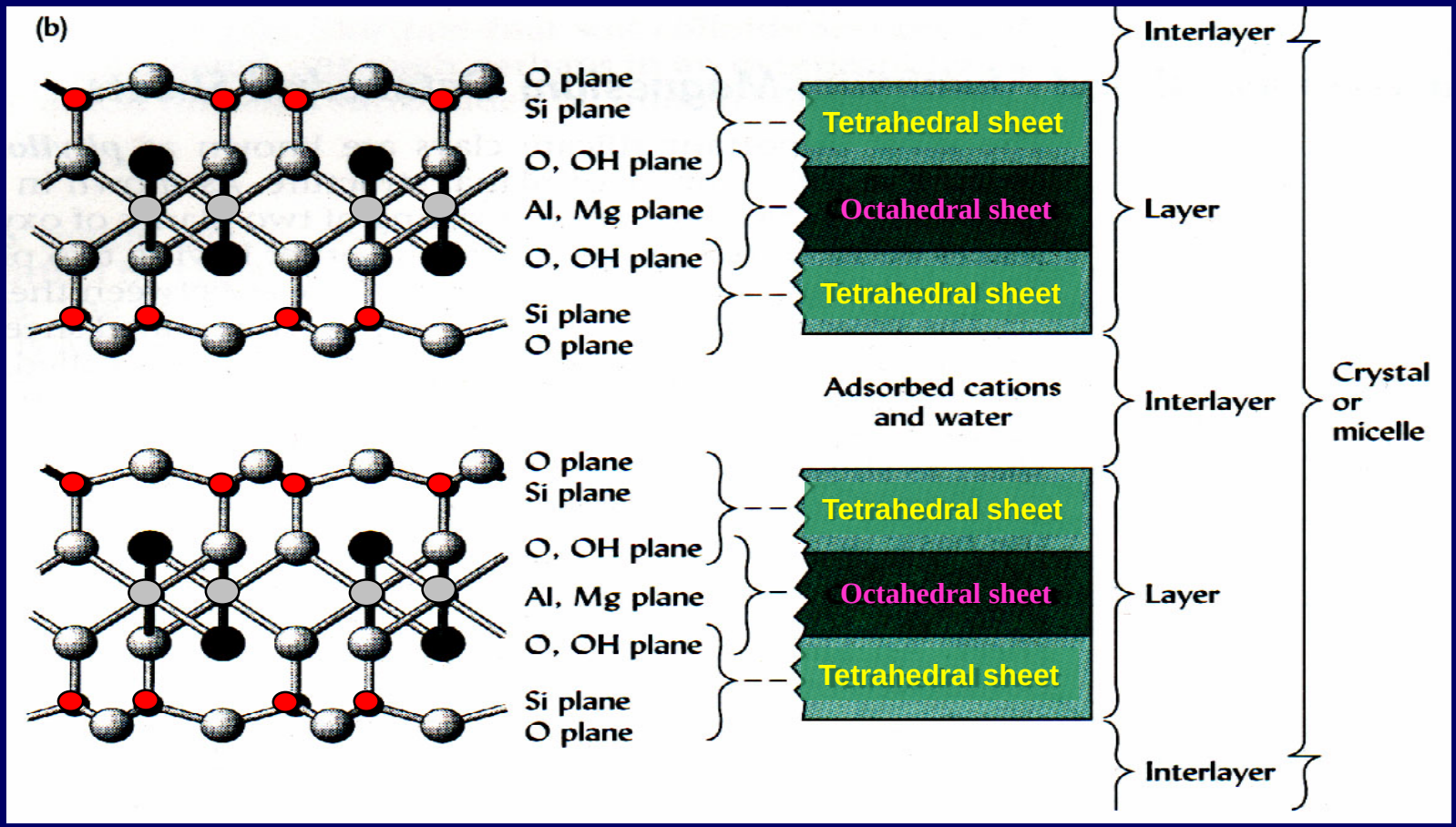
When rocks dissolve…

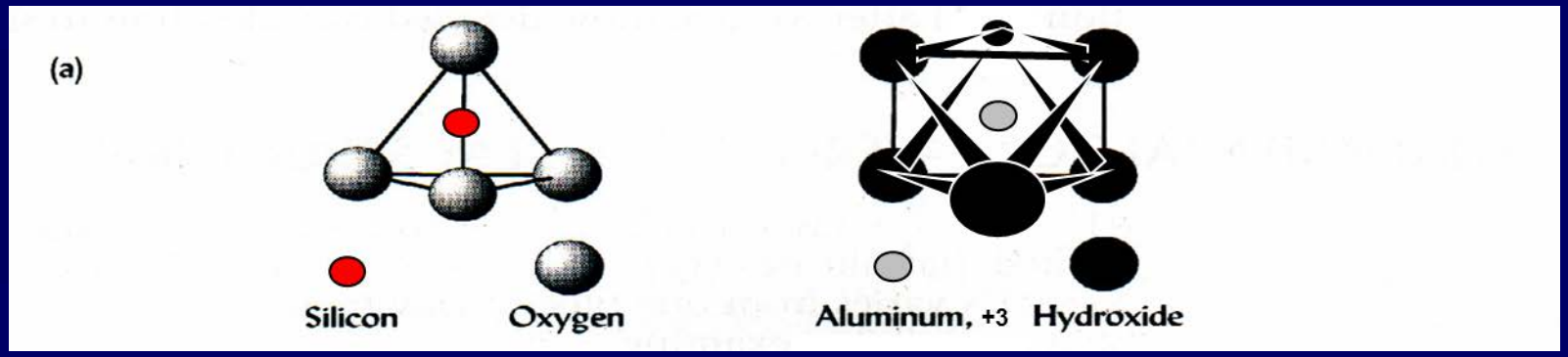


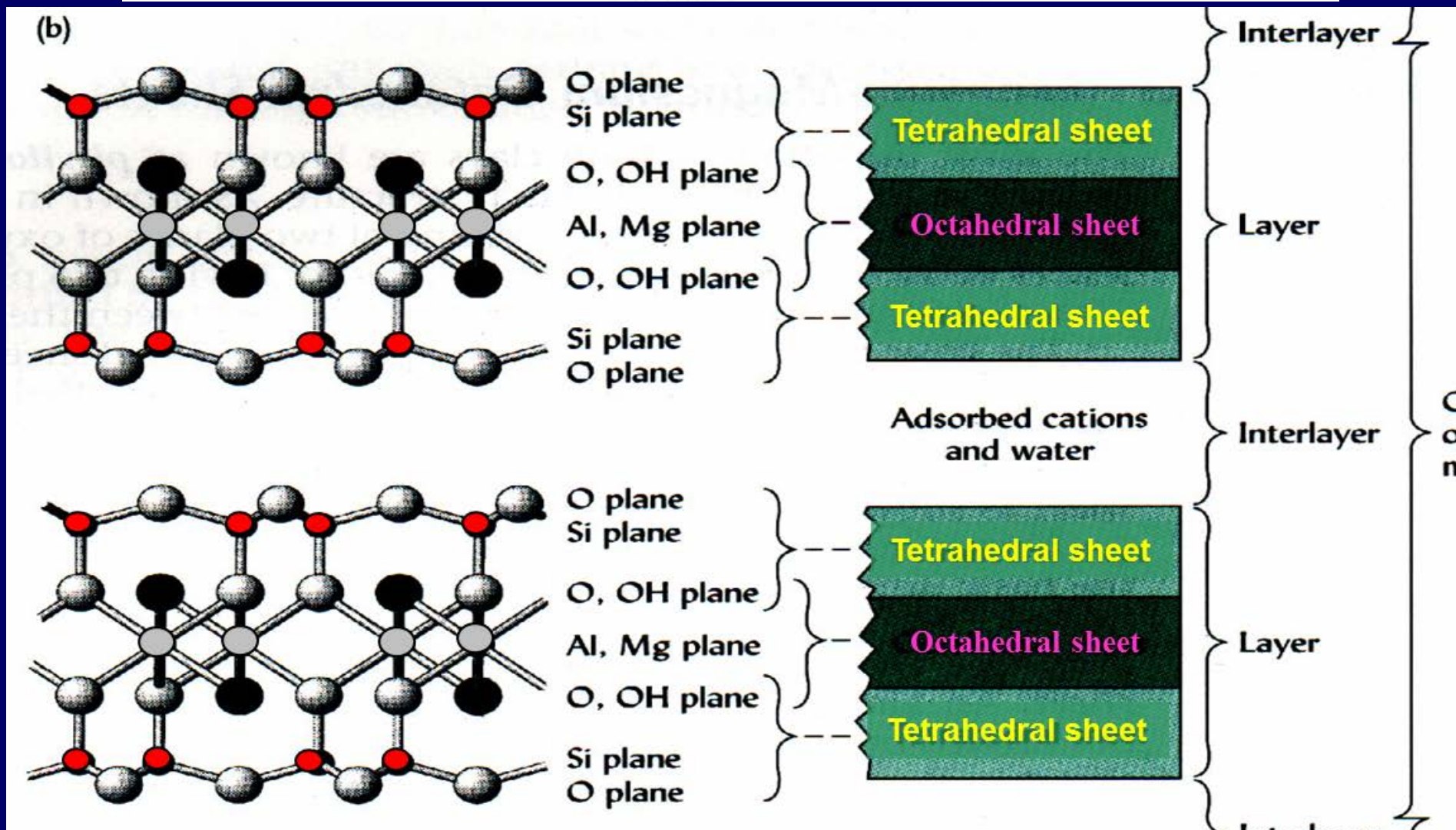
Tetrahedron - a 3D geometric form contained by four plane faces; a triangular pyramid.

Octahedron - a 3D geometric form contained by eight plane faces.

...and recrystallize.
Clay – secondary mineral

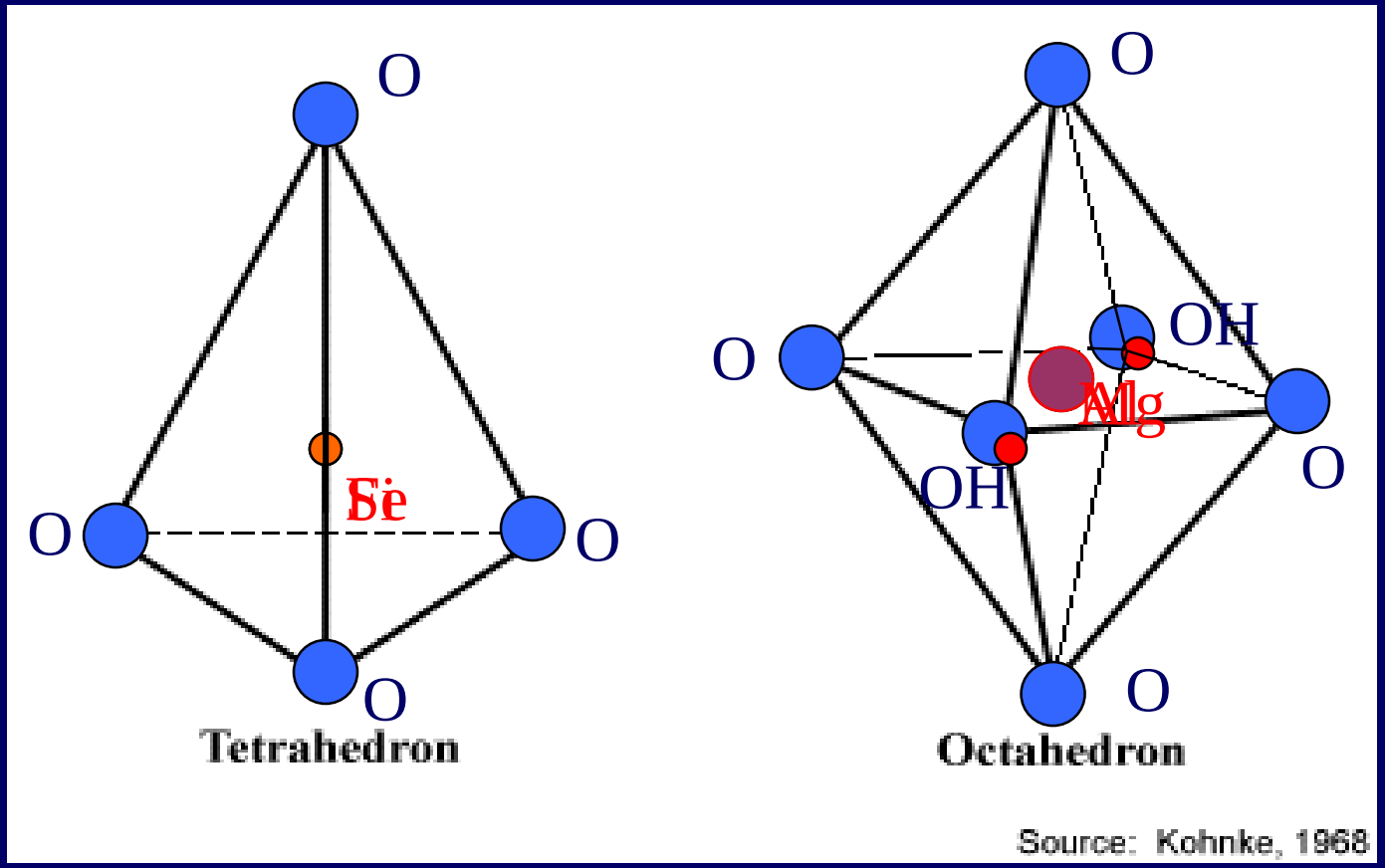



(a)
Silicon
Oxygen
Aluminum, +3
Hydroxide


(b)
O plane
Si plane
O, OH plane
Al, Mg plane
O, OH plane
Si plane
O plane
Tetrahedral sheet
Octahedral sheet
Tetrahedral sheet
Adsorbed cations
and water
O plane
Si plane
O, OH plane
Al, Mg plane
O, OH plane
Si plane
O plane
Tetrahedral sheet
Octahedral sheet
Tetrahedral sheet
Interlayer
Layer
Interlayer
Layer

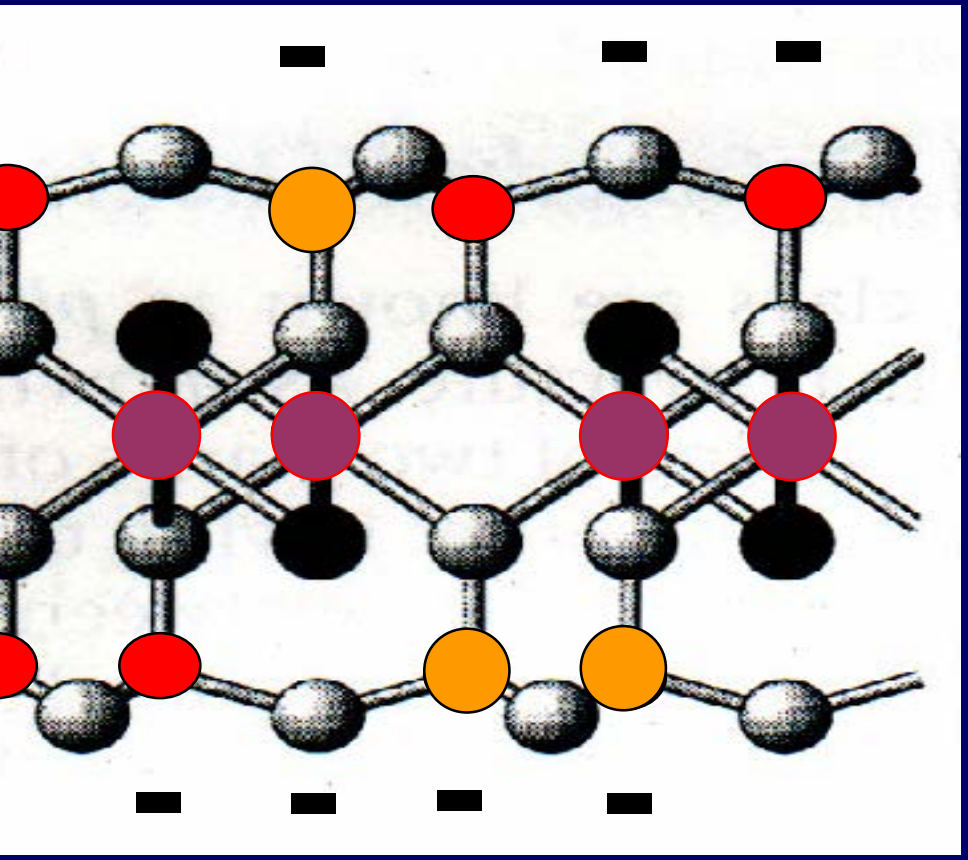
Isomorphous substitution

Within the silica tetrahedron and aluminum octahedron



What ions are present in the soil water solution is determined by the PM and the weathering environment.

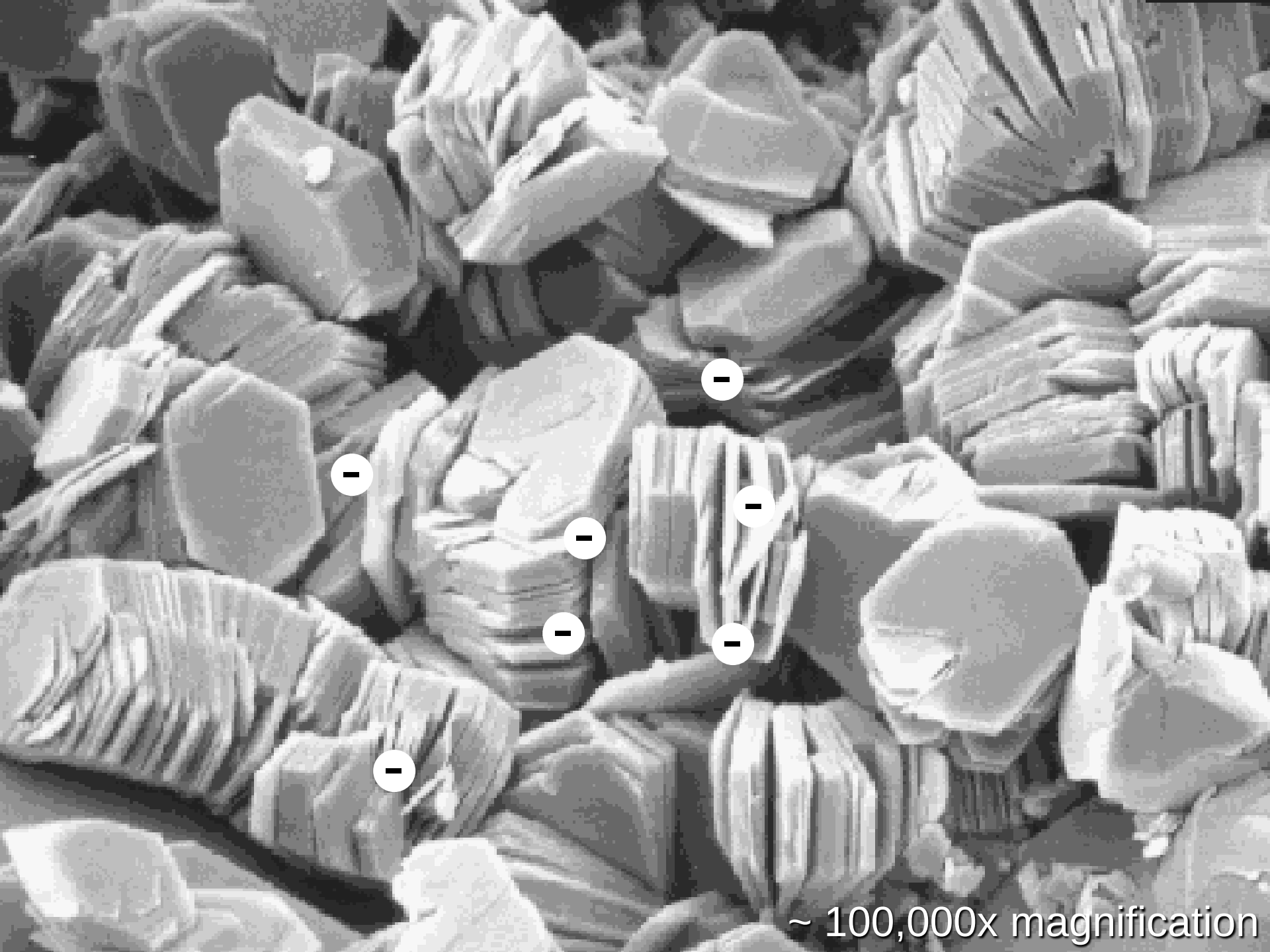
Isomorphic Substitution… a source of negative charge in soils!

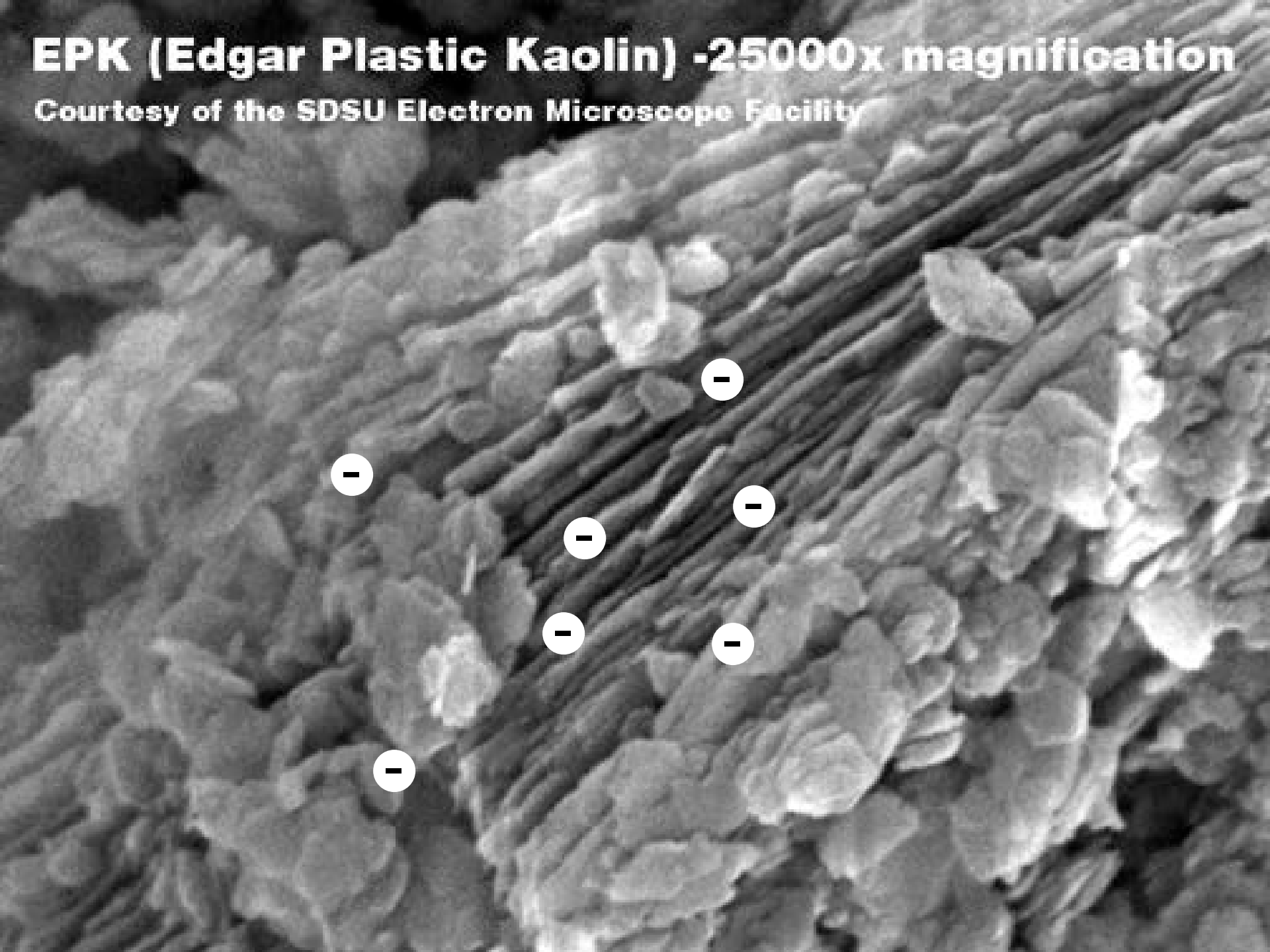


Silica Tetrahedral sheet

Aluminum Octahedral sheet

Silica Tetrahedral sheet

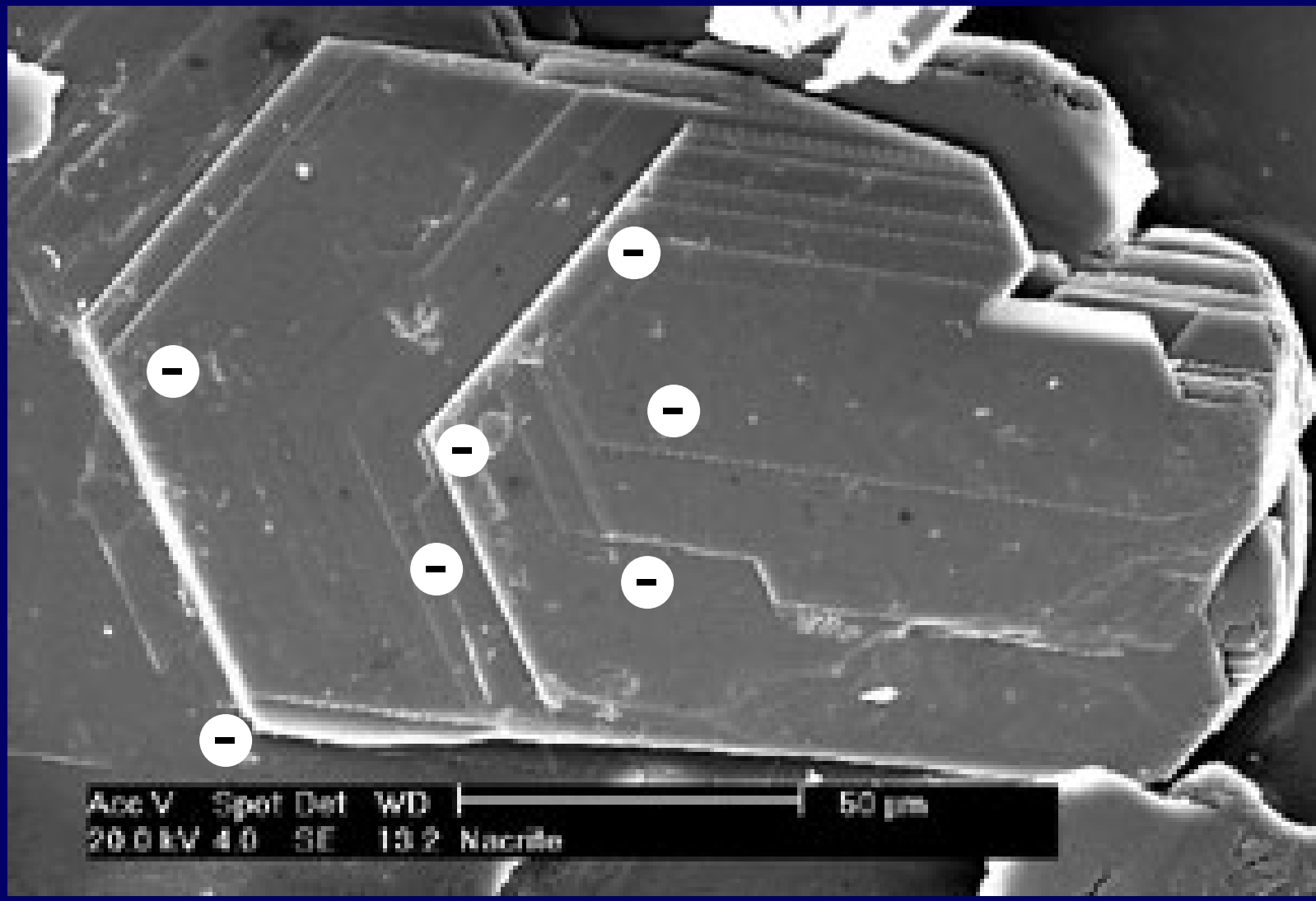

~ 100,000x magnification


EPK (Edgar Plastic Kaolin) -25000x magnification
Courtesy of the SDSU Electron Microscope Facility

Fibrous illite (a clay mineral) in Tordillo sandstone, Neuquen basin, west-central Argentina

Nacrite, Lodève Basin, France

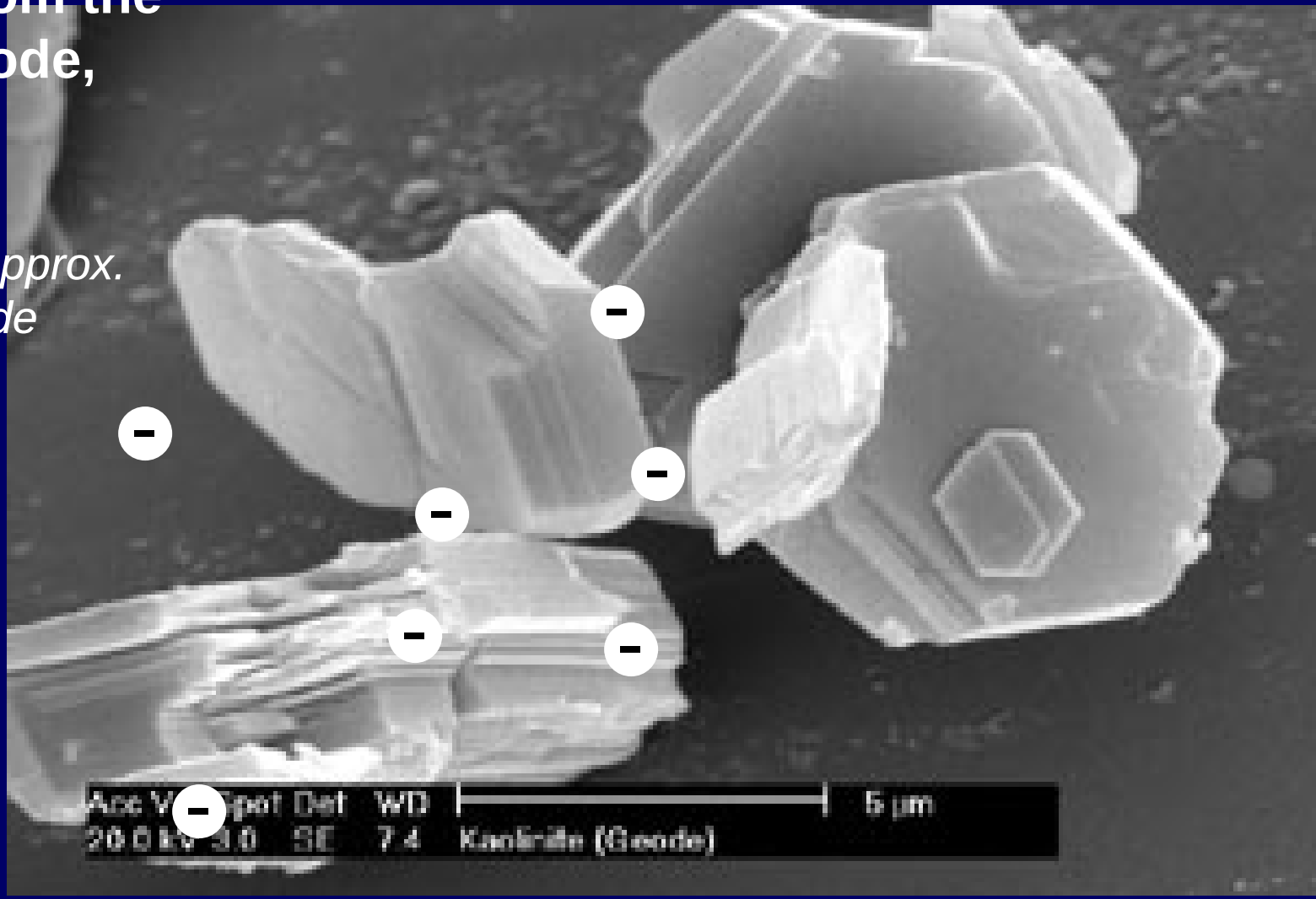
Field of view approx. 200 microns wide

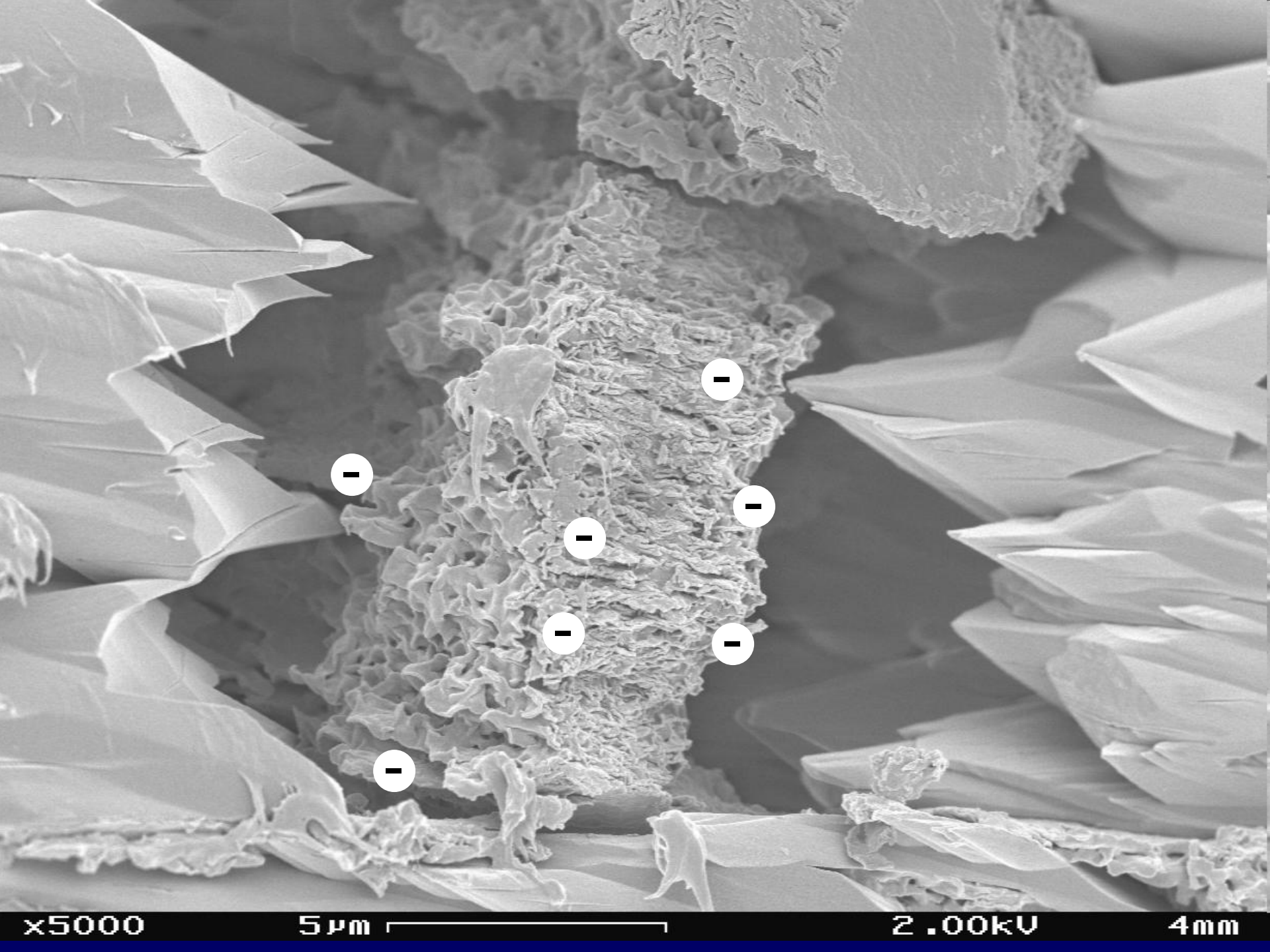


Kaolinite

Well crystallized kaolinite from the Keokuk geode, USA

Field of view approx. 18 microns wide




x5000
5µm
2.00kV
4mm

…net negative charge due to isomorphic substitution on the secondary mineral called clay!!!

Clay

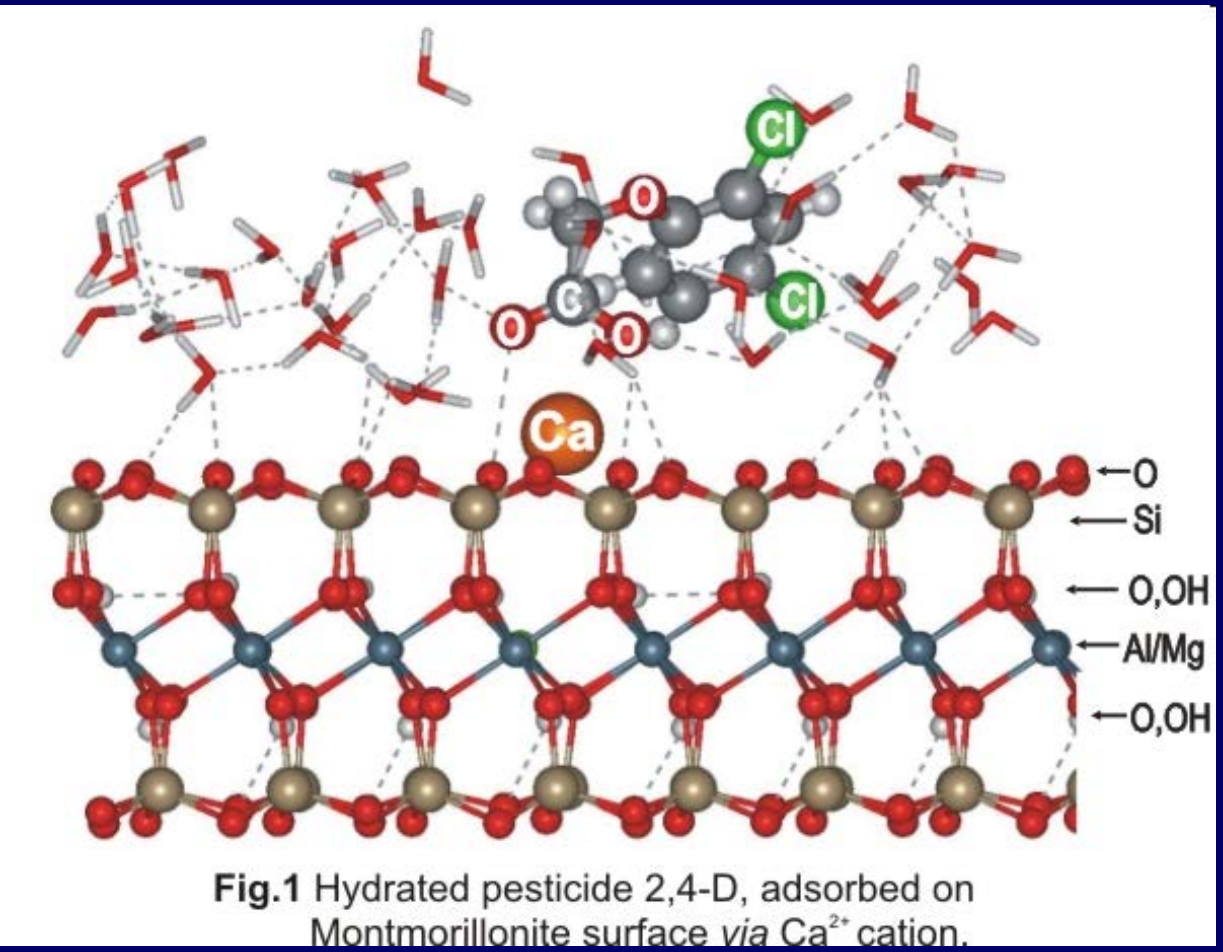
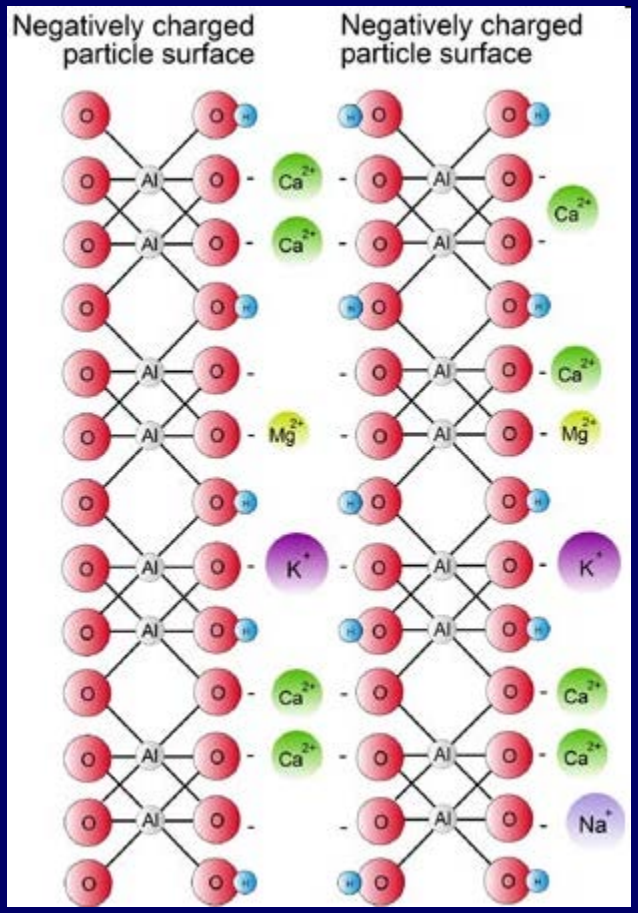


Fig.1 Hydrated pesticide 2,4-D, adsorbed on Montmorillonite surface *via* Ca^{2+} cation.



http://virtual-museum.soils.wisc.edu/soil_smectite/index.htm

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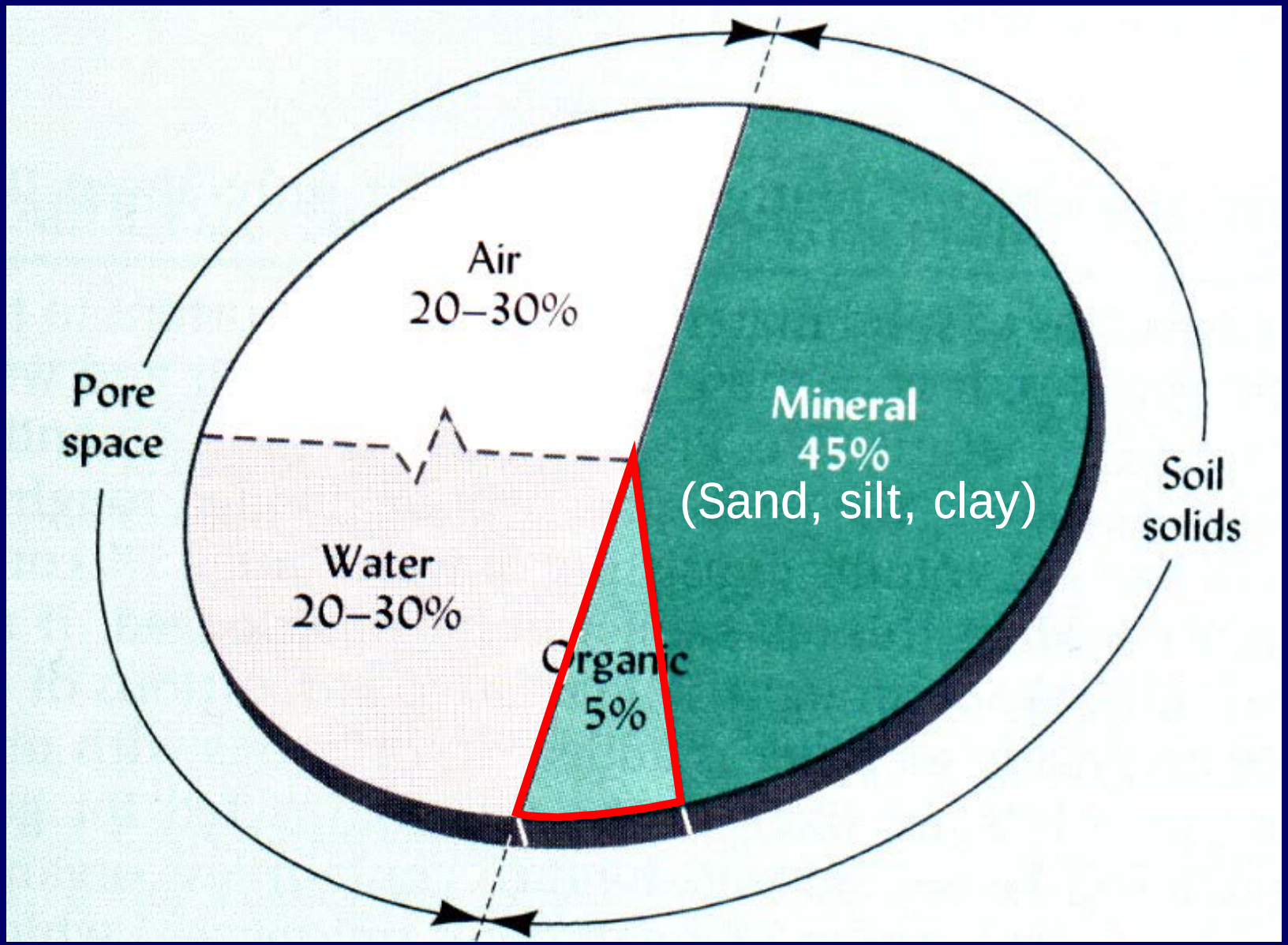
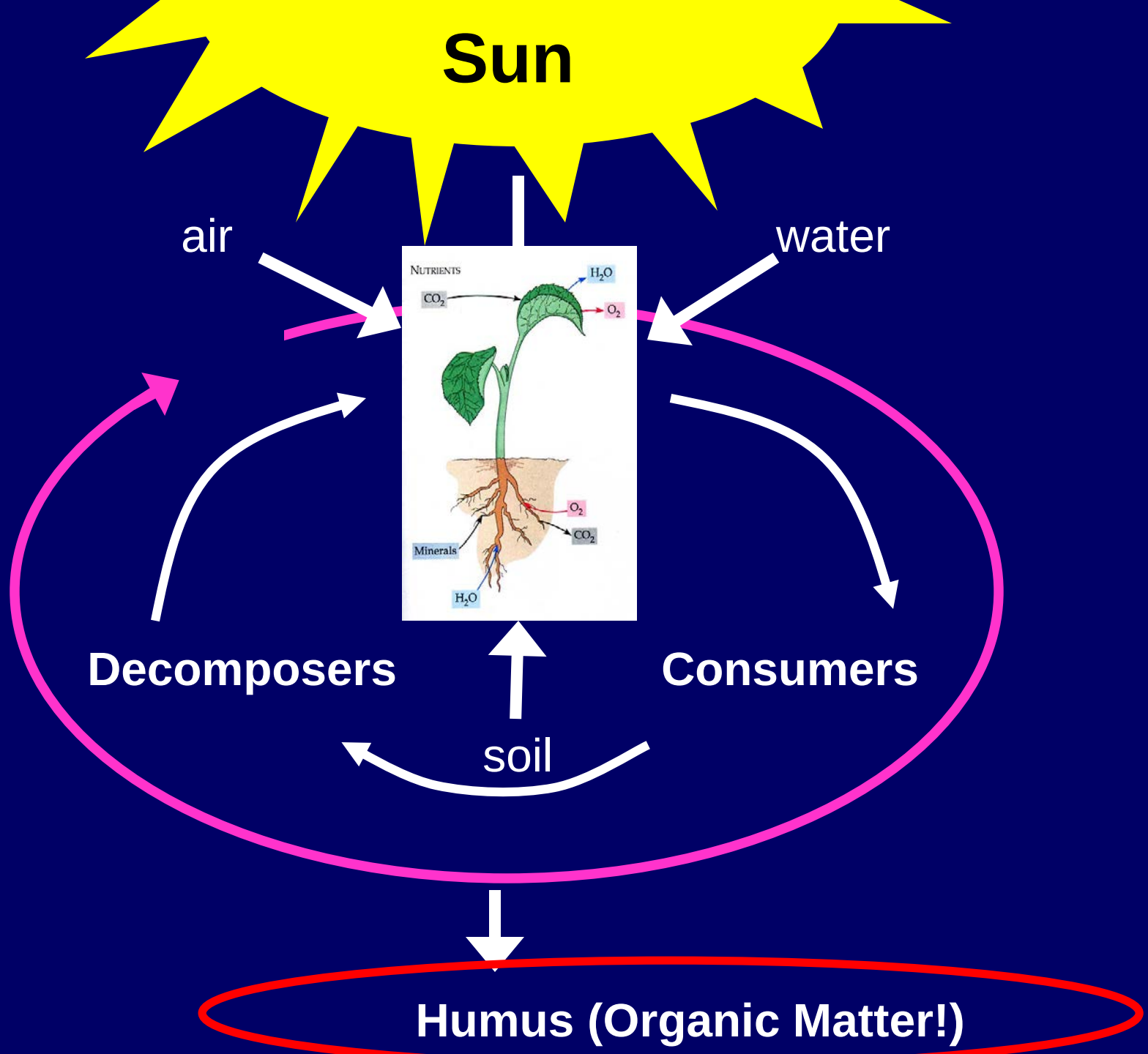
- **Decomposed Organic Matter**

What is Organic Matter?

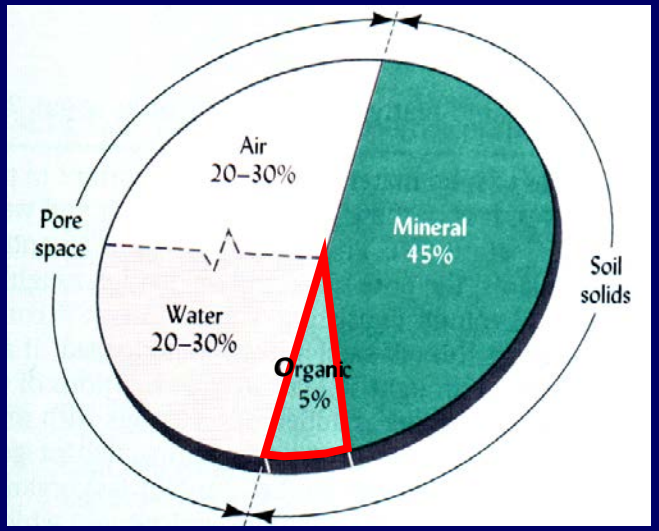



Sun
air
water
Nutrients
H_2O
CO_2
O_2
O_2
CO_2
Minerals
H_2O
Decomposers
Consumers
soil
Humus (Organic Matter!)

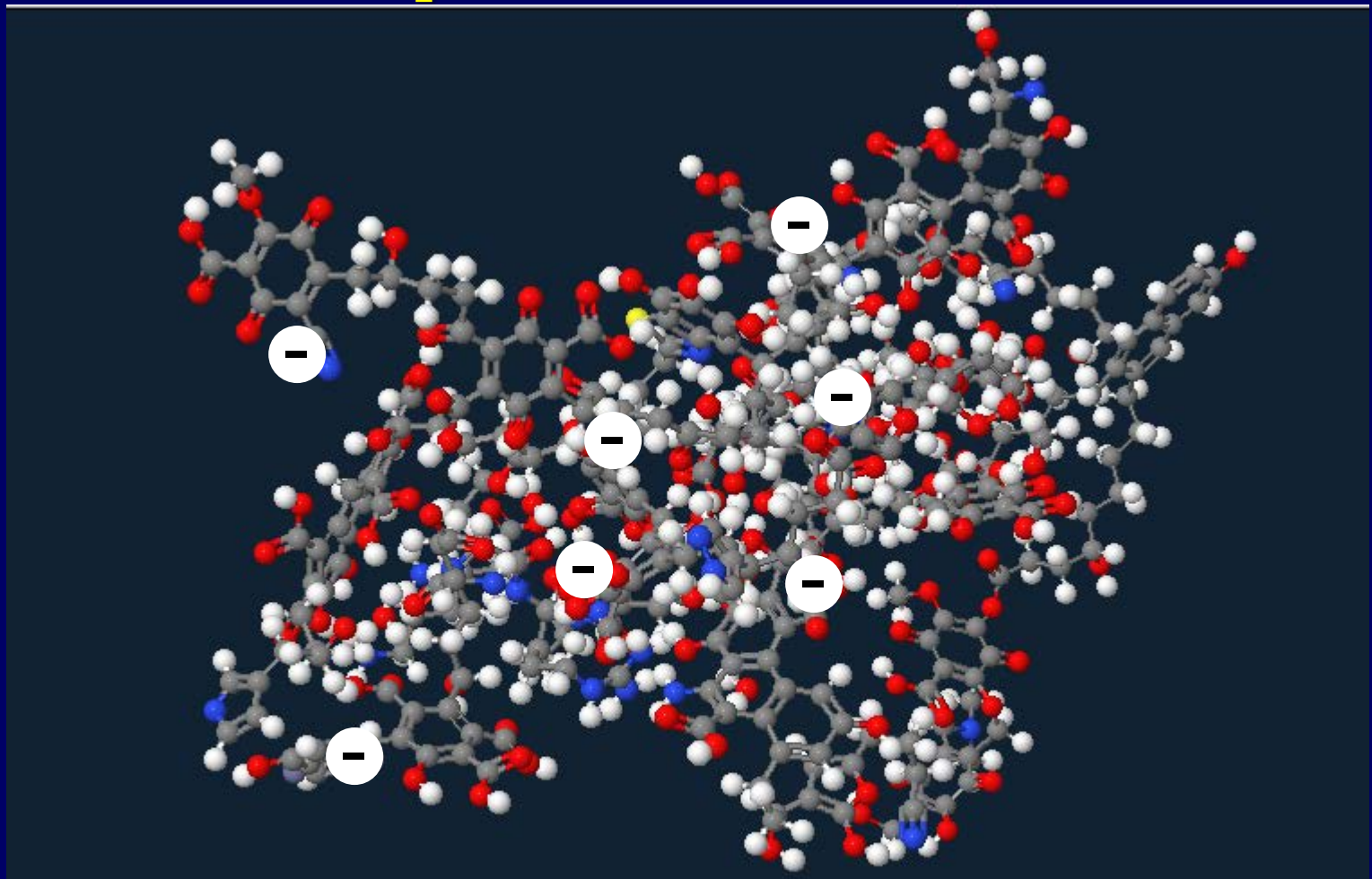
Functions of Organic Matter

Organic Matter

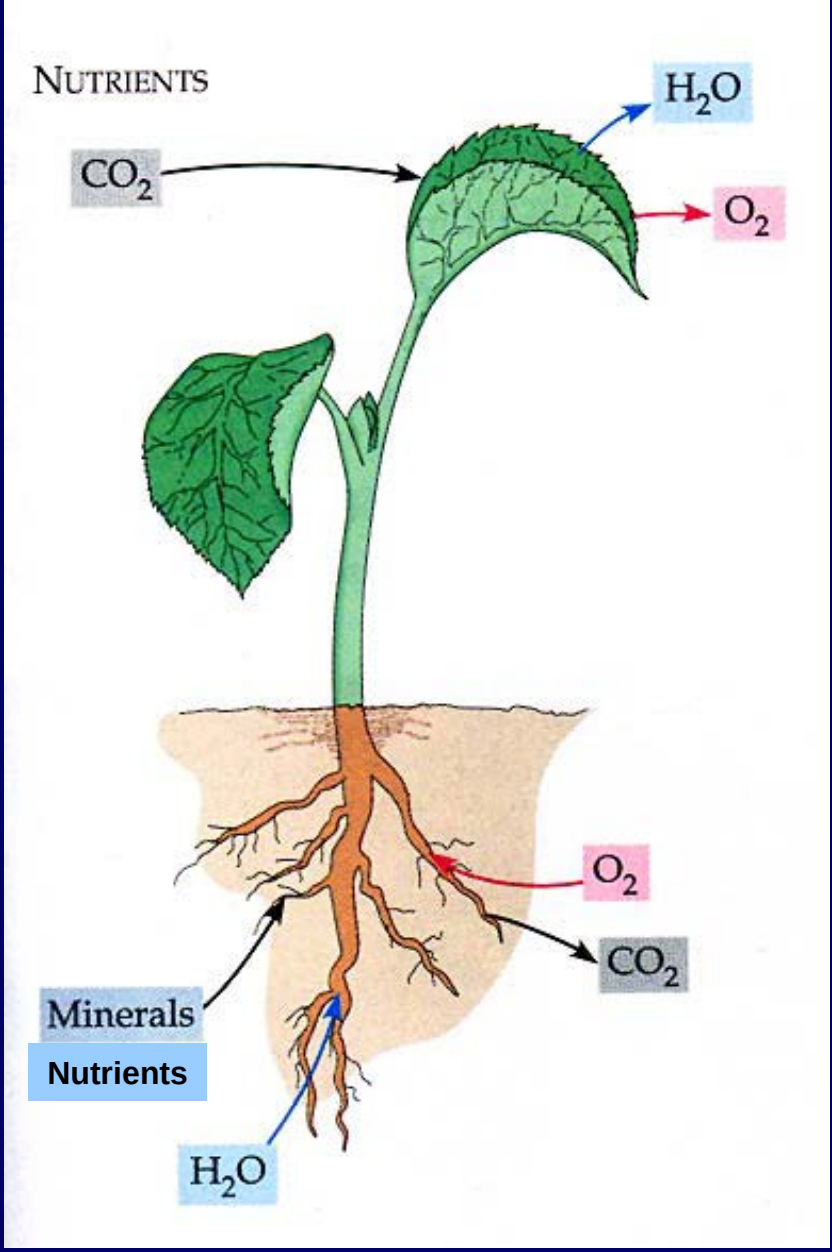
…provides another source of charge in soils – twice that of clay!



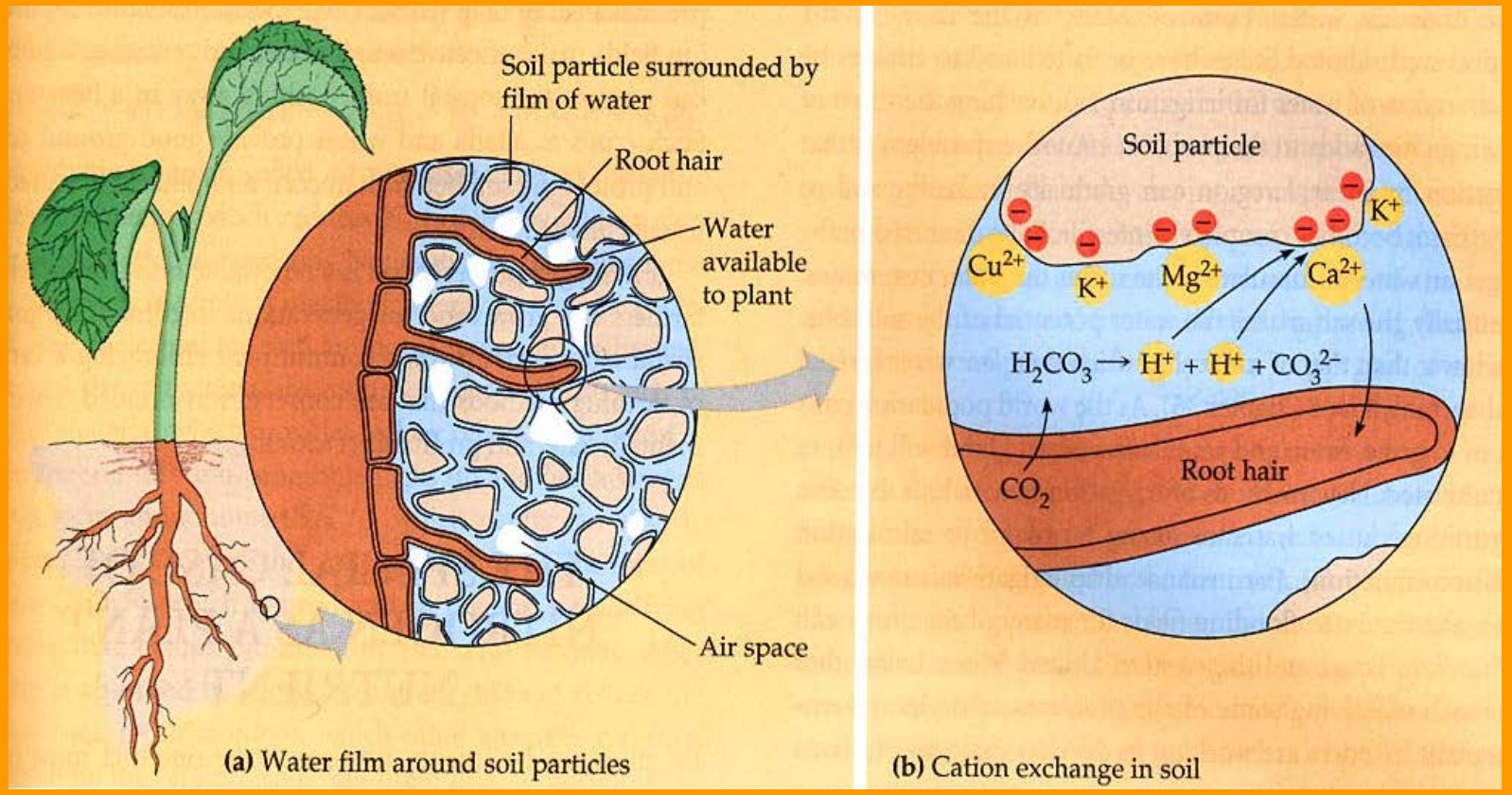
Organic Matter – a random complex molecule!

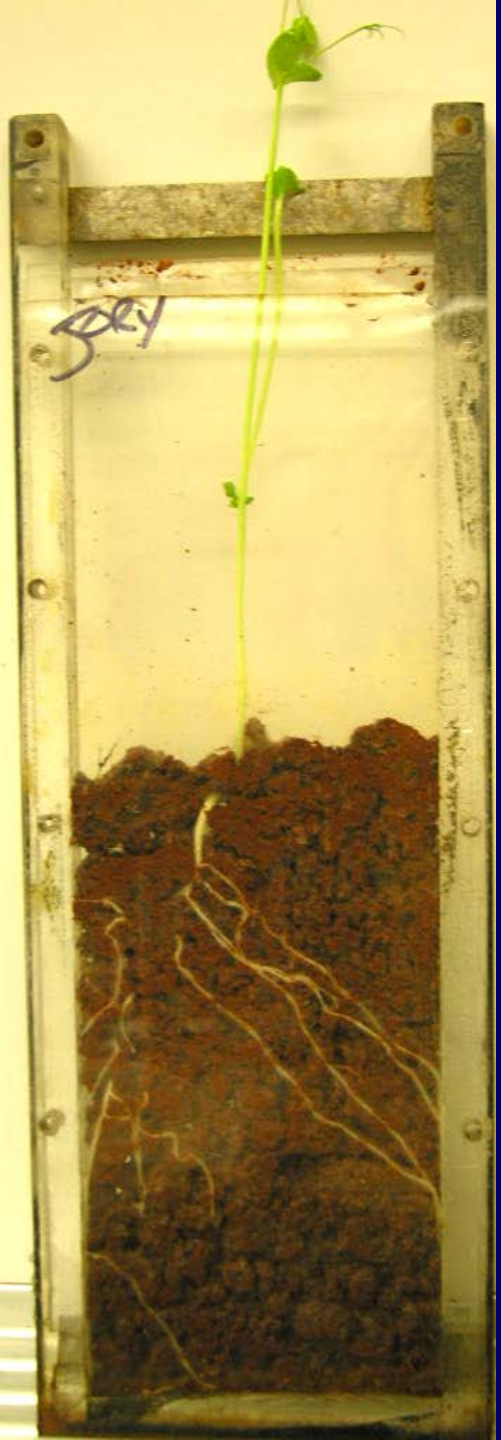


How a plant works



How a plant works




Grey

Soil the foundation of nutrition

2015 International Year of Soils

fao.org/soils-2015

Promote plant growth

Improves winter hardiness

Involved in photosynthesis

Increases disease resistance

Reduces plant respiration

Promotes root formation and growth

Increases water-use efficiency

Stimulates microbial activity

Promote nodule formation on legumes

Involved in carbohydrate metabolism and translocation of starches

Promote reproduction

Aid translocation of photosynthesis from leaves to fruiting organs

Acts as an O_2 carrier

Fruit formation

Quickens maturity

Fruit quality

Fruit flavour

Seed formation

Seed quality

Enhances maturity of small grains

Aids in enzyme functionality and plant use of Fe and P

Responsible for enzyme activity

Helps enzyme activity and increases the availability of P and Ca

Role of 18 nutrients necessary for plant growth and human health

Plays a key role in brain and muscle function

Contributes to perception of taste

Needed for immune system health

Key component of protein

Essential for muscle and nerve activity

Important in immune system health, blood clotting and pressure regulation

A component of proteins, DNA, RNA and blood

Promotes digestive process

Maintains acid-base balance

Needed for proper fluid balance

Essential to fetal development and functioning of reproductive system

Key component of enzymes

Helps deliver oxygen to the tissues

Important for healthy bones

A component of enzymes, DNA, RNA, proteins and promotes immune system health

A component of enzymes and involved in Fe metabolism

Soil degradation leads to the **loss** of **soil micro** and **macronutrients**

Nutrient-poor soils are **unable** to **produce healthy food** with all the **necessary nutrients** for a **healthy person**

Over **2 billion people** suffer from micronutrient deficiencies

O OXYGEN

C CARBON

H HYDROGEN

Cl CHLORINE

Si SILICON

Mg MAGNESIUM

P PHOSPHORUS

K POTASSIUM

Ca CALCIUM

Mo MOLYBDENUM

Na SODIUM

S SULPHUR

N NITROGEN

B BORON

Fe IRON

Zn ZINC

Cu COPPER

Mn MANGANESE

Soil macronutrients

Soil micronutrients

Sustainable soil management for **healthy soils, healthy food and healthy people**

Reduce erosion

Ensure crop rotation

Keep soil surface covered

Minimize tillage

Increase soil organic matter content

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Food and Agriculture Organization of the United Nations

With the financial support of the Russian Federation

Healthy soils for a healthy life

ADD ORGANIC MATTER!!!

- Reservoir of plant nutrients
- Food/energy source for soil organisms
- Provides cation exchange capacity (200 cmol/kg)
- Increases water-holding capacity
- Decreases Al toxicity at low pH
- Improves soil structure (but doesn't change soil texture)
  - Positive effects on physical characteristics: infiltration, drainage, aggregation potential, pore-size distribution, available water holding capacity, erosion potential, deep water storage, diverse habitat, increased function
  - Positive effects on soil chem: buffers for neutral pH, increases nutrient availability, increased vegetation…increasing organic matter…

Find out more about your soil!

Soil plug-in for Google earth

California Soil Resource Laboratory

SoilWeb Earth

And this too!

https://casoilresource.lawr.ucdavis.edu/see/

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