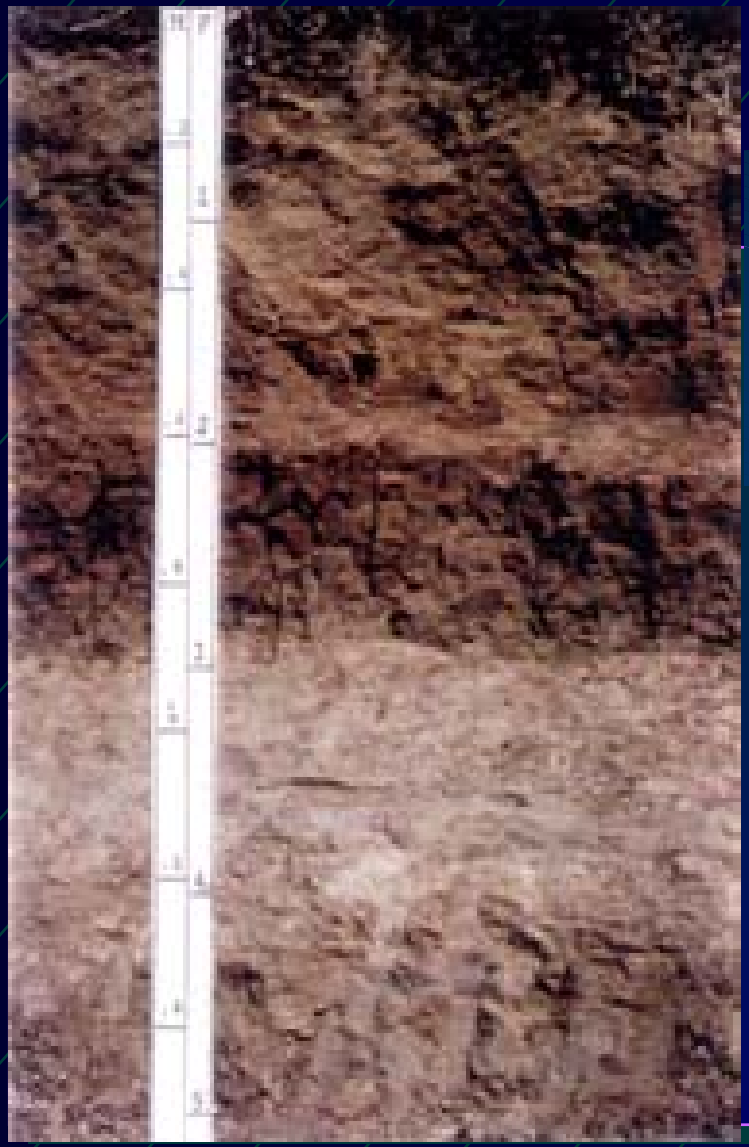
GES175, Science of Soils

Lecture 11

K, Mg, Ca, Micronutrients, and Metal Contaminants



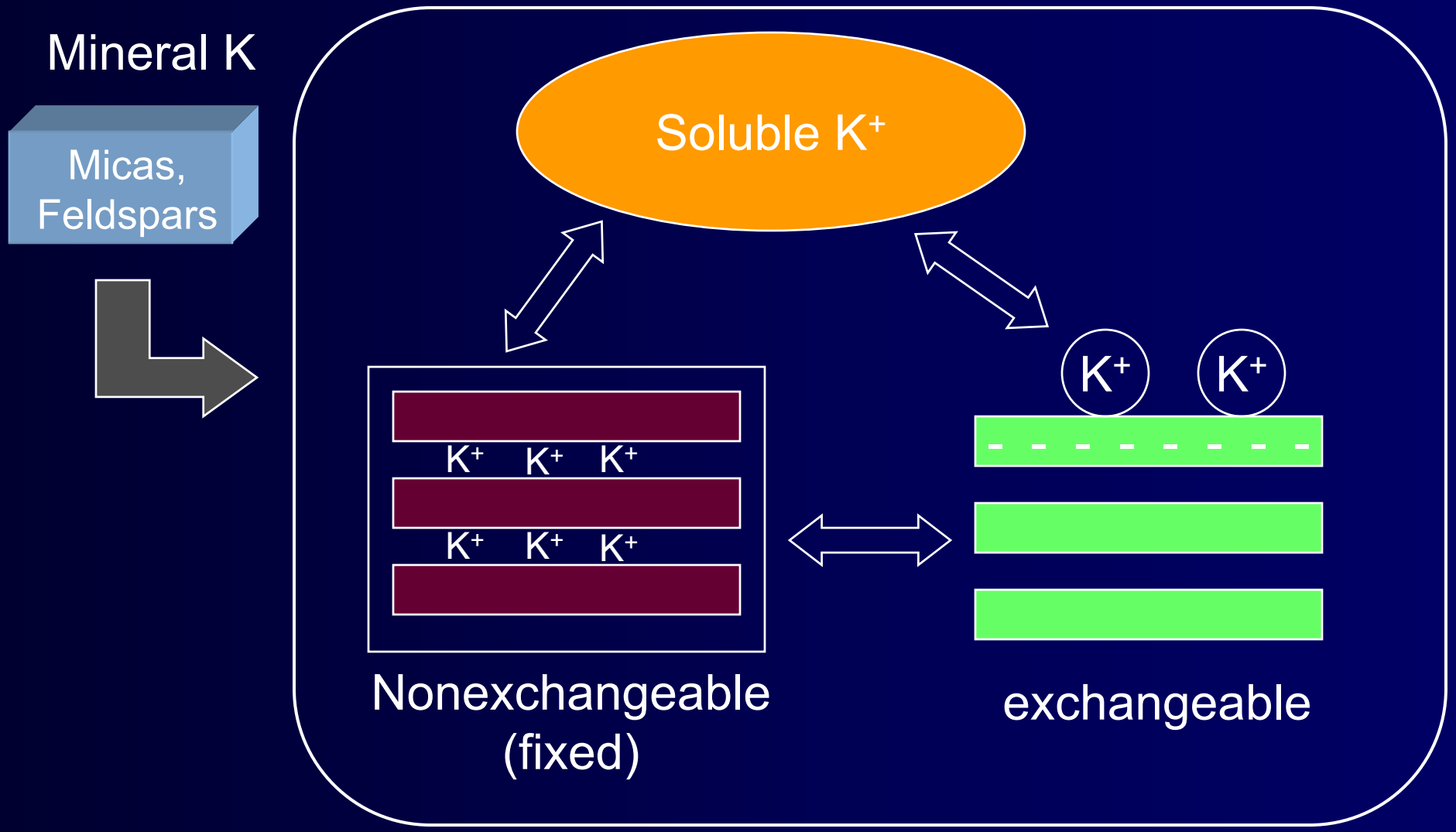
Soil:
Natures Filter and Storage Bank

Fine, mixed, active, thermic
Abruptic Durixeralfs

K^+, Ca^{2+}, Mg^{2+}

- Derived from weathering of primary minerals
- Ca and Mg usually in ample supply.
    -Balance of Ca:Mg is important
- K often needed as supplement (fertilizer)
- Typically held by electrostatic forces (not chemically reactive) and are thus exchangeable
    -Exceptions are K-vermiculite/illite and Ca,Mg-carbonates
- K fixation by clays can severely limit availability

K-Cycle


Mineral K
Micas, Feldspars
Soluble K+
K+ K+ K+
K+ K+ K+
K+ K+
Nonexchangeable (fixed)
exchangeable

K Fertilizer Rating

- N-P-K
  - K as K_2O!
  - $\%K = \%K_2O * 0.83$
- Fertilizers
  - Potassium Chloride (KCl): 0-0-63
  - Potassium Nitrate (KNO_3): 13-0-44
  - Potassium Sulfate (K_2SO_4): 0-0-50 (-22)

Macronutrients

C, H, O, Ca, Mg, K, S, P, N

Micronutrients

Fe, Mn, Cu, Zn, B, Mo, Cl, Co

Se (animals), Si (beneficial), Ni (beneficial),

Metal(loid) Contaminants

Cu, Zn, Mo, Ni, Cr, Hg, Pb, As, Se

Radionuclide Contaminants

U, Cs, Co, Pu, Tc, I

Plant Deficiency vs Toxicity

Examples of Values

Plant Tissue Concentration in mg/kg or ppm

Element	Deficient	Sufficient	Toxic
Zn	<15	15-150	>250
Mn	<25	25-200	>250
Cu	<4	5-20	>20
B	<20	20-50	>100

Soil Forms

$Fe = Fe^{2+}, Fe^{3+}$

$Mn = Mn^{2+}$

$Cu = Cu^{2+}$

$Zn = Zn^{2+}$

$Co = Co^{2+}$

$Ni = Ni^{2+}, Ni^{3+}$

$Pb = Pb^{2*}$

$Hg = Hg^{2+}, Hg^{o}$, organic-Hg

$Mo = MoO_4^{2-}$

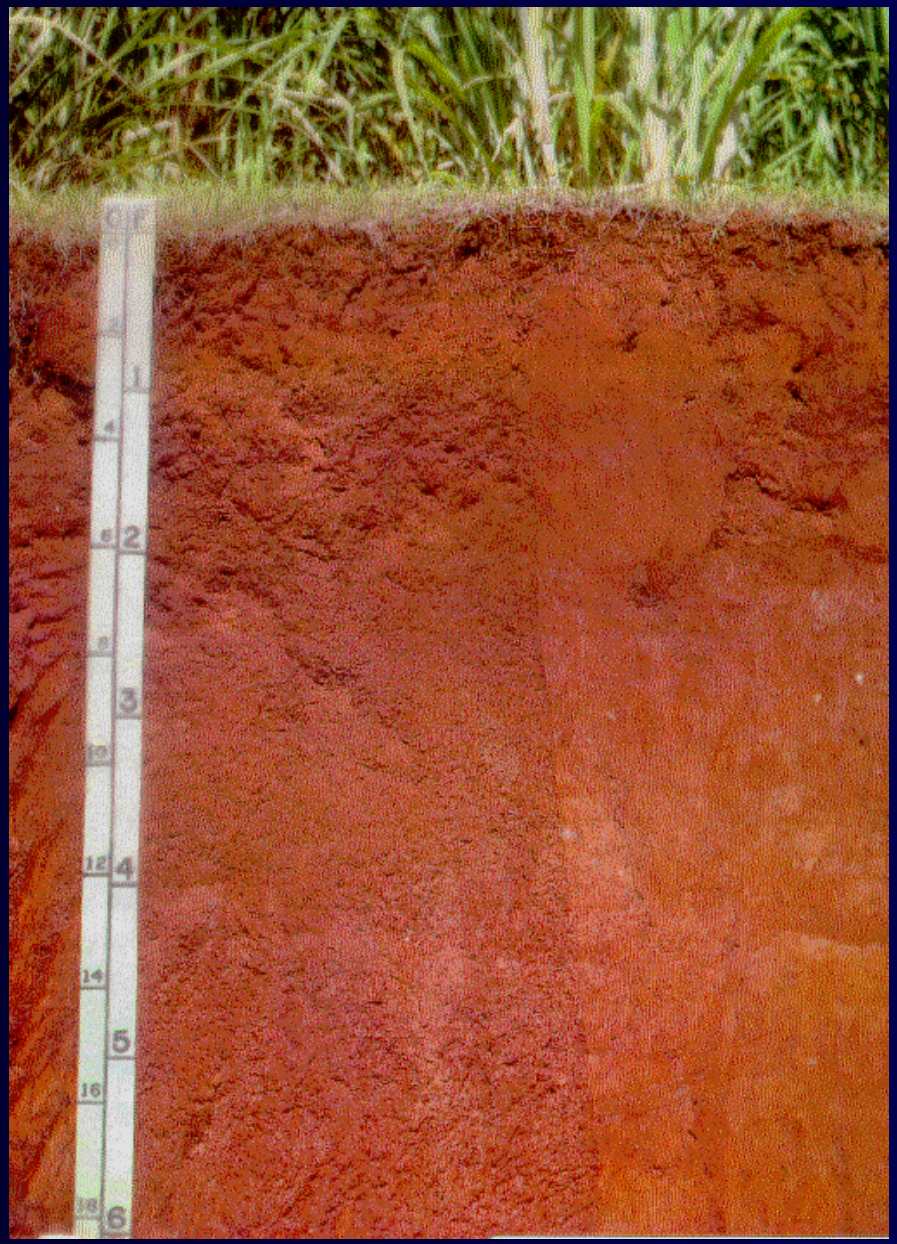
$B = H_3BO_3$

$Cl = Cl^{-}$

$Se = SeO_4^{2-}, SeO_3^{2-}, Se^{o}, H_2Se$

$As = AsO_4^{3-}, AsO_3^{3-}, (As_2S_3, FeAsS)$

Silver Valley & Bunker Hill Smelter: toxic metals released to soils



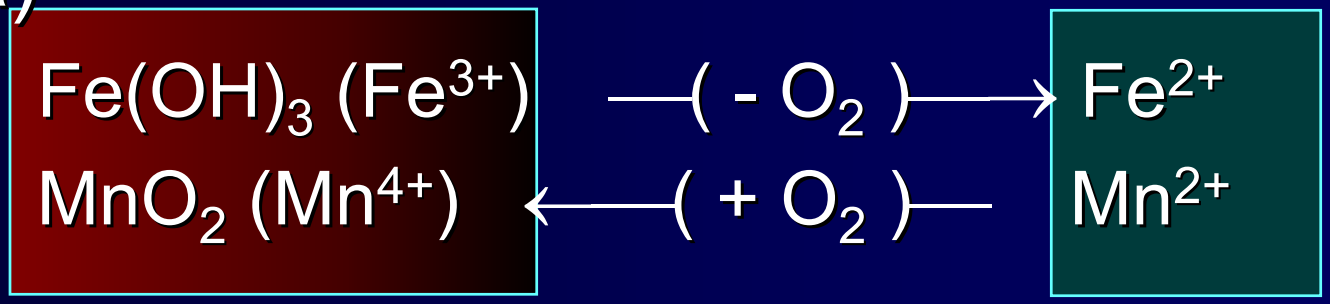
Nutrient and Contaminant Retention

Importance of Metal Oxides

Redox Conditions

Role of Fe & Mn:

(a)

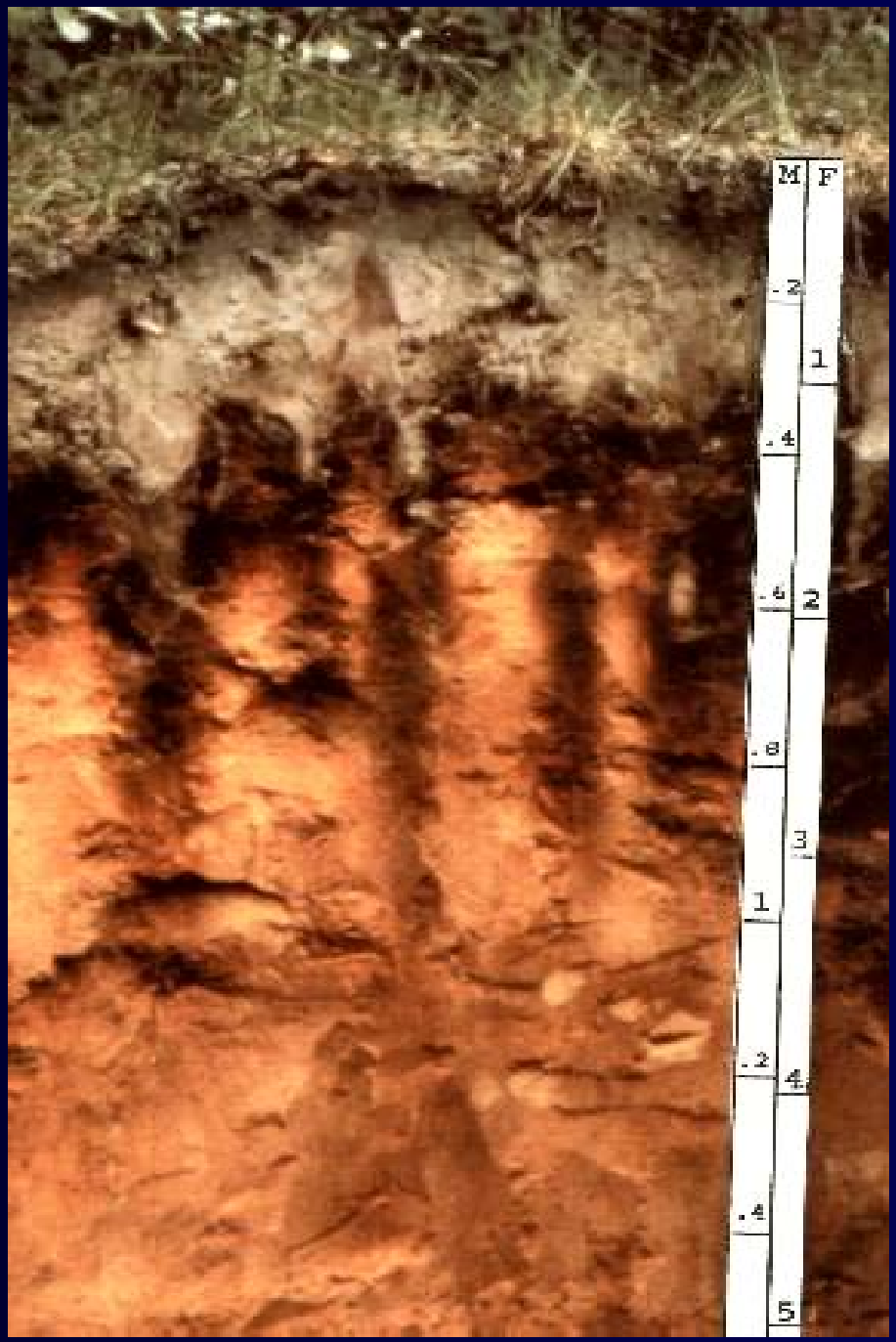


oxidized form
insoluble

reduced form
more soluble

- primary adsorbents

Reductive Dissolution

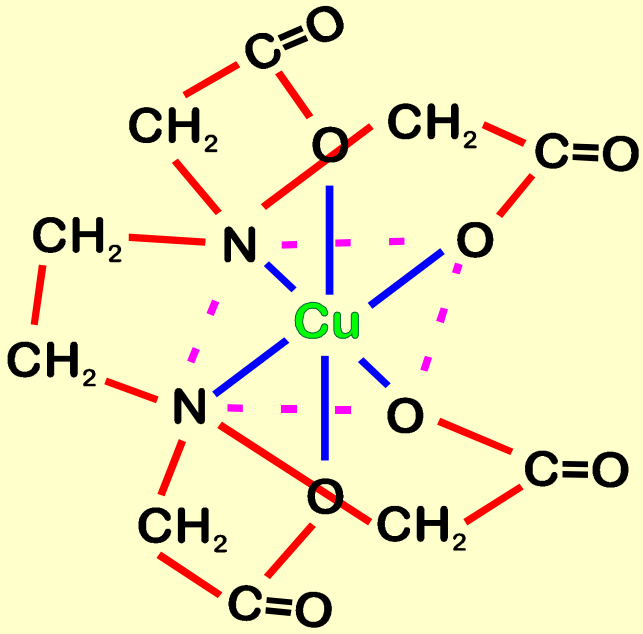


Organic Ligand Promoted Dissolution

Role of Metal Chelating Agents

Chelates = ligand forming multiple bonds with metal

EDTA is a common synthetic chelate



$(CuEDTA)^{-2}$

Role of Metal Chelating Agents

Chelates keep cations in solution

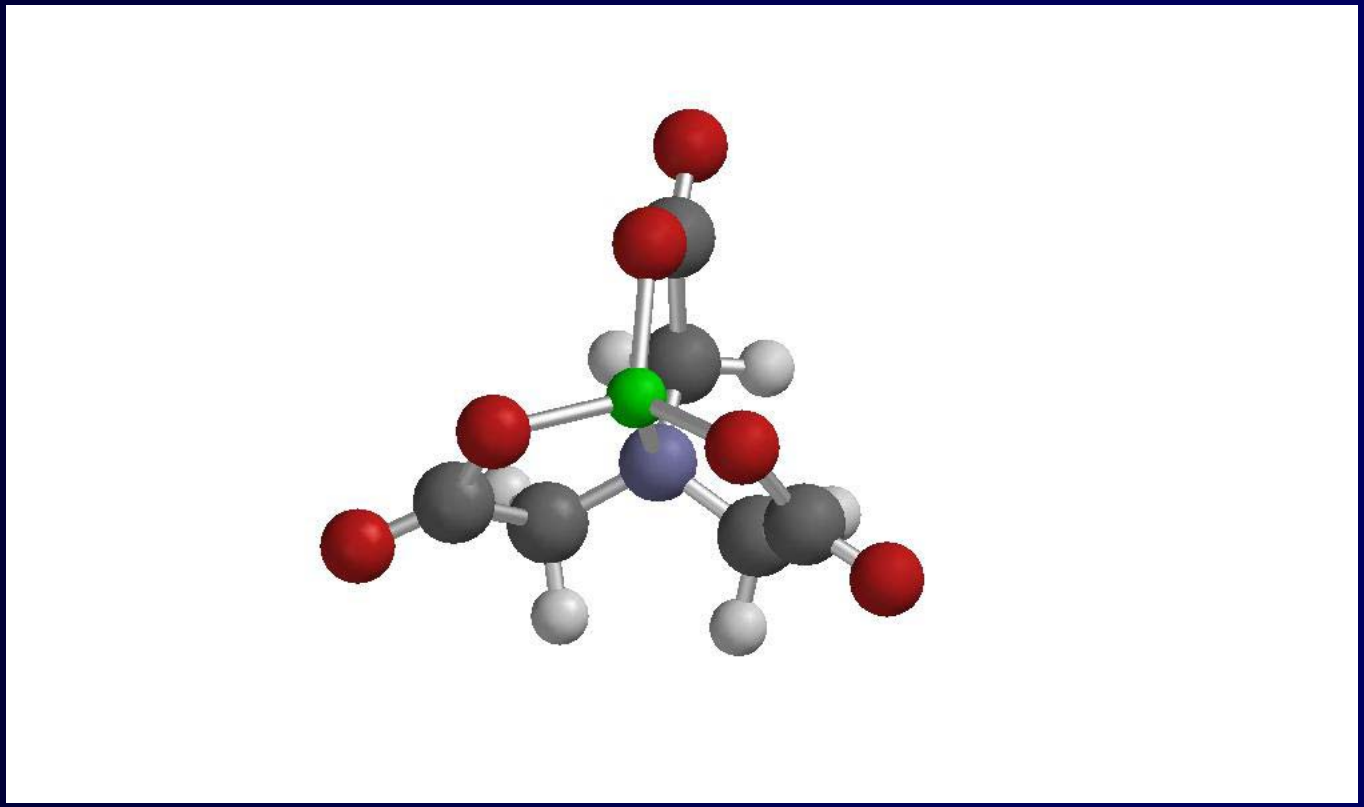
$Fe^{3+} \longrightarrow Fe(OH)_3$

$(FeEDTA)^{-1} \longleftarrow Fe(OH)_3$

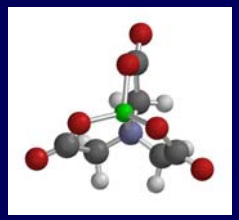
soluble (mobile) — insoluble

Naturally occurring organic chelates

- fulvic acid
- citric acid
- oxalic acid
- acetic acid
- ascorbic acid



Co-NTA



Acid Promoted Dissolution