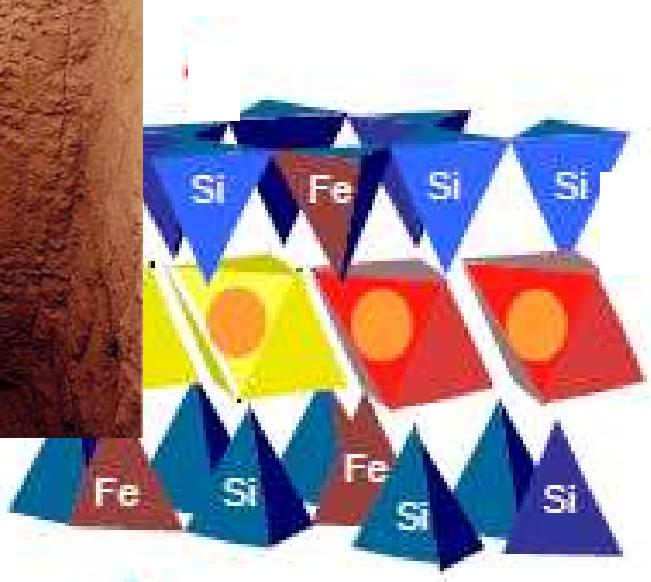


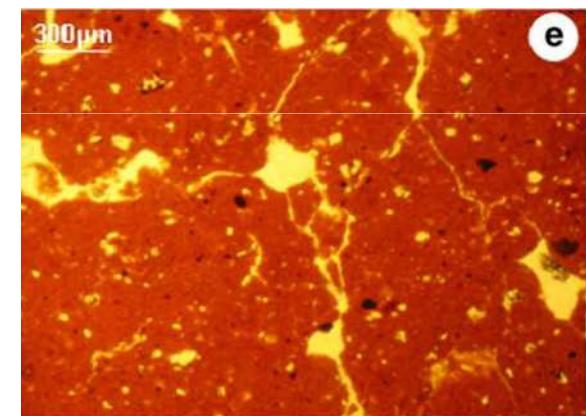
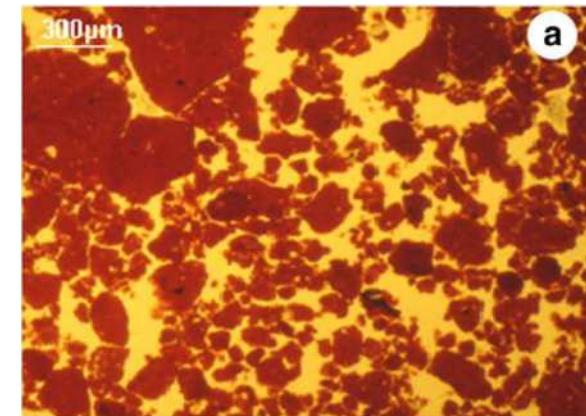
Le sol: les constituants, leurs propriétés.



Thierry BECQUER
IRD, UMR Eco&Sols

thierry.becquer@ird.fr

Constituants des sols.



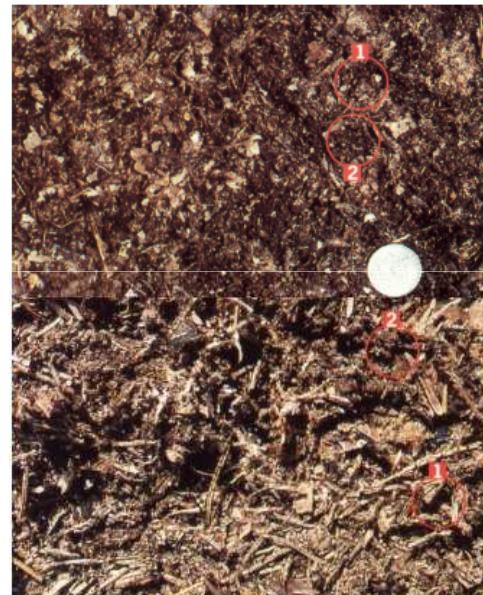
Sol : un milieu multiphasique, dans lequel se développent et vivent les racines des plantes

- ✓ organismes
- ✓ Liquide 20-30 % (vol.)
- ✓ Gaz 20-30 %
- ✓ Solide 50-60 % (45-50 % minéral, 5-10 % organique)

Constituants organiques des sols : Evolution d'une litière (hor. O)



litière s.s. (OL)



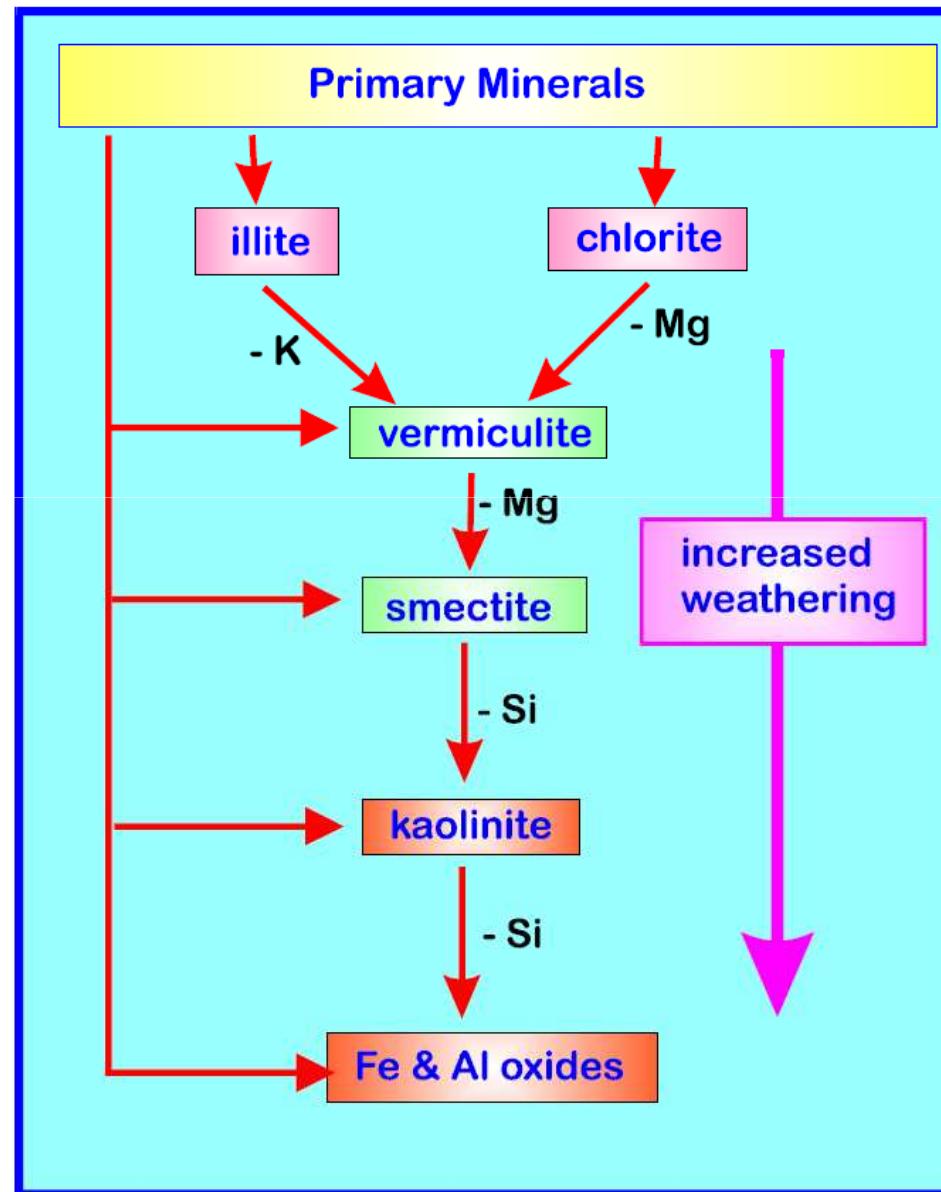
litière
fragmentée
(OF)



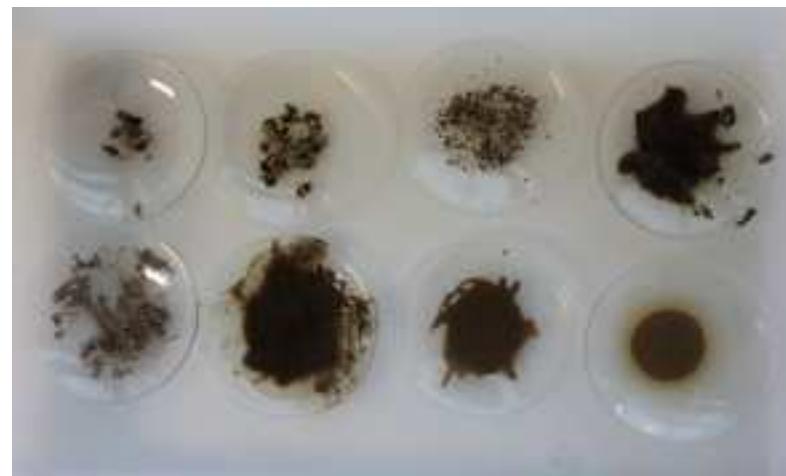
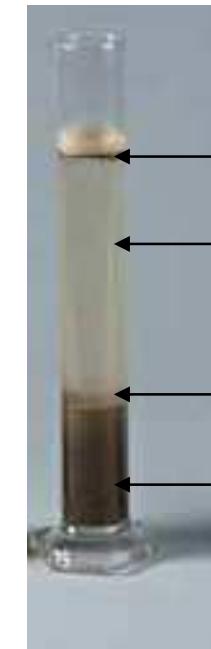
litière
humifiée
(OH)

⇒ différents types d'humus

Constituants minéraux des sols : Evolution en fonction du degré d'altération

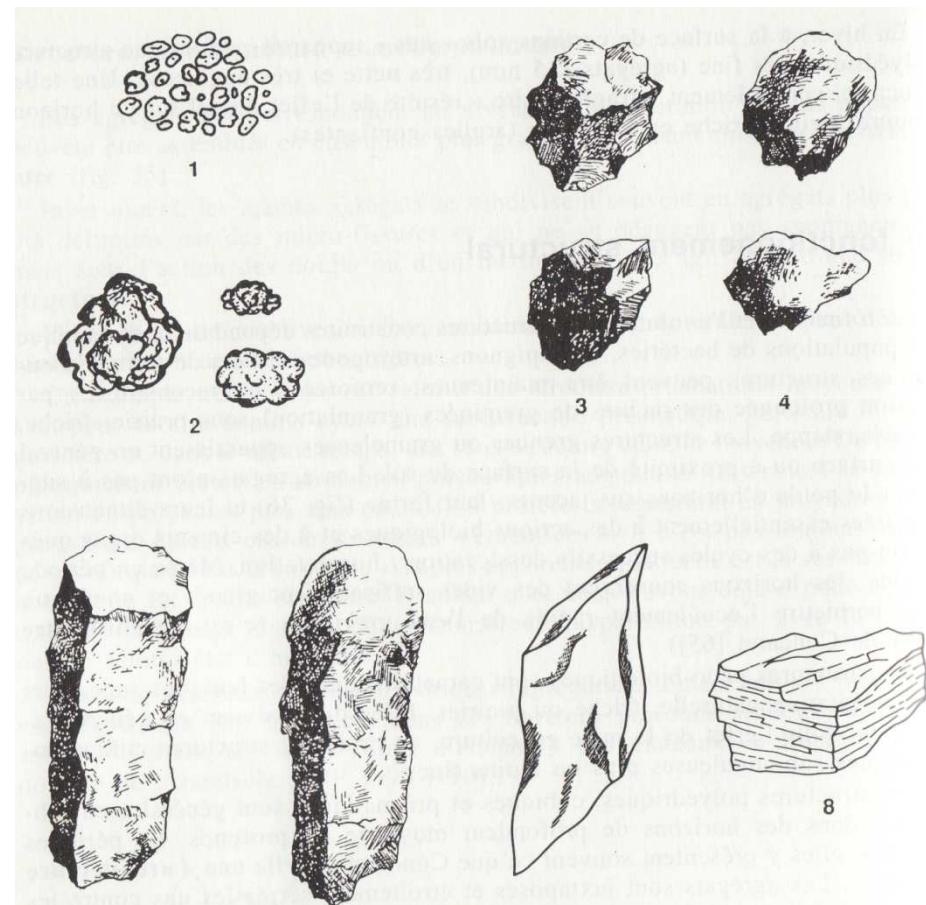
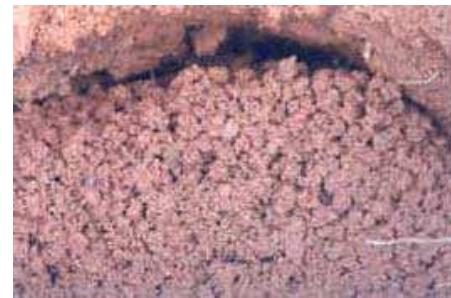


Les constituants du sol : texture



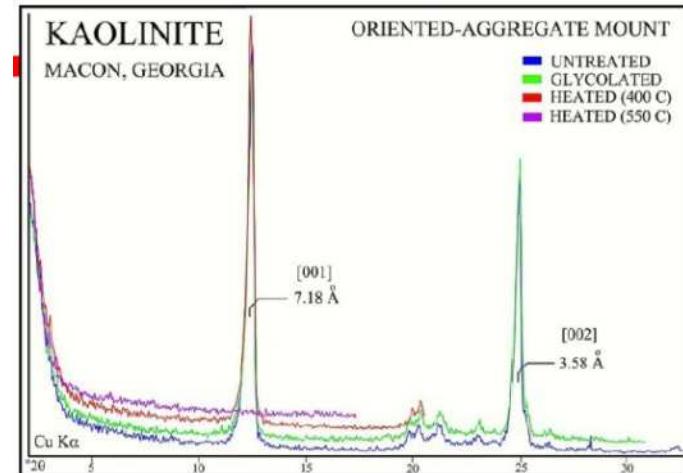
Source : <http://www.svt.ac-versailles.fr/spip.php?article590>

Les constituants du sol : structure

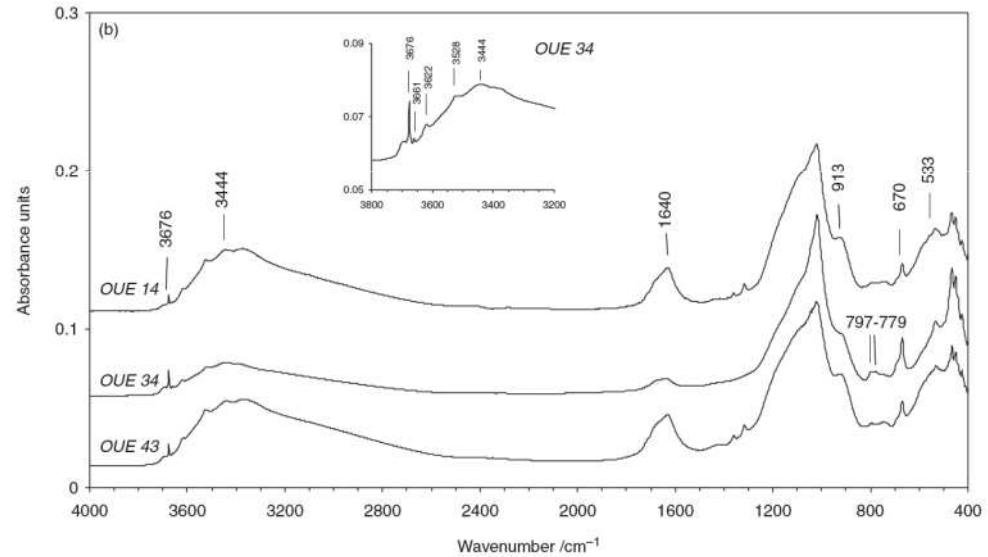


Caractérisation

□ DRX



□ Spectrométrie IR



□ Analyses chimiques

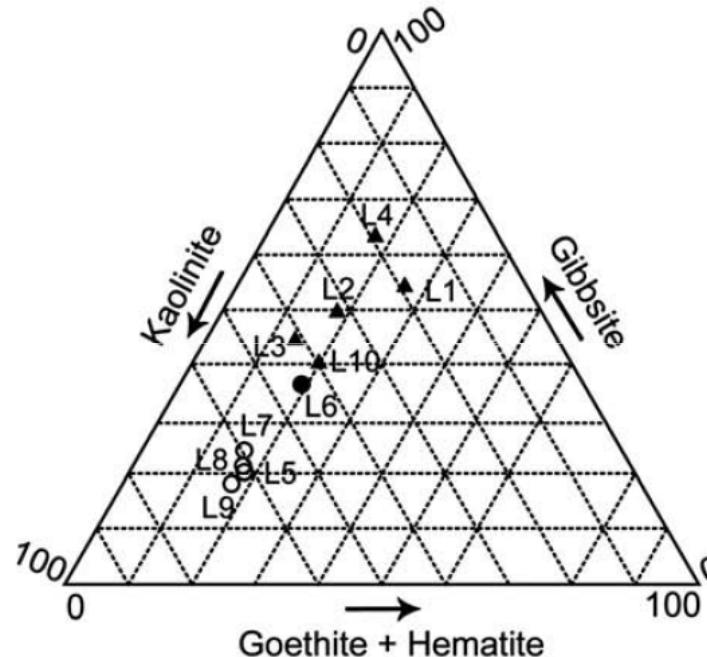
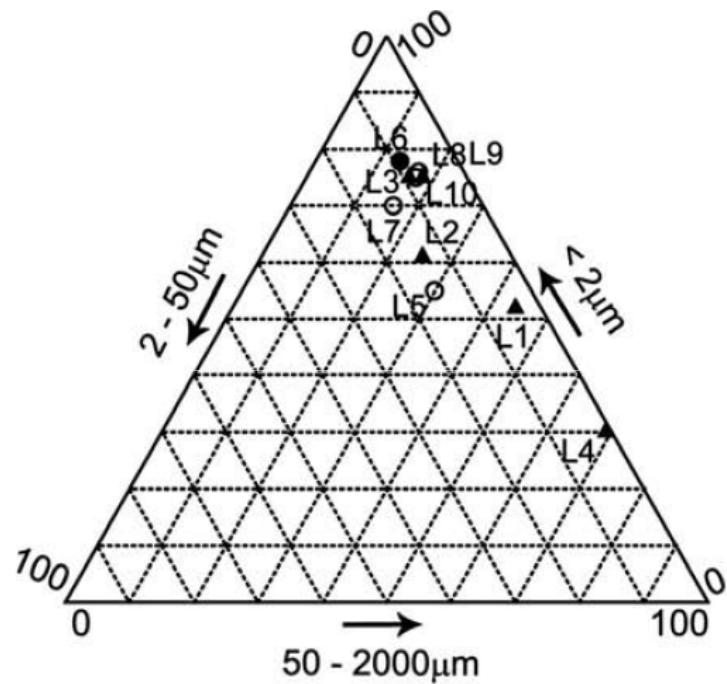
- ✓ Ataque totale
- ✓ Ataque sulfurique

Abondance

Attention pour les "argiles":
Granulométrie

vs

Minéralogie



Reatto et al., 2009,
Catena, 76, 122-134

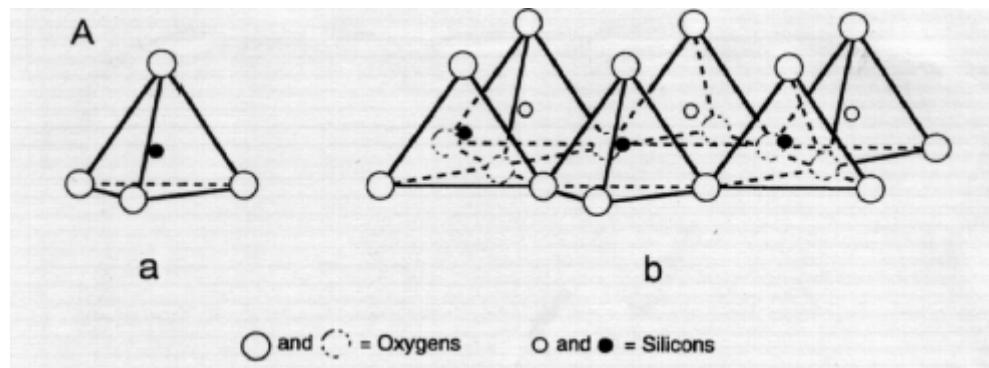
Principaux groupes minéralogiques

- Argiles minéralogiques (phyllosilicates)
 - ✓ Argiles 1/1 (T-O) (kaolinite)
 - ✓ Argiles 2/1 (T-O-T) (micas, vermiculites, smectites)

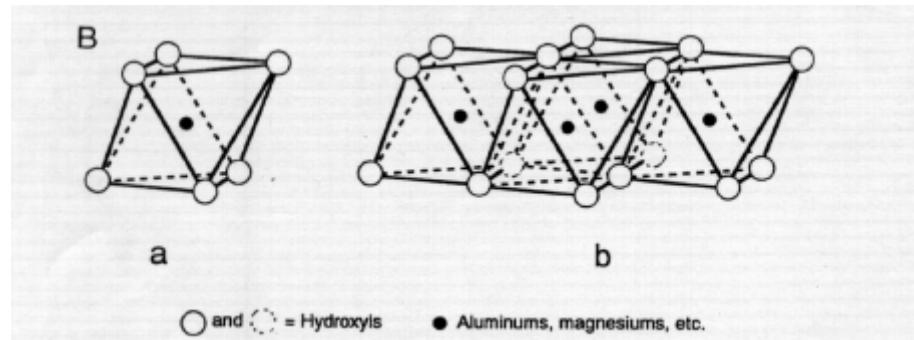
- Oxydes
 - ✓ Oxydes de Fe
 - ✓ Oxydes d'Al
 - ✓ Oxydes de Mn

Argiles : structures de base

□ Couche tétraédrique (T)



□ Couche octaédrique (O)



Couche **dioctaédrique**

2 sites sur 3 occupés par (Al^{3+})



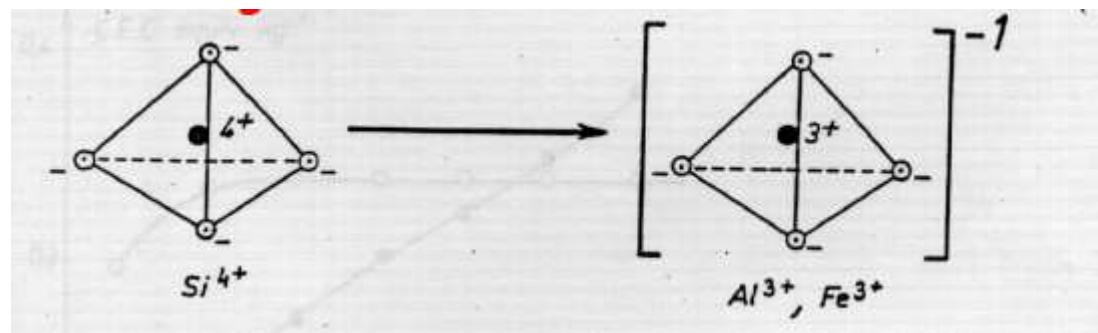
Couche **trioctaédrique**

3 sites sur 3 occupés par (Mg^{2+})

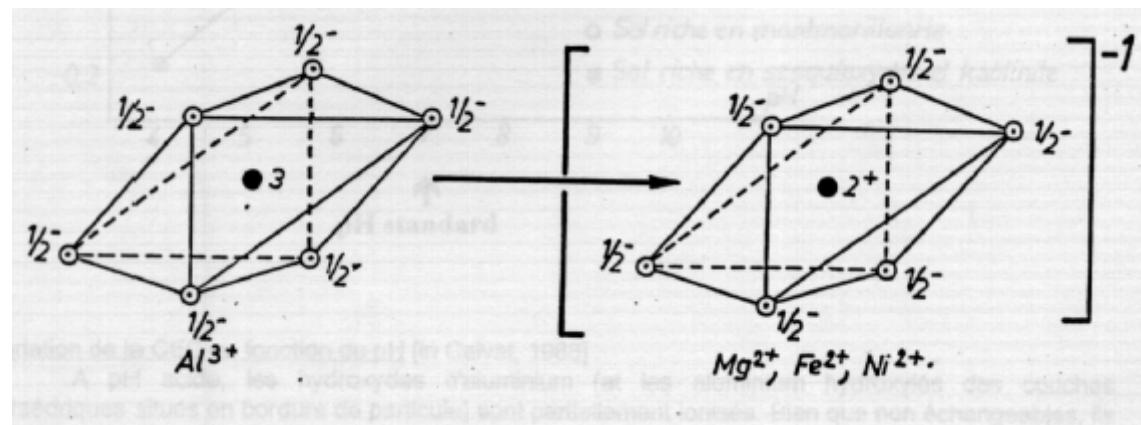


Argiles : substitutions isomorphiques

□ Couche tétraédrique (T)



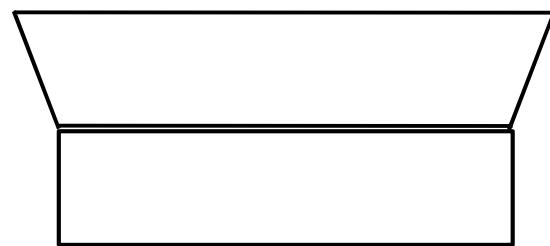
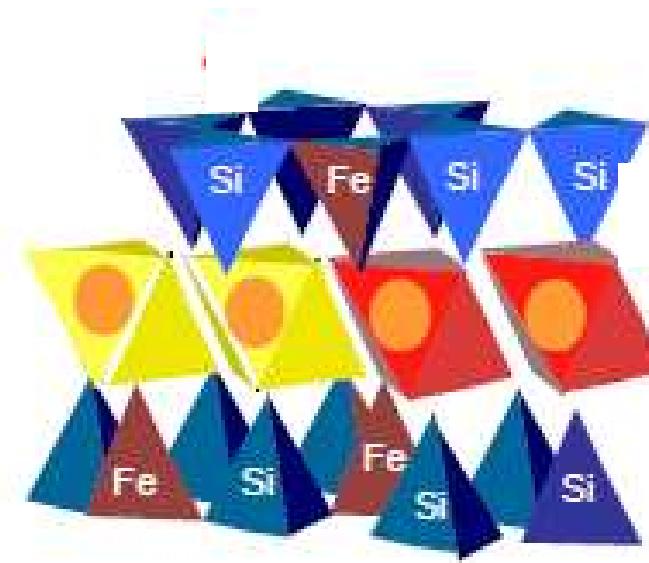
□ Couche octaédrique (O)



Argiles 1/1 (T-O)

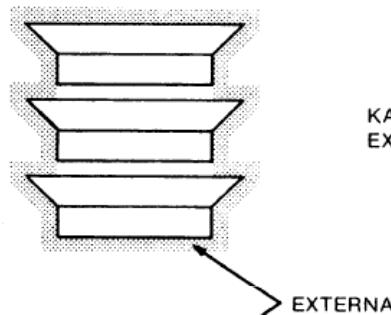


Argiles 2/1 (T-O-T)

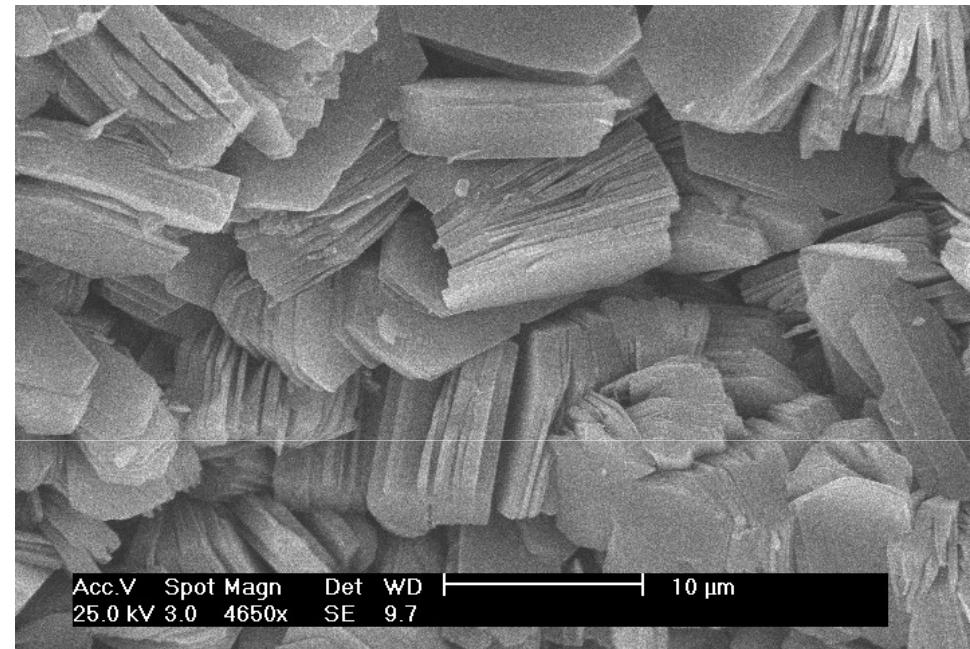


Argiles 1/1 (T-O)

Kaolinite...



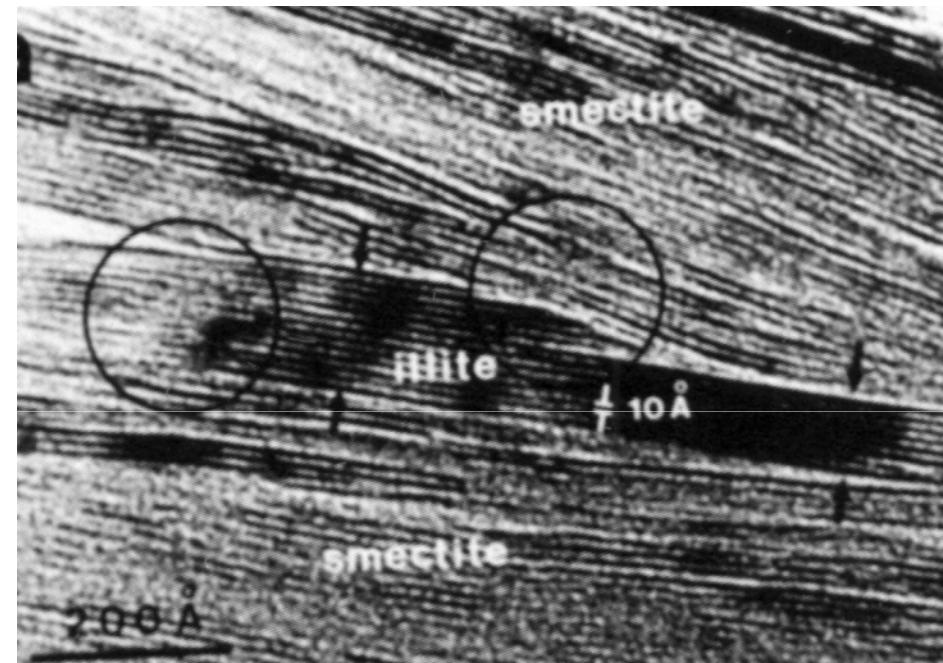
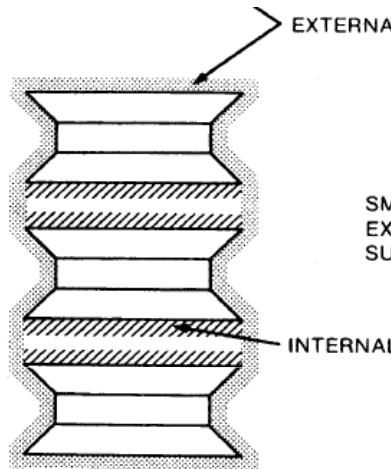
KAOLINITE HAS ONLY AN
EXTERNAL SURFACE AREA



- ✓ feuillets T.O « collés », $d = 0.7 \text{ nm}$
- ✓ pas de substitution \Rightarrow pas échange
- ✓ O = dioctaédrique

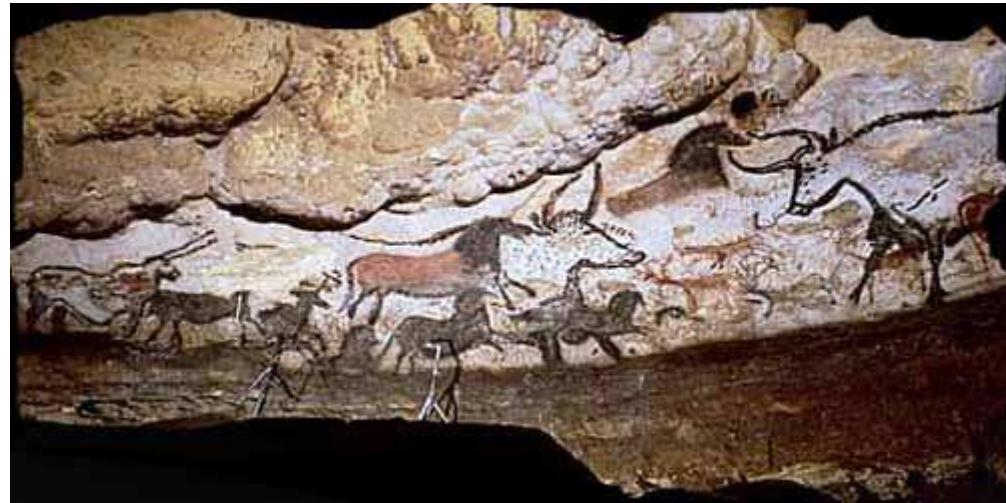
Autres argiles de la même famille : halloysite, serpentine

Argiles 2/1 (T-O-T) Smectite



- ✓ feuillets T.O.T non « collés », $d= 1.4-1.5 \text{ nm}$
- ✓ Substitution isomorphiques \Rightarrow échange

Oxydes, hydroxydes, oxyhydroxydes



(grotte de Lascaux, site web)

□ Oxydes de Fe, Mn, Al

- ✓ peu abondants
mais très réactifs
- ✓ Ubiquistes,
formes variées

- ⇒ rôle majeur dans les processus chimiques des sols
- ⇒ cristaux, revêtements,
associés à MO, gels...

□ Origine

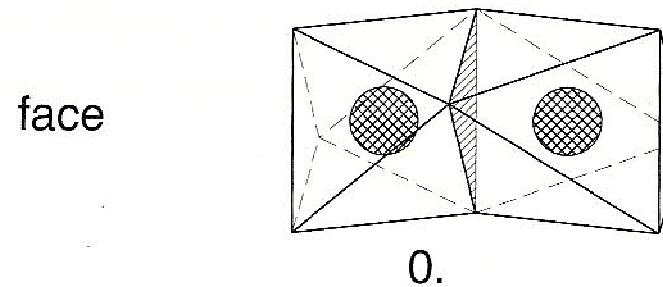
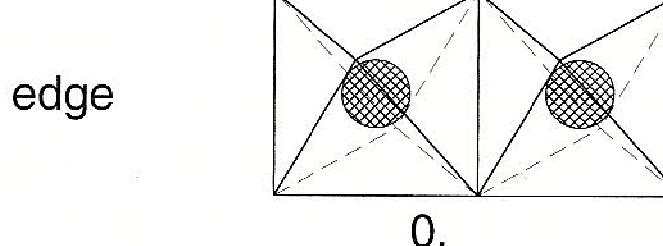
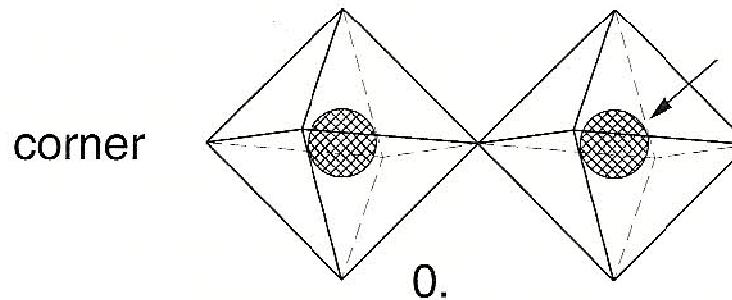
- ✓ Altération minéraux

libération de Fe, Mn, Al qui réagissent
avec O_2 et H_2O

Oxydes : structures de base

□ Couche octaédrique (O) :

1Me entouré de $6O^{2-}$, OH^-



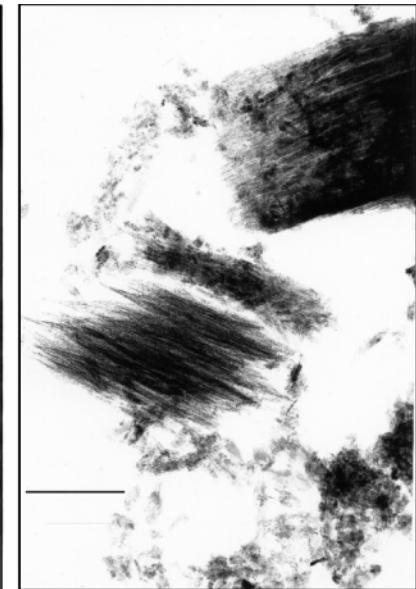
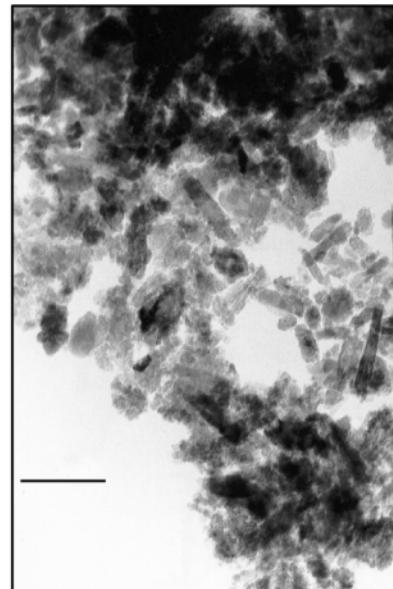
Oxydes de fer

□ Propriétés

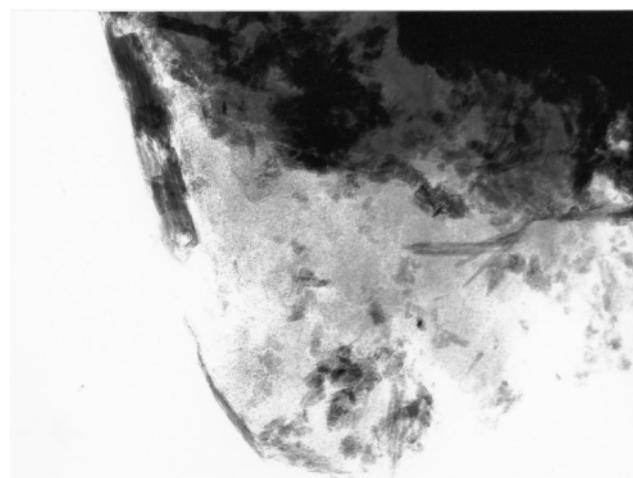
- ✓ Produit solubilité faible (subst. Al augmente stabilité)
- ✓ Grande surface spécifique
 - Cristallisé : # $40-80 \text{ m}^2 \text{ g}^{-1}$
 - Amorphe : # $800 \text{ m}^2 \text{ g}^{-1}$
- ✓ Charges variables (+) = rétention d'anions
- ✓ Fort pouvoir pigmentant

□ Substitutions

- ✓ Nombreuses (Al, Ni, Mn, Co, Cr, Cu, Zn)
- ✓ Al : 33% dans goethite, 17% hématite (stabilise la structure)



Goethites (Nouvelle Calédonie),
Becquer et al., 2006



Oxyde de fer amorphe (Nouvelle Calédonie),
Quantin et al., 2002

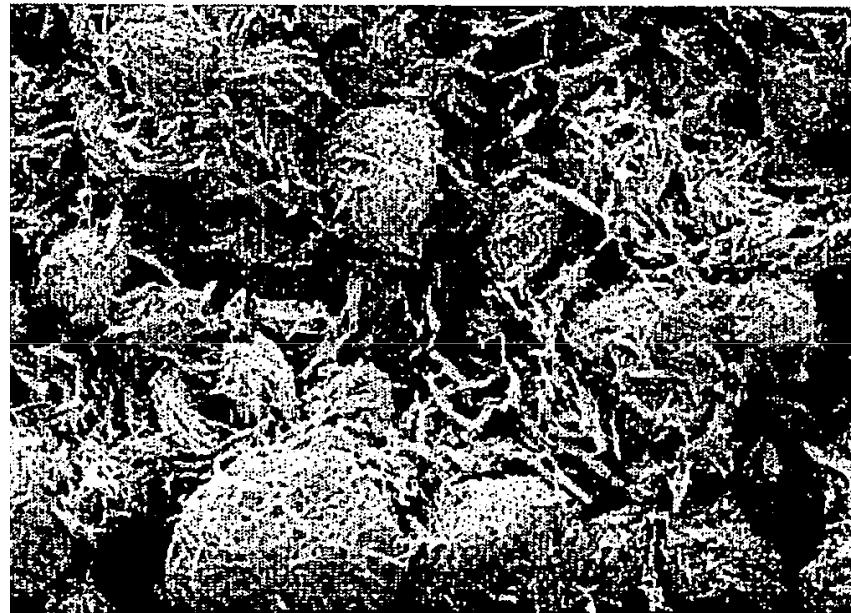
Oxydes d'aluminium

□ Propriétés

- ✓ Surface spécifique $\approx 45 \text{ m}^2 \text{ g}^{-1}$
- ✓ Charges variables (+) = rétention d'anions

□ Substitutions

- ✓ Peu substitués

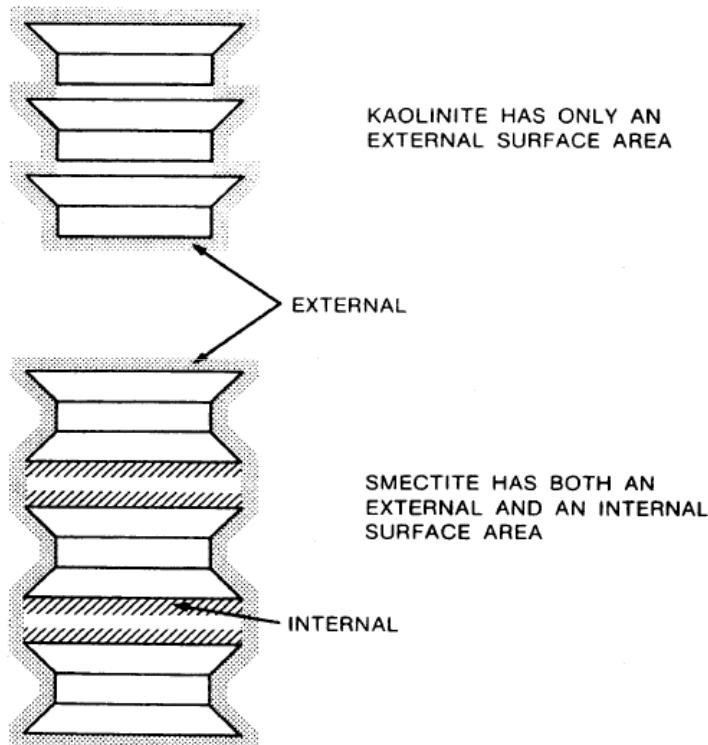


Propriétés de surface:

Charge = f
$$\begin{pmatrix} \text{- Surface spécifique des particules} \\ \text{- Propriétés de surface} \end{pmatrix}$$

Propriétés de surface: Surface spécifique des particules

Kaolinite vs smectites

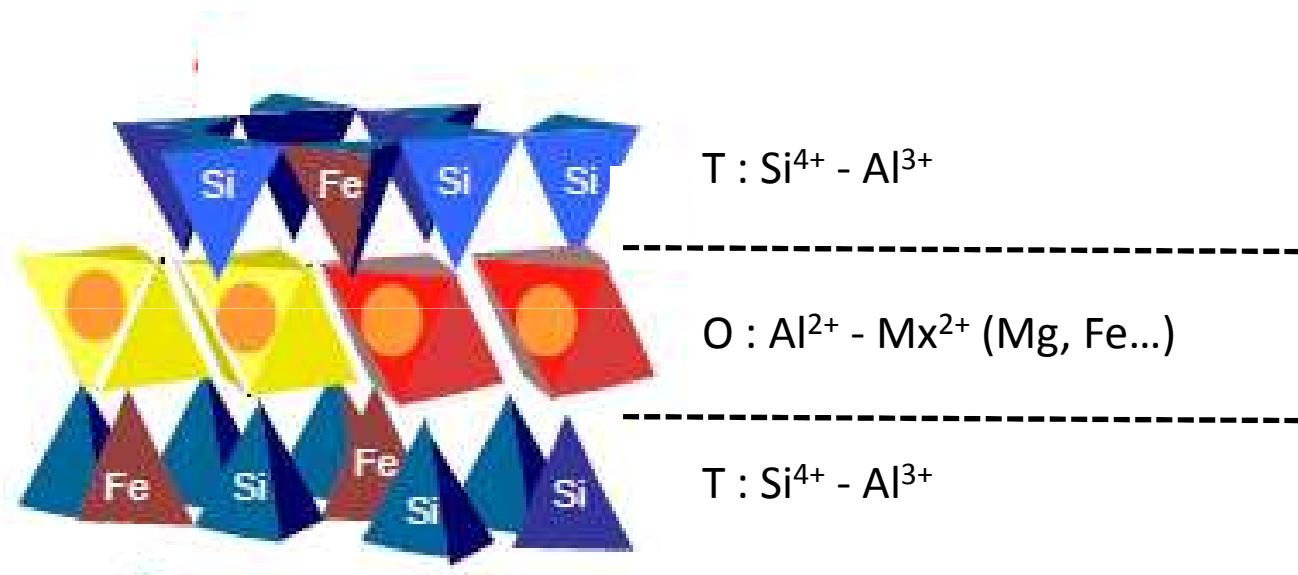


	Surface spécifique (m ² / g)		
	Interne	Externe	Totale
Smectite	750	50	800
Vermiculite	750	<1	750
Kaolinite	0	15	15
Ox. Fer crystalysés			40-80
Ox. Fer amorphes			# 800
Gibbsite			??

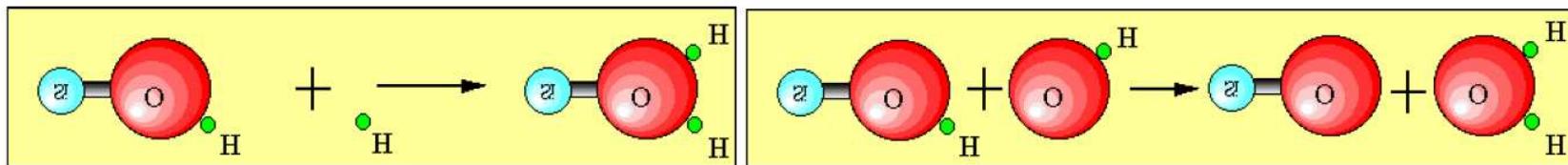
Propriétés de surface:

Propriétés de surface

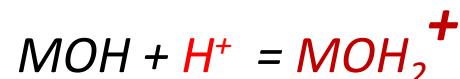
□ Charge permanente (structurale)



□ Charge variables (avec le pH)



A faible pH



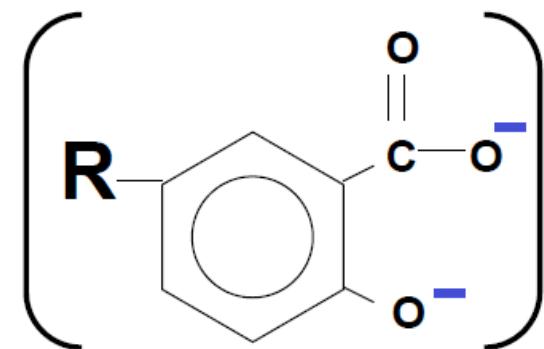
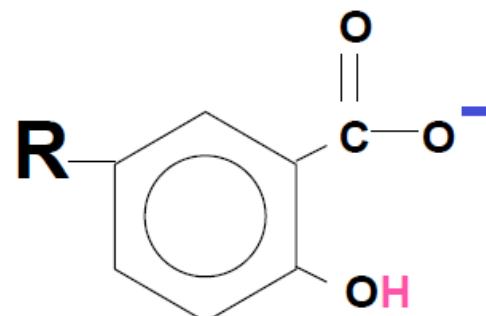
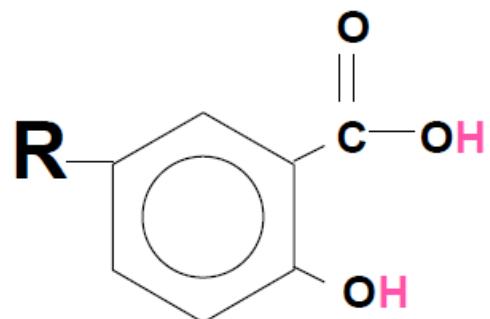
A pH élevé



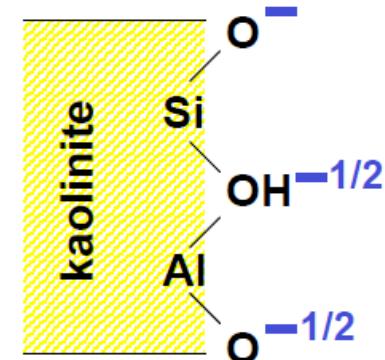
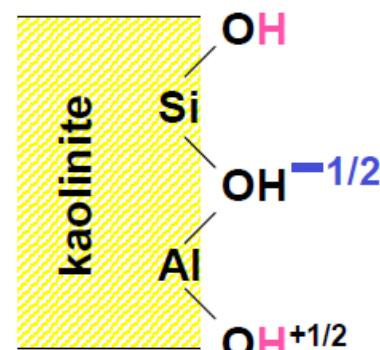
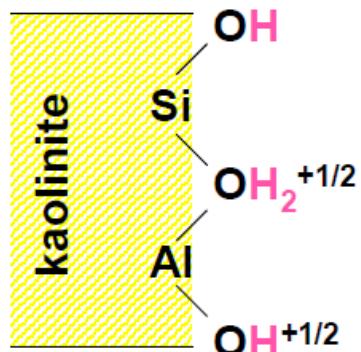
Constituants amphotères :

- Matière organique
- Oxydes de fer
- Oxydes d'aluminium
- *Kaolinite (tétraèdres non substitués – SiOH)*

Acides humiques



PROTONATION



Bordures alumino-silicates

Charges de surface des constituants

□ Charge des constituants des sols

- ✓ MO ~ 200 cmol_c kg⁻¹
- ✓ Smectite/Vermiculite ~ 100 cmol_c kg⁻¹
- ✓ Illite ~ 25 cmol_c kg⁻¹
- ✓ Kaolinite ~ 10 cmol_c kg⁻¹
- ✓ Fe and Al oxides ~ 5 cmol_c kg⁻¹

□ Origine des charges

Colloid	Negative charge	Positive charge	% constant	% variable
Humus	200	0	10	90
Vermiculite	120	0	95	5
Smectite	100	0	95	5
Illite	40	0	80	20
Kaolinite	12	4	5	95
Fe & Al Oxides	5	5	0	100