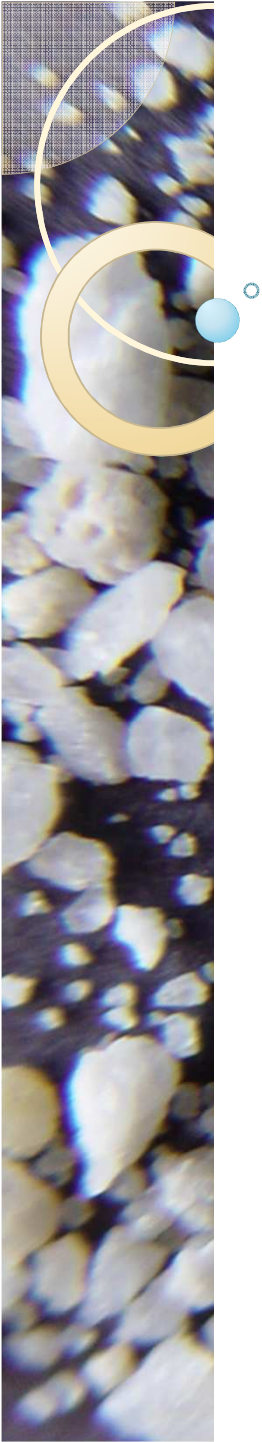


Mineralogia como fator determinante do manejo do solo

Vander de Freitas Melo

Depto de Solos e Engenharia Agrícola - UFPR



Mineralogia x Manejo do Solo

- ❑ Reserva de nutrientes em Latossolos?
- ❑ Argila x estabilização da matéria orgânica?
- ❑ Parcelamento de K em Latossolo argiloso?
- ❑ Menor fixação de P em solo corrigido?
- ❑ Demanda de corretivos em Latossolos?
- ❑ Caráter retrátil dos LB x caulinita?
- ❑ Óxidos de Fe e Al x macroporosidade?
- ❑ Calagem x dispersão dos coloides do solo?

Quantidade de Argila ($< 0,002$ mm)

Arenito - 10 % de argila



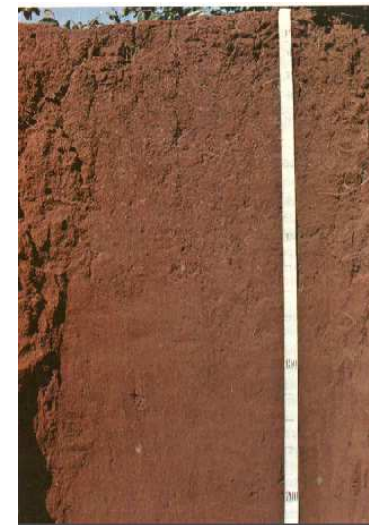
Basalto - 0 % de



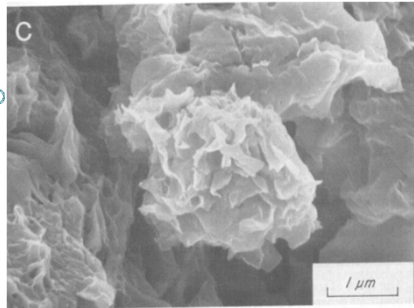
Solo - 10 % de argila



Solo - 80 % de argila

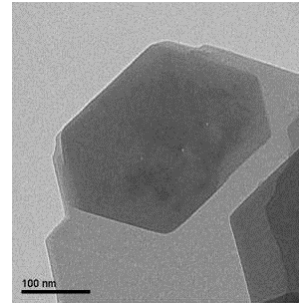


Qualidade da Argila



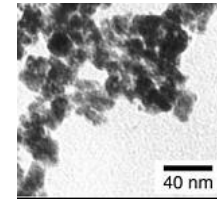
Esmectita

Filo

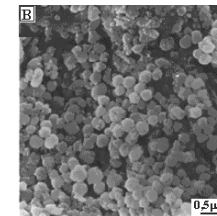


Caulinita

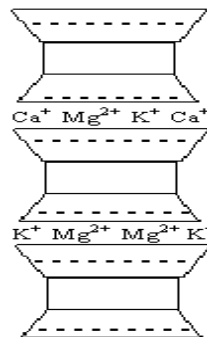
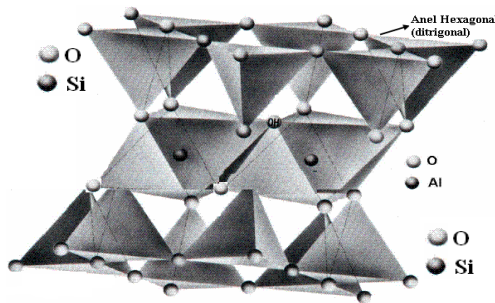
Esférico
O



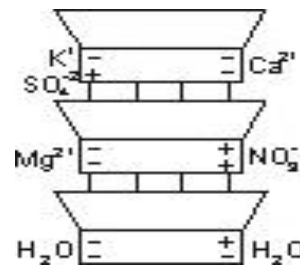
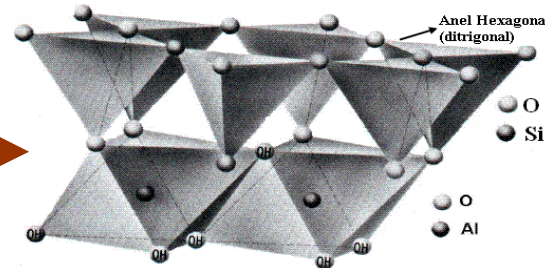
Hematita



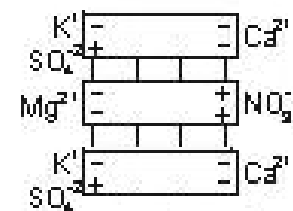
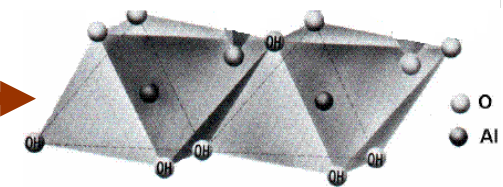
Gibbsita



CTC es. = 100 cmol_c kg⁻¹
ASE elevada



CTC pH = 15 cmol_c kg⁻¹

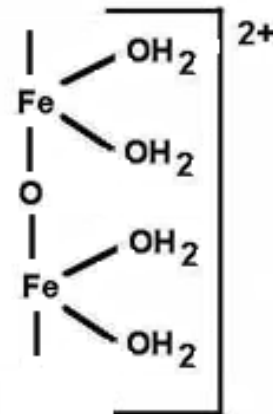


CTC pH = 5 cmol_c kg⁻¹

Mineralogia x Manejo

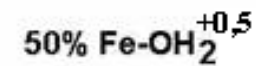
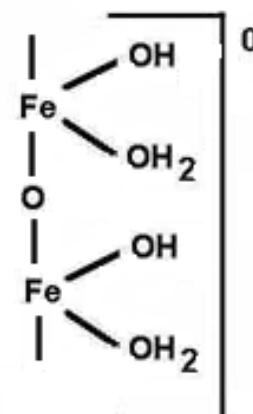
Aspectos Químicos

I. Adubação com cátions e ânions: Óxidos de Fe e de Al



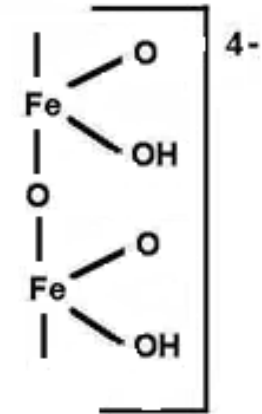
pH = 4,0

CTA



pH = 9,0

pH_{PCZ}



pH = 11,0

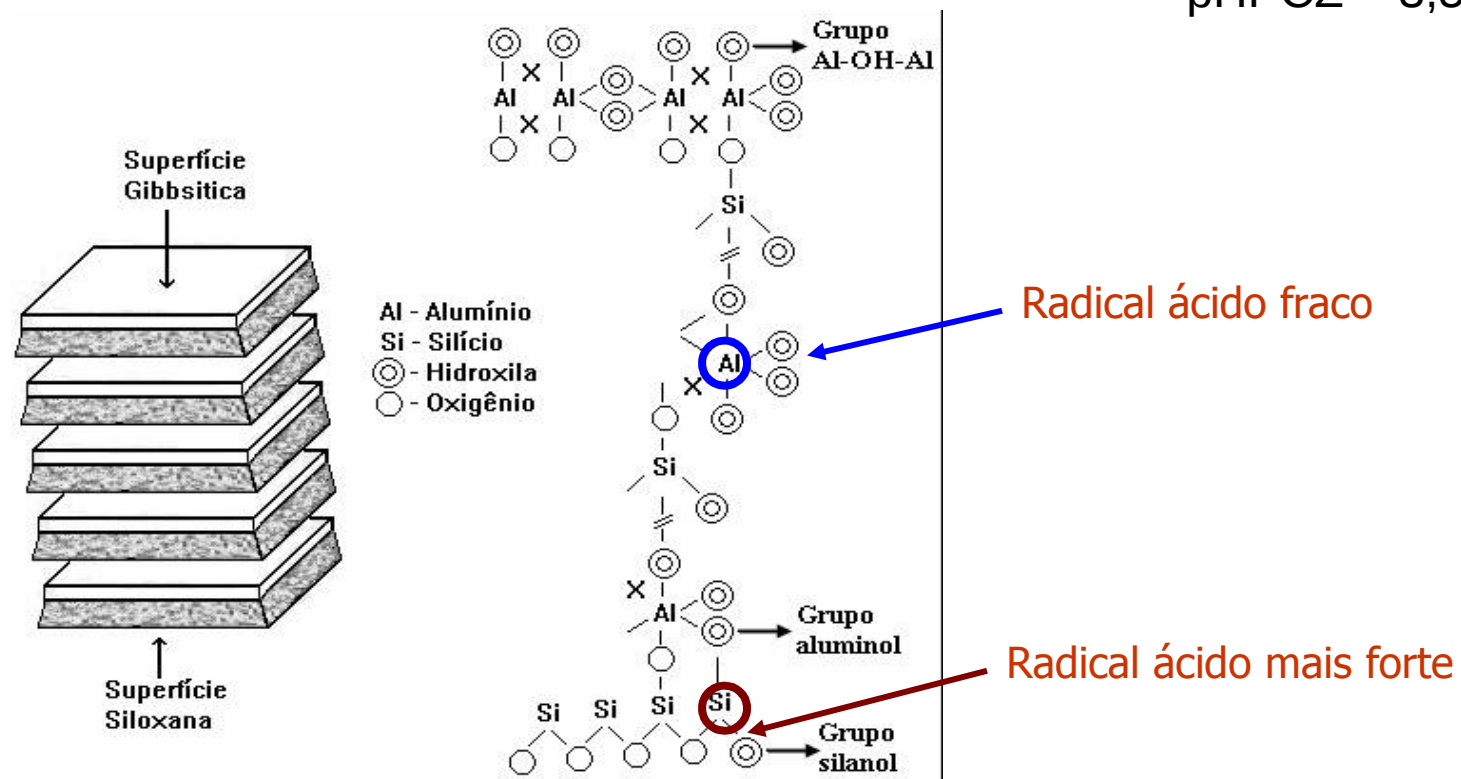
CTC

Mineralogia x Manejo

Aspectos Químicos

I. Adubação com cátions e ânions: Caulinita

pHPCZ = 3,5



Fontes et al. (2001).

Mineralogia x Manejo

Aspectos Químicos

I. Adubação com cátions e ânions

1) radical - SiOH. Grupo mais ácido: $\text{pH}_{\text{pcz}} \sim 2,0$.



2) radical -AlOH. Grupo de acidez intermediária: $\text{pH}_{\text{pcz}} \sim 7-8$.

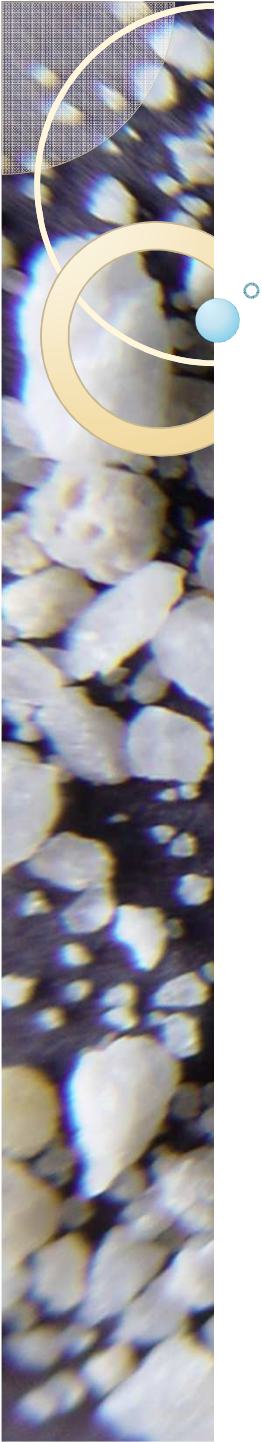


2) radical -FeOH. Grupo de menor acidez: $\text{pH}_{\text{pcz}} \sim 8-9$.



<http://www.chemkeys.com>

8	9	10	11	12	5	6	7	8	9
26	27	28	29	30	BORO B 10,811(7)	CARBONO C 12,011	NITROGÊNIO N 14,007	OXIGÊNIO O 15,999	FLUOR F 18,998
Fe	Co	Ni	Cu	Zn	ALUMÍNIO Al 26,982	SÍLCIO Si 28,086	FÓSFORO P 30,974	ENXOFRE S 32,065(5)	CLORO Cl 36,453
55,845(2)	58,933	58,693	63,546(3)	65,41	GÁLIO Ga 69,723	GERMÂNIO Ge 72,64(1)	ARSÊNIO As 74,922	SELENÍO Se 78,96(3)	BROMO Br 79,904



Mineralogia x Manejo

Aspectos Químicos

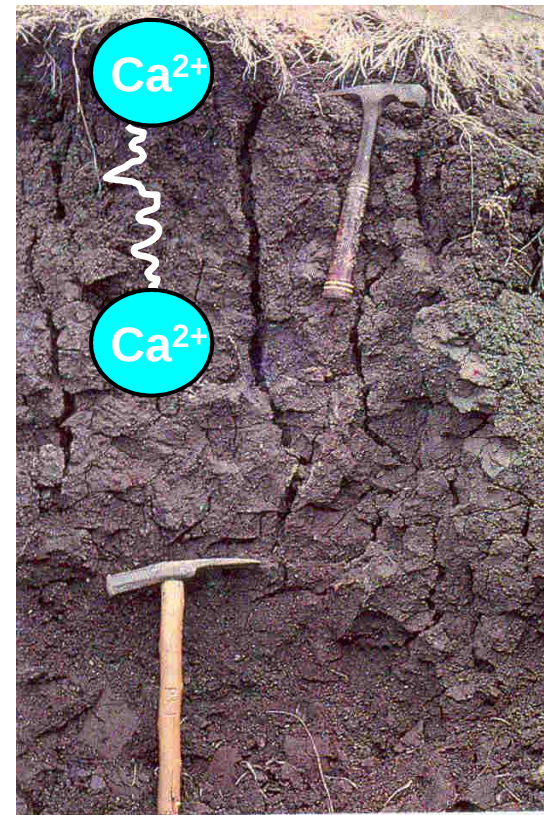
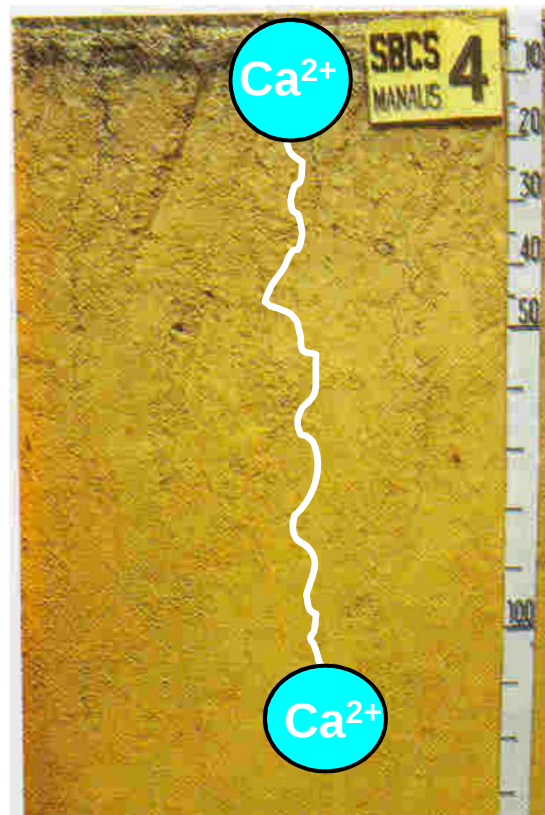
I. Adubação com cátions e ânions

	pH						
	2	3	3,5	4	5	6	7
Ct	+++	++	=	-	--	---	----
Hm/Gt	++++ +++	++++ ++	+++++	++++	+++	++	+
Gb	++++++	+++++	++++	+++	++	+	=
Esm/Verm	----- -----	----- -----	-----	-----	-----	-----	-----
Húmus	+++	++	=	-	--	---	----

Mineralogia x Manejo

Aspectos Químicos

I. Adubação com cátions: solo caulinítico x solo esmetítico



Mineralogia x Manejo

Aspectos Químicos

I. Adubação com cátions e ânions



Latossolo Ácrico

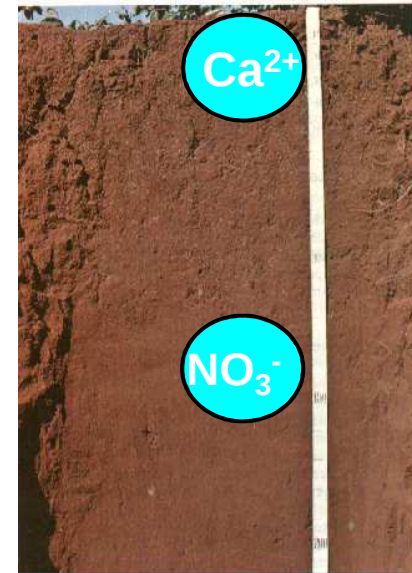
A

- > teor de matéria orgânica;
- < valor de pHPCZ;
- pH do solo > pHPCZ;
- carga líquida (-): $CTC > CTA$.

B

- < teor de matéria orgânica;
- predominam os óxidos;
- > valor de pHPCZ;
- pH do solo < pHPCZ;
- carga líquida (+): $CTA > CTC$.

Parcelamento da adubação K em solo argiloso ??

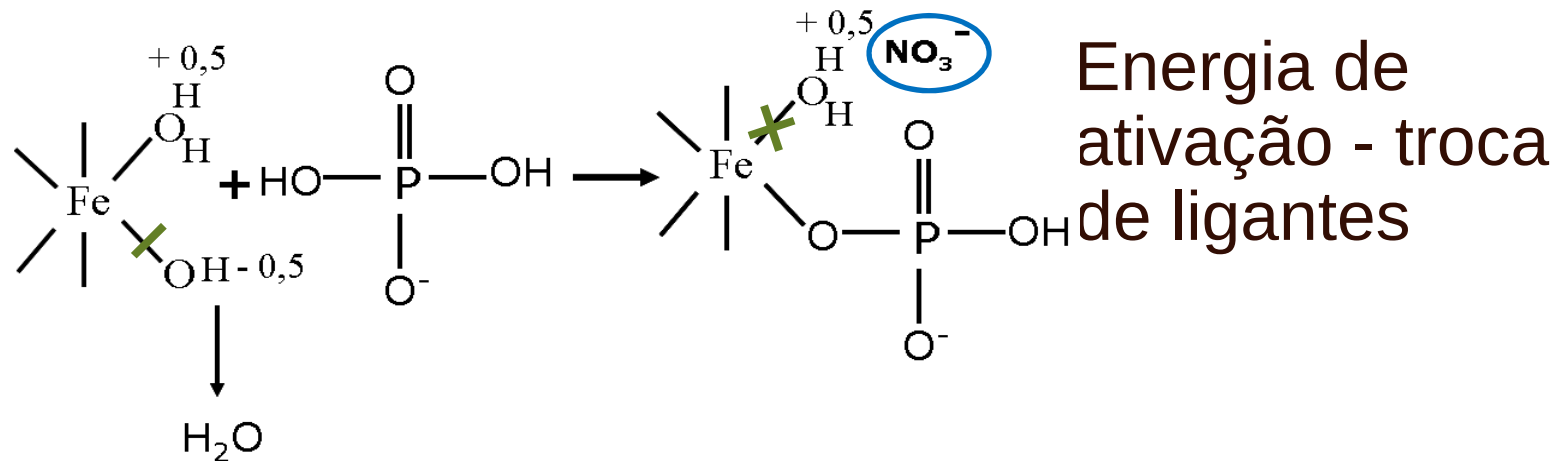
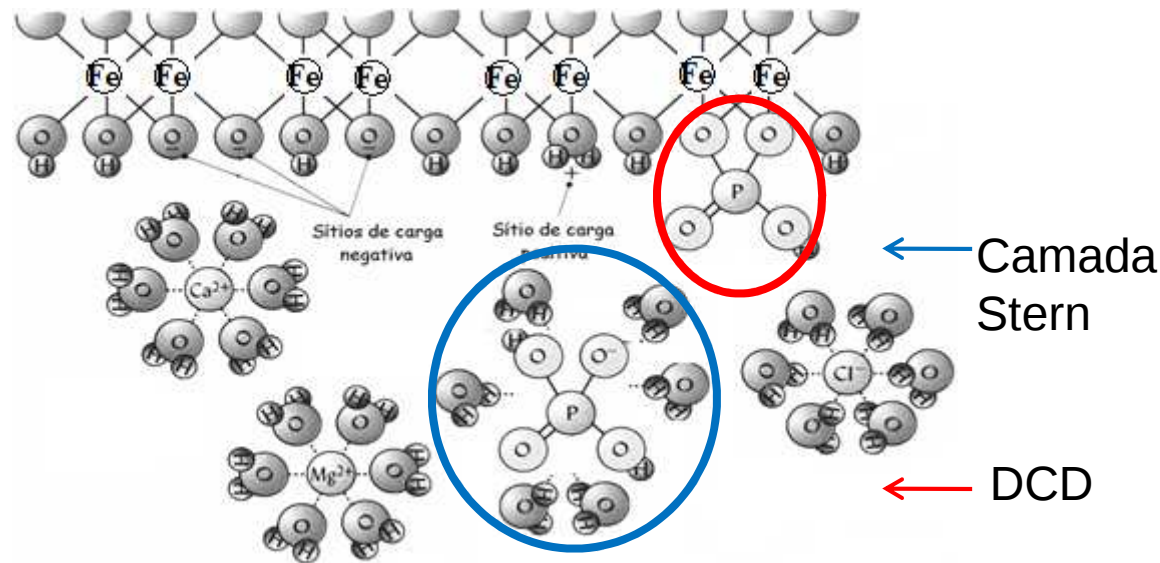
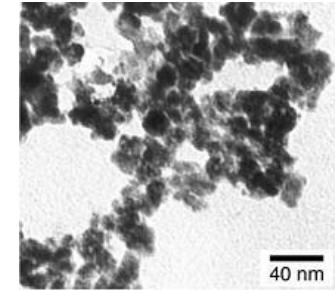


Mineralogia x Manejo

Aspectos Químicos

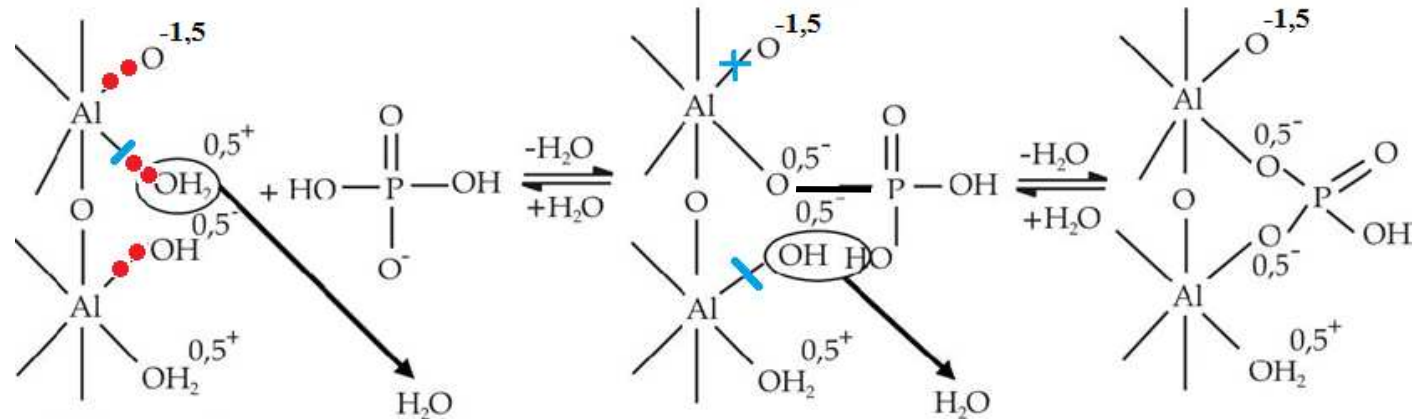
II. Fixação de P

Hematita



Mineralogia x Manejo

II. Fixação de P



Solo oxídico

- ❑ Adubação de fonte solúvel de P em sulco de plantio
- ❑ Adubação de fonte solúvel de P em solo corrigido
- ❑ Solo com alto teor de Si (quartzo x mineral amorfo)
- ❑ Aplicação de SiO_4^-

CMAP Latossolo Vermelho Distroférico = 1.700 mg kg^{-1} (Lopes, 1977)

-1 ha (20 cm) = 3.400 kg P

-1 ha (20 cm) = 40 ton. Super Fósforo Simples.



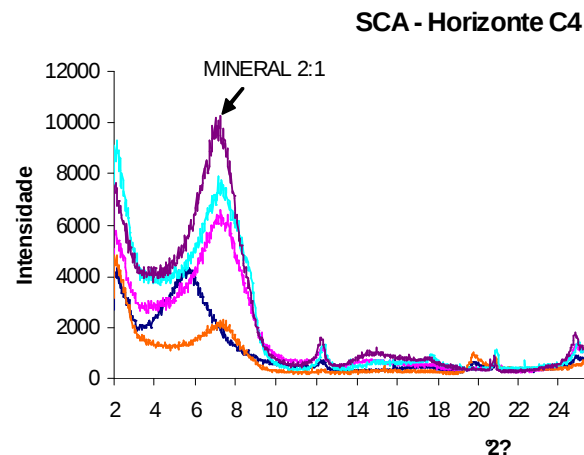
Mineralogia x Manejo

Aspectos Químicos

III. Tamponamento da acidez x Intemperismo

Argila de alta atividade (2:1): acidez Al^{3+} (calagem)

Horizonte	pH		Al^{3+}	CTC efetiva	CTC $\text{pH } 7,0$	Argila	T	Ki	Kr	$\text{Al}^{3+}/\text{H}^+$	C.O.
	H_2O	KCl		$\text{mmol}_c \text{ kg}^{-1}$		g kg^{-1}	$\text{mmol}_c \text{ kg}^{-1}$				g kg^{-1}
Rubrozem – Perfil 72 (Curitiba – PR) (EMBRAPA, 1984b)											
A1	4,9	3,8	66	95	215	560		2,12	1,73	0,6	23,9
A3	4,9	3,8	70	80	195	570		2,05	1,63	0,6	20,0
B1t	4,9	3,8	81	91	154	620		2,08	1,66	1,3	10,6
B2t	5,0	3,8	103	111	155	640		2,38	1,91	2,3	5,6
C	5,0	3,6	142	247	286	740	386	2,82	2,25	3,6	1,1



Tamponamento até pH 5,5

Al^{3+}

Mineralogia x Manejo

Aspectos Químicos

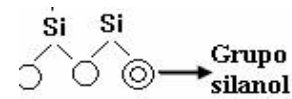
III. Tamponamento da acidez x Intemperismo

Sistema 1:1: acidez - H e pouco Al ³⁺											
Horizonte	pH	Al ³⁺	CTC efetiva	CTC pH 7,0	Argila	Ki	Kr	Al ³⁺ /H ⁺	C.O.		
	H ₂ O	KCl	mmol _c kg ⁻¹	mmol _c kg ⁻¹	g kg ⁻¹	mmol _c kg ⁻¹			g kg ⁻¹		
Latossolo Vermelho Amarelo distrófico - Perfil 10 (Linhares – ES) (EMBRAPA, 1978)											
A1	3,8	3,2	9	20	71	110		2,1	1,80	0,2	15,4
B1	4,3	3,8	13	20	42	450	93	1,93	1,69	0,6	5,1
B21	4,6	3,8	7	18	38	480	79	1,93	1,69	0,4	4,0
B23	4,6	3,9	6	12	26	450	58	1,91	1,67	0,4	2,6

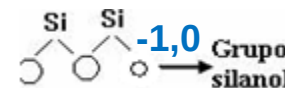


Caulinita - tamponamento em três faixas de pH:

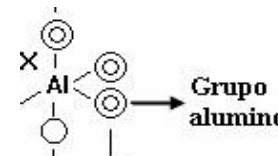
2 - 3



H covalente



até pH 5,5



H covalente

Mineralogia x Manejo

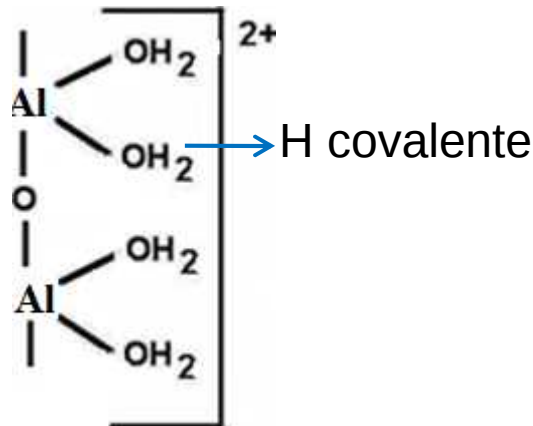
Aspectos Químicos

III. Tamponamento da acidez x Intemperismo



Sistema oxídico: acidez H (calagem e fonte de Ca e Mg)

Horizonte	pH		Al ³⁺	CTC	CTC	Argila	T	Ki	Kr	Al/H	C.O.		
	H ₂ O	KCl		efetiva	pH 7,0						g kg ⁻¹	mmol _c kg ⁻¹	g kg ⁻¹
				mmol _c kg ⁻¹	mmol _c kg ⁻¹								
Latossolo Vermelho Escuro distrófico - Perfil 10 (Pires do Rio – GO) (EMBRAPA, 1983)													
A1	5,2	4,4	4	11	6	600		0,62	0,43	0,1	15,7		
B1	5,0	5,0	0	3	2	640	31	0,64	0,45	0,0	7,0		
B21	5,0	5,7	0	2	14	630	22	0,62	0,43	0,0	4,8		
B22	5,1	5,9	0	3	12	650	18	0,62	0,43	0,0	3,3		



Tamponamento
pH ~ 7,0

Mineralogia x Manejo

Aspectos Químicos

pH = 5,5 elimina acidez
potencial trocável
($H^+ + Al^{3+}$)

SB = 30 $mmol_c kg^{-1}$;

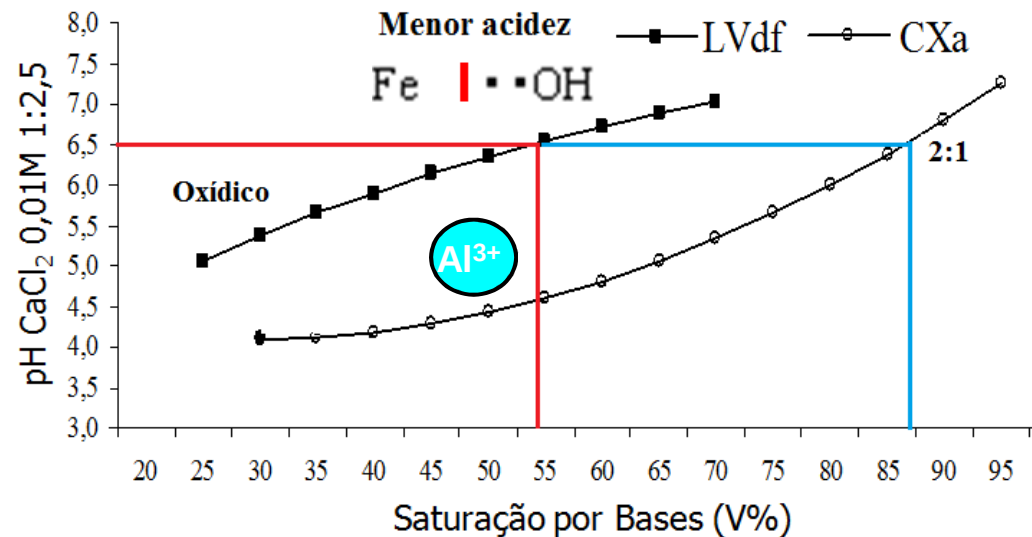
$Al^{3+} = 0 mmol_c kg^{-1}$;

CTC pH 7,0 = 60 $mmol_c kg^{-1}$;

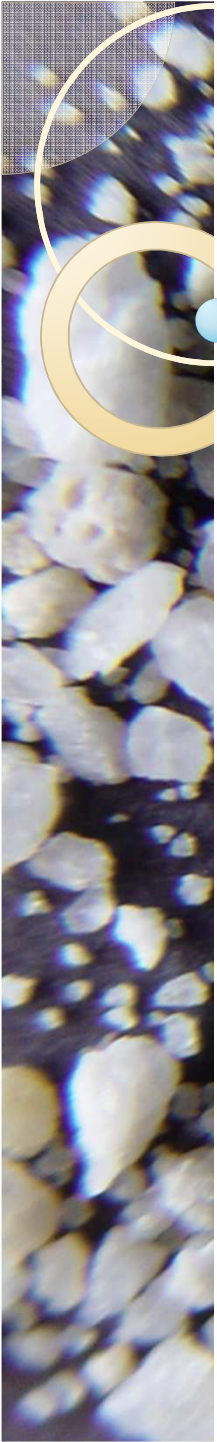
$V\% = [SB / (SB + Al^{3+} + H^+)] \times 100$;

$V\% = (30 / 60) \times 100 = 50\%$.

Elevação pH para ~7,0: liberação
de H covalente e formação de mais
30 $mmol_c kg^{-1}$ - dificuldade por ter
curvatura convexa (tamponamento
-FeOH)



Silva et al. (2008)



Mineralogia x Manejo

Aspectos Químicos

I. Tamponamento da acidez x Intemperismo

- ❑ Solos 2:1 jovens (Vertissolo): Al^{3+} ~ zero, baixo poder tamponante, $V \sim 100\%$.
- ❑ Solos 2:1 intemp. Moderado (Cambissolo Alítico): alto Al^{3+} , altas doses de calcário, alto poder tamponante até pH água 5,5.

NC = 10 ton ha⁻¹

- ❑ Solos oxídicos: baixo Al^{3+} , baixo poder tamponante até pH água 5,5, maior tamponamento pH ~7,0, maior dificuldade de altos V%.

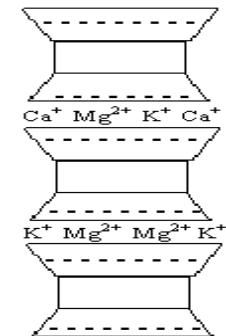
NC = 1 ton ha⁻¹ - evitar método do V% ??

- ❑ Solos cauliníticos ($K_r > 0,75$): comportamento intermediário.

Mineralogia x Manejo

Aspectos Físicos

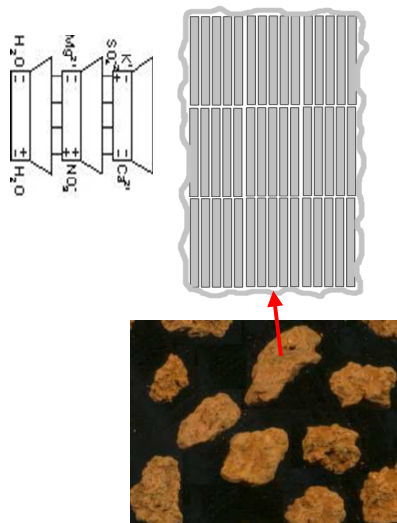
I. Solos esmectíticos: intervalo de umidade ótimo (friabilidade) muito estreito



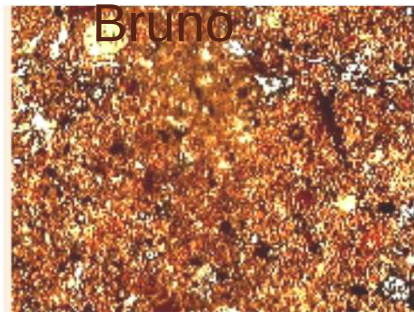
Mineralogia x Manejo

II. Solo caulinítico x Solo oxídico

Caráter retrátil



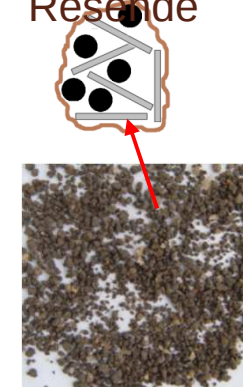
Latossolo



Latossolo



Prof. Mauro Resende



$D_s = 1,27 \text{ g cm}^{-3}$

PT = 54%

Macro = 2%; Micro = 52%

> Ct: > DMG, > alon. vertical, < rugosidade

Consistência: macio-lig. Dura, friável-firme e pegajoso

$D_s = 0,81 \text{ g cm}^{-3}$

PT = 70%

Macro = 36%; Micro = 34%

> Óxidos de Fe e Al: efeito oposto

Consistência: solto-macio, muito friável e lig. Pegajoso e pegajoso

Fonte: Ghidin et al. (2006); Melo et al. (2008).

Mineralogia x Manejo

III. Calagem x Dispersão do solo: horiz. A - caulinítico

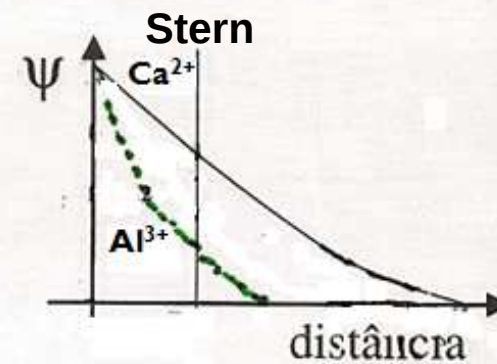
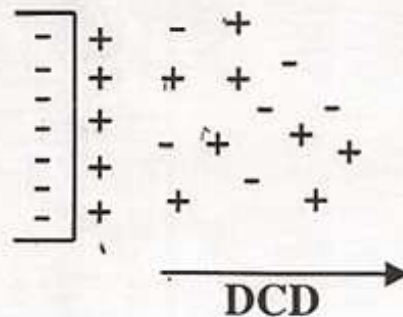
☐ Aumento de pH

	pH						
	2	3	3,5	4	5	6	7
Ct	+++	++	=	-	--	---	----
Hm/Gt	++++ +++	++++ ++	+++++	++++	+++	++	+
Gb	+++++	++++	++++	+++	++	+	=
Húmus	+++	++	=	-	--	---	----

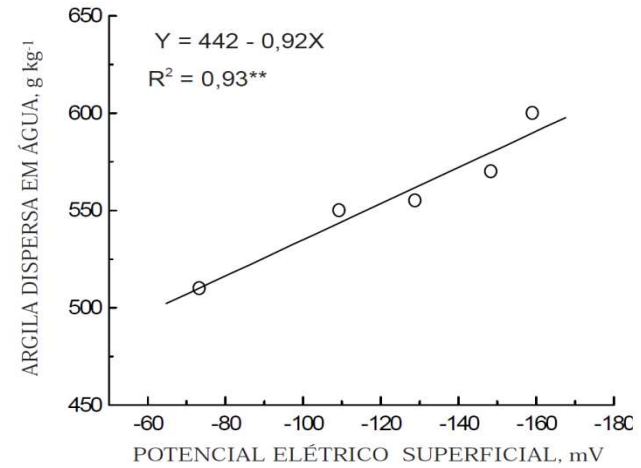
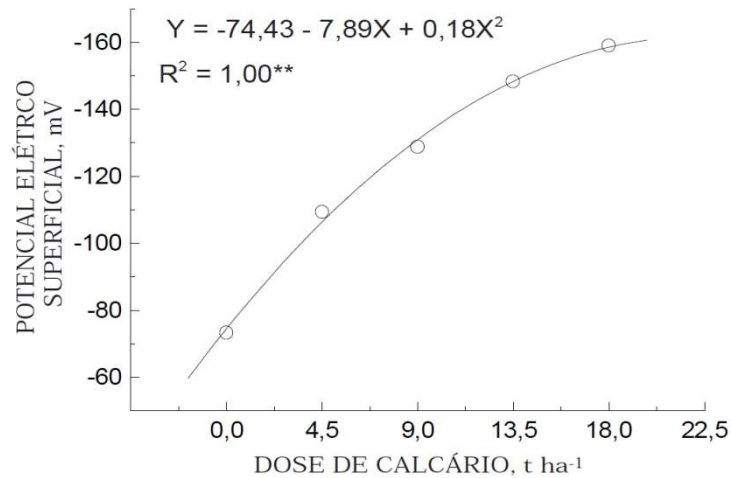


☐ Troca de cátions

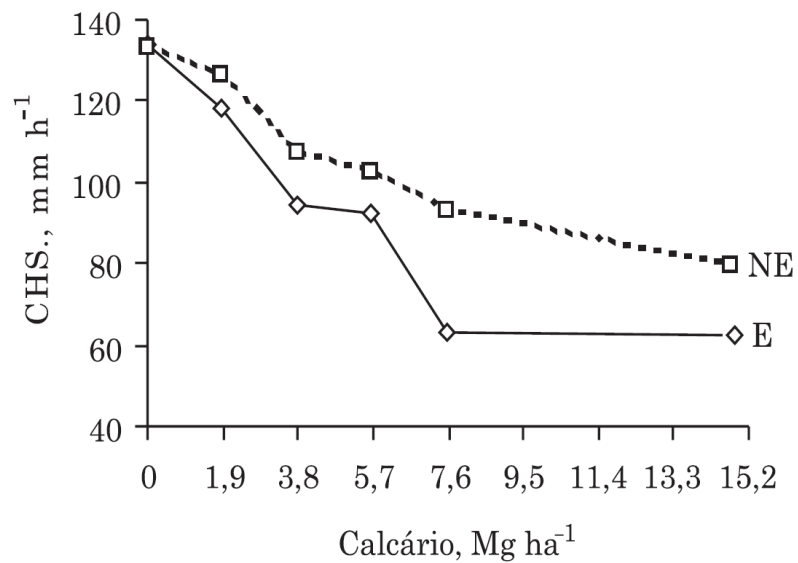
✓ Teoria de Stern



Mineralogia x Manejo



Fonte: Albuquerque et al. (2000) - Latossolo Bruno



Fonte: Spera et al. (2008) - Latossolo Vermelho

