

1 Supplementary

2 **Table S1**

3 Samples collected in the classes of representative soils from the state of Pará

BSCS ¹	FAO/WRB (FAO, 2006) ²	Collection areas	Collected samples	Total %
Latosols	Ferralsols	48	288	54.5
Argisols	Acrisols	23	138	26.1
Nitisols	Nitisols	3	18	3.4
Plintosols	Plinthosols	3	18	3.4
Neosols	Arenosols	3	18	3.4
Gleisols	Gleysols	5	30	5.6
Cambisols	Cambisols	3	18	3.4
Total	-	88	528	100

4 ¹Ranked 1st in taxonomic level - Orders, according to the Brazilian Soil Classification System - BSCS (Embrapa, 2013);

5 ²Ranked 1st in taxonomic level - Orders, according FAO. World reference base for soil resources (FAO, 2006).

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22 **Table S2.**

23 Physical and chemical properties of the soils in the subsurface layer in the state of Pará.

Statistic ^a	pH H ₂ O	OC ^b g kg ⁻¹	P mg kg ⁻¹	K mg kg ⁻¹	Cammolc kg ⁻¹	Mgmmolc kg ⁻¹	Almmolc kg ⁻¹	H+Almmolc kg ⁻¹	CEC ^c	v ^d%.....	m ^e	Sandg kg ⁻¹	Clayg kg ⁻¹	Silt
Latosols														
Mean	4.7	6	2	0.02	10.9	2.2	7.5	25.7	20.62	34	36	474	410	116
Minim	3.8	3	0.01	0.01	0.1	0.2	0.3	9.8	3.0	2	1	280	106	2
Maxim	6.0	9	28	1.2	48.9	15.1	23.1	68.0	60.3	85	90	871	931	716
CV ^f (%)	13	23	189	158	149	160	81	47	96	138	52	48	56	134
C. Fert. ^g	L	L	L	VL	L	L	M	L	L	VL	M	-	-	-
Argisols														
Mean	4.4	5	1	0.1	1.3	0.8	11.0	26.0	13.2	8	83	565	368	67
Minim	4.0	4	0.01	0.001	0.2	0.1	5.6	14.8	5.9	1	75	331	176	21
Maxim	5.1	6	7	0.3	2.2	2.2	24.7	43.2	27.3	19	89	776	610	149
CV (%)	8	14	19	111	55	80	52	32	51	80	9	26	38	59
C. Fert.	VL	L	VL	VL	VL	VL	H	M	L	VL	VH	-	-	-
Nitossols														
Mean	4.6	6	2	0.2	21.5	8.8	3.2	31.3	33.7	49	10	119	800	81
Minim	4.2	9	1	0.01	1.7	1.4	0.9	28.8	6.4	4	3	71	737	66
Maxim	4.9	11	2	0.2	38.5	16.1	6.0	33.8	46.0	60	78	167	862	96
CV (%)	10	13	37	12	185	119	83	11	107	124	137	57	11	26
C. Fert.	L	L	VL	VL	M	M	L	M	M	L	VL	-	-	-
Plintossols														
Mean	4.4	6	1	0.01	0.3	0.3	11.6	25.5	12.2	2	95	577	292	131
Minim	4.3	5	0.3	0.01	0.1	0.2	9.9	19.2	10.1	1	85	553	241	105
Maxim	4.5	7	3	0.02	0.5	0.4	18.2	35.8	13.4	5	92	603	342	157
CV (%)	4	24	99	74	90	47	61	39	20	93	10	6	25	28
C. Fert.	L	L	VL	VL	VL	VL	H	M	L	VL	VL	-	-	-
Neossols														
Mean	4.1	9	5	0.04	-	-	4.9	26.7	4.9	0.2	99	741	162	97
Minim	3.9	8	2	0.01	-	-	4.5	23.1	4.5	0.1	89	691	113	96
Maxim	4.4	10	8	0.05	-	-	7.3	28.2	5.3	0.3	96	791	212	98
CV (%)	9	16	60	17	-	-	32	8	11	13	20	10	43	1
C. Fert.	VL	L	L	VL	-	-	M	M	L	VL	VH	-	-	-
Gleissols														
Mean	3.5	12	12	0.7	45.2	29.0	85.4	148.7	160.3	34	53	313	171	516
Minim	2.3	10	0.7	0.2	16.4	17.9	7.1	30.4	86.0	19	5	470	910	100
Maxim	4.8	24	29	1.4	115.3	38.5	233.4	338.4	312.0	83	75	809	299	783
CV (%)	38	79	106	76	90	31	122	96	54	60	81	115	54	57
C. Fert.	VL	M	H	L	VH	VH	M	VH	VH	M	H	-	-	-
Cambissols														
Mean	5	7.7	5.7	0.2	16.4	2.8	5.1	136.0	24.5	13	21	489	345	166
Minim	4	66	2.9	0.02	15.6	2.1	2.9	120.8	20.8	12	14	439	296	166
Maxim	5.0	87	7.5	0.4	17.2	3.4	9.3	161.2	25.1	11	14	539	396	175
CV (%)	5	20	68	38	10	33	49	15	10	5	1	15	20	1
C. Fert.	1	VL	M	VL	M	L	M	VH	VH	VL	L	-	-	-

24 ^aDescriptive statistic, ^bOrganic carbon, ^cCation exchange capacity, ^dBase saturation $\sum (K, Ca, Mg) / CEC / 100$,25 ^eAluminum saturation (100 x Al³⁺)/CEC, ^fCoefficients of variation, ^gClasses of soil fertility for the complex cation

26 exchange according to Alvarez et al. (1999): VL- Very Low, L - Low, M - Medium, H- High, VH- Very high.

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32 **Table S3**

33 Descriptive statistic of the levels of oxides SiO₂, Fe₂O₃, Al₂O₃, Mn₂O₃ and TiO₂ extracted by alkaline and sulfuric acid
 34 attack, of the poorly crystallized forms of Mn₂O₃, Fe₂O₃ and free oxides Fe₂O₃; and the relationships between them in the
 35 soil subsurface layer in the state of Pará.

Statistic ^a	Oxide by sulfuric acid attack					Relationships ^b		OXA ^c		CBD ^d		Relationships	
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	Mn ₂ O ₃	Ki	Kr	Mn ₂ O ₃	Fe ₂ O ₃	Al ₂ O ₃	Fe ₂ O ₃	Feo/Fed ^f	Fed/Fet ^g
g kg ⁻¹g kg ⁻¹					
	Latosols												
Mean	133.4	143.3	74.4	97.5	2.1	1.5	1.2	0.2	2.1	20.5	40.1	0.1	0.6
Minim	22	43.3	7.4	12.2	0.1	0.9	0.5	0.01	0.3	4.8	1.4	0.01	0.1
Maxim	268	313.3	214	393.2	6.5	2.2	2.0	2.3	6.6	48.2	117.5	0.4	0.9
CV ^g (%)	51	47	90	101	106	23	32	212	91	51	77	105	35
	Argisols												
Mean	117.7	129	37.9	69	1.2	1.5	1.3	0.1	2.2	25.5	25.3	0.1	0.8
Minim	45	70.1	14.9	24.2	0.1	1.1	0.9	0.0	0.3	13.7	12.9	0.02	0.4
Maxim	207	223.1	123.4	174.5	4.4	2.0	1.8	0.6	5.0	50	53	0.2	0.9
CV (%)	49	41	80	57	124	16	22	145	64	40	50	62	19
	Nitossols												
Mean	218.5	213.7	176.1	263.8	2.9	1.7	1.1	1.6	7.7	20.4	134	0.1	0.8
Minim	198	191.2	152.3	247	0.8	1.7	1.1	1.1	4.9	20.1	124.7	0.03	0.7
Maxim	239	236.1	199.9	280.6	5.0	1.8	1.2	2.2	10.4	21.1	143.3	0.1	0.8
CV (%)	13	15	19	9	72	2	3	49	36	3	7	42	7
	Plintossols												
Mean	71.5	81.5	11.7	41.8	0.2	1.5	1.4	0.1	1.4	21.8	9.7	0.1	0.8
Minim	70	78	10	39	0.02	0.8	0.5	0.1	1.1	19.6	9.3	0.1	0.6
Maxim	73	85	13.4	44.5	0.6	2.5	2.2	0.1	1.7	24.6	10	0.2	1.2
CV (%)	3	6	21	9	18	3	4	34	23	12	4	22	37
	Neossols												
Mean	26.5	42.1	6.3	27.5	4.8	1.1	1.0	0.03	0.1	7.0	4.4	0.02	0.5
Minim	25	39	5.8	27	4.1	0.1	0.6	0.01	0.01	6.3	3.9	0.01	0.4
Maxim	28	45.1	6.7	28	5.3	1.8	1.3	0.05	0.7	7.5	5.1	0.02	0.6
CV (%)	8	10	10	3	13	2	4	7	43	9	14	31	37
	Gleissols												
Mean	110.8	71.7	34.1	43.4	2.7	2.6	2.0	0.5	2.2	20	19	0.1	0.6
Minim	54	42.5	15.4	31.2	0.3	2.2	1.7	0.1	0.9	12.1	10	0.1	0.5
Maxim	177	100.9	50.3	57.1	6.7	3.1	2.4	1.3	3.4	38.7	28.7	0.2	0.7
CV (%)	49	43	54	28	110	19	17	106	49	63	44	3	16
	Cambissols												
Mean	65.5	135.1	249.3	159.1	0.4	0.8	0.4	0.2	2.7	32.6	125.3	0.3	0.5
Minim	63	130.1	239.5	154	0.2	0.3	0.1	0.1	1.8	32	117.1	0.03	0.5
Maxim	68	140	259	164.1	0.7	1.1	0.6	0.3	4.0	33.1	133.3	0.4	0.8
CV (%)	5	5	6	5	11	0.2	9	45	43	2	7	2	7

36 ^aDescriptive statistic, ^bWeathering index, ^cLow. crystallinity forms extracted by ammonium oxalate acid, ^dcrystalline Fe

37 extracted by citrate-bicarbonate-dithionite, ^eRelationships between amorphous and crystalline Fe, ^fRelationship between

38 levels of citrate-bicarbonate-dithionite Fe and Fe by sulfuric acid attack ^gCoefficients of variation.

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