IRON CONSTITUENTS OF THE LATOSOLIC COVER IN NORTHEAST BRAZIL

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ABSTRACT

The latosolic soils (Oxisols) are distributed all over the Brazilian Northeast. They occupy different geomorphological levels and are found either in humid or in semiarid environment. Their mineralogical composition is simple: they are all constitued of quartz, kaolinite, iron and aluminium oxides. The total iron values range from 5 to little more than 10% of Fe_2O_3. The main forms of iron oxides are goethite and hematite. These are associated to the clay fraction.

The ferric components had been studied by X-ray diffraction on concentrate obtained by dissolution of kaolinite mineral in 2N NaOH on clay soil fraction. The results on fifty Northeastern soils show a zonality in the distribution of goethite/hematite rate; but it is the Al-substitution, and mainly the division state of goethite, estimated by X-ray diffraction line shift, that indicate the most interesting geographical variations.

The latosolic soils of the intern oldest geomorphologic levels contain highly substitued and finely divided goethite; in these soils there are also occurrences of hematite and gibbsite. Al-substitution and microdivision in goethite become more pronounced when we go from the driest zones to the more humid ones; at the same time there is a remarkable increase of the gibbsite rates. The Al-substitution and division state of goethite of latosolic soils of semiarid plains are lower. In these soils goethite is associated with hematite; there is no gibbsite. In the latosolic soils of coastal plains, generally only goethite occurs; there is not either hematite or gibbsite. The Al-substitution and microdivision in goethite are moderated, but they increase under more humid climate.

Therefore, it seems there is a significant correlation between the characteristics of the ferric components of the soils, the climate environment and the age of the latosolized materials.

INTRODUCTION

The "Nordeste", between the 4th and the 16th parallels, is clearly distinct from the rest of Brazil due to its semiarid characteristics. It receives, in the main, less than 1,000 mm of annual precipitation. Furthermore the rainfall regime is much irregular with long drought seasons. The adapted vegetation to this climate is a brushwood formation (locally called "caatinga") quite different from savannah ("cerrado") of Central Brazil and the coastal dense forests.

The "Nordeste" soils are varied (Brazil 1970, 1971, 1972, 1973a, 1973b, 1973c, 1973d, 1975a, 1975b, 1976, 1977). The latosols are frequently present and in the states of

Piauī, Bahia, Minas Gerais, they are found in great extensions. These latosols (Brazil, 1980), like ferralsols (FAO/UNESCO, 1971) and oxisols (Soil Survey Staff, 1975), are perfectly drained soils, ranging from 1 to 3 m depths, formed by quartz, kaolinite plus variable proportions of iron oxide and sometimes of gibbsite; they do not present textural gradient and are characterized by a specific constituents organization which gives them a high porosity and friability. The latosols on the Northeast generally occupy plane or little undulated topography. They are associated with plateaus, and like the latters are regularly distributed over consecutive surfaces (Feio, 1954, King, 1956, Dresh, 1957, Ab'Saber, 1969); it is easy to regroup them according to their geomorphological locations. We can then distinguish (Fig. 2):

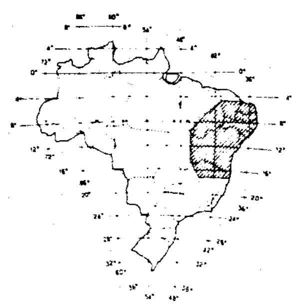

FIG. 1. Brazil map showing the location of the study zone (hachured area).

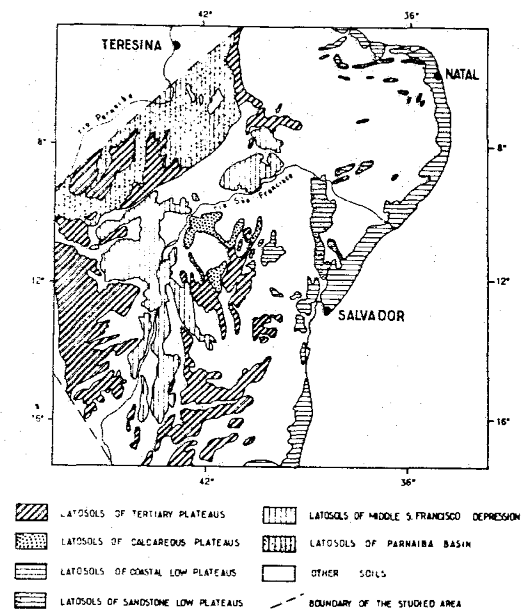

FIG. 2. Simplified map of the latosol distribution in the Northeastern Brazil.

. the latosols on the tertiary plateaus that occupy an altitude level from 600 to 1,000 m. These are generally deep soils, of clayed texture and with very low base saturation. They are in all types of substracts (crystalline rocks, quartzites, sandstones and schists);

. the latosols on the calcareous plateaus. These are soils of clay-sandy or sand-clayed textures and with high base saturation;

. the latosols on the coastal low plateaus and on the low sandstone plateaus. The latosols on the coastal low plateaus are clay-sandy and clayed, with low base saturation. On the low sandstone plateaus of the inland, the latosols are much sandy and with medium base saturation;

. the latosols of the Middle São Francisco Depression that are sand-clayed and clay-sandy, medium unsatured, eutrophic in some cases soils;

. at last, the latosols of the Parnaiba Basin that occupy the 200 to 400 m altitude zones on the Northwest, and directly derived from sandstone. These soils are medium textured, with low base saturation.

The ferrous constituents of Brazilian northeast latosols have not been much studied. Field studies on the State of Bahia (Volkoff and Cesar, 1977) showed significant differences among latosols of the State and an ordered geographical distribution if we consider the nature and the cristallinity of their iron oxides.

The iron oxide nature in the soil, as well as its crystallinity, are ruled by the physico-chemical environment (Lewis and Schwertmann, 1979, Melfi et al., 1979). This straitly depends on the climate conditions, chiefly on the amount of rainfalls and on its annual distribution. Therefore it is interesting to verify, on the entire "Nordeste" region, if the constitution of soil units with the same iron oxide mineralogy is possible and if their geographical distribution can be explained by the natural environment variations. The purpose of this paper is the study of iron oxides constituents of the Brazilian northeast latosols, and the analyse of their iron mineralogy according to the environment data.

The chosen region is bordered (1) on North by a parallel passing a little North of Mossorō (Rio Grande do Norte State), (2) on South by the parallel of Teōfilo Otoni (Minas Gerais State) and (3) on East by a broken line linking Floriano (Piauī State) on the Parnaiba River, to Pirapora (Minas Gerais) on the São Francisco River (Fig. 1).

MATERIALS AND METHODS

Samples of B2 horizon of 50 latosol profiles distributed all over the "Nordeste" were analyzed. Each sample was submitted to the granulometric analysis: Ph_{H_2O} and pH_{HCl}, exchangeable cations and cationic exchange capacity by ammonium acetate pH 7 method, were determined. The total iron was dissolved by $HCl-H_3ClO_4$ and analyzed by atomic absorption.

The iron oxides were only studied on the fine fraction, inferior to 2 μ, because the observation of the granulometric fractioning products has shown that the sands have not been formed but by quartz and some residual opaque minerals, and that fine silt fraction was not expressive. This fine fraction was obtained by siphonning suspensions of soil dispersed by soda at pH 9 after mechanic agitation. The collected fraction was floculated by $MgCl_2$, and then, washed and dried at 60°C. Then it was boiled for 30 minutes, by a soda 2N solution (0.4 g of material for each soda litre: Perinet, 1974). The residue of the attack was washed out, dried and fixed with CCl_4 drops on a glass plate for X-ray diffraction analysis (Kα copper radiation; goniometer speed: 1/4°/min.; 2,000 CPS; time constant: 4 seconds).

The hematite was identified for the (104) spectrum line at 2.69 Å and (110) at 2.52 Å, and the goethite by (130) line at 2.69 Å and (111) line at 2.45 Å. The position of the goethite (111) line was precisely located, using (311) lead nitrate line at 2.370 Å

(Norish and Taylor, 1961) and it deviation ($\Delta\mathring{A}$) with d(111) of pure goethite (at 2.447 Å: ASTM) was calculated. This deviation is directly related to the substitution of iron for aluminium and to oxide crystallinity (Norish and Taylor, 1961).

To precise and confirm the results of X-ray diffraction, samples of < 2μ fraction, not attacked by soda, of 5 selected latosols were analyzed by Mossbauer spectrometry (Janot and Gibert, 1970, Lamouroux et al., 1977).

The gibbsite, with quantitative evaluation on richer samples, was investigated by Differential Thermic Analysis (DTA) on total soil crushed samples.

RESULTS

The iron content of the studied latosols varies from less than 1% of total Fe_2O_3 to more than 10% (Tables 1, 2 and 3). The most frequent values are around 2-3%.

TABLE 1. ANALYTICAL DATA OF LATOSOLS OF THE COASTAL LOW PLATEAUS AND THE SANDSTONE LOW PLATEAUS (GI = GIBBSITE; HE = HEMATITE; GO = GOETHITE).

Sample	Location	Clay %	pH H_2O	pH HCl	V %	Fe_2O_3 %	Gi	He	Go	$\Delta\mathring{A}$
Latosols of the costal low plateaus										
VFF 23	Belmonte, BA	60	5.2	4.4	38	2.9	-	-	+	0.0285
VFF 3	Salvador, BA	61	5.0	4.3	20	4.4	-	-	+	0.0285
DBA 8	Esplanada, BA	27	4.8	4.2	52	2.1	-	-	+	0.0253
DAL 1	Arapiraca, AL	38	5.1	4.8	68	3.5	-	-	+	0.0238
DRN 3	Mossorõ, RN	22	4.6	4.0	62	0.9	-	-	+	0.0175
Latosols of the sandstone low plateaus										
DPE 6	Ibimirim, PE	nd	4.6	4.3	nd	nd	-	-	+	0.0175
DRN 4	Açu, RN	25	5.5	4.7	nd	2.2	-	+	tr	0.0128

nd = not determinated; tr = trace; + = detected; - = not detected

X-RAY DIFFRACTION STUDIES

Tables 1, 2 and 3 indicate that the hematite is not identified but in half of analyzed samples, while the goethite, with rare exception, is always present. It can be perceived that the fact of the hematite being present, does not interfere on the goethite parameter $\Delta\mathring{A}$ values. This goethite $\Delta\mathring{A}$ parameter presents a large interval of variations since it can take on any value between 0.0112 and 0.0395.

If we observe for the spacial distribution of the goethitic soils, of the goethitic and hematitic soils, and for the spacial distribution of $\Delta\mathring{A}$ values, no ordering is found.

TABLE 2. ANALYTICAL DATA OF LATOSOLS OF THE MIDDLE SÃO FRANCISCO DEPRESSION, THE PARNAIBA BASIN AND THE CALCAREOUS PLATEAUS (GI = GIBBSITE; HE = HEMATITE; GO = GOETHITE).

Sample	Location	Clay %	pH H_2O	pH HCl	V %	Fe_2O_3 %	Gi	He	Go	$\Delta\mathring{A}$
Latosols of the Middle São Francisco Depression										
DPE 1	Petrolina, PE	19	4.8	4.0	40	1.6	-	tr	+	0.0175
DPE 2	Rajada, PE	30	4.9	3.9	43	2.9	-	tr	+	0.0206
DBA 6	Remanso, BA	23	5.2	4.4	82	1.6	-	-	+	0.0175
ABD 1	Ibitiara, BA	36	5.2	4.2	nd	3.2	-	-	+	0.0175
DBA 33	O.dos Brejinhos,BA	31	5.7	4.9	nd	2.9	-	-	+	0.0206
DBA 10	Boquira, BA	28	5.1	4.4	85	2.2	-	+	+	0.0206
DBA 32	Macaubas, BA	26	5.3	4.6	nd	3.2	-	tr	+	0.0175
DBA 12	Livramento, BA	28	4.6	4.0	22	2.3	-	tr	+	0.0206
DBA 23	Brumado, BA	26	5.8	5.0	80	4.1	-	+	+	0.0175
DBA 27	Guanambi, BA	28	5.6	4.4	62	2.2	-	tr	+	0.0206
DBA 28	Urandi, BA	27	5.7	5.0	91	5.5	-	+	+	0.0206
DMG 10	Monte Azul, MG	32	5.2	4.5	84	2.5	-	-	+	0.0206
DBA 5	Formoso, BA	32	4.7	4.2	55	4.7	-	tr	+	0.0238
Latosols of the Parnaiba Basin										
DPI 2	Gilbues, PI	21	4.9	4.1	8	1.0	-	+	tr	nd
DPI 8	Picos, PI	28	4.4	4.1	10	2.6	-	-	+	0.0144
DPI 3	Cristino Castro,PI	39	4.4	4.2	9	2.4	-	tr	+	0.0206
Latosols of the Calcareous Plateaus										
DBA 2	Irecê, BA	35	5.3	4.8	76		-	+	tr	nd
DBA 25	Souto Soares, BA	15	7.3	6.6	60		-	+	+	0.0112

nd = not determinated; tr = trace; + = detected; - = not detected

But if we analyse separately the latosols of the low plateaus, those of the Middle São Francisco Depression, Parnaiba Basin and Tertiary plateaus, the results will show some coherent relationships.

Latosols of sandstone and coastal low plateaus

These are iron-poor soils (always less than 5% of total Fe_2O_3) and soils without gibbsite (Table 1). The goethite is sistematically present.

The latosols of the low costal plateaus are sand clayed and clayed soils. Only goethite is found. The $\Delta\mathring{A}$ of this goethite is 0.0175 northwards, close to Mossorõ (Rio Grande do Norte State), in a zone where the annual pluviometry is of the order of 750 mm. It is 0.0285 on the south of Salvador (Bahia State) where the annual pluviometry is over 1.500 mm. It takes intermediary values between Natal and Salvador, in intermediary pluviometric conditions (Fig. 3).

In the latosols of the sandstone low plateaus, goethite is only present. Hematite was found on a single case, which indicate that latosols derived from sandstone could also be hematitics.

TABLE 3. ANALYTICAL DATA OF LATOSOLS OF THE TERTIARY PLATEAU (GI = GIBBSITE; HE = HEMATITE; GO = GOETHITE).

Sample	Location	Clay %	pH H_2O	pH HCl	V %	Fe_2O_3 %	Gi	He	Go	$\Delta \mathring{A}$
DBA 9	Poções, BA	44	4.6	4.0	20	2.9	-	-	+	0.0206
DBA 20	Maracás, BA	39	4.5	4.4	35	7.4	-	-	+	0.0206
DRN 5	Cerro Corá, RN	30	4.6	4.0	19	0.7	-	-	+	0.0206
DCE 1	Campos Sales, CE	39	4.6	4.0	12	2.1	-	-	+	0.0206
DBA 30	Itaberaba, BA	53	5.1	4.8	nd	5.0	-	tr	+	0.0238
DRN 1	Martin, RN	60	4.9	4.1	77	3.5	-	-	+	0.0238
DPI 4	Eliseu Martin, PI	39	4.3	3.9	18	3.0	-	-	+	0.0253
DRN 6	Jaçanã, RN	41	4.7	4.0	8	2.3	-	-	+	0.0253
MPI 1	S.R. Nonato, PI	20	4.6	4.3	6	2.6	-	tr	+	0.0270
DBA 37	Mundo Novo, BA	37	5.3	4.1	nd	6.3	-	tr	+	0.0270
DBA 26	Caetité, BA	21	5.2	4.5	14	2.3	-	-	+	0.0285
DCE 3	Crato, CE	39	5.1	4.3	3	3.3	-		+	0.0285
VFF 10	V.da Conquista, ES	53	4.5	3.7	5	7.5	-	tr	+	0.0285
VFF 21	Barra da Estiva, BA	64	4.9	4.2	7	10.0	+	+	+	0.0285
DBA 36	Morro do Chapéu, BA	18	5.7	5.1	nd	2.4	tr	tr	+	0.0300
DBA 34	Seabra, BA	50	5.0	4.9	nd	5.1	-	-	+	0.0300
DMG 11	Salinas, MG	55	5.0	4.4	2	8.8	+	+	+	0.0300
VFF 15	Barreiras, BA	36	4.9	5.6	2	6.0	+	+	+	0.0316
DPE 5	Garanhuns, PE	32	4.9	4.3	18	2.7	-	-	+	0.0332
VFF 19	Seabra, BA	42	5.1	5.6	10	7.5	-	tr	+	0.0332
DMG 13	Montes Claros, MG	14	4.9	5.3	7	9.6	+	+	+	0.0332
DMG 15	Montes Claros, MG	41	4.4	4.5	21	2.6	+	+	+	0.0332
DMG 7	Pedra Azul, MG	46	5.3	5.1	9	5.0	-	+	+	0.0395
DMG 20	Montes Claros, MG	61	4.5	4.8	2	15.6	+	+	tr	nd
DMG 21	Turmalina, MG	69	4.9	4.6	2	12.4	+	+	tr	nd

nd = not determinated; tr = trace; + = detected; - = not detected

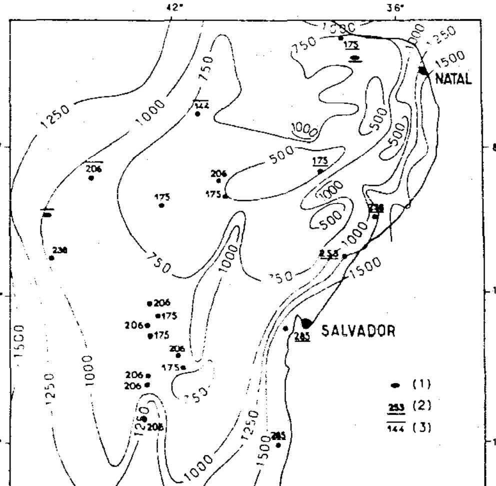

FIGURE 3
Map of annual isohyets (mm of mean annual precipitation) after Nimer (1972) and location of d(111) goethite line deviations ($\Delta \mathring{A}$. A^4) on the Middle São francisco depression, low plateau and Parnaiba basin latosols. (1) Latosols with many hematite; (2) latosols of the low plateaus; (3) latosols of the Parnaiba basin.

In all sandstone low plateaus latosols, the $\Delta \mathring{A}$ goethite parameter is of little high value (Table 1). It will be noted here that all the soils on the low sandy plateaus are located in low pluviometric zones with less than 750 mm of annual rainfall (Fig. 3).

The low plateau latosols are but for rare exceptions soils with goethite only. In these soils there is a clear relation between the pluviometric conditions and the goethite $\Delta \mathring{A}$ parameter values.

Latosols of Middle São Francisco Depression

These are equally iron-poor soils: the maximum found is 5.5% of Fe_2O_3 (Table 2). Goethite and hematite are both present, but the hematite is never well characterized by X-ray diffraction. There is no gibbsite in latosols of this depression. The $\Delta \mathring{A}$ parameter of the goethite ranges from 0.0175 to 0.0238. The most frequent values, 0.0175 and 0.0206, are aleatory distributed over the Middle São Francisco Depression, in an area which is totally placed in the pluviometric zone of less than 1.000 mm of annual precipitation. There are no evidences that the lowest values (0.0175) are preferably located in the dryer zones. It can be only noticed that the highest value (0.0238) was found on the occidental part, close to the moisty region of Central Brazil.

Latosols of the Parnaiba Basin

These are sandstone-associated latosols. They have a poor iron content (Table 2). There is either predominance of hematite or goethite. The $\Delta \mathring{A}$ value of the goethite is always less than 0.0206. There is no gibbsite in these soils.

Latosols of the Tertiary Plateaus

These latosols present highly variable iron contents. Some have less than 1% of total Fe_2O_3, others, over than 15%. It looks like, though it is not an absolute general law, that soils with low iron contents will be located in the north plateaus while those with high iron contents, on the south plateaus. We can distinct: the hematite-only latosols, the hematite and goethite latosols and the goethite only latosols.

The hematite only latosols. In some cases, there are traces of goethite. These latosols are found only at the south of the studied zone. Their iron content is high (Table 3). Furthermore they are highly gibbsitic (generally over 30% of gibbsite).

The hematite-goethite latosols. The hematite can be either very well characterized by X-ray diffraction or present only in traces. The goethite is always perfectly identified. Its $\Delta \mathring{A}$ parameter ranges from 0.0238 to 0.0395. The higher values correspond to the richer hematite soils, those which are at the same time gibbsitic soils. The low values are correlated with the goethite of the hematite-poor soils, generally lacking gibbsite. The goethite and hematite latosols seem to be preferably extended over the southern half part of the studied zone.

The goethite-only latosols. The $\Delta \mathring{A}$ is low (0.0206-0.0300). There is no gibbsite. These goethite-only latosols are located on north and southeast of the tertiary plateaus zone.

The goethite ΔÅ parameter on the whole tertiary plateaus soils range, therefore, from 0.0206 to 0.0395. It was stated that both the hematite and the gibbsite are present when the goethite ΔÅ exceeds a certain value. Systematically, there is goethite only when ΔÅ is low, and there is hematite + gibbsite following the goethite when ΔÅ is very high.

The observation of the geographic distribution of the goethite ΔÅ (Fig. 4) shows that there are 2 zones of low ΔÅ values: one on the north borders of the plateaus, and the other on south of Salvador. They are not explained by any climatic evidence; nothing indicates that they are related to specially dry climate zones. On the other hand, the high ΔÅ values are regrouped on the south, on a zone where the annual pluviometry ranges from 750 to 1.250 mm. There is, visibly, on the tertiary plateau area, no relation between the ΔÅ parameter and the pluviometric data.

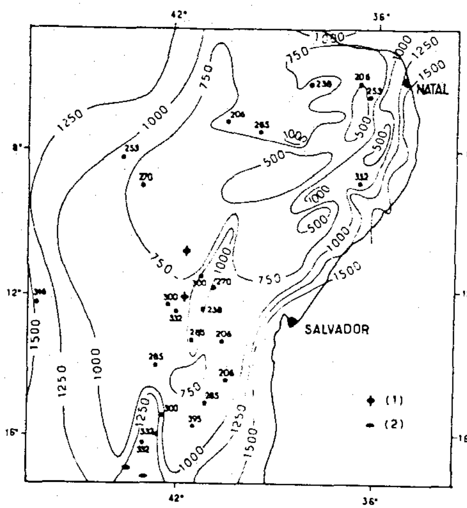

FIG. 4. Map of annual isohyets (mm of the mean annual precipitation) after Nimer (1972) and location of d(111) goethite line deviations (ΔÅ . 10^4) in the tertiary plateau latosols. (1) latosols with many hematite on calcareous plateaus; (2) latosols with many hematite on tertiary plateau.

Latosols of the Calcareous Plateaus

These soils are located at the center of the "Nordeste", in a single climatic zone (less than 750 mm of annual rainfall). The hematite is the principal iron oxide. The goethite exists only but in very low amounts. The ΔÅ parameter presents very low values (0.0112). Gibbsite is never found (Table 2).

MÖSSBAUER SPECTROMETRY STUDY

The analyses results of 5 samples show there is a very good correlation between the X-ray identifications and Mössbauer Spectrometry. Nevertheless, in ABD 1 sample, the hematite found by Mössbauer Spectrometry (Table 4) is not clearly identified by X-ray diffraction. In fact, on the diffractogrammes (Fig. 5) the 2.52 Å hematite line does not exist; however, the enlargement to 2.69 Å of the goethite peak at 2.65 Å confirms the hematite presence.

TABLE 4. Fe DISTRIBUTION TO NON-FERROUS MINERALS, GOETHITE, HEMATITE AND AMOUNT OF VERY FINELY DIVIDED GOETHITE AND HEMATITE (IN PERCENT OF Fe TOTAL) FROM MÖSSBAUER ANALYSIS OF < 2μ SOIL FRACTIONS.

Sample	Fe in substitution in non-ferrous minerals	Goethite		Hematite	
		Grain Size		Grain Size	
		< 100 Å	100 to 250 Å	40 to 100 Å	> 100 Å
ABD 1	35	-	45	10	10
DAL 1	10	10	80	-	-
DRN 1	20	10	70	-	-
DPE 5	10	20	70	-	-
DMG 7	10	40	10	30	10

The results of Table 5 point that, on the goethite, iron substitution for aluminium is always important. For high rates of substitution, the goethite ΔÅ parameter does not provide exact informations about the iron replacement but it is in close relation with the goethite grain size (Table 4), reflecting very well the soil goethite division. This has already been pointed out (Norish and Taylor, 1961, Bigham et al., 1978). Fig. 6 shows that a same ΔÅ variation indicates greater increasing of the goethite state division in the 0.0300/0.0400 interval than on the 0.0100/0.0300 one.

The iron substitution for aluminium in the hematite, when this oxide is present (Table 5) seems to be equal in all the cases, but its division state could de different. The finest hematite is associated with the more divided goethite.

DISCUSSION AND CONCLUSION

Results show that in the Northeast Brazil latosols, the iron oxides associated with the fine soil fraction are the hematite and the goethite. Their relative proportions and their division states are much variable. According to this, we can distinguish: (1) latosols with only hematite, (2) latosols with only Al-substituted goethite, (3) latosols with both Al-substituted goethite and hematite.

The geographic distribution of these latosols leads to a schematic division of the Northeast in three domains (Fig. 7):

TABLE 5. DEVIATION Å OF THE D(111) REFLECTION LINE OF GOETHITE AND MÖSSBAUER DETERMINED Al-SUBSTITUTION IN GOETHITE AND HEMATITE FROM < 2µ SOIL FRACTIONS.

Sample	Goethite		Hematite
	ΔÅ	Al-substitution, mole %	Al-substitution, mole %
ABD 1	0,0175	20	20
DAL 1	0,0238	20	-
DRN 1	0,0253	> 20	-
DPE 5	0,0332	> 20	-
DMG 7	0,0395	> 20	20

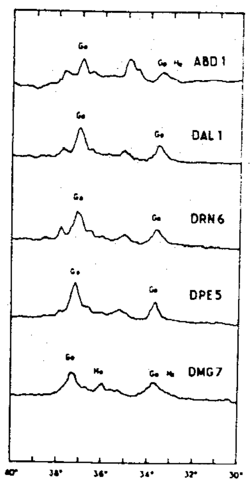

FIG. 5. X-ray diffractograms of 2N-NaOH treated 0-2µ soil fractions (Go = goethite, He = hematite).

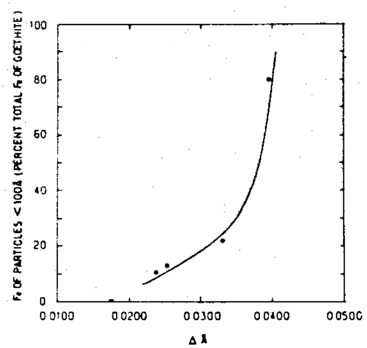

FIG. 6. Relationship between deviation (ΔÅ) of d_{111} line and particle size of soil goethite.

Domain I where the hematite is the dominant iron oxide in the soil. There the climate is moist. On the tertiary plateau position the soils have remarkable gibbsite proportions.

Domain II with goethite and hematite. The present climate is dry. On the tertiary plateau the goethite is very finely divided and gibbsite is, at times, present; on the Middle São Francisco Depression and the Parnaiba Basin, the goethite is much coarser.

Domain III with only Al-substituted goethite. In this case there is no correlation

with the climate, that can be dry or moist. In this domain we can find goethite in a very fine divided state, on the tertiary plateau as well as on the low plateau.

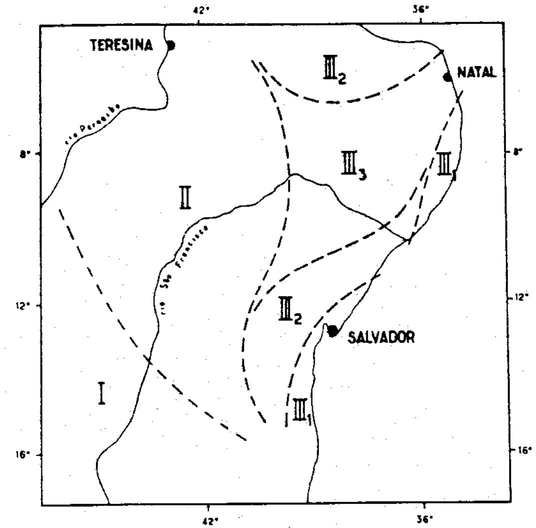

FIGURE 7

Schematic division of Brazilian Northeast based on latosol iron oxide mineralogy. I: latosols with hematite and gibbsite; II: latosols with Al-substitued goethite and hematite; III: latosols with only Al-substitued goethite; III_1: very finely dibided goethite of the moist low plateaus; III_2: with coarser goethite of the dry low plateaus; III_3: very finely divided goethite of the dry tertiary plateaus.

The low topographic level of the domain II (Middle São Francisco Depression and Parnaiba Basin) has taken place after the high surface elaboration and, consequently, its latosolic cover would be younger than those of the tertiary plateau. On the tertiary plateau the goethite is finely divided, while it is coarser on the Middle São Francisco Depression and the Parnaiba Basin. This would indicate there is a relationship between the division of the goethite and the age of the latosols the elders having the more divided goethite.

Then, all the latosols of the tertiary plateau with only goethite, would not be of the same age because some have a very finely divided goethite and the rest have goethite in a coarser state. The first would be elder than the latters. On this hypothesis it is possible to isolate the soils of the east and north borders from other soils of the plateau and to include them in the low plateau soils units constitued of younger soils. This is in accordance with the schema proposed by King (1956). Domain III would be then divided into:

Domain III_1 with very finely divided goethite. This domain is located on the part of coastal low plateau under actual moist climate.

Domain III_2 with Al-substituted, much coarser goethite, corresponding to another part of the low plateaus and to the eastern and northern borders of the tertiary plateaus. Soils of this domain are under a present dry climate.

Domain III, with very finely divided goethite, located on the central part of the tertiary plateau and under a present dry climate.

On the other hand, it has been observed that the hematite occurrence is correlated with high base saturation, or, in acid soils, with a humid tropical climate with contrasting seasons (case of the southwestern soils of the studied zone). There is, indeed, no hematite in unsatured soils of the coastline zone, under moist and well-distributed rainfall climate. This would indicate, according to Melfi et al. (1979), that a humid tropical climate with dry season, is needed for the hematite formation and that under a humid equatorial climate, with well distributed annual rainfall, only the goethite is present. It was also observed that the microdivision of iron oxides in acid soils is influenced by the rainfall abundance. The microdivision of soil iron oxides could be then subordinated to the rainfall volume while the relationship goethite/hematite is ruled by the pluvial regime, that is, by the length and severety of the dry season. On these conditions the characteristics of the iron oxides of latosols presently under a dry climate should have a paleoclimatic signification.

Thus, the latosols of the Domain II have probably never been under an equatorial climate without dry seasons, since they contain hematite. But, domain III soils have all been marked by such a climate.

A very moist period is necessary to explain the microdivision of the goethite of Domain II and Domain III plateau soils. This period must be previous to the formation of the low plateau, Middle São Francisco Depression and Parnaiba Basin latosols, in which the goethite is less divided.

The low topographic level soils have probably been formed under a moister climate than the present one, but this climate have never been very rainy. Their goethite have not been strongly divided.

In conclusion, this paper shows that the iron oxide mineralogy is a good differentiation criterion of Northeast Brazil latosols and that the knowing of the iron oxides allows the outlining of interesting hypothesis about the formation of these soils. The interpretations made here are much partial ones for they are not supported by a sufficient number of observations. They have been proposed notwithstanding aiming to point out what type of information the studies on the iron constituents of the soils can bring.

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