MINERALOGY OF THE CLAY FRACTION OF SOILS ON TOPOSSEQUENCE IN A TRANSITION SLOPE-QUATERNARY ALLUVIAL SEDIMENTS OF THE MOGI GUAÇU RIVER IN THE ECOLOGICAL STATION OF JATAÍ, LUIS ANTÔNIO, SP

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ABSTRACT – Through mineralogical analysis of the soils of the topossequence "Infernão", it has aimed to understand what information soil forming could provide about how it configures the transition slope/quaternary alluvial sediments of the Mogi-Guaçu river terrace, what role relief and origin material have in the origin of the soil in the Ecological Station of Jataí (ESJ), in Luis Antônio-SP. For that, the sequence basalt-sandstone and the plain of the Mogi-Guaçu river have been observed, peculiar for the several abandoned meanders. The results indicate that in the topossequence "Infernão" there are two rather distinct dynamics: segment III responds to a dynamic more associated to the materials that have been deposited on the old Mogi Guaçu river alluvial plain, with small contribution of colluvial material, while segments I and II respond to a dynamic associated to their position in the slope and strictly related to the type of rock which it is associated.

Keywords: Mineralogy, Soil forming, Mogi-Guaçu river.

RESUMO – *A.L. de S. Celarino & F.S.B. Ladeira - Mineralogia da fração argila de solos em topossequência numa transição da inclinação quaternária de sedimentos aluviais do rio Mogi Guaçu na Estação Ecológica de Jataí, Luis Antônio, SP*. Através da análise mineralógica dos solos da topossequência "Infernão" objetivou-se entender quais informações a pedogênese poderia fornecer acerca de como se configura a transição vertente/sedimentos aluviais quaternários do terraço do rio Mogi Guaçú, qual o papel do relevo e do material de origem na gênese dos solos na Estação Ecológica de Jataí (EEJ), em Luis Antônio-SP. Para isso foi observada a seqüência Basalto-Arenito e a várzea do rio Mogi Guaçú, peculiar pelos seus inúmeros meandros abandonados. Os resultados indicam que na topossequência "Infernão" existem duas dinâmicas bastante distintas, o segmento III responde a uma dinâmica mais associada aos materiais que foram depositados na antiga planície aluvial do rio Mogi Guaçu, com pouca contribuição de material coluvial, enquanto que os setores I e II respondem a uma dinâmica associada à sua posição na vertente e estritamente relacionada ao tipo de rocha a qual está associada.

Palavras-chave: Mineralogia, Pedogênese, rio Mogi Guaçú.

INTRODUCTION

Soil is a result of the continuous interaction among five factors: weather, relief, climate, organic matter and rocks or sediments of origin. Understanding how these factors relate themselves in distinct situations through the geological history has a great importance in studying the formation of the soils.

Among these factors, it is highlighted in this article the influence exerted by the minerals that constitute the source area, regarding the fact of existing in the studied place a known set of rocks and sediments, following: Serra Geral Formation – Botucatu Formation – Quaternary Alluvial Sediments of the Mogi-Guaçu river.

It is known that the resistance to the weathering of the minerals of the rocks in the source area determines which chemical elements will constitute the soil. According to Birkeland (1999), rocks or minerals in varied weathering situations can produce different minerals of clay, following Barnhisel & Rich (1967) granite and gneiss have minerals with low rate of Ca^{+2}, Mg^{+2} e K^{+}, usually form more kaolinites (clay mineral 1:1), while rocks that have minerals with higher rate of these elements, for instance basalt, gabbro or diabase usually form more esmectites, montmorillonites, in other words, clay minerals 2:1. The level of weathering of the rock can also control with rather efficiency the formation of clay minerals through processes of monosialitization, bisialitization, total hydrolysis and acidolysis.

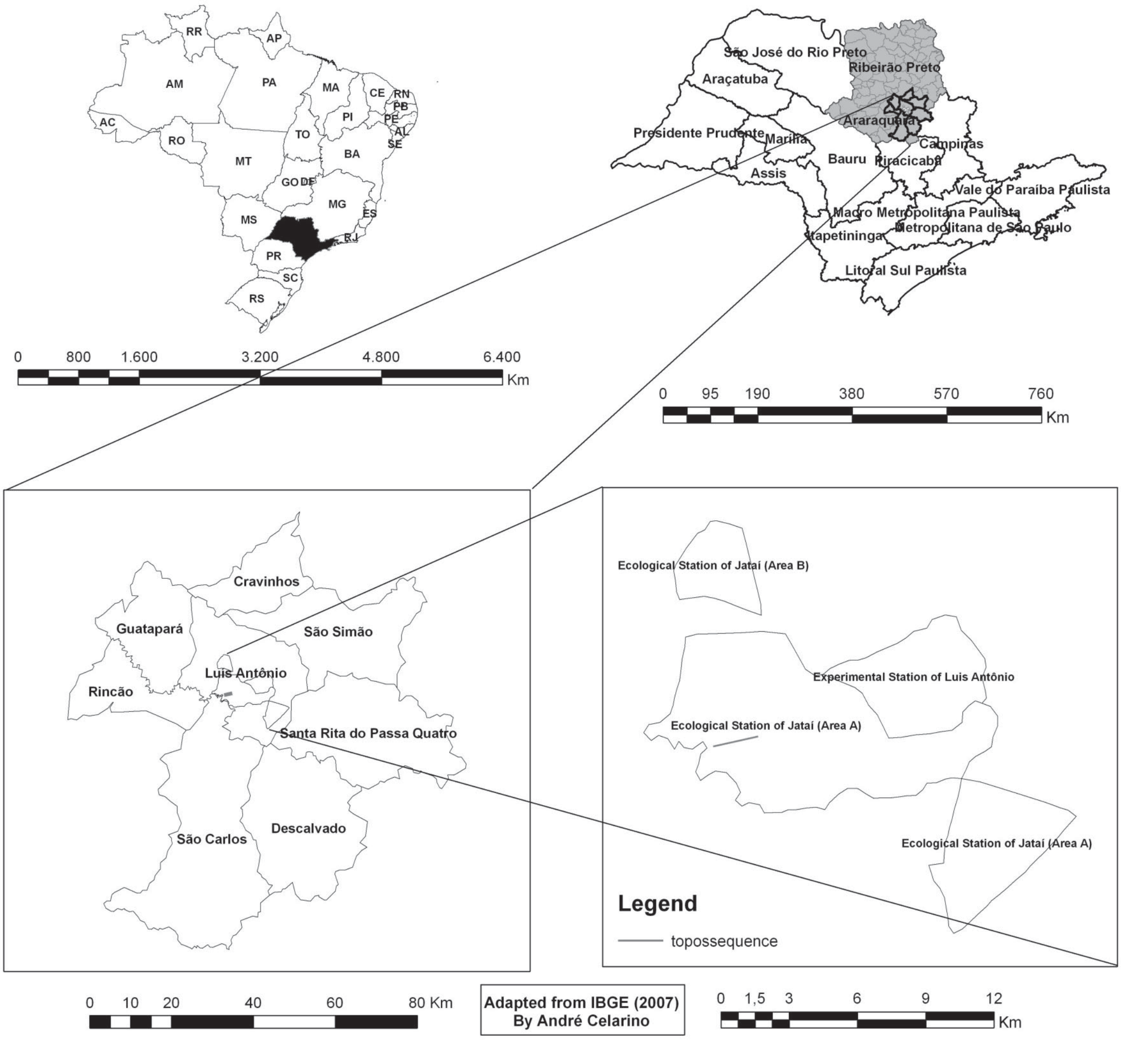
Moreover, on this article will be analyzed the minerals of the fraction clay of the soils in the Ecological Station of Jataí (ESJ) area, in Luis Antônio-SP with the objective of understanding which evidence can prove the influence of this factor in the soil formation of the studied topossequence, also considering the local geomorphologic partitioning.

MATERIAL AND METHODS

Characterization of the Study Area

The topossequence of soils worked on this article, named “Infernão” (it has this name for being next to a stream of same nomenclature), is located at the Ecological Station of Jataí (ESJ) in the northeast of the São Paulo State, in the town of Luis Antônio-SP (Figure 1).

In the geomorphologic map proposed by Ross & Moroz (1997), part of the area of the Station includes the floodplain of the Mogi Guaçu river in the portions identified as “Small Fluvial Plains”, composed by not



Adapted from IBGE (2007)
By André Celarino

FIGURE 1. Location of the study area.

very consolidated sediments that date from Cenozoic, and another part includes the domain of the Ribeirão Preto Structural Levels, located in the Western Plateau of São Paulo (*Planalto Ocidental Paulista*) in the Sedimentary Basin of Paraná.

The forms of regional relief are not much dissected with wide hills and low ones with tabular tops, not very cut valleys with less than 20 m and big interfluvial dimensions that range from 750 m to more than 3,750 m (Ross & Moroz, 1997).

Following the climate differentiation map for the Southeast region, proposed by Nimer (1979), the climate of the region – where ESJ is located – is inserted in the transition between hot semi-humid tropical and sub-hot humid tropical. The average of the annual precipitation in the period from 1970 to 2004, according to the measurement made by pluviometer at Luis Antônio Station, of prefix -096, situated at 670 m of altitude (coordinates 21º 35'S and 47º 42'W), was 1,470 mm. (DAEE – available on www.daee.sp.gov.br).

According to Toppa (2004), 60.72% of the area of ESJ have the appearance defined as cerradão, 19.52% appearance of cerrado in regeneration, 13.6% appearance of mesophyll semi-deciduous forest and 1.09% of floodplain vegetation.

ESJ belongs to Hydrographic Basin of the Medium-Upper Mogi, receiving the flow of the streams Boa Sorte, Cafundó (Infernão) and Beija Flor. (CBH – Mogi – UGRHI – 09, 1999). In the region, the channel of the Mogi-Guaçu river has meanders and many of them are abandoned, responsible for the existence of lakes situated on the alluvial plains.

About the regional geology, it can be distinguished three main formations. In the segment I of the "Infernão" topossequence (Figure 2) Serra Geral Formation (Jurassic/Cretaceous) occurs, composed by a set of volcanic rocks composed by basalt and diabase dykes. According to Squisato et al. (2009), the petrographic analysis of basalt of the Ribeirão Preto-SP region has demonstrated that they are constituted by 30-50% of plagiocases, 20-35% of pyroxines and 5-15% of opaque minerals as magnetite and ilmenite; as accessories were found quartz, apatite and olivine.

In the segment II sandstones of Botucatu Formation occur, this one composed by a pack of sandstones with fine and medium granulation with crossed stratification characteristic of dunes. "Botucatu Formation represents the diverse sub-environment of a big climatic desert of increasing aridity, whose existence has extended until basaltic volcanism occasion." (IPT, 1981). Following Wu and Caetano-Chang (1992), the petrography of the Botucatu sandstones is composed by 40-80% of quartz, feldspar 3-10% orthoclase, microcline, partially weathered alkali plagioclase and altered to kaolinite and/or olivine), fragments of rocks 1-2%, Mica <1% and cement 3-5% "it consists of iron oxide-hydroxide and authigenic clay on the surface of the framework grains and partially in the void among the grains".

In the segment III quaternary alluvial sediments occur, following Lorandi et al. (2006), they are alluvional plains that occur along the rivers Rio Mogi-Guaçu, Pardo, Jacaré Guaçu and Jacaré Pepira, they are

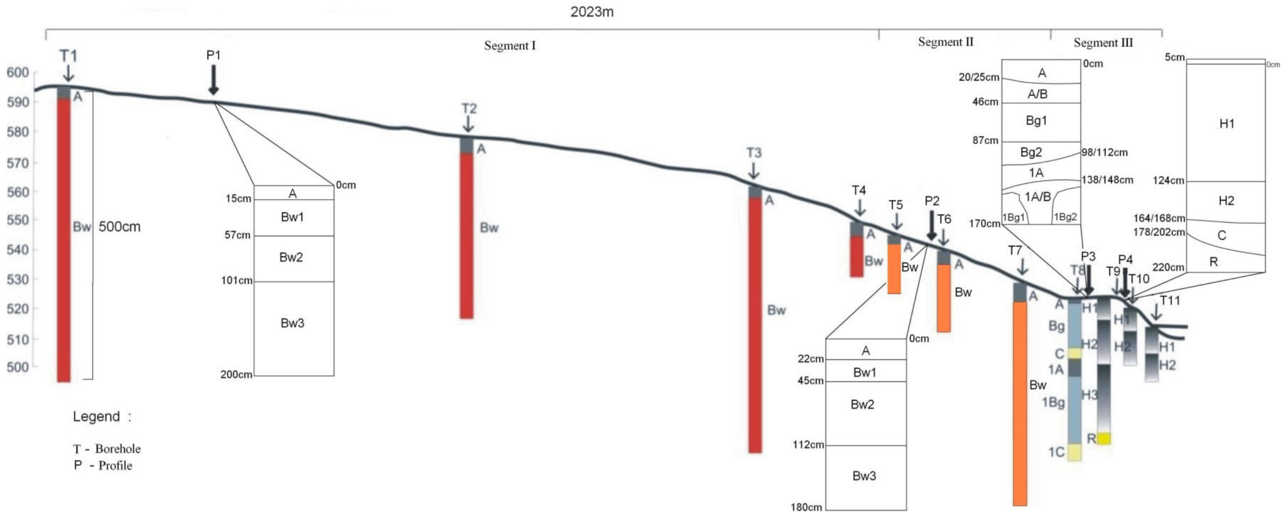


FIGURE 2. Topossequence "Infernão".

associated to the last phases of humid climate and are constituted by sand and gravel, according to Ab'Sáber (1969).

In areas or levels of usual thickness, the deposits of covering have been sufficient to create zones of transition among the slopes and terrains, as well as among different levels that participate on the partitioning of the topography (Ab'Sáber, 1969).

FIELD WORK

Field work has been done where boreholes (T1, T2...) have been made for the identification and description of the texture and color of the horizons of the soils of the topossequence. In the sequence, 4 trenches have been opened to collect samples for the X-ray diffraction and drawing of the macromophology of the soil profiles, taking into account the attributes proposed by Lemos e Santos (2002): color, texture, structure, porosity, consistence, presence of roots and transition among the horizons.

The soils have been classified following the criteria of USDA (1999) for American classification and Embrapa (2006), for Brazilian classification. There are: P1 - Typic Hapludox (EEEO) – *Latossolo Vermelho Distrófico Típico (LVd;* P2 – Typic Hapludox (EEEO) – *Latossolo Vermelho Amarelo Distrófico Típico (LVAd)*, P3 – Typic Udorthent (LEEF) - *Gleissolo Háplico Tb Distrófico Argissólico (GXbd)* and P4 – Typic Udifluvent (LDEH) - *Neossolo Flúvico Tb Distrófico Típico (RYbd).*

MAPS

The hypsometric map (Figure 3) has been made after the scanning of the contour lines of the maps IGC (1990a) and IGC (1990b) in the software ArcGis®O and later generation of the elevation model 3d. The trench points (P1, P2...) and boreholes (T1, T2...) have been also plotted with the support of the same software.

The geological map (Figure 4) has been made from the CPRM (s/d) database through the Geobank site. The pedological map is adapted from the maps produced by Lorandi et al. (2006), also with the support of software ArcGis® (Figure 5).

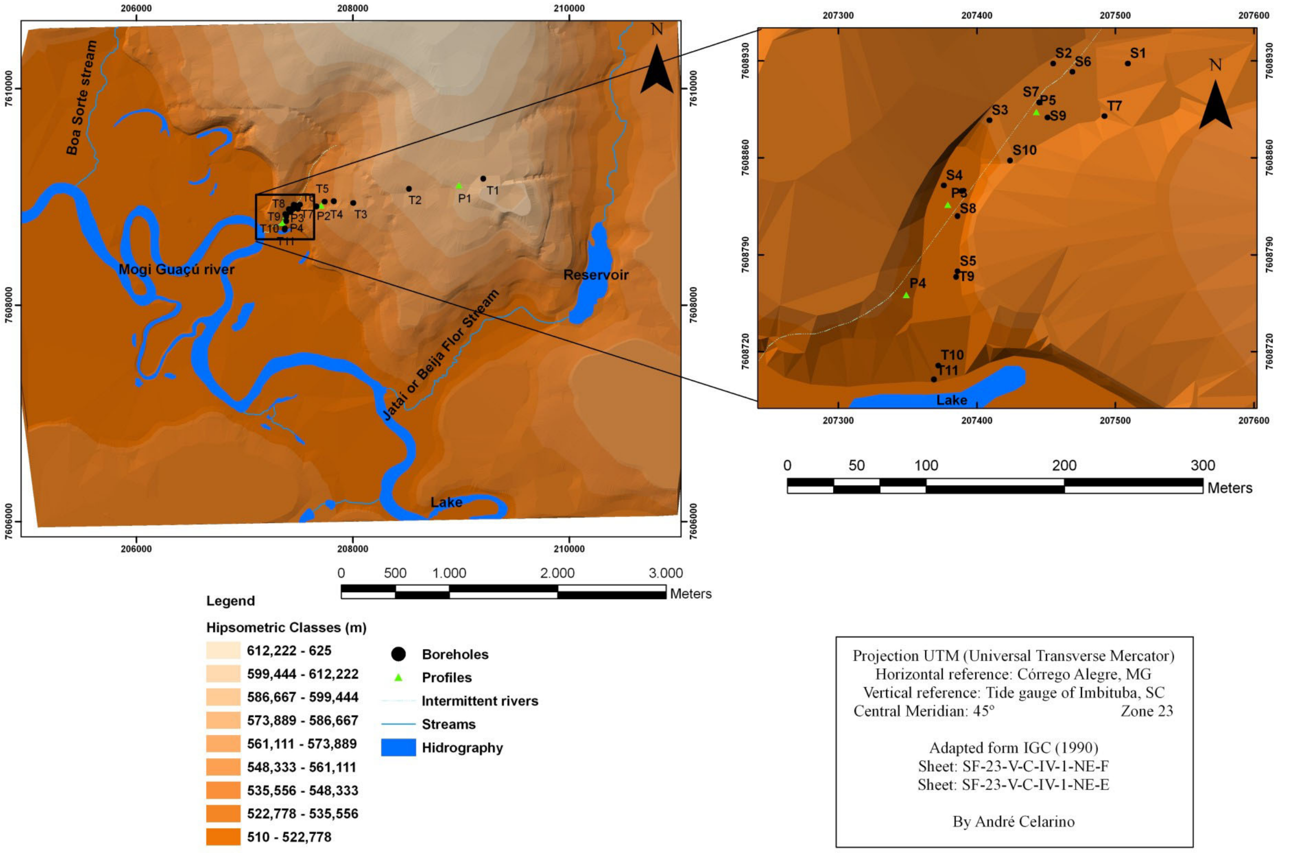


FIGURE 3. Hipsometric map of the study area.

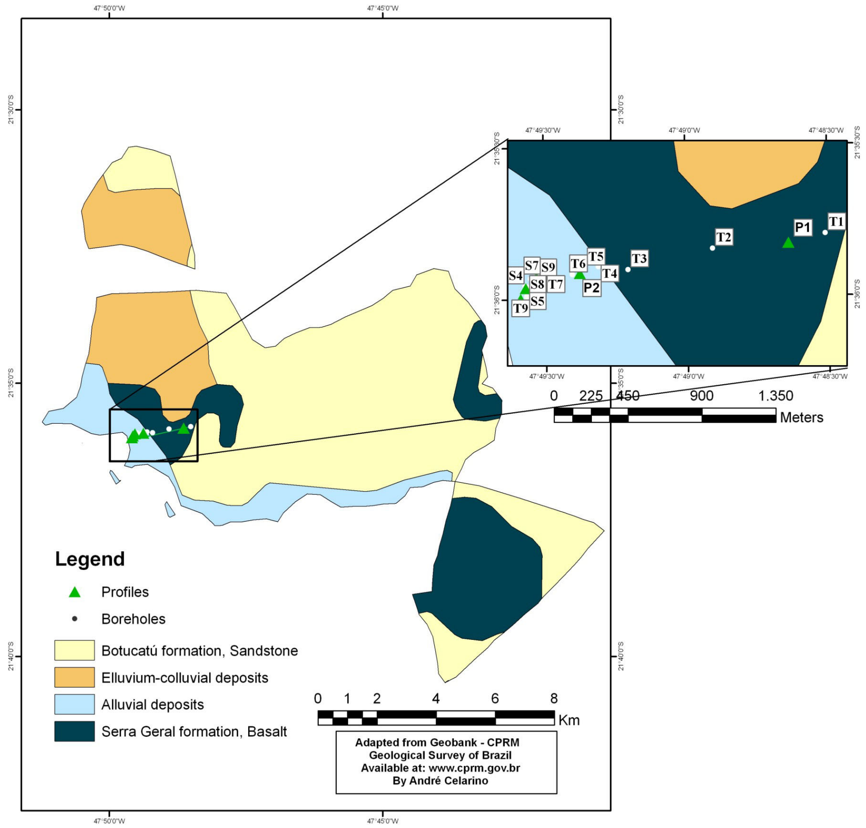


FIGURE 4. Geologic map of the study area.

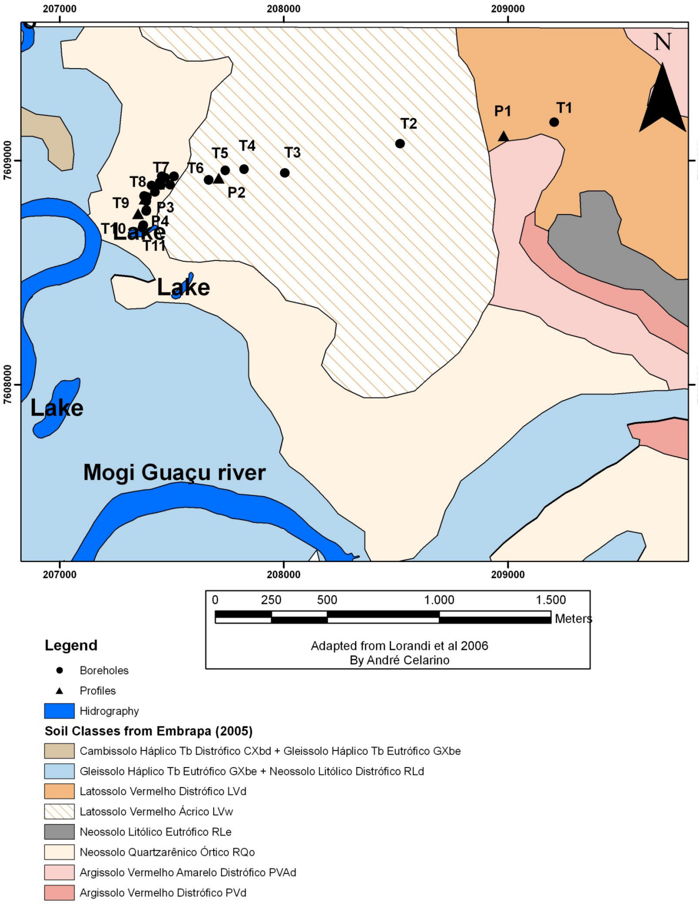


FIGURE 5. Pedologic map of the study area.

PREPARATION OF THE SAMPLES FOR THE X-RAY DIFFRACTION

This analysis has demanded pre-treatments which have been done at the Mineralogy Laboratory of Esalq-USP. Initially, the samples (already obtained the TFSA in 2mm sieve) have been put in 600ml beakers where 40ml of H_2O_2 was added and let it react for 20 minutes for the removing of organic matter, after, to accelerate the process it has proceeded the hot removal, where the samples were heated at 75ºC in board of heating. As the removing has not been still completed, it has proceeded the cold removal again, adding 10ml of H_2O_2 when it was noticed that the material was almost dried. This procedure has been done for about 3 weeks.

After this procedure, the washings have started. The samples were passed to centrifuge tubes where they were washed twice with NaOAc (Sodium Acetate) and once with Ethanol. For each washing the samples have been agitated for 3 minutes and after centrifuged for 10 minutes at 2400 rpm.

For the removing of iron oxides, it has separated the samples of the profiles 1 and 2 for them to be identified, while the other ones have kept on being treated.

After throwing away the supernatant of the samples from the past washings, 40ml of Sodium Citrate + 5ml of Sodium Bicarbonate solution have been added and the samples heated at 75ºC in water bath. After, 1g of Sodium Dithionite has been added and the samples agitated for 1 minute with glass tube. After 15 minutes, the process was repeated and then 10ml of saturated NaCl solution + 10ml of Acetone have been added, the samples agitated and centrifuged at 2400 rpm for 10 minutes. This process has regarded the methodology proposed by Mehra & Jackson (1960).

After this process, some samples still showed brownish color, still indicating the presence of iron and then it demanded another extraction with dithionite; the other ones have shown rather gray color which it has indicated that the iron had already been removed; therefore, it has gone to the final washing with saturated NaCl.

Finishing these treatments, the process of obtaining clay fraction has started. The samples were put in bottles with dispersing agent (NaOH) and then they were dropped in a measuring tube with a funnel and sieve with net of 0.053mm (limit between very fine sand and silt).

Then, the sand has been retained in the sieve and the clay fraction and silt have been in suspension in the measuring tube. The separation has been done by decantation working out the time of the siphonations based on Stokes' equation. After the siphonations, the clay fraction was flocculated with concentrated HCl.

Each sample of Clay has been separated in two tubes that have been saturated with $MgCl_2$ e KCl, being agitated several times on the day and left for decantation during one night. On the day after, the supernatant was thrown away and all the samples were washed with ethylic alcohol for five times for removing the excess of salts, doing test with $AgNO_3$ the verification.

The followed methodology was based on Camargo et al. (1986) with adaptations to procedures followed by the Mineralogy Laboratory of Esalq-USP, headed up by Prof. Dr. Antonio Carlos de Azevedo.

The samples have been put in polypropylene tubes of 5cm and sent to the X-ray diffraction laboratory of Unesp-Rio Claro, where the samples have been spread over glass slide and taken to diffractometer D 5000 Siemens, with Copper tube at 40kV and current of 30mA; two of them which have been saturated with KCl have been also heated at 550°C for the confirmation of the kaolinite and two saturated ones with $MgCl_2$ been solvated with ethylene glycol for the identification of clay minerals 2:1 through expansion or not of the basal distance (d001) of the interlayers.

RESULTS AND DISCUSSION

Four points have been selected along the slope for the description, collecting of samples and classification of the soil profiles in trenches, regarding the information provided by boreholes previously made.

P1 –Typic Hapludox (EEEO) - *Latossolo Vermelho Distrófico Típico (LVD)* (Figure 6)

On the diffractogram of the total fraction of the horizon Bw2 (P1) without treatments (Figure 7) there are peaks of kaolinite, gibbsite, quartz, iron oxides and anatase. Following Tardy & Nahon (1985), oxisols developed in humid tropical climate usually show the association kaolinite, gibbsite and iron oxides, which it corroborates with the mineral identified in this sample.

Being an alteration of basalt, the peaks of quartz have been not very expressive in this profile because the material of origin shows petrography with low amount of quartz. However, according to Clemente e Marconi (1994) this quartz can be a result from neoformation by weathering of plagioclases and pyroxines, predominant minerals in basalt.

This occurence can be explained through neoformation, due to the release o silica in the weathering of plagioclases and pyroxines, which it is

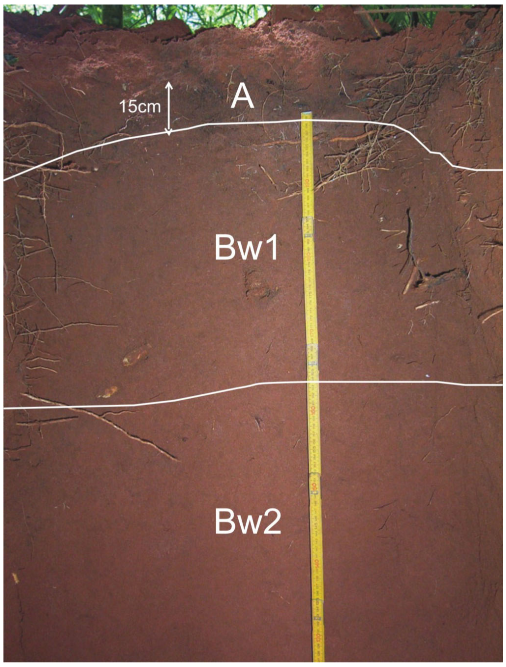


FIGURE 6. Typic Hapludox (EEEO) profile.

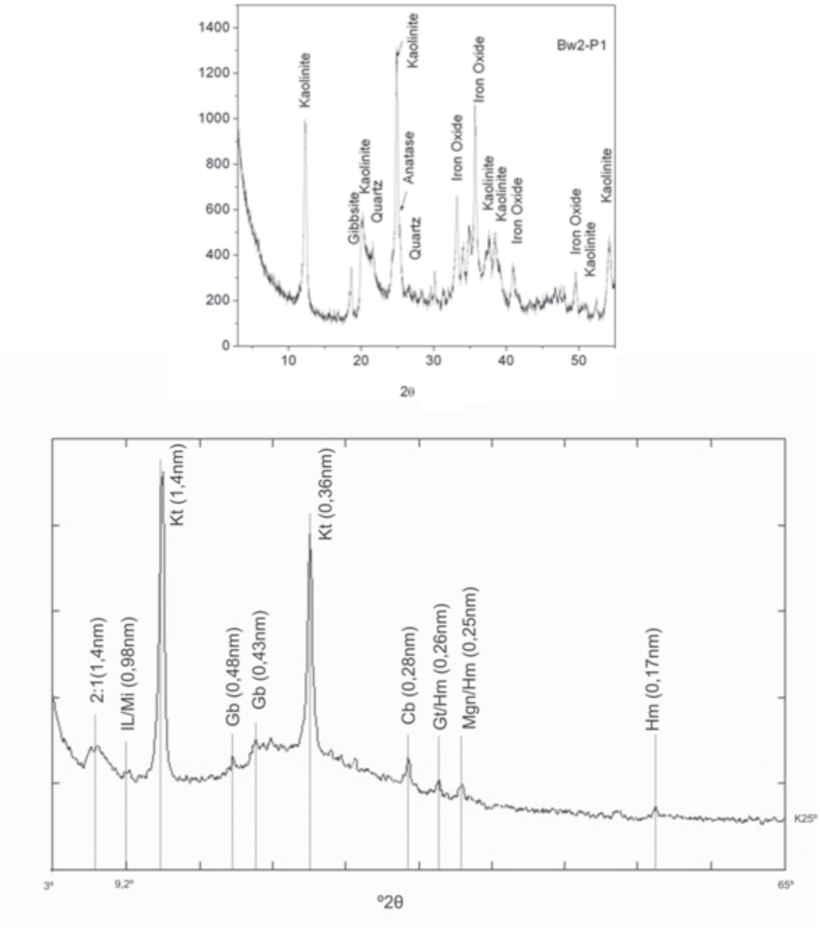


FIGURE 7. X-Ray difraction of the samples of Bw2 horizon (P1). Above: Total fraction from the powder method without pre-treatments. Below: clay fraction from the oriented thin section method. The values in parenthesis are the d-spacings in nm. 2:1: expansive clays; IL: Illite; Mi: Mica; Kt: Kaolinite; Gb: Gibbsite; Cb: Cristobalite; Gt: Goethite; Hm: Hematite; Mgn: Magnetite/Maghemite.

perfectly accepted by many authors, as Flach et al. (1969) and Wilding et al. (1977).

Kaolinite is also resulted from the alteration of silicate minerals; the intense peaks of this clay mineral can be explained through the hard weathering which this soil has been subjected, however, even with a very efficient drainage it has still showed peaks of clay mineral 2:1, according to the observed in the saturated sample with KCl in the basal distance of 1.4nm (Figure 7). The presence of not very high peaks of gibbsite can be related to the small availability of feldspar in the origin rock, main mineral originated from the gibbsite or the weathering has not been rather enough to remove the silica present in the kaolinite, once the peaks of these ones are very high (Ker, 1991). According to Truffi and Clemente (2002), gibbsite can also be formed through direct alteration of plagioclases ferralitic environment, through exposition to conditions of intense weathering; once basalt has considerable amount of plagioclase and the peaks of gibbsite have not been frequent, it can infer that weathering has not been sufficiently hard to its formation, what it makes us believe the desilification in this area has not been as fast as in other areas, as Albuquerque Filho et al. (2008) has demonstrated on his work.

It is also observed a peak of illite at 0.98nm, originated from the alteration of plagioclases that can be changing and forming the 2:1 mineral mentioned before (Pedron, 2007). The peaks of cristobalite corroborate with other works that have also identified this mineral in soil profiles that had as origin material basic rocks of Serra Geral Formation (Kämpf & Schwertmann 1983; Melo et al., 2004).

The origin of the iron oxides in the soils is related to the release of Fe^{+2}, contained in the pyroxines of the source material and its rapid oxidation to Fe^{+3}, being hydrolyzed to secondary forms, more stable in the current environmental conditions (Corrêa, 2005). In this profile, the peaks of iron oxides found in the not treated samples of the total fraction of the soil can also be inherited directly from the magnetite of the origin rock (Ferreira et al., 2003).

But in the sample treated treated with KCl, it can be observed a peak at 2.6nm of goethite or hematite, however, the applied method is not the most appropriate for a more specific identification of the oxides because the sample were not treated with NaOH 5mol/L to eliminate the silicates and diffractions in powder were not either made because this was not the objective of the analysis.

Anatase (TiO_2), following Milnes e Fitzpatrick (1989) from Souza Júnior (2006), has its origin related to the heritage of sediments coming from the continent that remain in the profile due to their strong resistance to weathering.

P2 – TYPIC HAPLUDOX (EEEO) - *LATOSSOLO VERMELHO AMARELO DISTRÓFICO TÍPICO (LVAD)* (FIGURE 8)

In the Figure 9, it is observed that the diffractograms of the horizon Bw2 look like the diffractograms of Figure 7, with the same peaks of kaolinite, clay mineral 2:1, gibbsite, anatase and iron oxides.

The peaks of quartz (in the diffractogram of the total fraction of the soil) have shown a little higher, besides the peaks of ilite and cristobalite have not been observed anymore. The small range has been expected, once in these areas, volcanic rocks can be interlaced to sandstones of the Botucatu Formation.

This fact reinforces the hypothesis that in this point there can be a mixture of basalts of Serra Geral Formation with sandstone of Botucatu Formation, following what it has been verified in several bibliographies (Mantesso Neto et al., 2004; IPT, 1981).

P3 – TYPIC UDORTHENT (LEEF) - *GLEISSOLO HÁPLICO TB DISTRÓFICO ARGISSÓLICO (GXBD)* (FIGURE 10)

This profile has been opened in the segment III of the topossequence “Infernão”, on a place where there is a planation of the relief and a bigger accumulation of water. Probably this soil has developed from alluvial deposits in the old alluvial plain of the Mogi Guaçu river, through periodic floods that have been able to carry sediments from other slopes to the upstream direction. With the abandonment of the meander and the 8m

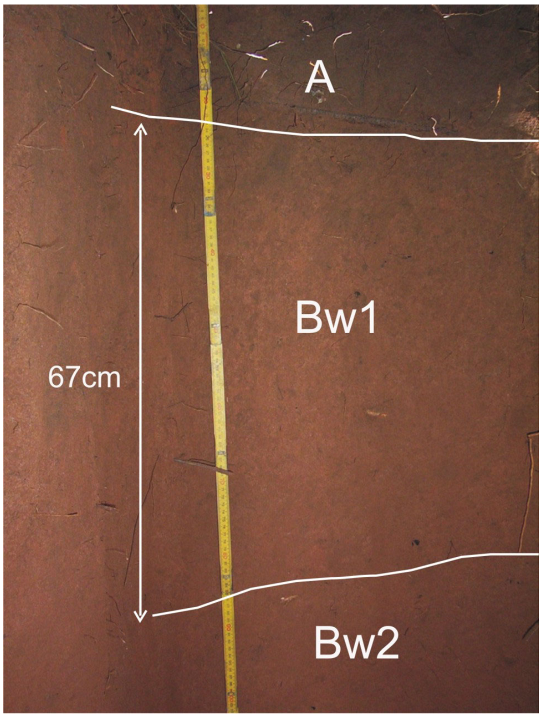


FIGURE 8. Typic Hapludox (EEEO) profile.

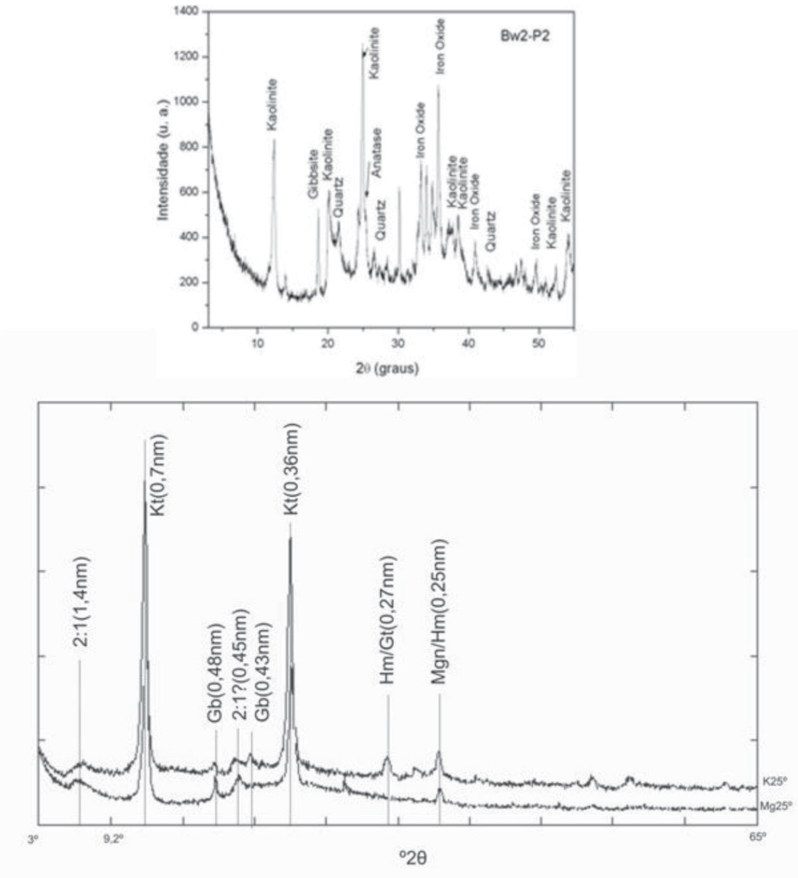


FIGURE 9. X-Ray difraction of the samples of Bw2 horizon (P2). Above: Total fraction from the powder method without pre-treatments. Below: clay fraction from the oriented thin section method. The values in parenthesis are the d-spacings in nm. 2:1: expansive clays; Kt: Kaolinite; Gb: Gibbsite; Gt: Goethite; Hm: Hematite; Mgn: Magnetite/Maghemite.

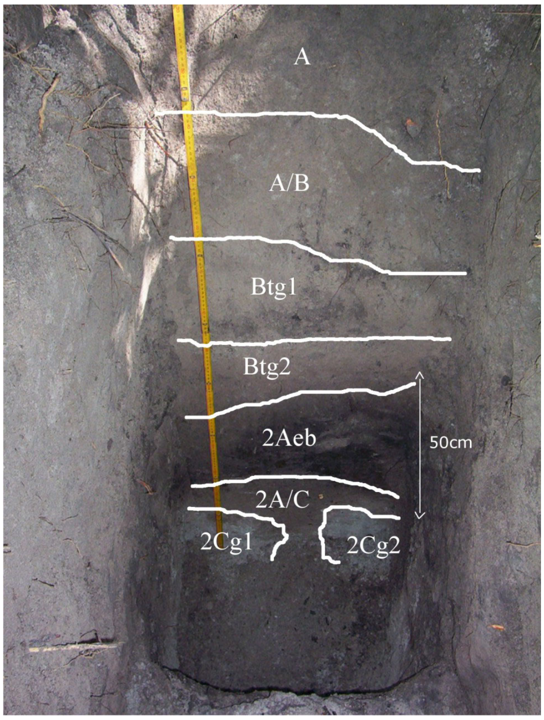


FIGURE 10. Typic Udorthent (LEEF) profile.

incision of the current thalweg of the river due to the change to hot and humid climate, this profile starts having a least availability of water and it develops drainage looser than in the moment of its formation, even with the planation of the relief.

Thus, it is necessary to understand that this soil has its characteristics linked to another formation environment which nowadays is very different, conditioned by the changes in the fluvial geomorphology of the Mogi Guaçu river linked to climatic changes and/or structural factors.

About the mineralogy, Figure 11 shows a decrease of the peaks of gibbsite and iron oxides in concentration, demonstrating a change in the pattern of the soil mineralogy shown in P1 and P2 (segments I e II). Besides, peaks of quartz are not also observed.

It is observed since Figure 12 that the heating at 550ºC has collapsed the main peaks of kaolinite, confirming the majoritary presence of this mineral. However, peak at 1.4nm has remained, what it has proved the presence of a clay mineral 2:1. In the sample of the left (solvated with ethylene glycol) it is observed that there has not been expansion of the interlayers from 1.4nm to 1.7nm, characteristic of the clays of the esmectite group, therefore, it refers to a vermiculite.

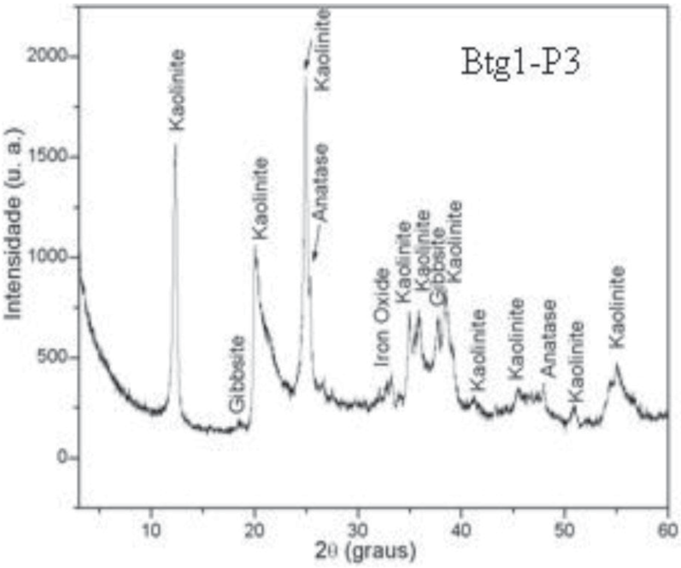


FIGURE 11. X-Ray diffraction of the total fraction of Btg1 horizon (P3) without treatments.

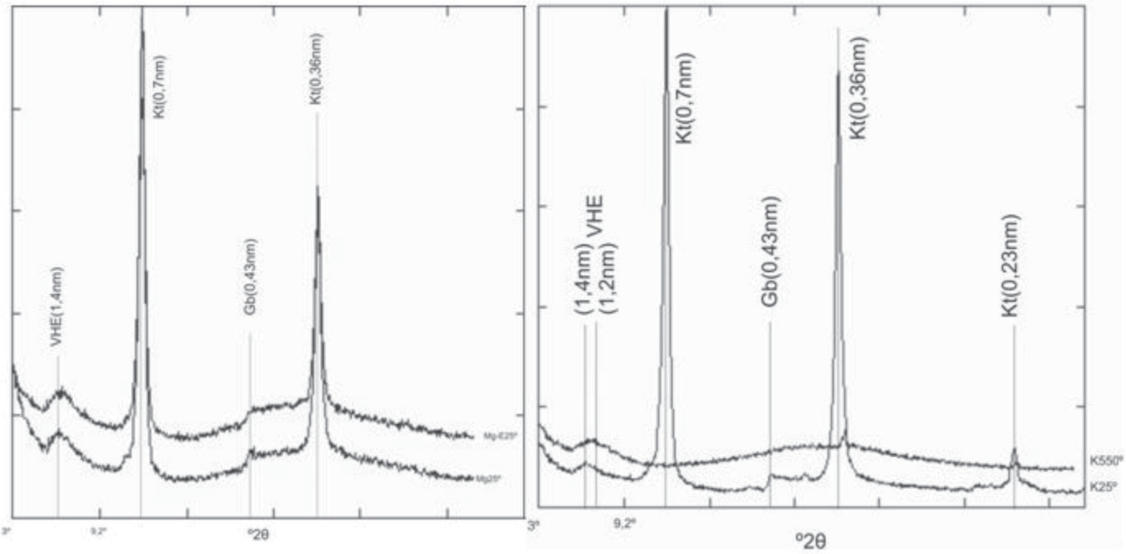


FIGURE 12. Clay Fraction from the oriented thin section method. Left: $MgCl_2$-satured solution at 25ºC and solvated with E-Glycol. Right: KCl-satured solution at 25ºC and 550ºC. The values in parenthesis are the d-spacings in nm. Kt: Kaolinite; Gb: Gibbsite; VHE: Hidroxy-Interlayered Vermiculite.

Clay mineral 2:1 can have been formed in a period where this section of the slope was in the active alluvial plain of the Mogi Guaçu river, periodically receiving the water of the river floods and that it is why have provided least mobility of the water in the profile, once it is a location with low declivity which it favors the hydrical accumulation, then keeping part of the cations necessary for the organization of these materials in solution.

It is also noticed that there is certain reduction of the basal spacing in the saturated sample with ethylene glycol at 25º (1.4nm) from the saturated with KCl at 550º, reaching the rate of 1.2nm, what it can indicate the presence of Al-Hidroxi in the interlayers (VHE). This demonstrates that the current soil formation condition in this section has changed through the last thousands of years because the occurrence of VHE is common in soils with free drainage and stable in weathered soils (Mafra et al., 2001), in other words, in the past the formation of this profile was related to the constant presence of water in the profile, while nowadays, due to the changes in the drainage pattern of the river in the last years (Zancopé, 2005), this section does not have the same amount of water in the profile and drainage is less limited.

The peaks of goethite/hematite (0.27nm) and maghemite/Hm (0.252nm) observed in other profiles disappear, demonstrating the reducer environment in which the soil has developed. When the soil is flooded, oxygen is consumed by the aerobic microorganisms and by the chemical reactions of oxidation, making that element lacking. Under reducer environment anaerobic microorganisms intensify their activity and increase the amount of CO_2. Therefore, two forces of alteration of the pH of these soils occur, the accumulation of CO_2 makes it decrease by the reaction $CO_2 + H_2O \leftrightarrow H^+ + HCO_3$ and the reduction of the oxidized compounds makes it increase by the consume of ions H^+ exemplified by the iron oxides: $Fe(OH)_3 + 2H^+ + 2e^- \leftrightarrow Fe^{2+} + 3H_2O$ (Silva & Ranno, 2005; Lima et al., 2005).

The solubilization of iron oxides makes ions Fe^{+2} be released in the soil solution (Silva e Ranno, 2005), causing grayer tones.

P4 – Typic Udifluvent (LDEH) - *Neossolo Flúvico TB Distrófico Típico (RYBD)* (Figure 13)

This profile is found on the alluvial plain of the Mogi Guaçu river, near a abandoned meander in the end of the topossequence “Infernão”. Horizons are rather enriched in organic matter and there is a deposit of coarse sand in its base, indicating that the river used to deposit a much bigger amount than it deposits today (currently, the channel of the Mogi river is 8m below this deposit).

Figure 14 shows the mineralogy of the horizon Ah4 do P4; it is observed that the graphic shows peaks of kaolinite, anatase, quartz and gibbsite. But in the Figure 11, it is noticed that clay minerals of the type 2:1 occur as several bibliographies about Histosols and Fluvents show (Demumbrum & Bruce, 1960; Razzaq & Herbillon, 1979; Corrêa et al., 2003; Prada-Gramero et al., 2004).

Non-observations of peaks of iron oxides in the Figure 14 can be linked to fact that the environment of reduction provided by periodical floods of the Mogi Guaçu river has taken a solubilization of iron oxides, as it has happened in P3.

In the Figure 15 it has mainly identified peaks of kaolinite, gibbsite and VHE. About the previous profile, the only noted difference was the appearance of peaks of gibbsite also at 0,48nm. Due to the position of this profile in the relief, the deficiency of drainage does not favor the establishment of an environment of strong leaching of silica and other primary minerals, that it is why peaks of gibbsite can be related to the coming of other minerals in, through deposition of sediments made by the Mogi Guaçu river, matching up to other works about Fluvents (Correa et al., 2003).

The deficient drainage has occasioned – in minor solubilization and the abandonment of silica from the system – what it has been proved by the presence of clay minerals 2:1 in the sample, as it can be observed in the Figure 15. Heating (KCl 550º) has proved the preponderance of the peaks of kaolinite over the other

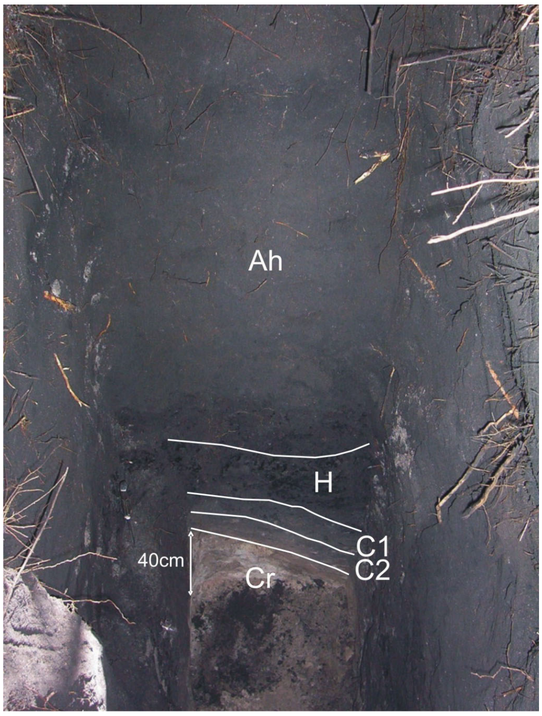


FIGURE 13. Typic Udifluvent (LDEH) profile.

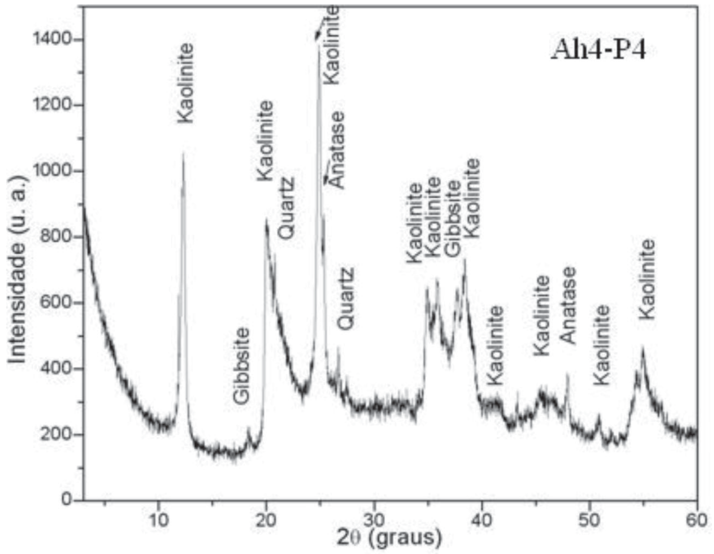


FIGURE 14. X-Ray diffraction of the total fraction of Ah4 horizon (P4) without treatments.

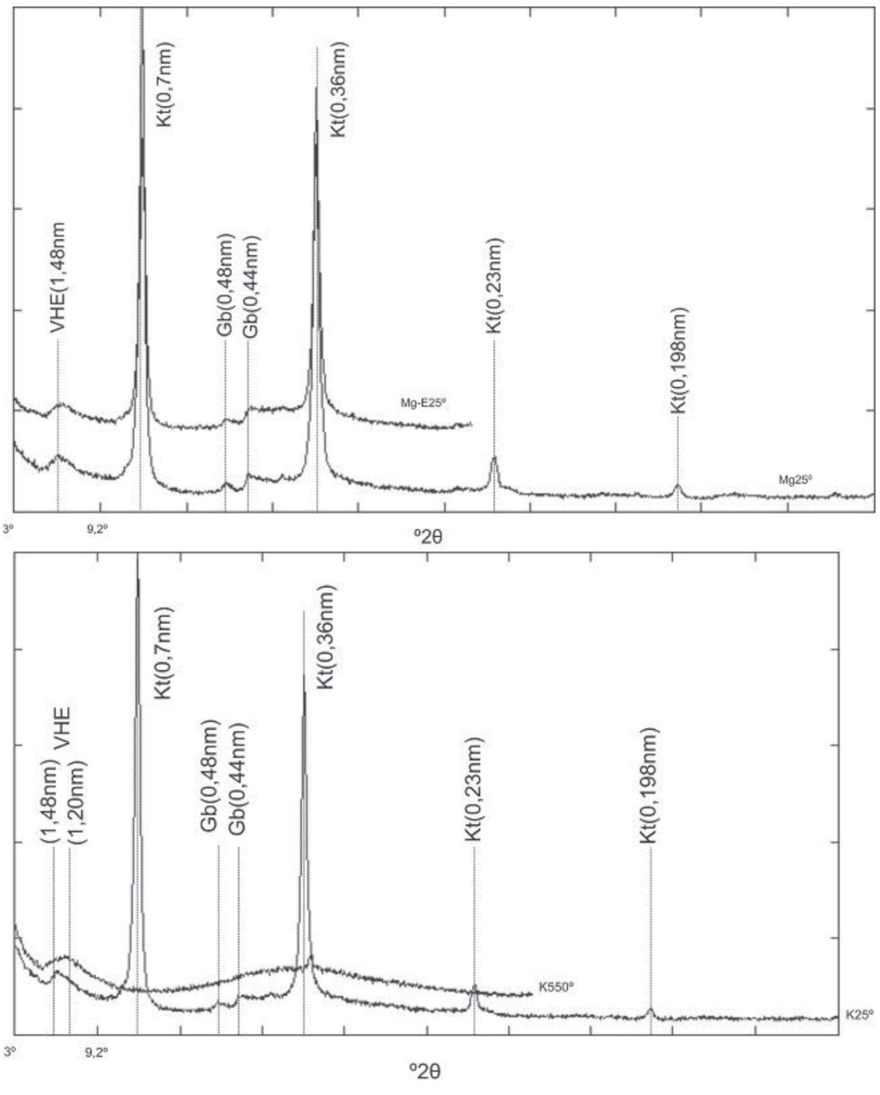


FIGURE 15. Clay Fraction from the oriented thin section method. Left: $MgCl_2$-satured solution at 25ºC and solvated with E-Glycol. Right: KCl-satured solution at 25ºC and 550ºC. The values in parenthesis are the d-spacings in nm. Kt: Kaolinite; Gb: Gibbsite; VHE: Hidroxy-Interlayered Vermiculite.

ones, but it has also indicated that the peak of clay mineral 2:1 has had a small reduction of the spacing from 1.4nm (E-Mg 25º) to 1.2nm, what it can indicate the presence of Al-Hidroxi in the interlayers (VHE), as the example of what it has occurred in P3. The solvated sample with ethylene glycol (Mg- ethylene glycol 25º) has not demonstrated expansion in the spacing of 1.4nm, what it has proved the presence of vermiculite.

FINAL CONSIDERATIONS

It has observed that the soil profiles were rather weathered, typical from humic tropical climate, with the association kaolinite, quartz, gibbsite and iron oxides. In the case of LVd, over basalt (Serra Geral Formation), the peaks of quartz have been less intense than in relation to LVAd over the sandstone (Botucatu Formation); this is explained through the differences between the mineralogical composition of both formations (Schobbenhaus et al., 1984).

But the analysis by diffraction of the soils GXbd e RYbd in the segment III, still in the terrace and alluvial plain of the Mogi Guaçu river, in comparison with the other two profiles 1 and 2 (LVd and LVAd, respectively), peaks of iron oxides have not been observed anymore, what it is explained through the reducer environment in which the profiles 3 and 4 of the segment III are found.

Vermiculite with Al-Hidroxi in the interlayers has been identified in GXbd and in RYbd, this can be linked to the fact that both profiles are extremely acid due to the presence of organic matter and the periodical floods and the proximity of the ground water, currently more frequent in RYbd (P4) than in GYbd (P3), due to the proximity of the abandoned meander. In the routine chemical analysis of these soils (Celarino & Ladeira, 2008) pH in H_2O found in these two profiles was always under 4.8, revealing an environment of high potential acidity ($H^{+}+Al^{3+}$), probably originated from the releasing of H^{+} of the organic matter. Hydroxyl is commonly linked to Al^{3+} (but it can be linked to other cations, according to Tremocoldi, 2004) and they can be depositing themselves in the interlayers of the vermiculite (Lacerda et al., 2001), forming these minerals that are rather stable even in weathered soils due to their structural stability (Bertolani et al., 2000 from Tremocoldi, 2004).

Faced with the data, it is concluded that the sections I and II of the topossequence have highly weathered soils and with low frequency of peaks of clay minerals 2:1, being more common the gibbsite, kaolinite and iron oxides. This dynamics of soil formation is more linked to the alteration of the origin material and to the control of weathering by the climate. In the section III, soils are rather less weathered due to the flatter relief and the consequent imperfect drainage, what it has resulted in accumulation of organic matter and reducer environment. This has been transposed in the mineralogy of the clay fraction of these profiles which has told a smallest solubilization of the silica where the iron oxides were absent and Gibbsite less frequent than in the other segments, due to a higher frequency of peaks of clay minerals 2:1 (Vermiculites with Hidroxi-Al in the interlayers) and the maintenance of peaks of kaolinite.

Mogi Guaçu river has been the most relevant controller agent of the weathering in this section of the slope, more precisely the variations on its course and flow along the quaternary period. Abandoning its alluvial plain in the past (section III), a set of changes in the soil formation dynamics have occurred and originated soils that today are on its terrace, having completely different origin from the soils located in the sections I and II.

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