

## **AN AMAZONIAN DARK EARTH PROFILE DESCRIPTION FROM A SITE LOCATED IN THE FLOODPLAIN (VÁRZEA) IN THE BRAZILIAN AMAZON**

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### **Introduction**

The Fluvent soils, called *Neossolos Flúvicos* in the Brazilian soil classification system characteristic of many areas in the border of Solimões river are developed predominantly by recent fluvial or lacustrine deposits. They are periodically flooded and occur alongside other 'typical' soils of aqueous sedimentary environments such as Gleysols and Arenosols.

The Fluvents receive fresh and rich sediments from the Andean mountains during regular floods. The Fluvent profile is stratificated with normally weak horizon differentiation but a distinct A-horizon. They have mostly AC-profiles and are predominantly brown (aerated soils) and/or grey (waterlogged soils) in colour. Alluvial soils in upstream parts of river systems are normally confined to strips of land adjacent to the actual riverbed. Their particle size is predominantly silt. The lower part of the profile may show mottling indicative of alternating reducing and oxidizing conditions. The most alluvial soils near the border of Solimões river have neutral or near-neutral pH values, large amount of calcium and magnesium. The good natural fertility of most of those Fluvent in the border of Solimões and many of its tributaries were recognized and intensively used by agricultural fields by the actual and probably by the pre-Colombian inhabitant.

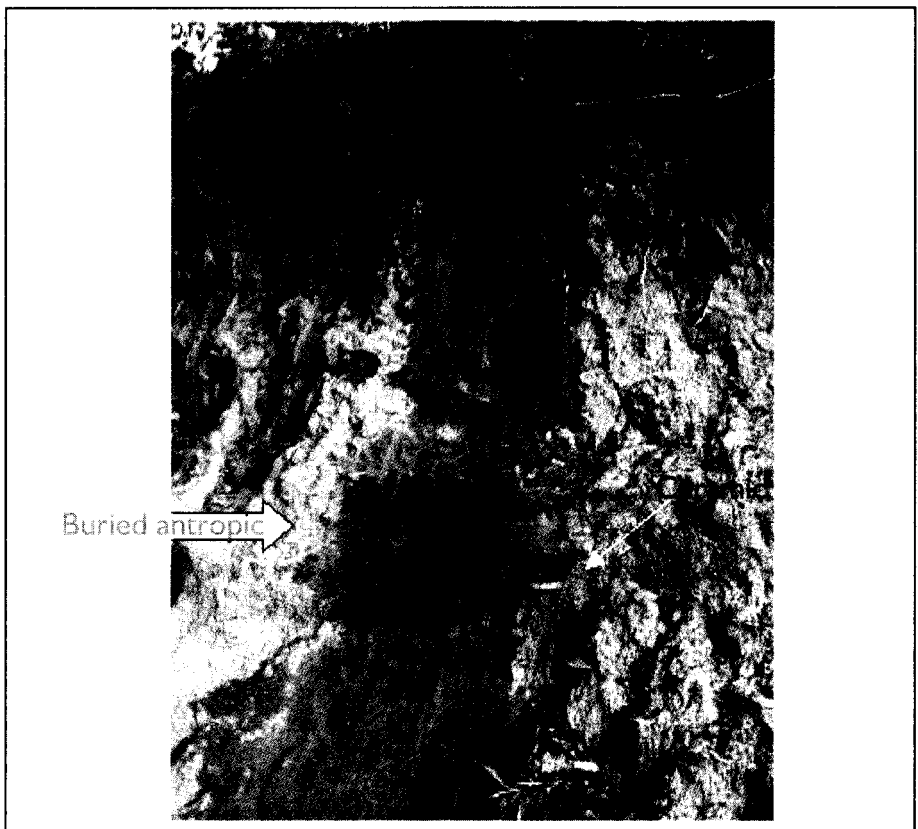
As the Fluvents near the called brown rivers in the Amazon basin have a natural high fertility, the formation of TPI as specific soil management to improve soil chemical quality doesn't fit in this situation. For the majority of essential nutrients for plant growing the available quantity are above the critical levels. However long lasting cultivation in those sites as supposed by Sombroek

(1966) is probably one of feasible hypothesis for the genesis of those rich soil horizons. The fire management was certainly involved: it is corroborated by the high amount of charcoal pieces found in those sites.

The question that remains is if the fire was used only for cooking or warmth reasons or had also an agricultural purposes; for land clearing as used traditionally by the *caboclos* or in more refined soil management as used in the Ethiopian highlands (Sertsu & Sanchez 1978) or Sumatra, Indonesia (Ketterings et al. 2000). Also if the charcoal present in the soil is only a remain of the fire or was used specific technique to carbonize biomass is question to be solved. The objective of this work was to characterize, compare and discuss a TPI profile - (Fluvent profile with a buried A horizon) with the adjacent soils and other TPI profiles and discuss the implication of the TPI profile in (Paleosol) soils of aqueous sedimentary environments.

Figure 1

Paleosol profile with a buried A antropic horizon



## Material and Methodology

A soil profile located near the Solimões River, in front of the city of Manacapuru – State of Amazon – Brazil were sampled and described. This area is locally called – Costa do Marrecão. The soil was classified as Fluvent (Neossolo Flúvico Ta eutrófico, following the Brazilian Soil Classification).

Disturbed soil samples were collected at each horizon described in Table 1. The soil was analysed for physical and chemical parameters. The analyses were carried out at the Laboratories of Embrapa Amazônia Ocidental in Manaus – AM – Brazil.

Particle size distribution: Disturbed were homogenised and a subsample of 20.00 g was taken to be analysed. The conventional sieve-pipette sedimentation method was used (EMBRAPA 1997). Dispersion was carried out using 1N NaOH and mechanical agitation. The scheme and criteria used for classifying particle size limits followed the Brazilian classification system (EMBRAPA 1997). Additionally, water dispersible clay was measured by repeating the above described texture analysis, except that the chemical dispersion agent was excluded. With the additional measurement of the natural clay content, indices of flocculation (IF) were calculated.

Particle density was evaluated with the balloon method (EMBRAPA 1997). This method consists basically to transfer a weighted oven-dried soil sample to the balloon and then determine the volume of alcohol needed to fulfil the balloon. Organic carbon was not removed before the analysis.

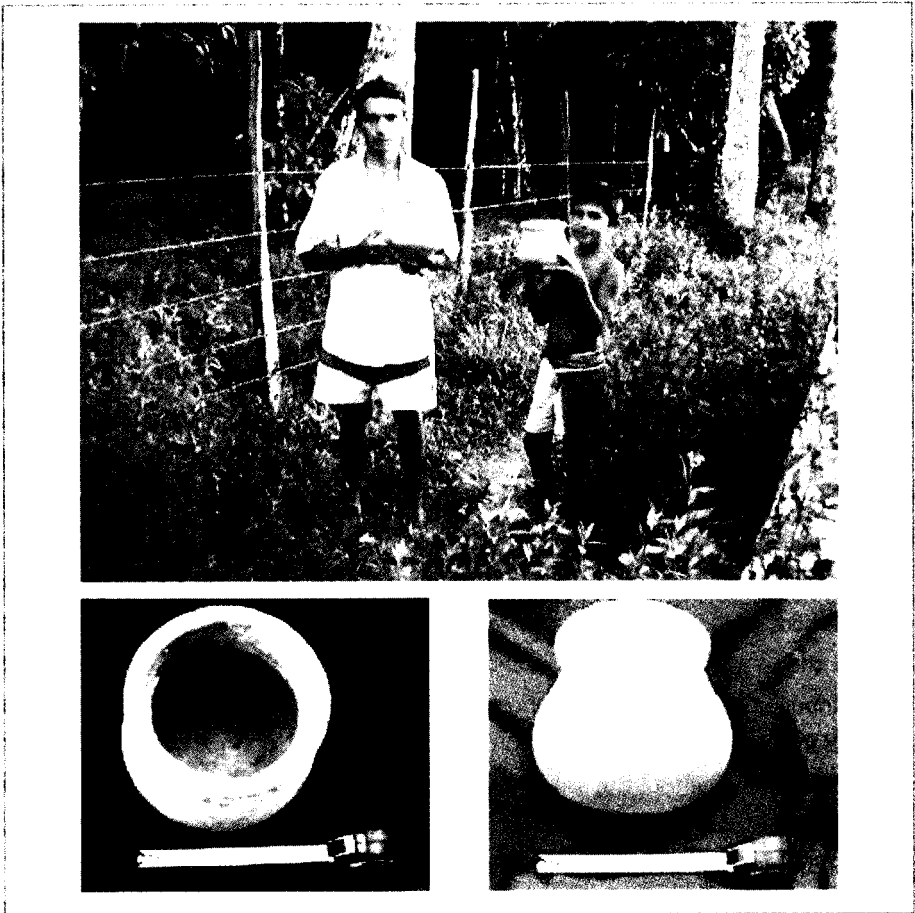
Chemical parameters: The soil samples analysed to determine chemical parameters were subsamples of the samples collected. The soil pH was measured with a glass electrode at a soil solution ratio of 1:2.5 in distilled water and 1M KCl. The cations calcium ( $\text{Ca}^{2+}$ ), magnesium ( $\text{Mg}^{2+}$ ) and aluminium ( $\text{Al}^{3+}$ ) were extracted by 1N KCl and determined by atomic absorption spectrometry (EMBRAPA 1997). Organic carbon (OC) was measured by the method of Walkley - Black with modifications described in EMBRAPA (1997).

Table 1 shows the soil profile description. Table 2 shows some physical and chemical characteristics of the profile characterized in seven horizons until 200 cm depth. The Figure 1 shows a photo of the profile and the position of it in the landscape. The particle size distribution shows a predominance of silt and fine sand in the whole profile, this is typical of the Fluvent in the Solimões border. The antropogenic buried horizon, shows an anormal higher content of fine sand. It will be consequence of this horizon was the soil surface in the past or a consequence of fire management as dicussed by Teixeira and Martins (2003). In this same layer the profile show an increment of the carbon, phosphorus, calcium and magnesium content. The calcium in this buried A horizon is almost ten times higher than the levels on the top horizon, normally the richest. In this buried horizon local inhabitants found some archeological pieces, many of them in very good conditions (Figure 2). In this horizon we found many ceramic pieces, charcoal pieces and some bones.

The levels of available phosphorus by the extractor Melich I is also 10 times higher in the buried antropoc horizon. For comparison, the mean value for phosphorus levels in the Ultisols and Oxisol in the Central Amazon is around 1-2 ppm.

The Fluvents enriched by the rich sediments from the Andean mountains in the Solimões rivers are very fertile for agricultural purposes. Nowadays the local farms, local called *caboclos*, used those sites intensively in the period where they are not flooded. Those sites are nowadays used to crop some vegetables, manioc and fiber cultures. The cycle from the planting to the harvest of those plants must be very short because of the annual flood. The site of this study is located in the called *varzea alta* that is not every year flooded. Therefore, nowadays it is in the

Figura 2



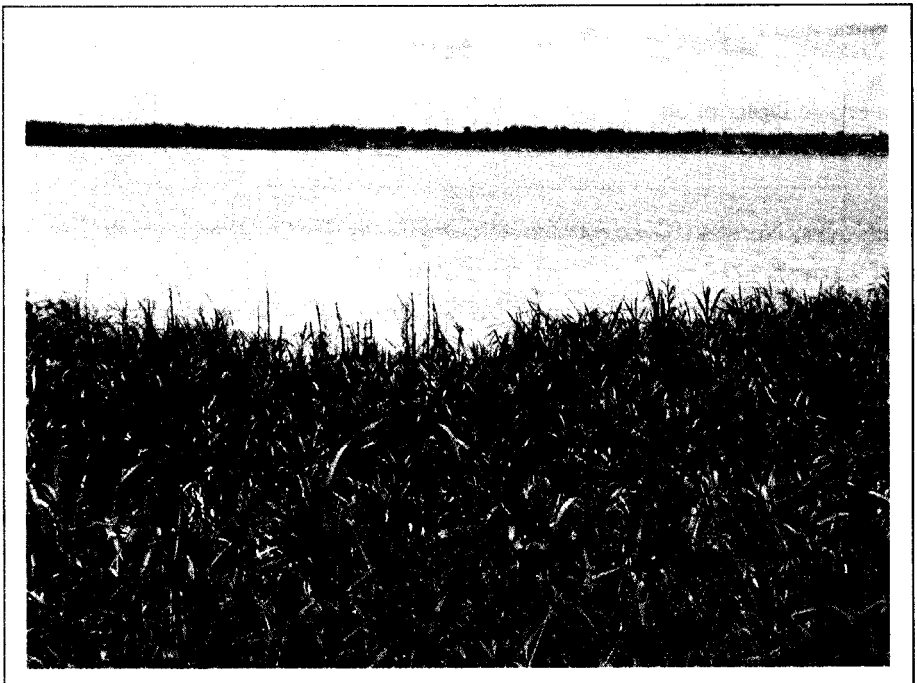
border of the river (Figure 3), it could be located hundreds meters from the border. In the border of Solimões River occur the phenomena called "*terras caídas*". It is a natural erosion process of the border of the river, this processes was occurring in our visit to this site. Probably this site, or at least a part of them will be lost in the near future. The few relates about TPI in the flooded soils may be related with the phenomena of *terras caídas*.

An important aspect in this profile is related to development of a width antropic horizon (about 60 cm wide) – called 2Aeb in the Table 1. The wide of this buried antropic horizon means that the population in those site were very large or were very numerous or probably both. Denevan (1996) discussed very well the questions about the riverine settlements in the pre-Colombian Amazon.

With more soil surveys in the Amazon, more paleosols may will be found in the floodplains areas. It may prove that large populations habited those areas in the past. However, many of those sites are lost by the phenomena of *terras caídas* and it may be a reason to explain that more frequent sites of Terra Preta de Indios are located in the *terra firme*.

Figure 3

Aspects of location of the profile in front of the city of Manacapuru –Solimões River AM-Brazil



**Table 1**

Morphological Description

0 - 5 cm, Ap (7.5YR 4/3 - moist); loam; weak very fine blocky; very friable slightly sticky and slightly plastic; gradual boundary, frequent roots.

5 - 45 cm, C1 (7.5YR 3/4 - moist); silt loam, moderate fine blocky; friable, sticky and plastic; clear boundary; common roots.

45 - 100 cm, C2 (7.5YR 4/3 - moist); silt loam, strong coarse blocky; friable, sticky and plastic; clear boundary, few roots.

100 - 110 cm, C3 (7.5YR 4/4 - moist); loam; strong coarse blocky, soft, very friable, sticky and plastic; clear boundary gradual; few roots.

110 - 170 cm, 2Aeb (7.5YR 2.5/1 - moist); loam; strong coarse blocky; soft, friable, slightly sticky and slightly plastic; gradual boundary; common roots; presence of many ceramic artifacts and charcoal pieces.

170 - 200 cm, 2C4 (7.5YR 4/2 - moist); loam; strong coarse blocky; soft, friable, sticky and plastic; gradual boundary; absent roots; mottling present.

200 - 400+ cm, 2C5 (7.5YR 5/3 - moist); silt loam; strong coarse blocky; soft, friable, sticky and plastic; gradual boundary; absent roots; mottling present.

## **Analytic Result**

### **Soil Profile Description**

Data: 02/03/2004

Classification: Neossolo Flúvico eutrofico - following the Brazilian Classification. Fluvisol following the FAO classification.

Localization, City, State: Sitio Caetano - Costa do Marrecão - City of Manacapuru - State Amazon - Brazil.

Landform and Topography: Plane, plateau in the border of the river

Land Use and Vegetation: Agroforestry system and abandoned rubber tree plantation.

Parent Material: Holocene fluvial sediments.

Surface Characteristics: Absent of rock outcrops and coarse fragments in the surface. It was observed the natural erosion of the borders by the water movement of the Solimões River. This phenomenon is local called "terras caídas".

Drainage: Well drained. Internal drainage: saturated for long periods. The groundwater in that period was 5-8 m above the soil surface.

Table 2

Analytic of soil characteristic (Análisis de caracterización de suelos)

**Análises Físicas e Químicas**

Perfil:  
 Amostra de Laboratório:  
 Solo: Neossolo Flúvico ta eutrófico

Horizonte	Frações da amostra total (g/g)			Composição granulométrica da terra fina (g/g)					Ág. lib. dispersa em água (g/g)	Grau de flocculação (%)	Porosidade total (%)	Densidade (g/cm <sup>3</sup> )		Porosidade e coeficiente (1/100cm <sup>3</sup> )
	Partic. > 20 µm	Calhaus > 20 µm	Carb. > 20 µm	Terra fina < 2 µm	Areia grossa 20-200 µm	Areia fina 0,20-0,075 µm	Silte 0,075-0,002 µm	Argil. < 0,002 µm				Solo	Partículas	
Ap	0-5	0	0	1000	2	436	420	119	93	22	3,55			
C1	5-45	0	0	1000	1	360	302	114	98	16	4,40			
C2	45-100	0	0	1000	7	178	602	215	192	11	2,80			
C3	100-110	0	0	1000	2	335	495	169	169	0	2,95			
2Aab	110-110	0	0	1000	4	296	475	265	217	18	1,79			
2CA	110-200	0	0	1000	2	501	390	117	117	0	3,25			
2CS	200-1000	0	0	1000	1	230	530	168	168	0	3,31			

Horizonte	pH (1:2,5)		Complexo Cátionico (cmol <sub>c</sub> /kg)										Valor V (rel. ao base) %	100 AP / 1 AP %	P. xamérel mola
	Água	KCl 1M	Ca <sup>2+</sup>	Mg <sup>2+</sup>	K <sup>+</sup>	Na <sup>+</sup>	Valor S (g/eq)	ΔP <sup>+</sup>	H <sup>+</sup>	Valor T	Cl <sup>-</sup>	S <sup>2-</sup>			
Ap	5,40	4,77	3,5	1,6	0,00	0,10	5,5	0,2	3,8	9,3	59	4	96		
C1	6,2	4,89	6,5	2,0	0,10	0,19	6,8	0,1	1,3	10,2	86	1	87		
C2	6,21	5,0	8,5	2,5	0,14	0,17	11,3	0,2	2,4	10,9	81	2	20		
C3	6,57	5,25	20,8	3,9	0,15	0,22	27,9	0,1	2,7	30,7	91	0	422		
2Aab	6,22	5,42	31,4	4,5	0,19	0,31	36,4	0	5,0	41,4	88	0	129,4		
2CA	6,35	5,02	7,4	2,4	0,12	0,18	10,1	0,1	1,7	11,9	85	1	124		
2CS	6,62	5,26	10,0	2,5	0,14	0,26	12,9	0	1,6	14,5	83	0	180		

Horizonte	C (orgânico) g/kg	H g/kg	C/N	Ataque sulfúrico (g/kg)							Relações Moleculares			Fe <sub>2</sub> O <sub>3</sub> line g/kg	Equival. de CaCO <sub>3</sub> g/kg
				SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO	SO <sub>4</sub> <sup>2-</sup> (N)	SO <sub>4</sub> <sup>2-</sup> (K)	Al <sub>2</sub> O <sub>3</sub> /Fe <sub>2</sub> O <sub>3</sub>			
Ap	12,2														
C1	2,2														
C2	2,2														
C3	2,7														
2Aab	13,6														
2CA	2,1														
2CS	2,3														

Horizonte	100 Na <sup>+</sup> T %	Pasta saturada		Sais solúveis (cmol <sub>c</sub> /kg)						Constantes hidráticas (g/100g)				
		C. c. de exsicc. m/sem zarc	Água %	Ca <sup>2+</sup>	Mg <sup>2+</sup>	K <sup>+</sup>	Na <sup>+</sup>	HCO <sub>3</sub> <sup>-</sup> CO <sub>3</sub> <sup>2-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	Umidade		Água disponível máxima	
Ap	1													
C1	2													
C2	1													
C3	<1													
2Aab	<1													
2CA	1													
2CS	2													

Reação textural:

Described and Collected by: Wenceslau Gerales Teixeira & Arivan Ribeiro Reis. – Profile was described in cloudy conditions and it was moist.

## **Acknowledgments**

The field excursion was a part of an Soil Survey project of the characteristic of the soil located in the border of the Solimões River PIATAM project. We also thanks the archeologists Carlos Augusto and Patricia (UFAM) for indicating this site to us and also Arivan Ribeiro Reis to help in the profile description and sampling.