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A transition between lateritic and hydromorphic soils in relation with variation of vegetation (SW Amazonia, Brazil)

Une transition entre sols latériques et sols hydromorphes en relation avec les variations de la végétation (SO de l'Amazonie, Brésil)

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The southern part of the upper Amazon basin is made of large plateaus developed from sediments of the Solimões formation. Plateaus are located 10m above mean river mark and covered with pristine forest and savannah. One striking feature of the plateaus is the occurence under the forest or in the savannah of paleovals and numerous depressions less then 2m depht which are temporally inundated. According to size and shape the depressions are of three types: (1) narrow and anastomosed depressions of dendrític shape, (2) narrow and elongated depressions following lithological structures and (3) large and flat botton depressions. Soil survey of the region indicates that hydromorphic laterites occur in the depressions whereas red-yellow laterites are located between the depressions on the highest plateau levels.

One 90m toposequence from a upslope area to a downslope depression at the forest-savannah transition was select as representative of the lateral soil differentiation within the plateaus for detailed field and micromorphological observations as well for geochemical and mineralogical investigations.

Soil observations along the toposequence permits to distinguish (1) a upper shallow clay soil layer (<1,5m) from na underlaying thick mottled then bleached loamy saprolite (Pallid zone) and (2) laterally na upslope red soil compartment from a downslope yellow-white soil compartment. Soil color change occurs downslop without important textural change and is linked to progressive removal of iron oxides which affects first hematite (yellowing) then goethite (bleaching) and locally to iron concentration (ferritisation). Yellowing and bleaching lead to soil structure breakdown whereas ferritisation forms dark red reticules and nodules (plinthite). Precise demarcation of the white features enable to differentiate a local perched watertable reservoirs in the depression from a generalised groundwater reservoir in the saprolite. Both reservoir are connected in the centre of the depression. This study tends to demonstrate thet aquic conditions have expanded in the plateaus from the depression. Aquic conditions has speeded up the yellowing, bleaching and ferritisation processes in the uppermost laterites and favours the enlargement of both perched watertable reservoir and depressions.

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Introduction

On the south border of the Amazon Sedimentary Basin, und a wet tropical weather, landscapes are formed by lowered plateaus associated with not-too- thick laterites, in the high part of relief , and in the depressions, with hydromorphic laterites. Important diverseness in vegetation are also present in this area, depicted by forest-savannah transition as well as features of the relief ,where there are depressions of various dimensions and patterns.

The Dylat-Amazônia Project aims at the study of hydro-biochemical organization and working of Amazon's lateritic coverages (Fritsch et al., this issue). This work is a part of the same project and aims at the study of a red-yellow-white soil sequence, attempting to aprehend the soil evolution dynamics and also link it to the landscape dynamics.

Material and Methodologies

Study Field

The study field is spotted on the south border of Amazonic Sedimentar basin.
The chosen area for detaled research is at Km 70 of BR 319 road which links Porto Velho city (State of Rondônia) to Humaitá (State of Amazonas) between the coordinates 6° and 10° (south latitude) and 65° and 66° (west longitude)(Fig. 1).

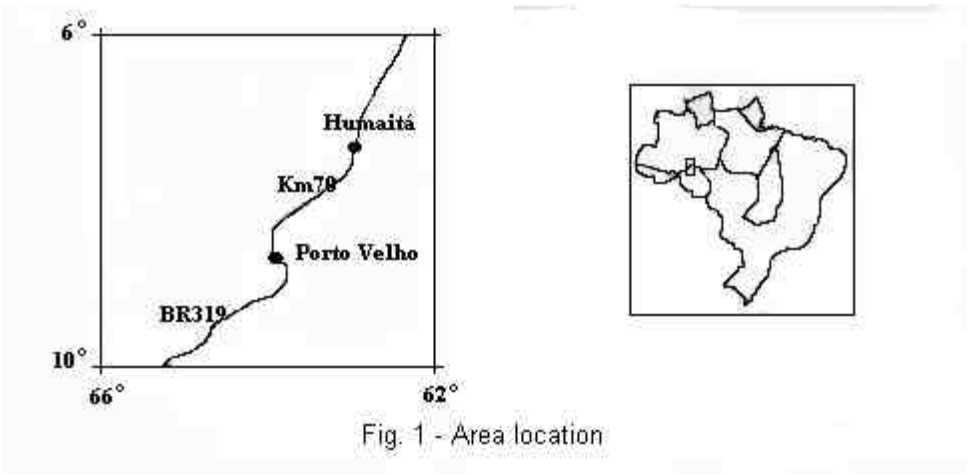

Fig. 1 - Area location

In this region, the average yearly rain precipitation is 2500 mm and the average temperature is 25°. The rainfall maximum occurs during summer mouths whereas the dry period takes place in June, July and August.

According to environmental mappings carried out by RADAMBRASIL Project (1978), the field of study lies on the morphostructural unit named Lowered Plateau of the western Amazon, which displays large flattened areas and dissecated relief.

This relief is developed on sedimentary rocks of the Solimões Formation which dates back to the gap between the high Pliocen period and low Pleistocen, one formed by continental sand-clay sediments, often micaceous and ferruginous (Sampaio & Norfleet).

In this area, the distribution of vegetation coverage is depicted by the forest-savannah contact. The vegetation distribution is often the following: in the plateaus, on the red-yellow Podzolic the forest is developed whereas on the Hidromorphic laterites is developed in the savannah. In the areas where the soil moisture is bigger, the palm vegetation is present.

The state of Rondônia , has been suffering an intense clearance process since the 70's this comes about in order to have fields cultivated and fire often happens in this region.

Mapping Study and Satellite Images

In order to recognize the landscape distribution in the Humaitá region, mapping research has been carried out by RADAMBRASIL (1978) in a scale of 1:2.500.000. Since information on regional aspects had been achieved, treatments were made (colorful composition, classification and filter), satellite images were also used (TM 4,5 and 7) in order to have a detailed contact observation as well as features of those two landascape.

Study of a Toposequence

The area choice to have the opening of a toposequence was made after sucessive sounding. They were performed in order to find a shorter toposequence of environmental variation (soil, geology, relief and vegetation).

A toposequence was oppened (90 meters long and 3 meters deep) for a detailed study of a red-yellow laterites transition and hidromorphic laterites in the forest-savannah contact.

The metodology used for this detailed study of toposequence was introduced by Boulet et al. (1982) and Fritsch et al. (1992), wich enables the identification, description,

relation and interpretation of soil structures defined by lateral and vertical limits between matrices. Through this metodology it's possible to observe and map the sequence of vertical and horizontal limits along the sequence.

Results of Maps and Satellite Images

The development of hydromorphic soils in this region is associated with the depression developments, wich has variable dimensions and forms. The studies carried out about the maps of RADAMBRASIL Project (1978) show that from the Madeira river's edge and beyond, the red-yellow soil develops (the Madeira river is the main wather receiver in this region) of the Solimões Formations, associated with hydromorphic lateritcs (Acrisol-Plintosol, FAO classification, 1971). The Podzólic soils don't fit chemically and morphologically, those features wich are attributed to this kind of soil in the classification their features are linked to the definition by a Cambissolo (Cambisol).

More detailed studies carried out though satellite images show that the hidromorphic laterites are associated with the dowslope position of the plateau. Such depressions own organization and orientation, live real axes of drainage however they don't present channel hierarchy. They can present dendritic patterns, paralell patterns with structural control or without a well-defined patterns. The images show that even under the forest the depression exist and, in some regions, they are connected to depressions developed in the fields, are hinting that they are about an open system.

Study of Toposequence

The chosen toposequence presents, in the hight part of the plateau, a lateritic soil (Red-Yellow Podzolic) recovered by wet rain forest and, in the law part of the relief, a hidromorphic soil (Hidromorphic laterites), recovered by field vegetation. The difference between the highest part and the lowest one of the plateau is two meters. Figure 2 show schematic form the organization of the soil in the toposequence.

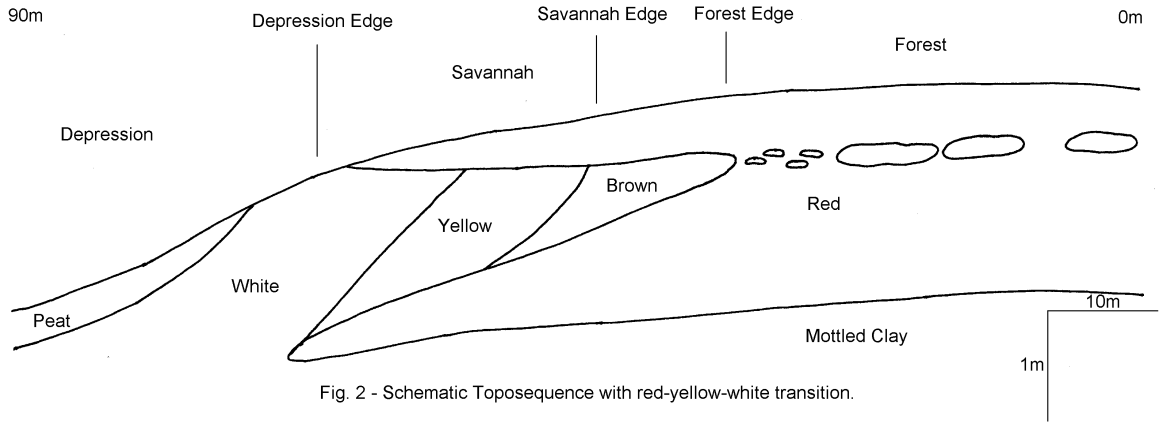

Fig. 2 - Schematic Toposequence with red-yellow-white transition.

The organic horizons of surface (A) have been divided in four sets according to the richness of organic material found in the field. The upslope position are yellowish horizons and in the forest-savannah transition become brow-yellow-greenish ones, both are about 20cm thick. In the edges and in the center of the depression, these horizons are very thick, about 60cm, displaying a color from grey to black, talking about peat horizon. All of then present clay texture.

The subsurface horizons (B) of upslope position, though they are classified as a Red-Yellow Podzolic they don't own important textural variation. They presents a sequence of brown-reddish and red horizons, little thick (80cm). Deep inside we found horizon named mottled clay. The contact of these horizons with the superior B is progressive. Firstly, a brown-reddish horizon appers with red-and yellow reticulate. This one becomes a horizon displaying a several yellow matrices, also red and dark red with a light grey botton. On the top of the mottled clay, there is a level with the presence of hardened nodules, aligned or not. This set features clay-loam texture and poliedric structure.

The side passage from red-yellow upslope position to hidromorphic soils of the depression is made through interpenetration and sucessive increase of volumes of the yellow phase. The yellow volumes can already be noticeable, although they are still little sharp, in the set of upslop position, in the contact of horizon B and the mottled clay. It becomes dominant in the forest-savannah contact, since it becomes greenish yellow when it reashes the edge of the depression. These horizons festures intense organic activit. The texture is clay-loam, poliedric structure and one can notice the appearing of vertical rift inside the volumes. Under the yellow-greenish horizon, the mottled clay subdivided in to three phases. It features a continuous white phase on the top, inside, abundant red hardned reticulate with nodules and deep inside, light grey botton displaying fewer red reticule.

From the edge of the depression and beyond, the red-hardnes phase becomes fine and vanishes completely in the center of the depression. This vanishing is linked to the appearing and dominance of white soils. On can notice that this color variation is also linked to structure variations. The poliedric structure of the red and yellow soils become solid with priamatic substructure in the white soils. The textural changes seen not to happen, for they are not easily noticeable in the field.

The detailed study of the toposequence allowed us to the precise recognition of the lateral soil distribution in the landscape. It consist of a sequence of red-yellow-white soil, from the high part to the low part of the relief. The morphologic relations established inside the toposequence especially those one linked to the color changes, allowed us to the delimitation of two dominances of pedological evolution: a red lateritic dominance and a yellow white hydromorphic one.

The hydromorphic one presents features of oxireduction which
invades the lateritic coverage. This process features the appearing of volumes
of yellow color and after that becomes white, when one reaches the maximum level of hydromorphy.

Discussion and Conclusions

The organization of this horizons in the landascape is essentially linked to hydrologic dynamics which provides the main morphologic diffrences found during the toposequence.

The expansion of hydromorphic coverages and regression of lateritic formations are a frequent evolution observed in the tropical lendscapes (Fritsch et al., 1989). This evolution leads to deep mineral structure transformations in the pedological cover and , consequently, to changes in the landscape feature. It’s mostly linked to mobilization of fine materials (kaolinite and iron oxides). In the researched area, the soil color change seems to be closely related to the variations of water stream and of the relief. This we can infer a hypothesis on soil evolution in relation to quality observation of the hydrous working.

The red coverages are in the higth parts of the plateau where the predominant environment is aerobic. The yellow coverages are in the central part of the toposequence where the environment are, during a short period of time, saturated. At last, the white coverages are present in the deppressions and are for long periods of the year, under conditions of intense water saturation. By contrast during dry mouths, the loss of water and coesion of those coverages seem to be extremely intense. This dynamics is stressed by the open vegetation coverage which leaves the soil uncovered and under a intense condition of loss of water.

It was possible to observe in the toposequence the levels of the deep watertable as well as the development of a watertable over the motlled clay. Both levels lie in the center of the depression, where the maximum of hydromorph come about. One can assume that the hydromorphy spreads to the plateaus from the depressions.

The sequence hints that soils have been changing, they feature an excessive saturation of water, loss of structure, clay and iron oxide and porosity. Such changing seems to be a feature of this region and it can be seem as a natural degradation which affects agriculture.

The detailed study of the toposequence along with the satellite image interpretation and field observations reveal that the pedological variation is not directly linked to the vegetation changes. The presence of hydromorphic soils related to the depressions don't occur exclusively in the savana areas.

Sounding carried out in the depressions under the forest have also shown hydromorphic soils containing the same field features. The advance of the research will allow us to get to know the depression origin and to find out whether they are connected with the past and/or present development of the watertable of hydromorphic formations.

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