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Comparative Study of the Cambisols of Aboisso-Comoé (Agropastoral Zone B29 Mamlanso) and Zuenoula (Agricultural Unit of the Sugar Complex)

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Abstract : ***A comparative study was carried out on soil characterization at Aboisso-Comoé and Zuénoula, located respectively in the south-east and in the center-west of Côte d'Ivoire, specifically in the agropastoral zone B29 of Mamlasso and in the sugar complex of Zuénoula. A high frequency has been set up in each of the sites. This study deals with the characterization of certain morphopedological, chemical and physicochemical parameters. Five (5) soil pits were established at Aboisso-Comoé according to the topographic positions at the top, on the slope, mid-slope, slope and bottom, then three (3) pits in Zuénoula at the top of the slope, half slope and slope. All the pits were described and soil samples were taken from each horizon and analyzed in the laboratory. It is clear from this description and analysis that all soils in these study areas are Cambisols. The results indicate a good representation of Cambisols, of which two types stand out: Cambisols (Paraplinthic) at the top, at the top of slope and at mid-slope, and Cambisols (Gleyic) at the bottom of slope and at the bottom. These soils have common characteristics, in particular: organic matter contents, cation exchange capacity and exchangeable base sum values, relatively high at the surface, associated with a coarse sand-silty texture; but richer in clay with depth. These characteristics confer to them, incontestably a rather good fertility. Such soils have as their main constraint the heavy load in coarse elements.***

Keywords: Cambisols, characteristics, Mamlanso, Zuénoula, Côte d'Ivoire

1. Introduction

The inventory of biophysical resources in Côte d'Ivoire has shown, from the pedological point of view, the dominance, in the CPCS (1967) scientific classification of soils:

- Typical modal weakly desaturated ferralitic products belonging to the group Cutanic Lixisols (Rhodic) according to WRB (2006);
- Ferruginous tropical leached with spots and concretions, belonging to the lixisolsgleyic group (Ferric, Chromic) (WRB, 2006, Kissou et al., 2014);
- Little evolved hydromorphic alluvial influx belonging to the group of Haplic Fluvisols (Epiarenic) (WRB 2006, Kissou et al., 2014).

But, by including soil properties in soil classification published by the World Reference Base for Soil Resources (WRB), the occurrence of reference soils such as Ferralsols, Vertisols, Cambisols, etc. is emerging.

According to Mukonzo's (2009) research, Cambisols are soils that are continually renewed and nourished. They remain, therefore, perpetually young and able to be flooded, irrigated and drained, where crops could be grown as in the deltas of East Asia, Egypt and Niger. . So, are these soils able to maintain permanent fertility?

Soil research carried out in Côte d'Ivoire by (Yao-Kouamé (2008), Yao (2014), Akotto et al., (2014a, b and c), N'guessan et al (2015), N'guessan and al (2016) and Yao (2017) indicate the presence of Cambisols in the Southeast, South, East, Center, West-Central and North-West.

However, the Cambisols observed in the South-East and Center-West precisely Aboisso-Comoé and Zuénoula present particular characteristics. It will be a comparative study of the different characteristics of these Cambisols observed, more specifically to evaluate the current physical, chemical and physicochemical characteristics of soils in these two zones. This study is a further contribution to sustainable and rational soil management in Côte d'Ivoire.

2. Material and Methods

2.1 Location and description of the study sites

Aboisso-Comoé and Zuénoula are respectively located in the South-East (Figure 1) and Center-West (Figure 2) of Côte d'Ivoire with respective geographical coordinates 5 ° 20 'and 5 ° 50'N; 4 ° 10 'and 3 ° 10'W; then 7 ° 30 and 7 ° 40 N and 6 ° 5 and 6 ° 15 W.

The relief of these two regions is weak to very slightly uneven varying from 0 to 1000 m, zones of plateaus and weak slopes (Gabriel, 1964). In Aboisso-Comoé, there are some plains towards the Potou lagoon and the presence of unexploited shoals in the rest of the Department.

The vegetation is a dense evergreen forest, while in Zuénoula it is a shrub savanna and forest in the form of galleries belonging to the mesophilic sector (Guillaumet and Adjanohoun 1971, Brou 2007).

The climate of the Aboisso-Comoé region corresponds to the Attiean equatorial transition regime and that of Zuénoula is a transition between the equatorial climate and the subtropical climate. These climates are characterized by four (4) seasons (Brou, 2005):

- A long rainy season, from March to June;
- A short dry season, from July to August;

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- A short rainy season, from September to October;
- A long dry season, from November to February.

Hydrographically, Aboisso-Comoé is crossed from north to south, by the river Comoé, the rivers the ME and KOSSAN, with many tributaries that irrigate the western and central parts of the department. In Zuénoula, we find a main stream: la Marahoué, and its main tributaries DYARE, ZOURE and YOURO (Biémi and Jourda, 2005). The Aboisso-Comoé geology consists of volcanic-sedimentary Euclidean rocks in which amphibole, pyroxene, plagioclase and green hornblende are easily distinguished. However, Zuénoula is characterized by granitic formations, shale formations and amphibolite formations. The soils of the Zuénoula sugar complex are, according to the WRB (2006) classification, ferrasols, gleysols and cambisols.

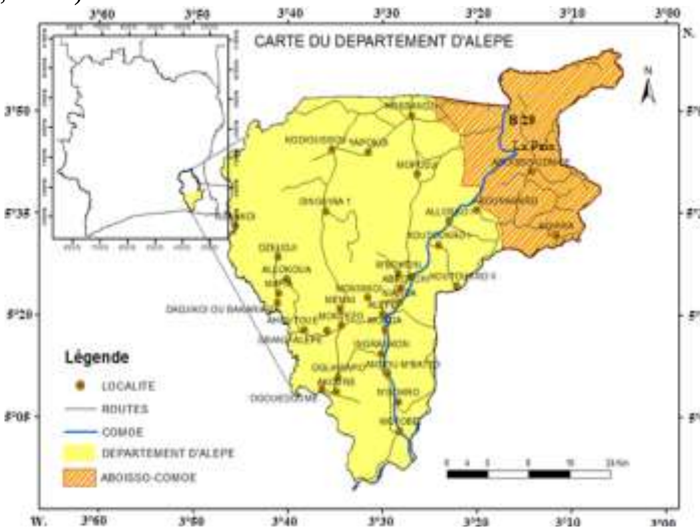

Figure 1: Location of Aboisso-Comoéarea (B29 Mamlanso)

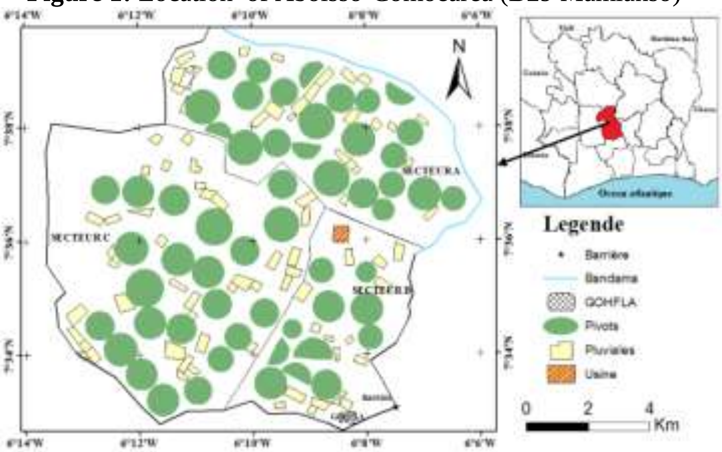

Figure 2: Location of the sugarcomplex of Zuénoula

2.2 Some elements of pedological and laboratory study material

For the realization of this study, the study material is constituted by usual equipment of field study having been used for the implantation of the toposéquences and the opening of the soil pits, then the usual equipment of study in laboratory (figure 3).

Figure 3: Some elements of soil and laboratory survey equipment

2.3 Morphopedological characterization

At Aboisso-Comoé, a N70 ° topological frequency has been established with five soil pits (a, b, c, d and e) while in Zuénoula three soil pits have been established, every 100 m, after orienting the soil face of the profile in the East-West direction, to have a better lighting of the faces to be described.

These pits had a depth of 1.20 m in the absence of natural stress, a length of 1 m and a width of 0, 80 m. Each profile has been identified by its topographic position following the model described by Yao-kouamé (2008). This is the summit; top of slope; half-slope; low and sloping bottom at Aboisso-Comoé and summit, half-slope and Slope at Zuénoula. The scientific classification used is that adopted by IUSS Working Group WRB (2014).

At the location of the pits, geographic coordinates were identified. These soil pits have been described, horizon by horizon. The studied variables are: color, texture, coarse load, depth, etc.

2.4 Laboratory analysis

The analyzes were carried out in the soil laboratory of the Agricultural Unit of the sugar complex of Zuénoula (Central West of Côte d'Ivoire). They concerned granulometry, pH measurement, determination of organic carbon, nitrogen and exchangeable bases, determination of cation exchange capacity (CEC) and assimilable and total phosphorus.

3. Results

3.1. Morphological and soil characteristics of soils of study sites

3.1.1. Aboisso-Comoé

Along the toposequence 70 ° N, the open, georeferenced soil pits described were the subject of this study (Figure 1). Different horizons have low to high humidity, from top to mid-slope, soils are cool to dry while soils of the shoal are wet to drowned.
The color of the horizons is uniform, very often spotted (5YR 5/6, 7.5YR 7/8, 10YR5 / 4); the red, yellow, and greenish yellow hues that appear as spots are dominant from top to bottom. A sandy clay-loam texture is observed in the surface horizons with a clay content of 60 to 75 p.c. silty-sandy-clay texture, with 80% clay content in intermediate horizons and sandy-clay texture in depth horizons with 10% clay.

Indeed, the rate of clay decreases from the top to the bottom, a decrease in the proportion of sand, from the surface to the depth in the profiles. On the other hand, the silt contents are appreciably more constant and very fairly average, ranging between 10 to 40 pc. In this zone, we also find a large proportion of very fine particles (clay + silt) compared to that of coarse particles (fine sand). + coarse sand). The porosity is average in all except the bottom soil which has a high porosity.Also, an abundance of millimetric to centimetric roots with subhorizontal preferential orientation in the horizons of surfaces and the intermediate horizons, but these roots disappear in the horizons of depths.

The structure is subangularpolyhedric with a lumpy tendency in the horizons of surfaces (0-30 cm), subangular polyhedral in the horizons of depths however we notice a particulate structure from the lower slope to the lowland and a loose coherence.
The proportion of coarse elements is relatively large over the entire site, varying from 48 to 80 p.c. depending on the topographic position. This coarse load varies from 3 to 90 p.c. depending on the soil depth. The drainage class varies from 1.2 to 13 depending on the topographic segments and the depth of the profiles.

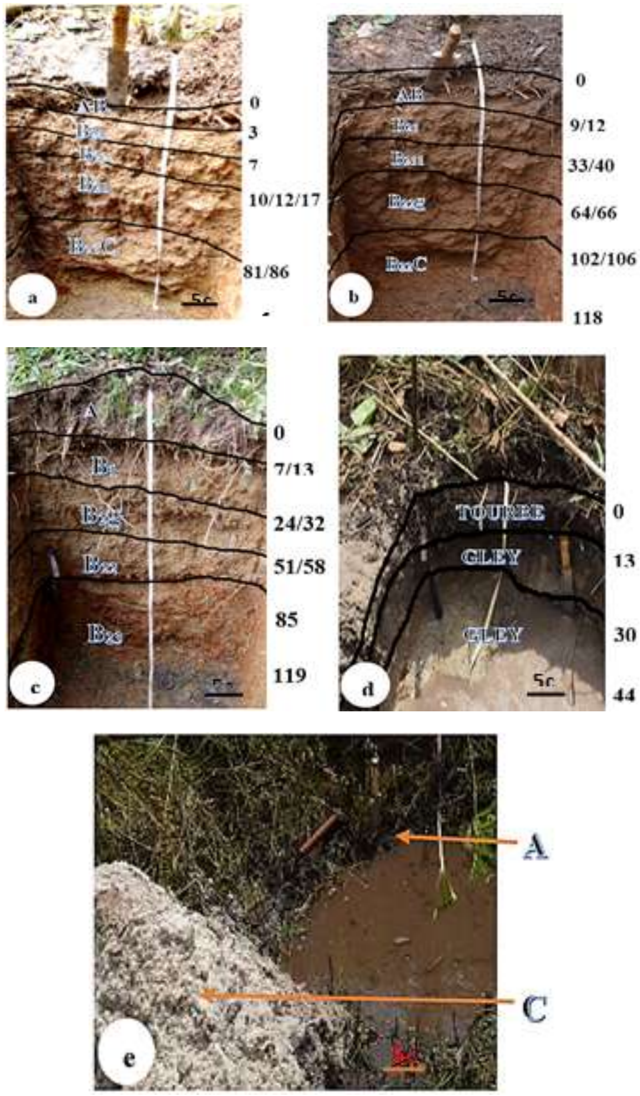

Figure 4: Cambisols observed along the toposequence in Aboisso-Comoé a and b) Cambisol (PseudogleyicManganiferricPlinthic); c) Cambisol (PseudogleyicManganiferric); d and e) Cambisol (GleyicHistic)

3.1.2. Zuénoula

Toposequence I was also the subject of this study. The soil pits have been opened, georeferenced and described. The humidity of the different horizons is relatively low. Most soils are cool to dry. The horizons are dark brown in color (7.5YR3 / 2 to 10YR / 2), spotted at depth horizons (brown, ocher-yellow, red and rust spots). This is 7.5YR 7/8; 2.5YR 4/4; 10YR 4/6; 10YR 5/8, gley1 4 / 5G; 2.5 YR 3/4.The texture is sandy-loamy-clay on the surface and deep-sandy clay with fine, medium and coarse sands. In fact, clay levels are relatively low in the surface horizons (0-20 cm), which is statistically different, from the two underlying horizons (20-40 cm and 40-60 cm). On the other hand, the silt content decreases with the depth and the proportion of sand does not vary along the toposequenceI. As in Aboisso-Comoé, the Zuénoula soils have an average porosity overall. Also, there are very few millimeter to centimetric, subhorizontal preferential orientation in the different horizons.The structure is fragmentary polyhedral subangular and well provided in coarse elements (50 p.c on average). The horizons are coherent and with a depth of 120 cm. The drainage class is good (1.8-1.7).

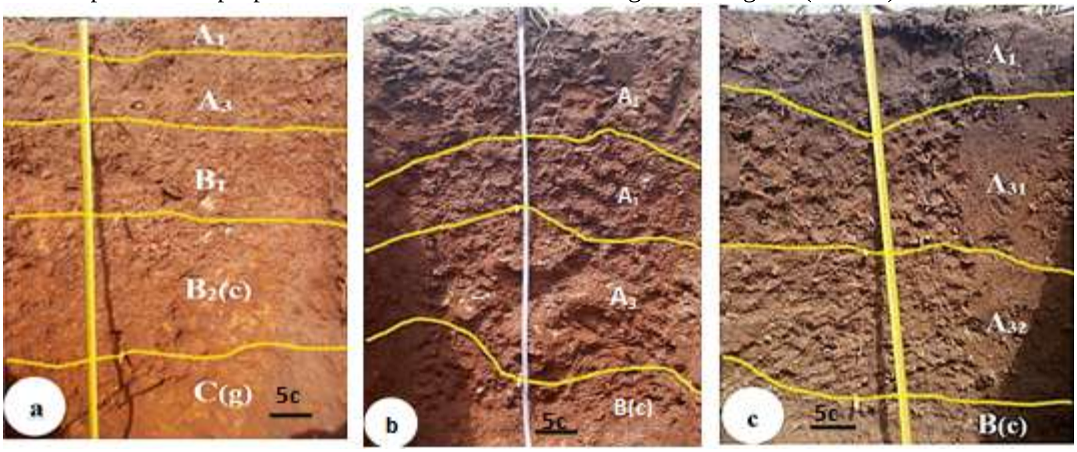

Figure 5: Cambisols observed along the toposequence in Zuénoula a) Cambisol (ParaplinthicFerralic); b) Cambisol (PseudogleyicManganiferricParaplinthic); c) Cambisol (GleyicArenic)

3.2 Chemical and physico-chemical characteristics of the Cambisols observed in the various sites

Site	**Aboisso-Comoé**
pH	Very strongly acidic to weakly acidic soil
Organic material	The content varies from 0.34 to 5.28 g.kg-1 on average at the 70 ° N toposequence. The surface horizons have a content greater than 14 g.kg-1. Nitrogen level moderately close to the allowed threshold (0.06 <N <6.33 g.kg-1). Low C / N <2 ratio
CEC	For horizons greater than 30 cm, 1.2 <CEC <15.7 cmol.kg-1. It varies along the to posequence 70° N
Exchangeable soil cations	The potassium content is normal (0.15 <K <0.4 cmol.kg-1) in the surface horizons. On the other hand, it is very low (<0.1 cmol.kg-1) at low (0.1 <CEC <0.15 cmol.kg-1) in depth horizons. Similarly, calcium is low to very low ranging from 0.17 to 10.1 cmol.kg-1. Magnesium also indicates very low values (<2.45 cmol.kg-1) in soils from top to bottom.
Phosphorus	Soils have a high total phosphorus content but the proportion of available phosphorus is very low. The phosphorus ratio available on total phosphorus is less than 50 p.c.

Site	Zuénoula
pH	The soils of the summit with almost neutral acidity (pH = 7.01), oppose the soils of low-lying which are acidic (ph = 5.63)
Organic material	Low mostly below standard with decreasing depth surface (0.74 to 0.32 g / kg). The values are also decreasing from the depth surface (0.74 to 0.32 g.kg-1) for the nitrogen content. The same is true for the C / N ratio.
CEC	The lowest mean value was observed at the top (3.36 cmol.kg-1) and the highest at the lower slope (4.49 cmol.kg-1)
Exchangeable soil cations	Exchangeable bases have a vertical dynamic with depth. The lowest values in exchangeable bases were recorded in the horizons higher than 20 cm (0.11 to 0.73 cmol.kg-1) while the highest values are located at the top of the slope (0.16 to 2, 52 cmol.kg-1) and middling (0.17 to 1.98 cmol.kg-1)
Phosphorus	The total phosphorus values are decreasing with depth while that of assimilable phosphorus remains stable in the same profile. Total phosphorus levels between 300 and 600 mg.kg-1 are the most widespread (69.62 p.c). The range of value, best represented, is for soils with contents of between 600 and 1000 mg.kg-1, ie 23.15 s.c.

4. Discussion

The morphopedological characteristics give important information on the soils of the different zones of study and are essential factors of the soil quality.

As part of our study, the description of the morphological features revealed several major features, such as the presence of browned soils, assimilated to "Cambisols" distinctly characterized by the properties of the medium on the different topographic segments.

This finding is attributed to the brown discolouration of soils confirmed by the work of Barnerias et al. (2004) that Cambisols are generally brown in color. Browning is the major pedogenetic process in these soils.The brown color of the soils is due to the combination of the black or brown-black hue of the humus and the red or orange hue of the iron compounds (Kouakou et al., 2013).

The parent material appears to be a shaly formation whose outcrops observed are being altered, which is related to the results of the work of Yao-Kouamé (2008) in Toumodi on average Côte d'Ivoire, which argues that Cambisols derive from volcano-sedimentary formations. The clay content increases and decreases in places of different toposéquences.The increase of the clay content with the depth, corroborates the thesis according to which the fine elements, in particular the clays, can be leached (obliquely and vertically), and enrich the deep horizons or the soils at the bottom of slope (Lompo, 1993). Moreover, According to Alongo et al. (2013), the increase in clay content from surface to depth is due to slope, destruction of epipedon clay, and earthworm or thermite activity.The soils studied have heavy loads in coarse elements as most of the soils of Côte d'Ivoire according to Avenard (1971), which increase with depth. This could have disadvantages on tillage and the development of some crops such as sugar cane. According to Koko (2008), quartz chippings, often mixed with ferruginized concretions over a large thickness, can constitute real constraints to the rooting of crops.This result is also similar to that obtained by Kassin (2009), who has already shown that beyond 50%, coarse elements reduce the volume of fine soil that can retain water and increase internal drainage.

The properties thus defined show, on the one hand, coherent aggregates and, on the other hand, a polyhedric structure with a lumpy tendency in the organic horizons or the first horizons of each profile, and subangular polyhedron in the other mineral horizons, creating flocculation conditions where exchangeable cations are trapped (Gallali, 2004).

On each toposequence, considerable soil variation was noted as a function of topographic position. This statement corroborates that of Poss (1982) who states that on each slope the soils vary considerably according to the topographical position, with very different cultural abilities.

The soils studied are characterized by two pedogenetic processes, namely the reworking and rejuvenation that accompany this process of browning. The reshuffle is the presence of a horizon rich in coarse elements (debris of cuirass, ferruginous gravel, gravels and more or less blunted and ferruginous quartz pebbles) (Avenard, 1971) while the rejuvenation is expressed by the presence of spots variously colored at the soil level (Yao-Kouamé, 2007b) resulting from hydromorphy and testifying to the presence of a temporary water table at a given moment (Yao-Kouamé et al., 2008).The hydromorphic spots observed in the different profiles have also been observed by Boyer (1982). For this author, many soils in western and central Africa in the Amazon often have a temporary and / or sometimes permanent hydromorphic horizon in many areas with imperfect drainage.

The soils of the toposéquences have a brown coloration at the top of slope and this coloration becomes more and more reddish at the bottom of slope. This lateral variation of the color is due to the reaction of iron, which is predominant in the zone; in fact, according to Koné et al., (2009), soil coloring would be linked to the constituents of soils, in particular, iron, aluminum and the mechanisms that govern it (in particular the transition from a Fe2O (OH) hydroxide to top of slope to an oxide Fe2O3 at the bottom of slope). Our results are consistent with those of Bongoua, (2009), who argues that the soils of Ivory Coast are rich in iron oxyhydroxides.

According to the pHeau interpretation scale indicated by the soil referential, these soils have acidic reactions (4.2 <pH> 5.0) to low acid (5.0 <pH> 6.5). In most of the soils studied, the organic matter content, from top to bottom, is medium to good, and low, at the bottom of the slope, except for soils of Aboisso which are very poor in organic matter.

The soils of Aboisso-Comoé and Zuénoula generally have a fairly good C / N ratio (8.53 C C / N ≤ 11.12), hence a very good decomposition of organic matter. This ratio is materialized by a low content of total nitrogen and organic carbon with average contents of between 0.067 and 0.3%. These results do not agree with those of Coulibaly et al. (2012), which states that 1.4% is needed for carbon and 0.14% for nitrogen for soils grown for good organic matter supply.

The values of the sum of the exchangeable cations and the cation exchange capacity are low, and lower than the reference values. This may be due to the strong association between organic carbon and CEC (Brady and Weil, 2002).

Total phosphorus levels are fairly moderate to high while phosphorus levels are low.

These results indicate that mineralization of organic phosphorus and the effects of organic matter on soil phosphorus did not contribute to the increase in the available form of phosphorus over time. Also, these results could be explained by the fact that the soils studied are quite poor in organic matter, whose action on the immobilization of phosphorus has already been reported by Gigou and Bertrand (2000), Luciens et al. (2012). According to Lompo (2009), the almost universal deficiency of tropical soils in phosphorus is one of the main limiting factors of agricultural production in sub-Saharan Africa.

All these deficiencies noted can limit the yield of certain crops and / or affect quantitatively and / or qualitatively the harvests. Also, a single nutrient, low in the soil, reduces the yield, even if the others are not at limiting values.

5. Conclusion

This study shows that the types of soils studied have different characteristics and are distinguished from each other by their topographic position, under the influence of various physical and chemical properties. At the top of the slope of the toposéquences, the soils are affected by the reworking and the induration, in the middle, they are soils characterized by the process of rejuvenation, with ferruginized concretions; at the bottom of the slope, the soils are hydromorphic.Also, these soils are strongly provided with coarse elements. They are at the same time composed of debris of rocks, more or less altered, small blocks of quartz, but especially of concretions and nodules made of alloys of organic matter, metallic oxides of iron, alumina and manganese. The physical and chemical properties of these soils are good to medium. The structures are good and present, in places, conditions of temporary hydromorphy.

Regarding the chemical parameters, it should be noted that soils are less well endowed with organic matter, whose rate of mineralization remains good. The balance of nutrients reveals, deficiencies in mineral elements. Given the importance of these elements, it would be interesting to apply adequate maintenance fertilization in nitrogen (N), phosphorus (P) and potassium (K) to correct these observed deficiencies.

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