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Morpho-Pedological Diagnosis Of The Hills In South-West Of Côte d'Ivoire: Case Of An Open Trench at University of San Pedro

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ABSTRACT: The very rugged relief of San Pedro region restricts the rational use of land for the agricultural activities on which people depend. This situation will result in a long-term threat to food and economic security of the region's populations. The aim of study was therefore, to suggest to farmers a primary approach to efficient use of ferralsol of San Pedro hills for their activities. To achieve this, a morpho-pedological study of a trench opened up during development work for building University of San Pedro was carried out, based on relevant soil description criteria, as used by Overseas Scientific and Technical Research Office. The study highlighted four major horizons in the weathering profile, and the major agronomic constraints to their development, including induration and a high load of coarse elements. In addition, these soils have a clay texture that makes them threshing in the rainy season and pulverising in the dry season. To make the best use of these soils, amendments and development of the indurated horizons are recommended. The adoption of contour cultivation is proposed to limit soil erosion on hillsides. On other hand, on higher ground (slopes greater than 30°C), the installation of grazing land was recommended. The students involved in this study were able to consolidate the knowledge they had acquired in the general pedology lecture course.

Keywords: *Trench – Morpho pedology - Ferralsol – University of San Pedro.*

INTRODUCTION

Soil is essential for plant production and the creation of infrastructure, providing abundant ecosystem services. To this end, geotechnical engineers take test pits no more than one meter (1m) deep to assess technical parameters, while agronomists take samples at a shallower depth. While these standard methods are universal, they are not immune to criticism: in soils deeper than one meter (1m), the nature and state of weathering of bedrock, the state of overlying regolith and physical state (structure, cohesion, etc.) of soil horizons are important features determining the agronomic and geotechnical quantities of soil (Kone, 2007). This is further illustrated by Kouadio et al, (2015). For the plant to flourish, it is necessary, even advisable, to carry out a soil diagnosis to assess its agronomic properties to design an appropriate technical itinerary. Soil morphology studies take into account both geomorphological and soil characteristics, as well as the physical environment and its climatic connections. This is why this method

has been described by Yoro (2004) as sustainable management of agricultural areas. It provides an inventory of soil surfaces in utilitarian terms according to cartographic units.

These studies are based on macroscopic observation and description of soil characteristics (Hien. et al, 2023; Yoboue and al, 2018). They initially proved to be effective in rapidly carrying out inventories of tropical soils, leading to an assessment of the agricultural potential of the land, particularly in French-speaking Africa (Jean, 1972). However, the shallowness of the soil observed remains a weakness of the method if its principle of data similarity according to geomorphology is to be validated. The opening of trenches down to bedrock is a good opportunity to address this problem.

The work of Bakayoko et al (2022) has successfully demonstrated the effectiveness of the trenching method in the physical and geotechnical characterization of soils. However, similar studies are still limited in Côte d'Ivoire. During the construction of San Pedro University, a trench of this type was created as part of the site development work. It extends over 300 (three hundred) linear meters at an altitude of around 400 (four hundred) meters. The study aims to offer farmers a primary approach for the efficient use of the ferralsol of the San Pedro hills for their activity by identifying these major morpho-pedological traits. It specifically aims to firstly, characterize physical and morphological heterogeneities of soil, secondly identify vertical variabilities of morphological and geological features, and finally estimate the spatial extent of the consequences of this morphogenesis. Ultimately, this work will provide a basic tool to better understand the prerequisites for civil and agricultural engineering works in the Lower ‘’Cavally’’ region with similar geomorphological landscapes.

II STUDY MATERIAL AND METHODOLOGY

2-1 Study area

The study area is located within the University of San Pedro, open in October 2021 (Figure 1). The trench, at coordinates 04°47'30"N and 06°42'10"W, was opened during development work for building the first phase of that institution, which is planned to be built on a very rugged site (hilly terrain with hills 600 m above sea level) covering three hundred and fifty hectares (305). According to data from SODEXAM (Airport, Aeronautical, and Meteorological Exploitation and Development Company), the San Pedro area is heavily irrigated, with rainfall of more than thousand seven hundred and forty millimeters (1,740 mm) /year and a humic tropical climate. It has a majority peasant population whose main activity is export agriculture (coffee, cocoa, oil palm, and rubber trees), and subsistence agriculture (corn, cassava, plantain, tomatoes, etc.). The soils are desaturated ferritic (CPCS, 1967) and are distributed along the ‘’topo sequence’’ of the hill relief (summit, slope, and lowland), with varied agronomic characteristics. The study of trench concerns a hill as a prototype relief for the region. This region has been the site of intense orogenic activity (‘’Liberian’’ and ‘’Leonian’’) leading to its geostructural and petrographic structuring, the signatures of which can be observed along the Tabou-Sassandra coastline (Djroh and *al* 2022; Yace 2002).

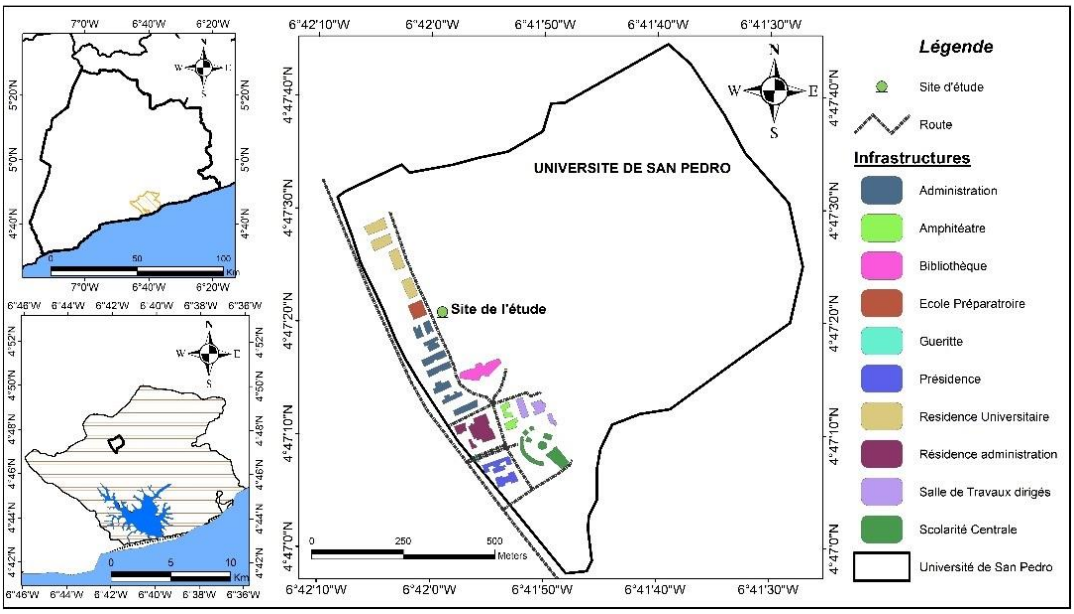

Figure 1: Location of the study area at the University (Editor: Yapo, a doctoral student at Félix Houphouet-Boigny University)

2-2 Technical material

The edaphic material concerns hills supplanting the geomorphology of the Ivorian Sea coastal up to four hundred meters (400 m) in altitude unlike the rest of the southern regions not reaching (one hundred meters (100m). Measurements of length, position, and coarse particle size fractions were made by tape measure, GPS, and sieve. A description sheet to provide information on the relevant criteria of pedogenesis. The geological map and the topographical background of the region at a scale of 1/200,000 were used.

3 STUDY METHODOLOGY

3.1 Horizon observation
The horizons were observed macroscopically from the bottom of the hill. Contrasts in color, composition, etc. were considered as vertical criteria for distinguishing layers, while the homogeneity of a layer was used to assess its lateral extent.

3.2 Consistency and crumbling
The resistance of the particles to crumbling under digital pressure or to crushing in the palm was used to assess consistency. Erosion notches have been observed, described, and located in layers that present structural weaknesses.

3.3. Level of weathering
The level of weathering was estimated about the depth of the weathering profile and not pedological. It is appreciated by ‘’arenization or laterization” which are the modes of physicochemical alterations that affect crystalline rocks in our tropics. The loose appearance, the presence of oxides, induration, and cracking are some relevant basic elements of this description.

3.4. The bedrock and geological structure
The location of bedrock was determined by the depth and bottom of the succession of soil layers and by its healthy appearance. The structurally of the geological formations was observed and described in the bedrock, where the structures appear more visible and distinct, about the geological events that have marked the study area.

3.5. Extent of the study
The limits of the bedrock observed, superimposed on those of the topography, made it possible to extrapolate the results to the Lower ‘’Cavally’’ region. All areas with the same bedrock and topography are considered similar according to the principle of continuity layers in stratigraphy.

3.6. Horizons and layers of weathering profile
The horizons constituting the profile are identified using discriminating criteria such as color, texture, soil constraints, etc. which appear on a dedicated description sheet.

RESULTS

Geologically, there is a more or less pronounced weathering profile from the top to the base of the hill. There is good zonation in the bedrock, with inclined planes at both ends of the trench, giving the configuration of the anti-shape fold. The innermost layers are almost vertical. The inclined planes bear witness to the compressive tectonic activity that led to the formation of hills. There is also abundance fractures, fissures, and faults that have caused a slight displacement of certain layers. The zonation observed indicates segregation between felsic and ferromagnesian minerals. The presence of schistose structures indicates a significant degree of compression of phyllite rocks. There are enclaves of quartz crystals in a clay matrix and muscovite minerals that sparkle in sunlight. Foliated and schistose structures are the result of the metamorphism of pre-existing magmatic or sedimentary rock. Regolith contains relics of the bedrock that has physico-chemical alteration, synonymous with arenisation (Figure 2).

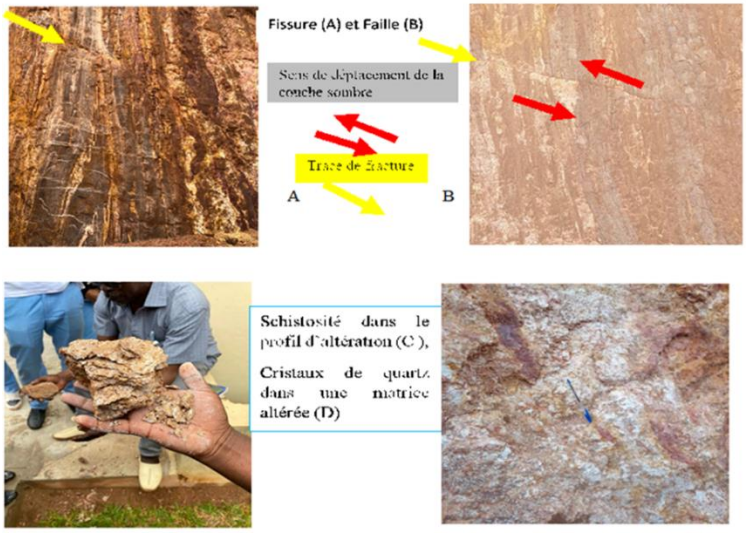

Figure 2: Some markings of geological phenomena (A and B: Fissures and faults; C: Schistosity; D: Clusters of quartz crystals)

From a pedological point of view, the weathering profile of this trench, which extends over approximately 300 m at its base and over 400 m in altitude, showed four layers or horizons with distinct vertical variability at morpho pedological level :

- ✓ A highly gravelly horizon, with almost 40% coarse elements (gravel), 5YR4/3 in colour, dark with an average thickness of sixty centimeters (60 cm), which represents the arable layer or horizon of the agronomist, on which the plants develop. The texture is sandy clay. There is a little biological activity. The high level of gravel is the main constraint to good root development.

- ✓ An indurated horizon of a more or less pronounced lateritic nature, with an average thickness of one hundred and fifty centimeter (150 cm). Its colour is 5YR4/6, light brown. This indurated layer is less than forty centimeter (40 cm) from the surface. The shallowness and strength of the armour layer is a major constraints to the root development of taprooted plants. The induration surrounds the hill in the form of a ring of varying thickness.

- ✓ A clay horizon 5YR4/6 in colour, ochre or brown, and two hundred centimeter (200 cm) thick, with a clay-loam texture containing significant relics of the parent rock. This suggests a horizon (B) in young or relatively undeveloped soil. It lies just below the indurated horizon. It is deep in its loose parts and shows almost no biological activity. It is an accumulation horizon. The size of the coarse elements is of the order of a decimetre, without preferential orientation.

- ✓ A horizon of bedrock that extends to a depth of around thirty metres. There is a foliation marked by light and dark bands that can be seen over most of rock, with shades of schistosity. It shows evidence of tectonic movements symbolized by fractures (cracks and faults). The colour is 5YR5/8, not homogeneous, but ochre is dominant. There are enclaves of quartz crystals in a clay matrix. This horizon is more or less consolidated, with the presence of fractures testifying to dominant mechanical alteration (Figure 3).

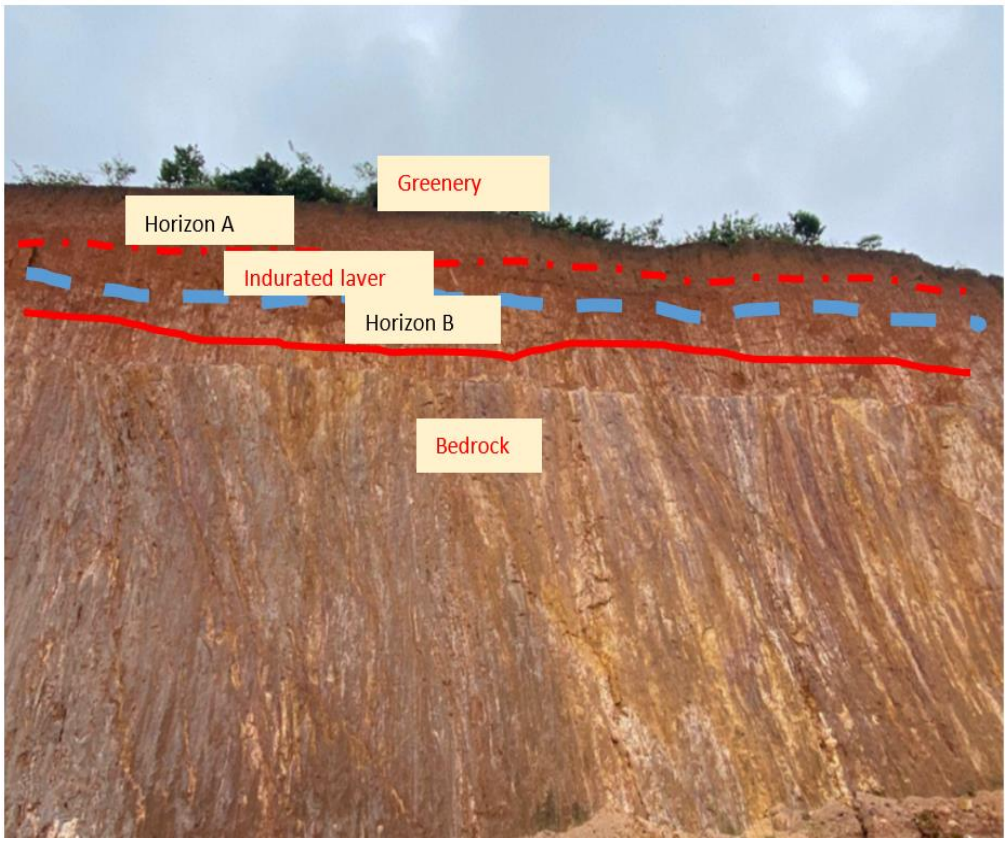

Figure 3: Soil profile in the trench

In addition, the soils on the hillsides and slopes are subject to erosion, which strips away the poorly fertile topsoil. They are developed up to some altitude. This involves growing food crops (maize, manioc, yams, potatoes) or vegetables (tomatoes, lettuce, peppers, okra), with ridges laid out in the direction of run-off, still not helping to mitigate the effects of erosion. Lowland soils are used for lowland rice and market gardening. However, extensive use is made of mineral and/or organic fertilizers to compensate for soil deficiencies. Generally, the soil is loose during the rainy season and pulverising during the dry season. To the touch, the soil sticks to fingers and skin. These characteristics mean that soil is predominantly clay and silt, with little sand. The main obstacles to its development are the uneven topography and the low level of gravelly or indurated horizon. The dominant colour is ochre, which is characteristic of soils rich in ferromagnesian minerals, particularly iron (Figure 4).

Figure 4: Shrinkage crack characteristic of silty soils (A), a panoramic view of relief of the study area (B)

DISCUSSION

From a geological point of view, we note in the trench structural elements that testify to the tectonic activity that took place in this area of the South-West. Indeed, this area was the site of several orogenic activities such as Precambrian orogeny. Yacé, (2002), noted in his studies that the San-Pedro region is characterized by poly deformation characterized by flattening and ductile shearing mechanisms with retrograde-type metamorphism. Furthermore, the area is characterized by several geological formations of magmatic, metamorphic and sedimentary nature. That observation was confirmed by the work carried out by Djroh et al. (2022); Lasm T. et al, 2011 which reveals that its gneisses, migmatites, granites, granodiorites, pegmatites, mica schists, graywackes, flysch and numerous veins of quartz and dolerites which constitute subsoil of San- Pedro.

Soil types are distributed along the top sequence of hills that dot the San Pedro area. The soils on the summits and hillsides are shallow, indurated, and contain a high proportion of coarse elements. This makes them unsuitable for agriculture. Koko and al (2006) have shown in their studies in this area of south-west Côte d'Ivoire (San Pedro) that coarse elements, induration, and poor drainage are the morpho-pedological characteristics closely linked to soil degradation on hilltops and upper slopes. In addition, the presence of shallow induration in hilltop soils is one of the major constraints to their development. The induration of these soils is thought to be linked to an accumulation of iron, aluminum and magnesium sesquioxides and seems to occur in this particular case at the top of the hills. According to Aubert (1963), induration is a common phenomenon in ferralitic soils. It manifests itself in the form of armouring that can be observed in different ecosystems, in this case savannah and forest ecosystems (Yoboue and al., 2018). In their study**,** Hien and al (2023) highlighted this induration phenomenon in ferruginous soils under shea in ‘’Bouna’’ (north-east Côte d'Ivoire), in the savannah zone, at a very shallow depth. Lowland soils are more or less suitable for farming. They have a temporary hydromorphic which favours the production of flooded rice and market garden crops. ORSTOM (Overseas Scientific and Technical Research Office) studies (**1994)** have shown that the hydromorphic soils of the lowlands (rich in colluvium deposit) are suitable for agriculture such as lowland rice growing and market gardening. Moreover, the low-lying soils that are the receptacles of erosion products will be subject to iron toxicity and siltation. Soils on higher ground should be protected using methods based on alternating transverse ridges, to reduce their vulnerability to erosion (Bozza et *al*., 2005 and 2007). As for indurated soils, only stripping and amendment can improve their production capacity. ORSTOM studies also show that almost all of the San Pedro region is made up of highly desaturated ferralsol, except part of the Nawa region, which is made up of moderately and/or lightly desaturated ferralsoil. However, optimum development of these soils will require an assessment of their fertility (Yoro, 2001 ; Koko et *al*., 2006). It would therefore be a good to combine a morpho-pedological study and chemical analysis of soil to improve the reasoning behind these soils for sustainable agriculture.

CONCLUSION

The morpho-pedological study identified the structure of the ferralsol of San Pedro hills. These hill soils are made up of three classic horizons, interspersed by indurated layer of varying thickness. soils are pounding in the rainy season and pulverizing in the dry season. Their overall coloring is the ocher red which characterizes lateritic soils. The shallowness of the indurated horizon and the high proportion of coarse elements are the main constraints to the development of these soils. Their development will require appropriate itineraries, humus amendments and mechanical stripping. Soil morphology is a good approach for primary mapping of the soil's suitability for cultivation. However, laboratory analysis will be necessary to perfect and refine our knowledge of soils.

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REFERENCES

Aubert G**.,** 1963. Soi1 with ferrugineous and ferrallitic trusts of tropical regions. *Soi1 Sci.* , 95, 4, p.235-242. DOI :https://journals.lww.com/soilsci/citation/1963/04000/soil_with_ferruginous_or_ferrallitic_crusts_of.4.aspx

Aoulou K. A., Severin P., Oga Y. M. S., Dewandel B., Lachassagne P, 2021. "Improving the Methods for Processing Hard Rock Aquifers Boreholes' Databases. Application to the Hydrodynamic Characterization of Metamorphic Aquifers from Western Côte d'Ivoire", Water, 2021 https://www.mdpi.com/2073-4441/13/22/3219

Bakayoko S., Kone, B., Honore, K. C., & Alex, M. K., 2022. Caracterisation et Renforcement des Proprietes Geotechniques des Briques de Terre avec Rajout de Paille du Riz *European Scientific Journal, ESJ, 8,* 230. 14p. DOI : 10.19044/esipreprint.8. 2022.p230

Bozza J., Chamssidine H**.,** 2007. Cirad-Ca, agronomy section: "Fiches techniques concernant la lutte antiérosive en zones de cultures à Mayotte" (Version l). DOI : https://agritrop.cirad.fr/539179/1/document_539179.pdf

Bozza J., Chamssidine H., Longcote J., 2005. Proposals for agri-environmental measures to combat erosion in agricultural areas. (M'Tsoharo area) Adaptation of crops on steep slopes (November 2005),14 p, CIRAD-CA. **DOI :** https://agritrop.cirad.fr/539243/

CPCS**,** 1967**.** Soil classification. Work by CPCS 1963-1967, 100 p. DOI : https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers16-03/12186.pdf

Djroh S.P., Gouedji G.E.F., Aka E.B.J.C., Sombo B.C. et al. 2022. "Magnetic Facies and Polymetallic Sulphides Deposit in the Mafic and Ultramafic Intrusions of Samapleu (Western Côte d'Ivoire)", Open Journal of Geology. DOI : https://www.scirp.org/pdf/ojg_2022102815155039.pdf

Hien M-P., Kone B., Ouattara A., Kouadio K-K. H.and Ettien D. J. B**.,** 2023. Morphopedological Characteristics of Soils under Shea Trees in the Bouna Region of Northeast Côte d'Ivoire**,** 10p. DOI : 10.9734/IJPSS/2023/v35i143035/

Jean K. (1972) - Les inventaires morphopédologiques. Conceptions - Applications au développement agricole. L'Agronomie Tropicale. Series 2, General Agronomy. Etudes Techniques, 27 (9): 930-938. Seminar on Soil Fertility, Ibadan, Nigeria, 22 May 1972/26 May 1972. DOI : https://agritrop.cirad.fr/435652/

Koko L. K., Yoro G., Ngoran, K.A. Assiri A. and. Assa A., 2006. Identification of morphopedological characteristics related to early degradation of cocoa trees in southwest Côte d'Ivoire. In : 15e International Conference on Cocoa Research, San José, Costa-Rica. 10 p. DOI :https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiizaX7LuDAxXHUqQEHS8YAhYQFnoECBUQAQ&url=https%3A%2F%2Fcnra.ci%2Fwp-content%2Fuploads%2F2021%2F08%2FArticles_com_scientifiques_14oct2019.pdf&usg=AOvVaw1RjLq2607bIYLwpmtelG5p&opi=89978449

Kone B. 2007. Colour as an indicator of soil fertility: use of data to study the potential fertility of ferrallitic soils above latitude 7° N in Côte d'Ivoire. Doctoral thesis, University of Cocody, Abidjan. 146 p. **Physical document.**

Kouadio K.P., Yoboue K.E., Kouadio K. - K. H., Bini Y.Y.P And Yao - Kouame A., 2015. Morpho-pedological characteristics of Ahoué soils in the Sub-Prefecture of Brofodoumé, South-East Côte d'Ivoire. Afrique SCIENCE 15(5) (2019) 140 – 150. DOI : http://www.afriquescience.net/PDF/15/5/12.pdf

Lasm T., De Lasme O., Oga M-S.Y., Youan Ta M., Baka D., Kouame F. And Yao T.K., 2011. Hydrochemical characterisation of fractured aquifers in the San-Pedro region (South-West Ivory Coast). Int. J. Biol. Chem. Sci. 5(2): 642-662, April 2011. DOI :https://www.researchgate.net/publication/322277537_Caracterisation_hydrochimique_des_aquiferes_fissures_de_la_region_de_San-_Pedro_Sud-Ouest_de_la_Cote_d%27Ivoire

ORTOM**,** 1994. Pedological study of the soils of San Pedro, (South-West Ivory Coast). N°, cie Convention O. R. S. T. O. M 6500/224 NU de Convention local. DOI : https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers15-09/29613.pdf

Yace I., 2002. Introduction to Geology. L'exemple de la Côte d'Ivoire et de l'Afrique de l'Ouest. Edition CEDA:Abidjan-Côte d'Ivoire; 183. DOI**:** **https://www.google.ci/books/edition/Initiation_%C3%A0_la_g%C3%A9ologie/CU3xuQEACAAJ?hl=fr**

Yoboue K.E., Kouadio K.P.,Ble L. O Et Yao-Kouame A**.,** 2018. Morphopedological and Geochemical Characteristics of the Brunified Soils of Anikro and Kahankro (Centre-South Côte d'Ivoire). ESJ, January 2018 Edition Vol.14, No. 3 : 281 - 300. DOI : 10.19044/esj.2018.v14n3p281/ URL:http://dx.doi.org/10.19044/esj.2018.v14n3p281

Yoro G., 2001. Analytical characteristics of soils allocated to Gabon's stabilisation and equalisation funds. Convention CNRA-CSPG. CNRA, Abidjan. 16 p. **internal document.**