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Fillings And Late Holocene Palaeoenvironments Of The Palustrine-Depressions Of The Lopé National Park, Middle Ogooué Valley In Gabon

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Abstract

This work is devoted to the study of fillings and late Holocene palaeoenvironments of two marshes located in the savannas of the northern part of Lopé National Park in Gabon. Sedimentological and geochemical analyzes associated with ^{14}C dating were performed on the sedimentary deposits of Yao and Vitex marshes. The results obtained were compared with these of the sedimentary core of the Lopé 2 marsh, previously analysed. All of these data show that the active filling of these marshes was carried out synchronously. The small variation observed are linked to specific physical characters to each of the marshes. This filling began between 2300 and 2000 cal years BP in all of the marshes. It started at the beginning of the humid climatic phase which followed the climatic pejoration recognized throughout the area of Atlantic Central Africa between 2500 and 2000 years BP. During this humid climatic phase, the rains were abundant and regular and the depressions were filled with sediments which are very rich coarse detrital elements from the erosion of slopes. The marshes and its banks were covered with sparse vegetation. Subsequently the sediments gradually become

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depleted in coarse detrital materials and enriched with organic constituents. This evolution would indicate a gradual reduction in erosion linked to the densification of the vegetation cover on the slopes. It is mostly related to the development of vegetation in the marshy basins. This development of the vegetation and the conservation of the organic matter of the marshes are due to the perennial flooding of the palustrine depressions.

Keywords: Gabon, late Holocene, filling, marsh, organic matter, sediment

Introduction

The Holocene evolution of landscapes in Atlantic Central Africa has been the subject of several studies in recent decades (Vincens et *al*., 1999; Maley and Chepstow-Lusty, 2001; Malounguila Nganga et *al*., 2017; Giresse et *al*., 2020). These studies have highlighted a major disturbance of the equatorial forest during this period. This disturbance, centered between 2500 and 2000 years BP, is characterized by the fragmentation of the forest, the expansion of the savanna or the emergence of pioneer vegetation species, accompanied by intense erosion. It was mainly caused by a dry climate linked to increased seasonality (Maley, 2001; Weldeab et *al*., 2007). This dry climate phase has been documented in western Cameroon at Barombi Mbo between 2800 and 2000 years BP (Maley and Brenac, 1998). It has also been recorded in the Mayombe of western Congo at Kitina between 2500 and 1200 years BP (Elenga et *al*., 1996). Studies in Gabon have shown this climatic deterioration between 2500 and 1950 years BP at lake Nguène (under rainforest) and at lake Maridor (under savanna) between 3500 and 2190 years BP (Makaya M'voubou, 2005; Giresse et *al*., 2009). This dry climatic phase was succeeded by a wetter climate at lake Barombi Mbo around 2000 years BP (Lebamba et *al*., 2012) and at Kitina at 1200 years BP (Bertaux et *al*., 2000). This was also the case at Nguène at 1950 years BP and at Maridor from 2190 years BP (Giresse et *al*., 2009).

In the Lopé National Park, the only lake sedimentary archive studied is that of Kamalété. The results obtained highlight a weakly humid climate between 1400 and 550 years BP, followed by a return to humid conditions from 550 years BP (Ngomanda et *al*., 2005; Giresse et *al*., 2009). Apart from lake Kamalété, the savannas of its northern part contain sedimentary archives accumulated in the marshes. Analysis of that of Lopé 2 marsh reveals a dry climatic phase recorded before 2320 cal years BP (Nfoumou Obame *et al*., 2017). It is characterized by the formation of hydromorphic soil surmounted by a deposit of coarse sand in the depression, as well as by sparse vegetation around and inside the marsh. From 2320 cal years BP, the Lopé 2 marsh

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records a humid climatic phase which is at the origin not only of the filling of the depression with sediments increasingly rich in organic matter and poor in quartz grains, but also of the densification of the vegetation of the marsh and its slopes (Nfoumou Obame *et al*., 2017). The palustrine sedimentary archives very often record the palaeoenvironmental evolution of the depression itself or of its immediate slopes. To know the paleoenvironmental history of the region through the study of palustrine sedimentary records, it is necessary to increase the number of sampling sites and proxies. This work will aim to determine the late holocene palaeoenvironmental variations of Lopé through the analysis of the filling of the marshes of this park. To achieve this objective, sedimentological and biogeochemical analyzes were performed on sediment records from two marshes in the Lopé National Park.

1- Vegetation, Climate, Geology Of Lopé National Park And Presentation Of The Sites

The Lopé National Park (fig. 1), located in central Gabon has a landscape characterized by vegetation of the forest-savanna mosaic type (Palla *et al*., 2011). It is covered 80% with forest and 20% with savannas which appear only in the northern and eastern zones. The marshes that are the subject of this study are located in the northern savannas where the granitoids attached to the Archean formation of the northern Gabon massif are exposed (Chevallier *et al*., 2002). The regional climate is of the equatorial type of transition, with an annual rainfall of 1500 mm and an average monthly temperature which varies between 20.6 and 30.8°C.

The Yao marsh (S 00°10’19,5’’-E 11°35’16,11’’) is a depression 100 m long and 20 m wide with relatively steep slopes. This marsh is a preferential flow area for water during the rainy seasons to the outlet where it flows into a stream locally called the Yao River. The immediate edges of the marsh are completely covered with a savanna made up of grasses (*Pobeguinea arrecta* and *Peratis indica*) and shrubs (*Crosopterix febrifuga* and *Nauclea latifolia*) which become denser as you get closer to the marsh. Behind the savanna of the western flank develops forest made up of various species. This forest connects those that have been established upstream and downstream (towards the outlet) of the marsh. The interior of the marsh is colonized by Cyperaceae.

The Vitex marsh (S 00°9’46’’-E 11°35’07’’) is the most northerly of those studied in this work. It is located 1 km from Yao Marsh. The Vitex marsh is a depression about 40 m wide and 220 m long with relatively steep sides. Rainwater flows preferentially there before being conveyed in a stream. A grassy and shrubby savanna covers the immediate slopes of the marsh. It is only from the outlet that a grove develops in which we find the species

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characteristic of the recent colonization of the savanna by the forest (*Lophira alata*, *Paurosa guineensis*, *Aucoumea klaineama*, *Vitex doniana*). The interior of the marsh is dominated by Cyperaceae.

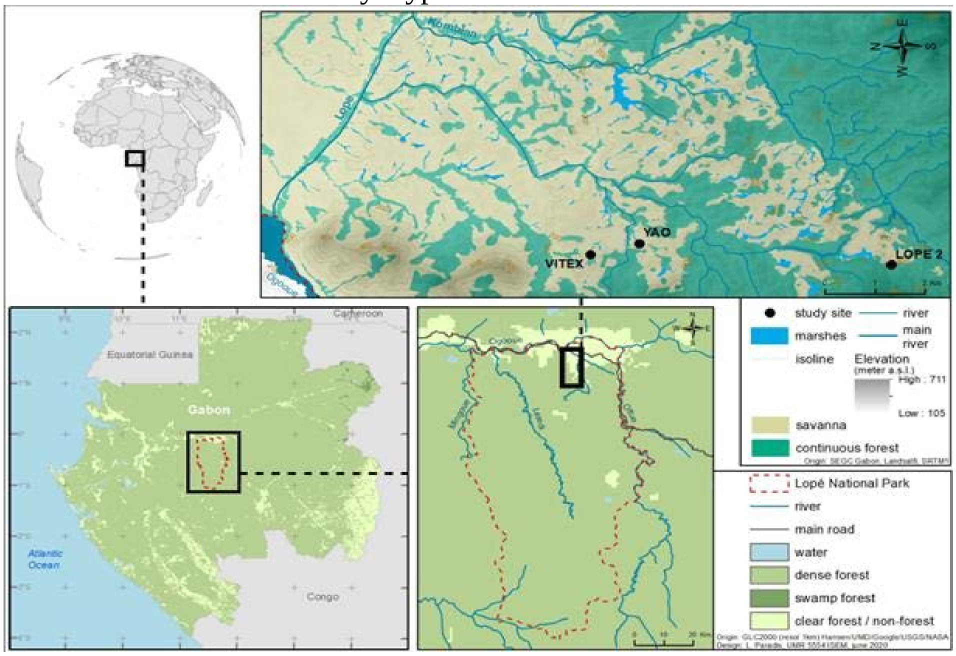

Fig. 1: Location of the Yao, Vitex and Lopé 2 marshes in the Lopé National Park (Bremond et *al*., 2021).

2- Materiel And Methods

2.1 Description Of Cores And Radiocarbon Datings

Two sedimentary samples were taken in the central part from two marshes in the Lopé National Park using a Russian mechanical corer (one at Yao and one at Vitex). During this sampling, the samples stop when the corer encounters a very hard compact zone which is difficult to cross by the tip of the latter. The sediments sampled were the subject of sedimentology and organic geochemistry analyzes (Rock-Eval pyrolysis). These sedimentary deposits were also dated with ^{14}C by accelerator mass spectrometry (AMS) at the ^{14}C measurement laboratory in Sacley (France), the radiocarbon laboratory in Poznam (Poland) and the Beta analytic laboratory in Miami (USA). The dates (tab. 1) were calibrated using the Stuiver calibration curve (Stuiver *et al*., 1998) for those obtained at Saclay and Poznam and by the Talma curve (Talma *et al*., 1993) for that obtained in Miami. The age models were established using Bacon software (Blaauw and Christen, 2011).

The core collected at the Yao marsh is 190 cm long. It consists of a light

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gray mud rich in plant debris and slightly quartzous between the base and 125 cm depth (unit 1), then a dark brown to light brown mud rich in plant debris (unit 2). Six samples of this core have been dated to ^{14}C, and the results show that it base is 2003 years old cal BP. The slope of the age-depth model (fig. 2) obtained from these dates varies from the base to the top of the core. Indeed, it is relatively important between 2003 and 1178 cal years BP (57.54 cm/10^3 years), then stabilizes between 1178 and 719 cal years BP (27.21 cm/10^3 years). From 719 cal years BP to the Present, the depth-age model exhibits its steepest slope (177.32 cm/10^3 years).

Core Name	Deph (cm)	Laboratory code number	Material dated	Age ^{14}C (Years BP)	Calibrated years BP
Yao	23	A37036	Charcoal	-24,41±1,38	-28,5/-19,5
	61	Poz-69212	Indéterminate seed	160±30	138-288,2
	99	A37037	Herbaceous seed	560±30	508,7-626,2
	127,5	Beta 397649	Bulk organic matter	820±30	679,5-883,8
	140	Poz-69213	Cyperaceae seed	1295±30	1015,2-1267,7
	187,5	Beta 397650	Bulk organic matter	2080±30	1843,7-2116,3
Vitex	9,5	Poz-57546	Cyperaceae seed	-48,37±2,3	-53,7/-40,1
	51,5	Poz-52086	Cyperaceae seed	275±30	151,9-378,7
	83,5	Poz-57547	Indeterminate seed	420±25	424,6-524
	115,5	Poz-53085	Indeterminate seed	110±25	606,3-844
	125,5	Poz-53082	Indeterminate seed	950±30	738,2-915
	174,5	Poz-57548	Elais seed	1320±25	1186,8-1357,7
	218,5	Poz-53083	Elais seed	2290±35	2106,8-2323,1

Tab. 1: Datings of cores from the Yao and Vitex marshes.

The core taken from the center of the Vitex marsh is 220 cm long. It consists essentially of a mud rich in plant debris and quartzous at the base. It varies in color from light brown to dark, passing through dark gray and black. Seven samples of this core have been dated to ^{14}C, and the results show that it base is 2188 years old cal BP. The age-depth (fig. 2) model produced from these datings globally presents two slopes which are not parallel to the lithology. The lowest is between 2188 and 1265.8 cal years BP (47.16 cm/10^3 years) and the highest between 1265 cal years BP and the present (137.85 cm/10^3 years).

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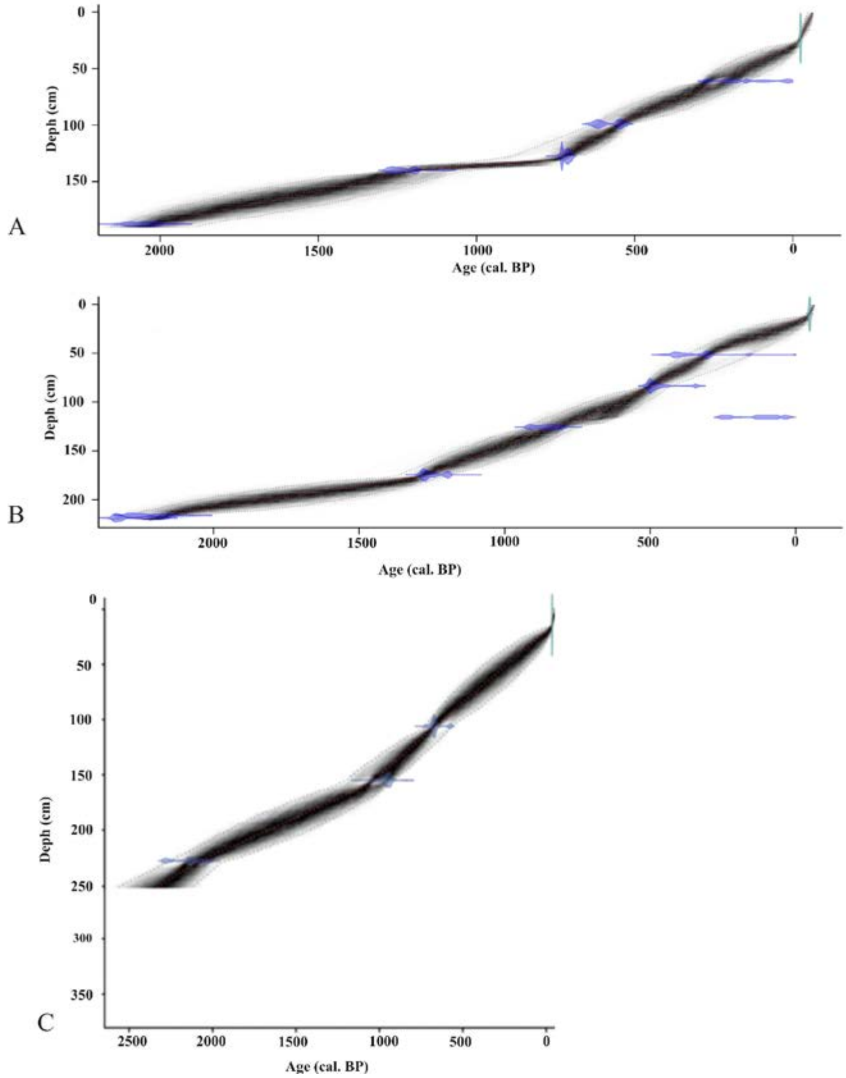

Fig. 2: Age-depth models of cores from the Yao (A), Vitex (B) and Lopé 2 (C) marshes.

2.2- Sediment analysis

The sedimentological analyzes were made on 44 samples from the Vitex marsh core and 36 from that of the Yao marsh, taken in a constant step of 5 cm. The samples taken are dried, weighed and washed through a 50 µm sieve in order to extract the fraction greater than 50 µm which will then be weighed and observed using a binocular microscope. The organic constituents of this fraction such as plant debris and charcoal are semi-quantified while the quartz grains diameters will be measured for the calculation of the clasticity index (average diameter of the four largest grains of quartz). The measured masses

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(total dry samples and fraction greater than 50 µm) allow the fraction content greater than 50 µm to be calculated. The clasticity index and the content of fraction greater than 50 µm are parameters which mark the intensity of erosion and the energy of deposition (Makaya M'voubou, 2005; Giresse *et al*., 2009). Plant debris is mainly a marker of the vegetation that develops in the marsh, but also of the humus horizons of paleosols (Kossoni, 2003, Nfoumou *et al*., 2017). Charcoal is linked to anthropogenic fires or natural fires (Oslisly and Dechamps, 1994; Oslisly *et al*., 2013; Bird and Calli, 1998). These analyzes were carried out at the Laboratory of the Research Unit for Earth and Environmental Sciences of the University of Science and Technology of Masuku (Gabon).

2.3- Rock-eval pyrolysis

For the Rock-Eval pyrolysis analyzes, the samples were taken in a constant step of 10 cm. Thus, 19 samples from the Yao marsh core and 22 from Vitex are analyzed. Rock-Eval pyrolysis is based on the analysis of 100 mg of sample (reduced to powder) using the RE6 pyrolyser (turbo model, Vinci Technologies®) from the Sedimentary Geochemistry Laboratory of the Institute of Sciences of Land of Lausanne (Switzerland). Standard parameters such as total organic carbon (TOC, in % of dry weight), maximum temperature (TpS2), hydrogen indices (HI, in mg HC / g TOC) and oxygen (OI, in mg O_2 / g TOC) are determined (Lafargue *et al*., 1998; Behar *et al*., 2001). Apart from these geochemical parameters, others can be obtained by integrating the S2 curve between 200 and 650°C. They correspond to the contributions of the various organic constituents of organic matter defined by their specific cracking temperature (Disnar *et al*., 2003; Sebag *et al*., 2007). Thus, Albrecht *et a*l. (2014), propose a breakdown of the S2 signal into five constituents ranging from A1 to A5. I-index (Log [(A1 + A2) / A3]) and R-index ([(A3 + A4 + A5) / 100]) are calculated from these relative contributions (Albrecht *et al*., 2014; Sebag *et al*., 2016).

3- Filling And Paleoenvironments Of The Marshes

3.1- The Yao marsh

3.1.1- Sediment analysis results

The values of the fraction content greater than 50 µm are between 5 and 66.2% in the whole core (fig. 3). Unit 1 (from the base to 125 cm) shows the relatively low values which regularly vary between 5 and 20.1%. Unit 2 (125 cm at the top of the core) has higher values than the previous deposit. These values ranging from 13.5 to 66.2%.

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The clasticity index is between 0.5 and 5.5 mm along the core. In unit 1, it has low values at the base between 187.5 and 162.5 cm depth (1.1-1.5 mm) except the peak recorded at 177.5 cm depth (2.75 mm). In the following, there is a clear increase in this parameter between 157.5 and 137.5 cm depth (2-5.5 mm) followed by a decrease between 132.5 and 127.5 cm depth (0.9-1, 6 mm). In unit 2 the values of the clasticity index vary very little (between 0.5 and 1.5 mm) and are lower than those of unit 1.

The fraction greater than 50 µm essentially contains organic constituents (plant debris and charcoal). Plant debris consisting essentially of remains of roots, stems, leaves, bark is more abundant in unit 2 than in unit 1. The charcoals are present in unit 1 between the base and 157.5 cm, while they are rare in the overlying unit.

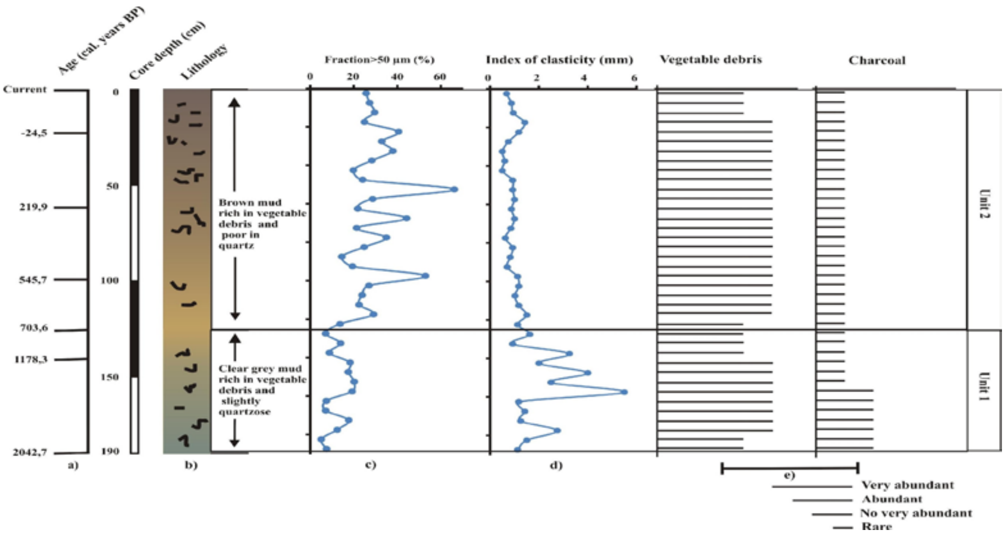

Fig. 3: Results of the sediment analysis of the core from the Yao marsh, a) Datation ^{14}C, b) Lithology, c) Fraction>50µm, d) Index of Clasticiy, e) Semi-quantitative analysis. The dates to 125 cm (703,6 cal years BP and 190 cm (2042 cal years BP) are deduced from the model age-depth.

3.1.2- Characterization of sedimentary organic matter

The results of the analysis of the core of the Yao marsh by Rock-Eval pyrolysis are summarized in the diagrams of the figure 4.

In the TOC vs TpS2 diagram we note that unit 1 has the lowest TOC (8.6% on average) and the variable TpS2 ranging from 370 to 462°C. While unit 2 shows the highest TOC (19.4 % on average) with TpS2 between 372 and 455°C.

In the HI vs OI diagram, unit 1 shows the variable HI (91.2-218.3 mg HC / g TOC) and the low OI (91.9-118.7 mg CO_2 / g TOC). Unit 2 is

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characterized by the highest OI (106.3-170.3 mg CO_2 / g TOC) and HI of the core (212-294.1 mg HC / g TOC). However, it can be seen that the OI values are generally low throughout the core (IO <200 mg CO_2 / g TOC).

The I-index vs R-Index diagram reveals that unit 1 is dominated by refractory organic matter with the lowest I-indexes (0.023-0.26) and the highest R-indexes (0.52- 0.68). Unit 2 is made up of more labile organic matter with the largest I-indexes (0.25-0.52) and the lowest R-indexes in the deposit (0.31-0.52) except a sample taken at 122.5 cm which has a very low I-index (0.14) and a high R-index (0.59).

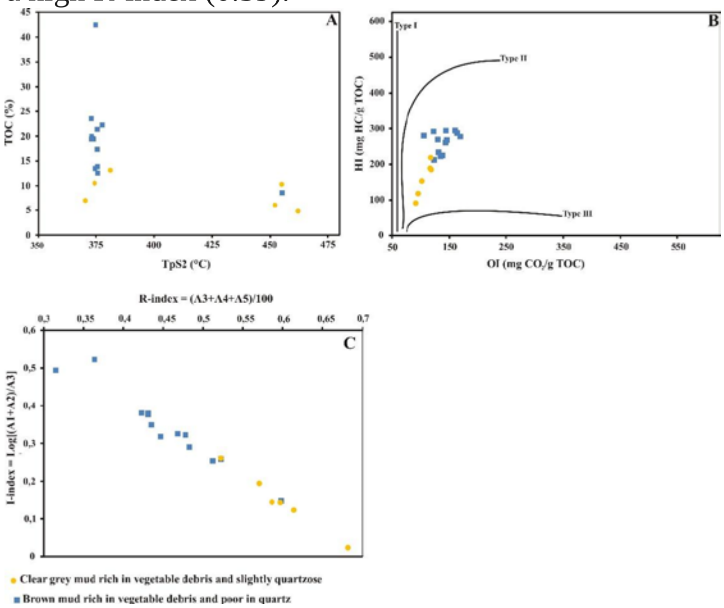

Fig. 4: Results of the analysis of the core of the Yao marsh by the Rock-Eval pyrolysis. Diagrams- (A) TOC vs TPS2; (B) HI vs OI; (C) I index vs R index.

3.1.3 - Interpretation

The analysis of the results obtained from the study of the core of the Yao marsh leads us to subdivide it into two units parallel to lithology.

Unit 1 ranges from 2042 to 703 cal years BP. It is essentially a mud rich in plant debris and slightly quartzous. The organic fraction is relatively abundant (8.6% TOC on average) and rich in refractory constituents (R-index between 0.52 and 0.68). The Rock-Eval parameters (HI between 91 and 218 mg HC / g TOC and TpS2 between 370 and 462 ° C) show that this organic matter seems to come from relatively degraded palustrine plants. The low values of IO (between 91 and 118 mg CO_2/g COT) indicate that this organic fraction degraded slowly in the oxygen poor waters of the marsh. These results can be explained by the presence of vegetation inside and on the banks of the

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marsh as evidenced by the abundance of plant debris. This relatively dense vegetation only partially traps the detrital terrestrial contributions (clay, grains of quartz) resulting from the erosion of the slopes underlined by the high values of clasticity index (between 0,9 et 5,5 mm). This may therefore suggest a relatively open environment around the marsh. The relatively high sedimentation rate observed on the basal part of this unit (between 2003 and 1178 cal years BP) may be related to this erosion. The presence of vegetation inside the marsh is favored by the permanent presence of water in the depression. Indeed this water is also at the origin of the organic matter conservation in the palustrine depression. These results are linked to the occurrence of a humid climate characterised by heavy rain fall on a soil covered with sparse vegetation.The presence of charcoal testifies to the action of fire. This fire (recorded between 2000 and 1000 cal years BP) would help to maintain more or less open vegetation on the slopes of the marsh.

The second unit ranges from 703 cal years BP to the Present. It is very rich in plant debris and poor in quartz grains. The organic fraction is therefore abundant (TOC of 19.4% on average), especially towards the top. This organic fraction is rich in labile constituents and has characteristics similar to non-degraded biological contributions (litter plants) (S2a = to 52 mg HC / g TOC on average). The increase in the organic fraction and the virtual disappearance of the coarse detrital fraction may reflect a densification of the vegetation of the marsh and its banks. This densification of the marsh vegetation is also evidenced by the abundance of plant debris which constitutes almost all of the fraction greater than 50 µm of the deposit. It is the consequence of the permanent presence of water in the depression. This water promotes the conservation of organic matter in the marsh. The marked increase in the sedimentation rate recorded in this part of the core is linked to the production and conservation of this organic matter (plant debris) in the marsh. The disappearance of the coarse detrital fraction of the sediments can also be the result of the weakening of erosion due to the densification of the vegetation of the slopes. Which explains the low clasticity indices. Here, the humid climate recorded since the first deposition phase was maintained.

3.2 - The Vitex marsh

3.2.1 - Sediment analysis results

The fraction greater than 50 µm (fig. 5) has a very high value (56.8% at 217.5 cm depth) at the base of the core. In the rest of the core (from 212.5 cm depth on the surface) the values are low and fluctuate between 0.96% (at 82.5 cm depth) and 12.10 % (at 147.5 cm depth) except a 34.4 % peak at 127.5 cm depth.

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The base of the core has a very high value of the clasticity index (5.25 mm at 217.5 cm depth) while the rest of the core (from 212.5 cm depth to the surface) has low values and little variable (between 0.1 and 2.05 mm).

Plant debris is abundant all along the core. However, they are more abundant from 177.5 to 112.5 cm as well as 72.5 cm depth at the surface.

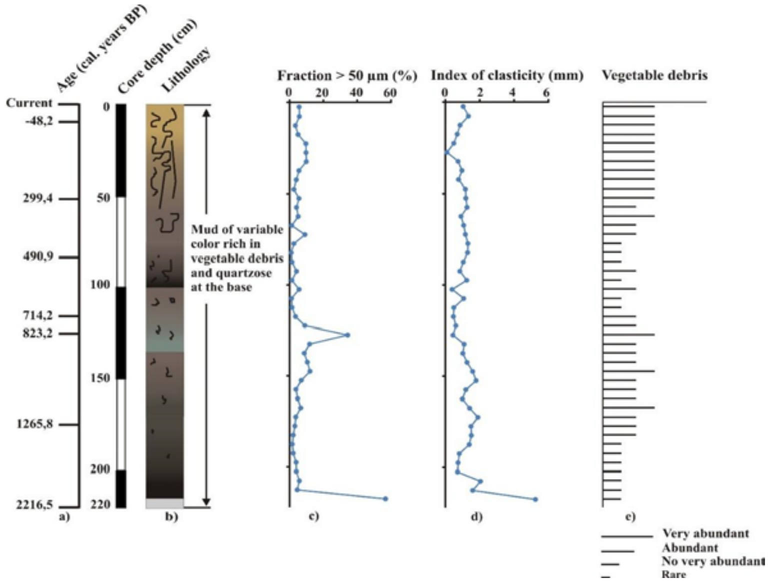

Fig. 5: Results of the sediment analysis of the core from the Vitex marsh, a) Datation ^{14}C, b) Lithology, c) Fraction>50µm, d) Index of Clasticiy, e) Semi-quantitative analysis. The date at 220 cm deph (2216,5 cal years BP) is deduced from the model age-deph.

3.2.2 - Characterization of sedimentary organic matter

The results of the analysis of the core of the Vitex marsh by Rock-Eval pyrolysis are summarized in the diagrams of the figure 6.

The TOC vs TpS2 diagram (fig. 6) shows that the samples of the Vitex marsh core are characterized by the highly variable TpS2 (363-463 ° C) and TOC (7.8-64.4%).

The HI vs OI diagram reveals that the samples of the core of the Vitex marsh are characterized by the OI (72-127 mg CO_2 / g TOC) and the HI (76-151 mg HC / g TOC) overall weak.

The I-index vs R-index diagram shows that the set of samples from the Vitex marsh core has the values of I-index (between -0.00208 and 0.34) and R-index (0.45-0.67) quite variable.

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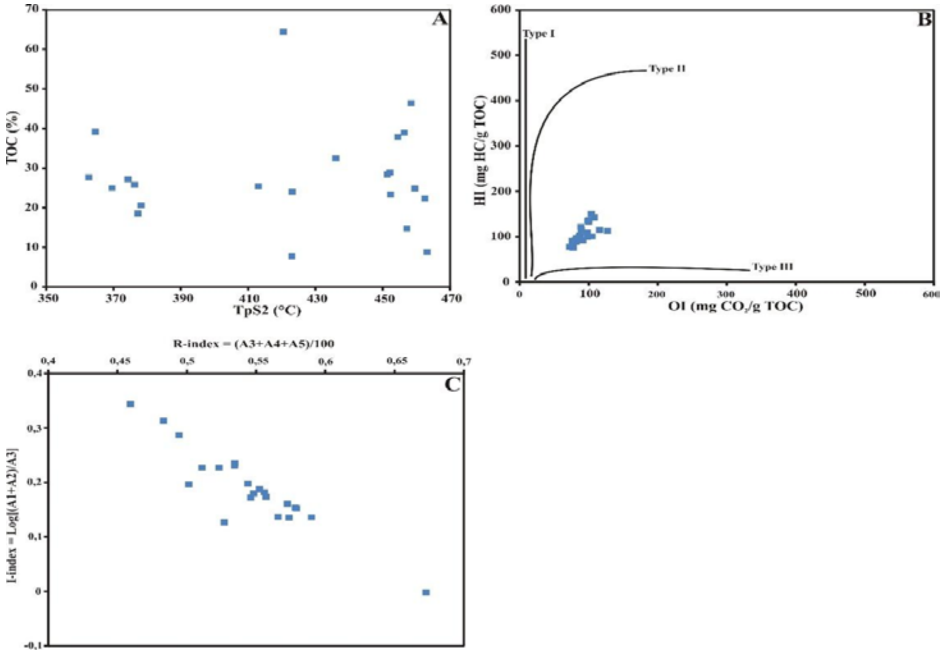

Fig. 6: Results of the Vitex marsh core analysis by Rock Eval pyrolysis. Diagrams- (A) TOC vs TPS2; (B) HI vs OI; (C) I index vs R index.

3.2.3- Interpretation

The sediments accumulation of the Vitex marsh studied was formed during last 2216 cal years BP. This deposit is rich in plant debris and quartz particles at the base. The quartz section (between 2216 and 2142 cal years BP), although not very thick, shows a fraction greater than 50 µm and a clasticity index very high compared to those of the rest of the sedimentary record. These results reflect not only significant hydrodynamics in the basin, but also incisive erosion of the slopes. This erosion shows that sparse vegetation covered the marsh and its slopes. The relatively abundant organic fraction (TOC = 7.8%) is quite rich in refractory constituents (R-index = 0.5). The Rock-Eval parameters of this fraction (HI = 113 mg HC / g TOC, OI = 127 mg CO_2 / g TOC) indicate a degraded palustrine contribution (degraded plant debris). All this information implies that this quartz level deposited between 2216 and 2142 cal years BP contains sediments which come from the erosion of the slopes (quartz grains) and the vegetation of the marsh. This still sparse vegetation does not trap the quartz flows from the erosion of the slopes.

The following filling deposit (from 2142 cal years BP to the present) shows particularly low values of the fraction greater than 50 µm and the clasticity index. Consequently, the mineral fraction consists essentially of particles lower than 50 µm (pelites). These results reflect a decrease in

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hydrodynamic in the marsh. The organic fraction is very abundant there (TOC = 27.8% on average) and relatively rich in refractory constituents (R-index> 0.45). The Rock-Eval parameters are similar to those of more or less degraded biological inputs (plant debris). These results may be linked to the proliferation of marsh vegetation which obstructs the arrival of coarse particles from the slopes and banks of the marsh. This vegetation is a sign of the permanent presence of water in the depression. The increase in the sedimentation rate in this sedimentary deposit is linked to the increase in the production of organic matter in the marsh as well as to its conservation. The abundance of organic production leads us to believe that the filling of the Vitex marsh took place during a humid climatic period characterized by regular rain.

3.3- Functioning of the Lopé marshes

3.3.1- Comparison of the sedimentological and geochemical data of the cores of the Yao, Vitex and Lopé 2 marshes

Among the sedimentary cores collected in the Lopé marshes, that of the Lopé 2 marsh has recorded the longest paleoenvironmental history (fig.7) (Nfoumou Obame *et al.,* 2017, Bremond *et al.,* 2021). The base of this core (period prior to 2320 cal year BP) is a soil formation containing sand, clay but very little organic matter . This soil is topped by coarse detrital sediments. This first part of the Lopé 2 marsh sediment record is unlike any part in the Yao and Vitex marsh sedimentary records.

On the sedimentary record of the Lopé 2 marsh, between 2320 and 2034 cal years BP, the sediments are very rich in quartz,and poor in organic matter. This composition is close to that of the base of the sedimentary record of the Vitex marsh (between 2216 and 2142 cal years BP). The Yao marsh core does not contain sediments very rich in quartz.

In the upper part of the sedimentary archive of Lopé 2 marsh (from 2034 cal years BP to current), there is a gradual decrease in the quantity of quartz, which goes until it almost disappears. Organic matter increases at the top of core . This evolution in composition of the sediments of the Lopé 2 marsh is akin to those of the top part of the Vitex Marsh core (from 2142 cal years BP to current) and to the whole marsh core of the Marsh core Yao.

3.3.2- Discussion

The sedimentological and geochemical examination of the sedimentary core of the Yao, Vitex and Lopé 2 marshes leads to subdivide their palaeoenvironmental history into two episodes (fig. 7).

The first episode corresponds to a period when the marshes are flooded only seasonally (Nfoumou Obame *et al.,* 2017). A hydromorphic soil consisting of clay, sand and highly degraded organic matter is then formed in

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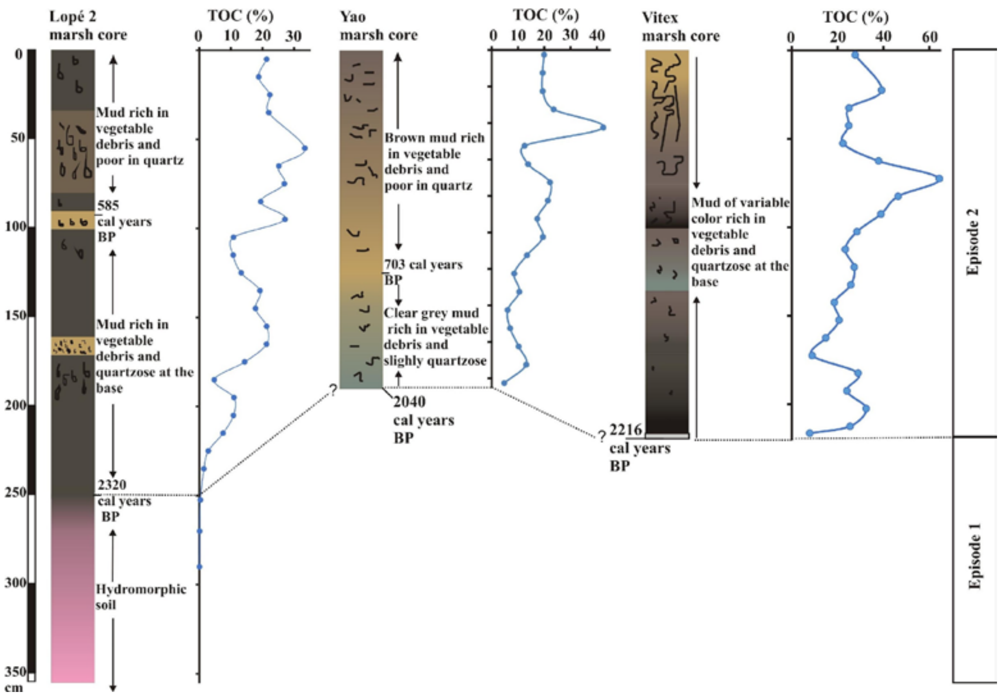
the depression. This soil is surmounted by coarse detrital sediments from the incisive erosion of the slopes. Vegetation around and inside the marshes is sparse. This first episode is only highlighted in Lopé 2 marsh before 2320 cal years BP. The coarse detrital sediments on top of the hydromorphic soil corresponds to a weakly humid climatic phase, characterized by rare and intense rains, as was the case at Lake Maridor between 3500 and 2190 years BP. This relatively dry climate can be associated with the climatic deterioration recognized in Atlantic Central Africa between 2500 and 2000 years BP.

Fig. 7: Lithological and geochemical comparisons of sedimentary records from Lopé 2, Yao and Vitex marshes.



The second episode is visible in all the marshes studied. It is that of the active filling of the palustrine depressions. This filling is effective in the Lopé 2 marsh from 2320 cal years BP (Nfoumou Obame *et al.*, 2017) and in the Yao and Vitex marshes respectively from 2000 and 2200 cal years BP. Filling begins with the accumulation of coarse detrital deposits (quartz grains) resulting from the erosion of slopes still covered with sparse vegetation. These coarse deposits are more marked in the sedimentary records of the Lopé 2 (between 2320 and 2034 cal years BP) and Vitex marshes (between 2216 et 2142 cal years BP).

Subsequently, the sediments that fill the marshes are increasingly enriched with organic matter and depleted in quartz. Indeed, the permanent

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presence of water in depressions will promote the development of plants around and inside marshes. This palustrine vegetation composed of hygrophilic plants constitutes a filter to the coarse detritic matter flow coming from the slopes. This favors the deposit of fine sediments (clay) accompanied by the debris of hygrophilic plants. A relative densification of the vegetation on the slopes may also have reduced the intensity of erosion. However at the Yao marsh a small erosive phase which is not visible at the Lopé 2 and Vitex marshes is recorded between 1400 and 1000 cal years BP. It could have been caused by a local event.

The main driving force behind the active and synchronous filling of the Lopé marshes was the permanent watering of these marshes. This permanent presence of water could be associated with the establishment of a humid climate characterized by fine and regular rains which affected all the marshes. The establishment of this humid climate at the origin of the filling of the Lopé marshes is contemporaneous with the return of the humid conditions recorded in several lakes in Central Africa. Indeed, at lake Barombi Mbo, this humid climate is recorded from 2000 years BP (Lebamba *et al.*, 2012) and at lake Maridor at 2190 years BP (Giresse *et al.*, 2009).

Conclusion

The analysis of the sedimentary records of the Yao and Vitex marshes has made it possible to know the functioning of the marshes of the Lopé National Park. The history of the filling of these depressions has taken place in two major episodes.

The first episode is only visible on the Lopé 2 marsh core. This episode corresponds to a period when the depressions are flooded only during the rainy seasons and exposed the rest of the year. In the depression, the hydromorphic soils are topped by sediments very rich in quartz.

The second episode is recorded in all the sites (Lopé 2, Yao and Vitex). It is that of the active and synchronous filling of marshes between 2300 and 2000 cal years BP. The depressions first fill with coarse detrital sediments from erosion of the slopes. These sediments are relatively poor in organic matter. These coarse sediments are subsequently succeeded by fine sediments which are increasingly rich in organic matter. The increase in the amount of organic matter in these sediments is due to the densification of the vegetation of the marsh and its slopes.

The filling of these marshes is made during a humid climate which permanently floods the depressions. This humid climatic phase highlighted in these Lopé marshes affected the whole region.

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