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Late Holocene swampy forest of Loango Bay (Congo). Sedimentary environments and organic matter deposition

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ABSTRACT

This region, comprised between the Kouilou estuary and Pointe-Noire, is characterised by a very specific morphological setting. On the continental side, the coastal sector is dominated by cliffs of sand over 100 m high, referred to as the Série des Cirques, whereas, on the ocean side, very active erosion is presently taking place which has resulted in a retreat of the shoreline of more than 100 m over the last hundred years.

New ^{14}C datings and different analyses of organic matter and clay minerals (X-Ray data) were performed in order to reconstruct the geological and ecological evolution of the area during the Late Holocene and replace it in the palaeoclimatic scheme deduced from previous regional studies.

From 7 to 6000 yr cal BP, the accumulation of important beach barriers by the oceanic drift allowed the definition of a narrow swamp depression several tens of kilometres long.

A dense ombrophile and hydromorphic forest, in spite of being very close to the oceanic coast, remained sheltered from any brackish influence and fed accumulations of peat and organic muds. The emersive trend of 3000-2000 yr BP, i.e. the passage from a vast forest swamp with a water body several metres deep to a wet zone with some emersions, is expressed by a large colluvial accumulation.

High primary production is not clearly attested in this wet area. High HI values would indicate rather long-lasting conservation in a swampy environment, the lowest values indicating alternating episodes of emersion and immersion. In such peatlands, OM preservation is favoured by an anoxic environment and rapid burial.

The $\delta^{13}C$ values of older peats dated ca. 7000 yr cal BP are −28 to −26‰, typical of a C3 origin. Thus, the ca. −16‰ value indicates the greatest opening of the cover, suggesting a forest-savanna mosaic ca. 2500 yr cal BP. At Kivesso, several proxies suggest a wetter trend towards 500 yr cal BP. An ultimate drier trend is observed during the last two centuries, which has been attested to by a $\delta^{13}C$ ratio indicating a clear decrease of the forest extent, probably linked to local Kivesso edaphic conditions.

1. Introduction

In recent years, various lakes and swamps have been studied repeatedly, providing comprehensive reconstructions of tropical rainforest changes over the last millennia, throughout Central Africa (Vincens et al., 2000) and even beyond (Maley, 1997, 2012; Bostoen et al., 2015)).

Palaeoenvironmental data indicate that a climate crisis affected the Central African forest block during the Holocene, first on its periphery, around 4000 BP, and later at its core, around 2500 BP (Bostoen et al., 2015). In a more regional area, Vincens et al. (1999) provided a composite comparison of forest response to climatic changes during the last five thousand years in western Central Africa. During the mid-Holocene period (ca. 5–4000 yr BP), the forest cover was largely extended and probably much more developed than it is today. The area least favourable to forest extent, the Niari valley with low precipitation, currently covered by savannas, was occupied between 5300 and 4000 yr BP by semi-

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deciduous forests. After the drying of Lake Sinnda, grasslands remained the dominant cover, seasonal water stress allowed a weak forest recovery from ca. 1000 yr BP and a brief dry event occurred again around 700 yr BP (Vincens et al., 1994).

By contrast, the rainy site of Lake Kitina shows a recovery of the forest cover during the last two thousand years. Slight changes are recorded around 1500 BP, later followed by the resumption of the enclosed savanna after 500–600 BP (Elenga et al., 1996). On the Congolese coast and in the Bateke region, with both medium rainfall and active drainage through sandy soils, the savanna maintained itself more or less up to the present time, although a short-lived moist episode occurred around 1500 yr BP, while present-day climatic conditions began around 500–600 yr BP (Schwartz et al., 1990; Elenga et al., 1992).

During the last few decades, various Holocene swampy soils and deposits of the Congolese coast were studied either in an outcropping position, such as in Loango and Pointe-Indienne, or buried under recent sands of the offshore bar, as in the Kouilou and Songololo estuaries (Delibrias et al., 1973; Giresse and Kouyoumontzakis, 1974; Giresse and Moguedet, 1982; Schwartz, 1985; Dechamps et al., 1988; Elenga, 1992; Elenga et al., 1992). A wet episode of swampy forest with *Monopetalanthus* is observed between 5800 and 3100 yr BP. After 3100 yr BP, pollen studies suggest a marked opening of the forest and an extension of emerged lands and hydromorphic soils. On the scale of the last centuries, several Congolese sites suggest increasing erosion (Giresse and Moguedet, 1982; Elenga et al., 1996, 2001).

Presently, under the action of oceanic erosion, numerous new outcrops have recently appeared in the Bay of Loango, located 20 km north of Pointe-Noire (Fig. 1). Such occurrences provide an approach for a new and much broader Holocene history of the continental environments close to the shoreline. As they are in an outcropping position, they permit an extended and direct observation of the lateral facies transition that cannot be carried out by soundings alone.

On the basis of ^{14}C AMS datings, a new sedimentary facies study of this specific morphological setting is proposed. Its aim is to substantially deepen and revise the previous studies based on a restricted number of sedimentary sequences. The study will be completed by geochemical analyses of the organic matter that is very highly concentrated in several black layers or several brown soils horizons and which had only been characterised in a fragmentary way.

2. General setting

A 1000-km-long N-S trending range, the Mayombe mountain range, separates the Congo Basin from the western flank of the basin. Seaward of these mountains, Cenozoic non-marine sedimentary rocks occur on the lower slope of the African Surface Basin. These deposits, like the 'Continental Terminal', are likely to have developed after the upwarping of Africa's swell ca. 30 Ma (Burke and Gunner, 2008). The upper 200 m of deposits are coloured clays and sands formations called 'Série des Cirques'. This series shows erosion forms in circuses that cut it at rather important depths, as in the Cirque of Diosso, letting appear a succession of alternating layers of sand and clay, which through lateritisation range in colour from yellow to pink to dark red (Hourcq, 1966).

This fossil-less series is dated as 'Plio-Pleistocene' by analogy with the Benin Sands of Nigeria (Cosson, 1955). Most quartz grains indicate a wind imprint (arcuate cracks) that can be widely erased by later water action, some of which are coated in a secondary siliceous film. The character and the alternation of beds evoke a continental sedimentation in fluvio-lacustrine closed ponds (Cosson, 1955; Massengo, 1970; Giresse et al., 1981).

There is no evidence of Quaternary marine deposits above the current oceanic zero. The Holocene sea reached the current level approximately 6000 years ago and has never overtaken it since (Delibrias et al., 1973).

As a general process going from Luanda to Cape Lopez, this coast is fed by very a powerful southwestern littoral drift. At the levels of Pointe-Noire and Port-Gentil harbours, the important northward sand transit reaches 300,000–400,000 m^3/year (Bourgoin et al., 1963). Sandy barriers constitute two, even three alignments, which can reach 10–15 m in height. Wind accumulation stemming from the deflation of the beach expresses a seaward highstand progradation (Giresse and Kouyoumontzakis, 1974).

The coastal plain consists of a slowly rising undulating plateau rising from sea level to heights of 150–170 m. To the north of the bay, the bank of the plateau is very close to the ocean, at Diosso, where cliffs rise to 20 or 30 m above the sea level. The plateau is intersected by river valleys and recent steep erosion gullies. The short rivers draining the hillsides of the Série des Cirques are called loubende, meaning dirty or shady waters. The best known is the Red River (Matoubi River), which acts as the main drainage channel of the Pliocene-Pleistocene Diosso Gorges. Its bed is sometimes blocked by poorly compacted sediment packages originating from the nearby cliff. The wideness of the valleys of these loubende may indicate past flows that were more effective than the current ones.

Soils are commonly ferralitic and psammitic (ferralic arenosols) with up to 95% sand content, while hydromorphic soils and podzols are restricted to the wettest areas. The podzol upper horizon is strongly leached and its white colour characterises a very wide surface of the littoral band (Jamet, 1967; Jamet and Rieffel, 1976). The real age of the beginning of the podzol process could be of the order of 3000–3500 yr BP (Schwartz, 1985; Elenga et al., 1992).

3. Material and methods

The Loango Bay shows a low coast lined with barrier beaches, except near Pointe Indienne where the Série des Cirques cliff approaches the coastline (Fig. 1). Locally, the progress of oceanic erosion affected the lowermost horizon of podzolic soils and different swampy forest organic deposits developed directly on the sands of the Série des Cirques.

The Loango site, with three studied sections (Loango South, Loango North 1 and 2), corresponds to Pointe-Indienne, the convex shape of which is due to the Lower Senonian fine sandstone forming cuesta above Turonian marls (Cosson, 1955; Giresse and Tchikaya, 1975). 1500 m further east, the North Loango 1 and 2 sections lies in the axis of a small palaeovalley, the limits of which are suggested by those of the organic soils (in blue, Fig. 2).

The site of Kivesso is located at the foot of the erosion cliffs of the Série des Cirques, the most spectacular "cirque" being the Gorges of Diosso. The five studied sections of Kivesso (KVS3, KVS4, then KVS5, KVS6 and KVS7) are located in the two northernmost kilometres (Figs. 1 and 3).

Studies of these eight selected sections are presented here on the scale of the sedimentary layers and pedological horizons successions (Figs. 1–3). Before sampling, the sections were described and the facies identified on the basis of their colour, lithology and sedimentary structures. Sediments were then sampled at some 10 cm intervals.

After wet sieving, the >50 μm sandy fraction was examined with a stereo microscope. Various markers of distinctive soil profiles were recognised: ochre-stained quartz, white quartz, oxidised debris, black vegetal debris. Images were obtained using the Scanning Electron Microscope (SEM) coupled with an Energy dispersive Tracor Microscope to study the nanostructures and composition of selected particles. Clay minerals were determined using a Philips R.X diffractometer.