SOME STUDIES ON THE TERTIARY DEPOSITS OF NIGERIA, WEST AFRICA

G. S. PURI
Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

ABSTRACT

Fossil leaves of Palms, *Terminalia* and *Combretum* have been described for the first time from tin mines of the Jos Plateau in Nigeria. These show affinities with modern vegetation of West Africa. However, *Terminalia* and Palms seem to have shifted away from the Jos Plateau, which at present has a dominant vegetation of Scrubby and Grassy growth. This is explained to be due to changes in the Soil and Climatic conditions. Some soil studies from the Jos Plateau are presented. The fossils are *Terminaliophyllum keayi* (new species), *T. jaggi* (new species) and *Combretophyllum josiensis* (new species).

INTRODUCTION

This paper is based on some angiospermic fossil leaf impressions collected by the author in 1962-63 from tin mines of the Jos Plateau in Northern Nigeria.

The climate, vegetation and other features of Natural Resources development follow a more or less latitudinal pattern of distribution in West Africa. The differences in geology and soils bring in variations on local or regional scale. These are sometimes sufficient to mask the general effect of the major factors (KEAY, 1947, 1949). Some general observations have been made by Keay (1959) and others on the vegetation of Nigeria to give a broad picture of the habitat factors in vegetational development. But in the absence of any detailed study on the vegetation of the Plateau it is not possible at present to generalize the effect of the causal factors.

The fossil leaves are embedded in kaolinitic clay that is usually white, sometimes greyish or bluish in colour. The fossiliferous layer usually occurs in a narrow band, overlying, almost invariably, the layer of the tin, ore in the mines studied (Pl. 1, Fig. 1). (a) points to the layer of tin. (b) indicates the upper limit of the fossiliferous layer. Overlying this there are several layers of fluvio-volcanic sediments marked (c) in which no macro-fossils have so far been discovered. The uppermost layer marked (d) in the photo is laterite, which extends upwards to the surface.

The depth of the fossiliferous layer varies considerably from 20-50 feet in different mines examined. In some mines on the Plateau there are two or three layers of fossiliferous clays, which are different in composition, structure and in nature of sedimentation. In one of the mines examined black, rich-in-humus clay was found in which leaf impressions, with or without bits of organic matter, were found.

During the summers of 1962 and 1963 a few collections of fossils were made from a number of tin mines. The study of this material may take sometime to complete, if further collections are made from the newly exposed mines on the Plateau. Some of the black clays are rich in microfossils and have shown pollen, bits of cuticles and wood. The pollen analytical studies of these clays, extracted from different depths in the mines will undoubtedly reveal an interesting sequence of volcanic activity, together with changes in vegetation development, as a result of fluctuations in one or the other factor of the ecosystem in the past. This is a long term study and may take several years to complete.

The present paper features only a few fossil specimens from two mines, with kaolinitic clays and is intended to bring to the notice of botanists attending the International meeting at Lucknow the vast field of research, that lies untouched in the tropics of Africa, in paleoecology and in the evolution in various factors of the ecosystem, since the Tertiary Period. I am, therefore, extremely grateful to Mrs. Savitri Sahni, the President of Institute for her kind invitation to present this paper at the meeting. In doing so I am also expressing my deep debt of gratitude to my late lamented teacher — Prof. Birbal Sahni.

GENERAL GEOLOGICAL FEATURES

The mainland of West Africa is formed of the Pre-cambrian rocks, which are grouped
together under the term "Basement complex". The basement complex comprises a large zone of gneisses, mica-schists, schists and amphibolites, invaded by older granites. The granites form isolated peaks and hummocks in a typical inselberg terrain in many parts of West Africa. The inselbergs have at present a characteristic mountainous vegetation, that differs from the general country and is of considerable ecological interest (Puri, 1963 b; Keay, 1959).

The Cretaceous and the Tertiary sediments are well developed in many parts of West Africa (Furon, 1963). The Tertiary system is rich in oil, lignite and peaty materials. The terrestrial Cretaceous deposits have abundant coal. The marine Cretaceous have lime-stone deposits. The Jos Plateau sediments appear to be Post-Eocene in age but there is very little evidence at present for a better dating of the fossils found in the tin mines (Grove, 1952).

The solid geology of the Jos Plateau is formed of a chain of mountains, comprising gneisses, schists and granites. These mountains form, now, a very greatly dissected and eroded plateau.

During the course of development the basaltic rocks have been greatly decomposed and eroded and the materials got mixed with the clays, forming the fluvio-volcanic series.

The changes in the development of vegetation and/or climate during the past transformed the granite and gneissic soils into laterites, which, at some places, now outcrop in low hills on the plateau, and also occur in the tin mines sequence. The laterite hills are widespread. In the past there have occurred several periods of erosion, sedimentation and volcanic activity, as a result of which layers of tin gravels are believed to have been formed all over the plateau.

It is believed that the Jos Plateau is a relict, which assumed its present configuration during the Cretaceous times. The newly formed basaltic hills during the Tertiary are called the younger granites. The maximum altitude to which the laterites have been found on the plateau mountains is nearly 500 feet, above sea-level.

It is also considered that a number of climatic fluctuations resulting in the increase of rainfall occurred during the Pleistocene on the Plateau. Various archaeological materials found together with fossil trees further indicate that pluvial conditions in the past were widespread than now. There have been also several periods of denudation, due to high rainfall, the records of which are preserved in some tin mines.

There are several small rapids and waterfalls along the Plateau escarpment, which seem to indicate again a sequence of interesting changes in climate and vegetation conditions that the plateau had witnessed during the past geological periods.

Whereas, there is an indication of a sequence of geological changes during the Tertiary to Pleistocene on the Jos Plateau the exact dating of the formation of the layers with fossils is not possible at present. Very little animal remains have been found in the tin mines and one has to rely mostly on the plant fossils that are now under study. It is, therefore, interesting to note that the present studies on plant fossils are likely to be of more than the usual interest in geological field, as well.

EARLY WORK ON PLANT AND ANIMAL FOSSILS

From the north and north-eastern parts of Nigeria, represented by the Provinces of Chad and Sokoto, several types of fossil echinoids, shells, mollusca, Ammonites, fishes and reptiles have been described belonging to the Eocene to Cretaceous ages (Reyment, 1955, 1956; Swinton, 1930; White, 1926). The Nigerian Cretaceous and Tertiary Periods are known at present by their fauna only.

Very little information is available on the flora of these periods in West Africa. Some fossil fruits belonging to the family Anonaceae, Icacinaceae, and (?) Passifloraceae were described by Chesters (1955) from Nigeria and Sierra Leone. These were associated with some Eocene fauna described by White (1926), and have affinities with the modern genus Anona, and the form genera Icacinaicarya and Carpolithus. This flora represents the same type of conditions as indicated by the London Clay flora (Reid & Chandler, 1933) and the upper Cretaceous and Eocene floras of Egypt (Chandler, 1954).

Several angiospermic fossils belonging to the families Anoraceae, Menispermaceae, Capparidaceae, Anacardiaceae, Connaraceae, Apocynaceae (?), Lauraceae (?), Urticaceae, Sterculiaceae, Tiliaceae, Olacaceae, Flacceinaceae, Combretaceae, Rubiaceae
and Boraginaceae were described from the Miocene deposits of Eastern Africa on the Rusinga Islands in Kenya (Chesters, 1957). There are several modern genera represented in these collections. From the middle Tertiary of Uganda, Chaney (1933) identified fossil leaf impressions belonging to the Leguminosae and the Combretaceae. The present day vegetation of the West and East African areas has a fairly prominent representation of the above families of plants that have been found as fossils and it was probably for this reason that Berry (1918) and Krystofovich (1929) expressed the opinion that there had been very little change in the vegetation of the tropics from the Cretaceous and Tertiary Periods. Krystofovich is reported to have stated that "in the tropics of South-East Asia the Malayan type of Flora has remained unmolested since its first descent from its Cretaceous ancestors" (see Chesters, 1957, p. 32). This statement needs modification in the light of several microfossils discovered from the Cretaceous and Tertiary of Nigeria (Puri, 1963b). Pollen analytic studies are in progress, but the information collected up-to-date seems to reveal in the Cretaceous to Eocene of the Nigerian tropics a vegetation in which Nothofagus, Podocarpus and several form-genera, which seem to resemble Araucaria and other southern gymnosperms, were prominent, in common with the fossil vegetation of the same periods of Australia, New Zealand and the Indian mainland. This would show that there had been prominent changes in the vegetation of the tropics from the Cretaceous through Tertiary and Pleistocene. This is corroborated from the evidence presented by other workers (Krige, 1927; Hammem, 1954) on the changes of sea level in Africa and S. America during the Cretaceous and Tertiary Periods. It is argued that this brought about interesting changes in climate that must have greatly altered the environmental complex for the development of vegetation in the tropics.

From the brief review of available literature it follows that the study of fossil floras of the Tertiary period in West Africa promises to yield results of some importance in our knowledge of the evolution, migration and succession of vegetation in the tropics. So far as the author is aware the fossils have never been described before, and Chesters (1955, p. 1) recorded that "a large number of leaf impressions have so far been identified". Dr. Chesters has kindly checked this from the records of the Natural History section of the British Museum at my request. The only account that appeared was by the author (Puri, 1963c) for the first time in 1963.

**DESCRIPTION OF THE FOSSILS AND THEIR IDENTIFICATIONS**

All the fossils are leaf impression—fragments, in which details of venation are seen reasonably well. These are identified by comparison with the modern vegetation of West Africa. In this work possible sources of error have been carefully considered and avoided in the same way as was done in the author's work on the Pleistocene flora of the Kashmir Himalayas, in India (see Puri, 1948; 1960 and references therein). The methods of identification are mainly ecological.

Ecologically, leaf is a dynamic system and the conception of regarding it merely as a plant organ of use and importance only in morphology or taxonomy has been avoided in this study (Mithorpe, 1956). Heredity and environment both control variations in the size, shape, area, etc. of an individual leaf and the several leaves on a growing branch (Went, 1956), and in any interpretation of ecological conditions of a fossil flora one has to be extra cautious.

A paleobotanist has generally little or no information on the heredity variations of fossil leaf fragments, but a considerable amount of information now available on modern vegetation seems to show that there is a close relationship of leaf to its environment (Gregory, 1956 in Mithorpe, 1956; Blackman, 1956; Penman, 1956). Leaf shapes in quantitative terms give a record of changes during life history and are expressed as a function of time (Ashby, 1948). There is a definite relationship between leaf length and breadth with time and this is governed by day length and time of light intensity. Photochemical reaction and photosynthesis affect the assimilation rate and the average area of the leaf. Besides these factors, vitamins, auxins and minerals salts are also concerned in leaf shape, size and area. Thus, taxonomical variations in leaves can be interpreted in terms of physico-chemical reactions. Soil and fertility are
important factors to be considered in any interpretation of the environment complex.

From the above brief discussion it is clear that the task of paleobotanist in the identification of fossil leaves and the interpretation of environmental conditions from these remains is extremely difficult and this must be presented with the greatest caution.

**MONOCOTYLEDONS**

*Family — Palmae*

**Genus — Palmophyllum**

(Pl. 1, Figs. 2, 3)

Two leaf fragments of palms are illustrated in Figs. 2, 3. Fig. 2 represents a part with the rachis and the other is a portion from a different part of leaf. Venation is not well preserved. None of the fossils seem to resemble any known species of palms at present growing in the Nigerian forests, or Savanna.

In the Southern part of Nigeria *Elaeis* (the oil palm), is the commonest and in the north *Borassus* is found, in low areas, in valley bottom or hillsides. No wild palm occurs now in the Jos Plateau near the fossiliferous area. In the absence of any additional information the fossils are identified with the genus *Palmophyllum*, without any definite commitment to their relationship with any known living or fossil species of palms.

**PROBABLE AFFINITIES AND DISTRIBUTION OF FOSSIL PALM LEAVES**

Fossil Palm leaves have been described from many parts of the World. Kaul (1960) has recently given a summary of the available information and the following remarks are offered on the basis of his study.

*Palmophyllum moleteinianum* Krasser and Kubart* is described from the Cretaceous rocks of Europe.

Fossil leaves somewhat resembling the Nigerian fossil shown in Fig. 2 ascribed to *Sabal major* Unger have been recognized from the Oligocene and the lower Miocene of the Kasauli Series in the Himalayas.

Heer* described *Sabal major* from the Miocene of Central Italy to North Germany. Small leaves were designated as *S. ziegleri* Heer and another species *S. haeringiana*

Unger was also recorded from the same deposits.

Other known species of *Sabal* on fossil leaf impressions are *Sabal lamanonis* Brongn.*; *S. miocenica* Axelrod* and *S. nipponica*. It is extremely difficult to say whether the present discovery of the fan-like palm leaf fragment from Nigeria would extend the distribution of *Sabal* to the western edge of the African continent.

Several fossil leaf impressions belonging to the Palmae have been described from the upper Tertiaries of W. Java by Göppart*. The species enumerated are *Anesoneuron anceps*, *A. calyptrocalyx*, *A. dracophyllum*, *A. sagifolium*, *Flabellaria licualaeolasia* and *Palmacites flabelata* Crié.

It is difficult at present to identify the Nigerian fossils with any of the palm fossil leaves. It may, however, be noted that the Nigerian fossil palms are found within the general limit of distribution of modern and fossil palms marked by Kaul in the world map in his paper.

**DICOTYLEDONS**

*Family — Combretaceae*

Fossil leaf fragments resembling several species of *Terminalia* and *Combretum* are found infrequently large numbers in these deposits. While it may be possible sometimes to distinguish living leaves of *Terminalia* from *Combretum* on leaf features, the separation of species of the two genera, on the basis of fossil leaf fragments, is clearly impossible (Keay, Onochie & Stanfield, 1960). I have, therefore, attempted the following account with a great deal of hesitation.

**Genus — Terminaliophyllum Geyler 1887.**

Fossil leaf fragments showing a general resemblance with leaves of *Terminalia* are described under this form genus (Andrews, 1955).

*Terminaliophyllum keayi* sp. nov.

(Pls. 1 & 2, Figs. 4a, b, c & 5)

This is a fragment of a large leaf that fits in general size, shape, venation and other characteristics with leaves of *Terminalia* sp.

*Reference to these are found in Kaul (1960).
in sheet No. FHI 14815 in the Forest Heb­
arium, Ibadan, Nigeria (PL. 3, Fig. 8).

Mr. Keay identified this as a hybrid be­
tween the two species of Terminalia, namely
T. macroptera Guill. & Perr. and T. laxiflora
Engl. var. pubescens, both from Nigeria.

In the absence of relationship with any
other plant from W. Africa the fossil is
identified as a new species of
Terminaliophyllum keayi, after Mr. R. W. J. Keay, the
distinguished botanist, who is the author
of several publications on the Nigerian vege­
tation and flora.

_Terminaliophyllum faggei_ sp. nov.
(Pl. 2, Figs. 6, 7)

There are a number of leaf fragments of
various sizes and shapes that show resem­
bliance fairly closely with leaves of _Terminalia
laxiflora_ Engl. (Pl. 3, Fig. 9). The leaves
of this are smooth textured, quite unlike
the pubescent variety. The lateral veins
in _T. laxiflora_ are arched upwards.

Although, there is some resemblance with
the living species the fossils are described as
_Terminaliophyllum faggei_, a new species,
after Mr. B. Fagg, the Director of the Jos
Museum, who first drew my attention to
the fossils from these deposits and helped
me in various ways in the collection of the
material described in this paper.

Genus — _Combretophyllum_ gen. nov.

_Combretophyllum josiensis_ sp. nov.
(Pl. 3, Figs. 10, 11)

The leaf fragments figured here are select­
ed from several dozens of specimens that
are smaller in size than the _Terminalia_
species. There is a distinct petiole preserv­
ed in some of these. The venation is not
well marked, with laterals characteristically
arching upwards. These leaves resemble
in general appearance, size, shape and
venation with several species of _Combretum_
from W. Africa but do not show distinct
affinities with any single species. The
fossils are described as _Combretophyllum
josiensis_, a new genus and species from the
Jos Plateau.

**REMARKS ON THE PRESENT VEGETA­
TION OF THE JOS PLATEAU**

The Jos Plateau, as already stated, has
two types of mountains, which are different
in land form and geology. The younger
granite mountains are at present almost
completely bare of any tree or shrub vege­
tation. There are some grasses and weeds,
and here and there, there may be some
heavily grazed shrubs. Even without the
biotic interference these younger granite
mountains at top are usually devoid of tree
vegetation. The strong wind and heavy
erosion make conditions unsuitable for the
development of tree vegetation at the
mountain topes.

A sequence of vegetation is shown in Text­
fig. 1 in one of the younger granite (basalt)
hills, with bare topes. The soil profile has
merged into rocks and finally laterite layer
is reached. The depth of the laterite varies
from a few inches from the surface to a few
feet. The laterite rock is usually solid and
there is little formation of soil. The profile
on the surface as well as in the lower layer
is acidic in reaction with low pH. The
moisture content in the surface soil may not
be low but the lower layer has very small
percentage of water, with low carbon content
and this factor may also be responsible for
the poor development of any shrub or tree
vegetation on the younger granite hills.

On the lower part of the slope of the
basalt (younger granite) hill where the
eroded soil, washed down from the above,
settles, and the area is sheltered from strong
winds, a scrubby vegetation with _Gardenia-
Terminalia-Nauclea_ is present. This is
heavily lopped and browsed by cattle. In
the nearby sites with little or no biotic
interference the vegetation does not develop
into a tree community of any dimension.
The surface soil is sandy with high amount
of carbon, but is acidic on reaction. The
lower layer has got fine clayey-sandy soil,
mixed with pebbles, and is less acidic to
neutral in reaction.

In the valley bottom, where seepage and
run off water collects, the soil is rich in
humus. There has developed a vegetation
of sedges and grasses. The surface soils
are fine clayey, deep black in colour, with a
very high amount of moisture content.
The soil below 8 inches from the surface
is also deep black with brownish and yellow
clay. This is also acidic due to high content
of soil water. The absence of tree and
shrub vegetation in this part is due probably
to the high moisture content and water­
logged conditions, which are associated with
low pH values.
TEXT-FIG. 2

Basalt hill

Gray-black
Fine sand
Full with
pebbles
pH 5.6
M 7.5%
C 0.9%

Brownish
Fine soil
Pebbles
Rock
pH 5.92
M 4.8%
C 0.2%

Laterite
Rock
Decomposing

Gardens - Terminalia - Nauclea
Heavily lopped
Erodend, heavily grazed (cattle) area in
Res - Bukuru area in Jio

Deep black
Fine clay
pH 5.96
M 65%
C 1.91%

Sedges, Grasses

Deep black
Brownish yellow
clay
pH 4.9
M 46.7%
C 1.6%
It may seem that on the younger granite hills the tree vegetation can develop only in sheltered parts of the slopes, where the soil is deep. Both the upper parts of the hills and valley bottoms have little or no tree vegetation for the reasons mentioned above.

Vegetation in another area on the Jos Plateau is represented in Text-fig. 2. Grassland vegetation is present on the upper parts of the slope, with some Euphorbia and other scrubby plants. The profile from these areas shows shallow soils, with quartz on the surface. Heavy grazing is also responsible for this poor vegetation in the area.

In the same area, however, mesophytic conditions may develop in pockets, behind
or in between rocks where plants like *Musa*, typical of southern Nigerian rain forests, have developed.

In the rocky areas several species of plants given in Text-fig. 1 form a dense community of trees and shrubs, and where soil is fine, sandy-clay, black with humus, trees like *Syzygium* form a community of evergreen plants, with ferns in the underground. Due to the collection of sub-soil water, there is a foul smell of \( \text{H}_2\text{S} \), throughout the profile, and mottling is seen.

In the present vegetation of the Jos Plateau *Terminalia* and *Combretum* are rather rare. This is probably due to the early stages of colonization of these rocky mountains, with shallow soils. In the bottom of the valleys there is a lake on the banks of which the same type of plants are present.

A vegetation dominated by *Borassus* palm is present below the escarpment of the Jos Plateau in valley bottoms and on low hillsides. Here, as shown in Text-fig. 3 soil is deep black and fine clayey in texture. It is sticky and throughout the profile carbon content is high, with moderate moisture content. Palms are accompanied by other shrubs, such as *Combretum* and *Pilostigma*. These soils are usually less acidic as compared to the Plateau soils studied in connection with the studies on vegetation reported above.

**CONCLUSIONS**

A brief survey of the present vegetation of the Jos Plateau seems to show that the palms and *Terminalia* communities occupy different types of landscapes, with the conditions of soil and moisture vastly different. It seems probable that the fossil palms and Terminalias belong to two different series, that may be associated either with succession sequence of vegetation development with the processes of land form transformation. Work on both the past and present vegetation of the Jos Plateau is in progress and further discussion of these questions will have to be left to a later date.

**REFERENCES**


**EXPLANATION OF PLATES**

**PLATE 1**

1. Section of the tin mines — Jos Plateau.
2. A part with the rachis ascribed to *Sabal major* Unger.
3. *Palmophyllum* sp.
4 a, b, c. *Terminaliophyllum keayi* sp. nov. ×

**PLATE 2**

5. *Terminaliophyllum keayi* sp. nov. ×

6. *Terminaliophyllum faggei* sp. nov.
7. *Terminaliophyllum faggei* sp. nov.

8. *Terminalia* sp. (Living)
10. *Combretophyllum josiensis* gen. et sp. nov.