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POLLENANALYTICAL STUDIES IN NE-NIGERIA: PRELIMINARY RESULTS FROM THE MANGA GRASSLANDS AND LAKE TILLA, BIU PLATEAU

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Abstract

Two sites situated in the Sahelian and Sudanian zones of NE-Nigeria were chosen for pollen analysis. A sediment core from an interdunal depression in the eastern Manga Grassland provides information on the Holocene vegetation history of the Sahel between c. 9600-3400 B.P. The 3 m pollen record indicates an open savanna during the mid-Holocene. The presence of Sudano-Guinean taxa, which were mainly restricted to the interdunal depressions, points to more humid conditions. Already before c. 4000 B.P., a slow change towards drier conditions and the establishment of the modern Sahelian vegetation is visible in the diagram. This development was accompanied by high fire frequencies. A 16 m core from a crater lake (Lake Tilla) in the Sudanian zone of NE-Nigeria provides a pollen record which can be dated back to approximately 11-12000 B.P. Preliminary pollen spectra show a relatively constant pattern with a dominance of grass pollen even during the middle Holocene.

Résumé

Deux sites situés dans la zone sahélienne et soudanienne du NE-Nigeria ont été choisi pour l'analyse de pollen. L'analyse palynologique d'une carotte provenant d'une dépression interdunaire dans les Manga Grassland de l'Est a mis en évidence de nouvelles informations sur l'histoire de la végétation holocène du Sahel entre ca. 9600 et 3400 B.P. Le profile pollinique de 3 m montre l'existence d'une savane ouverte pendant l'holocène moyen. La présence d'éléments soudano-guinéens dont l'extension était surtout limitée à la dépression interdunaire indique des conditions plus humides. Dès avant ca. 4000 B.P., un lent changement des conditions vers une plus grande sècheresse et l'établissement d'une végétation sahélienne comparable à l'actuelle est visible sur le diagramme. Cette évolution fut accompagnée de fortes fréquences de feu. Une carotte de 16 m d'un lac cratére (Lake Tilla) dans la zone soudanienne du NE-Nigeria proviens une profile de 11-12000 ans environs. Le spèctra polliniques préliminaires sont relativement constante avec une dominance de graminées même pendant l'Holocene moyen.

Introduction

Studies of pollen records give evidence on vegetational changes in time and thus allow a further reconstruction of former environments. Concerning the Sudanian and Sahelian zone of West Africa, only very little is known about the Holocene environmental history.

For the Sahel, terrestrial palynological data are mainly given by LÉZINE (1987, 1989), MALEY (1981) and BALLOUCHE & NEUMANN (1995). However, in accordance with other paleoecological results including those from the southern Sahara (e.g. JAHNS 1995, NEUMANN 1992, RITCHIE & HAYNES 1987, SCHULZ ET AL. 1995) and marine cores (e.g. DUPONT & AGWU 1992), these data point to a general pattern which is characterized by an increasing presence of Sudanian and Guinean elements in the Sahelian zone during the middle Holocene. Around 3000 to 2000 B.P. the modern Sahelian vegetation was already established. Beyond this basic pattern, the role of climate and human impact on this development are controversially discussed (SCHULZ & POMEL 1992, POMEL et al. 1994, NEUMANN & BALLOUCHE 1995). Furthermore it is questioned whether the change in vegetation took place in a belt-like manner or whether varying local site conditions instead favoured a mosaic of different vegetation types (BALLOUCHE & NEUMANN 1995).

For the reconstruction of the Holocene vegetation of the Sudanian zone of West Africa even less terrestrial data are available. Paleobotanical studies in Burkina Faso (NEUMANN & BALLOUCHE 1992) point to a relative stability of the Sudanian flora throughout the last seven millennia. The investigation of botanical macro-remains gives no evidence for a shift of vegetation zones, as it can be assumed for the Sahelian zone and the southern Sahara.

This paper presents first results of palynological studies in NE-Nigeria from two sites in the Sahelian and Sudanian zone. The Holocene pollen record from the Sahel was established from a core that was taken from an interdunal depression in the eastern Manga Grasslands (SALZMANN, in press). Comparable sites in this area have been studied for paleolimnology by GASSE et al. (1990) and currently for a comprehensive paleoecological account by STREET-PERROTT et al. (1995). The results presented in this paper will mainly focus on the Holocene vegetation history of the Manga Grassland. Furthermore preliminary data from ongoing research in the Sudanian zone will be presented. This second study site is Lake Tilla, a crater lake which is situated on the Biu Plateau.

Manga grasslands

Site description and setting

The study site (13°15'N; 11°34'E) is situated north of the Komadugu Yobe river in the Manga Grasslands. Rainfall is unreliable and regularly below 400 mm/a (AITCHISON et al. 1972). The Manga region belongs to the Sahelian zone and is characterized by large dune fields with intermediate dune depressions occupied by seasonal or permanent waterbodies. The dunes, several decametre in height, are part of an old erg system which reaches further north into Niger (GROVE 1958). According to previous studies in the Mangas of South Niger, the dune depressions there are supplied by an unconfined aquifer which is exclusively recharged by local rainfall (PIRARD 1962, cited after GASSE et al. 1990).

The vegetation of the Mangas is characterized by grasses (e.g. *Aristida ssp.*, *Cenchrus biflorus*) and very few trees or shrubs, mainly *Leptadenia pyrotechnica*, *Calotropis procera*, *Boscia senegalensis* and *Balanites aegyptiaca*. In contrast, the dune depressions are surrounded by a dense fringe of vegetation dominated by the palms *Hyphaene thebaica* and *Phoenix dactylifera*. The high groundwater table allows some gardening on the edge. Like most depressions of the Manga Plains, the studied site is filled with water only seasonally. During the dry season the playa is covered by a thin trona crust, which is regulary collected and sold as potash.

Material and methods

A 5 m sediment core (GD 95-1) was recovered from the center of the interdunal depression with a modified Kullenberg sampler in 4 cm diameter plastic tubes. For pollen analysis subsamples were taken every 8 cm and processed following the standard procedures (FAEGRI & IVERSEN 1964). To calculate pollen concentration *Lycopodium* tablets were added to each sample (STOCKMARR 1971). Pollen percentages were calculated on the basis of the total pollen sum of about 550 pollen grains and plotted by using Tilia 1.18 and TiliaGraph software. The most abundant pollen percentages are shown by a simplified pollen diagram. Taxa are grouped according to their phytogeographical distribution and their predominant habitats, following the outlines given by LEEUW & TULEY (1972), AUBREVILLE (1950, 1959), KEAY (1959) and TROCHAIN (1940). Radiocarbon dates were obtained from two samples of core GD95-1 by using the accelerator mass spectrometric technique (AMS). A third ^{14}C date (AMS) was obtained from a 380 cm test core, which was taken with a hand corer (Edelman) at about 50 m away from coring site GD 95-1. In order to establish a model for the interpretation of the fossil spectra, the modern pollen rain was additionally assessed by analysis of surface samples, which were collected at the study site and at comparable dune depressions of this region.

Apart from pollen analysis, each sample's charcoal particles were counted in order to obtain information about the intensity and frequency of fires in the vicinity of the lake (CLARK, 1982). The charred particle content is presented as surface area ratios per unit volume of sediment. The sediment was described by using the Munsell Soil Color Charts.

Results and interpretation

Modern pollen rain

In most of the surface samples, pollen is very poorly preserved. Most likely, this is due to the high alkaline status of the top soil. Pollen spectra of surface samples from three interdunal depressions closely correspond to the present vegetation. In accordance with previous studies on modern pollen rain in the Sahel (MALEY 1972, LÉZINE & EDORH 1991, SCHULZ 1990), the spectra document the open structure of the Sahelian vegetation. They are characterized by a general low diversity of pollen taxa, a weak presence of arboreal pollen and dominating *Poaceae* pollen percentages. *Cyperaceae* values rise with increasing vicinity of the sampling site to the edge of the depression. The dominance of *Hyphaene thebaica* inside the depression is well documented by high pollen frequencies of this palm. Beside this, the arboreal pollen percentages, mainly represented by *Combretaceae* and *Acacia*, stay below 1%. There is no evidence that long distance transport plays a significant role. Even high pollen producers like *Mitragyna inermis*, that are very abundant about 40 km to the south in the riverine vegetation of the Komadugu Yobe, are not present in the modern pollen rain.

Sediments and chronology

The 5 m core can be roughly divided into three sedimentary units:

- The upper unit (0-1.20 cm) is characterized by a dry section of olive brown (2,5Y 4/4), fine-sandy silt with a slightly higher percentage of clay in the uppermost part. The unit is covered by a thin trona-crust.
- The middle unit (120-403 cm) is composed of black (2,5YN2) fine-sandy silts with interbedded thin layers of fine sand occuring from 120-300cm. Between 308-333 cm a layer of pale yellow (2,5Y 7/4) fine sand with interbedded silt-layers occurs.
- Below 403 cm the sediment consists of yellowish sand (2,5Y 6/4) with a higher content of greyish silt in the uppermost part (403-420 cm).

Two radiocarbon dates from core GD95-1 give an age of 3461 ± 37 B.P. for 116cm (UtC 4205) and 9590 ± 60 BP for 396 cm (UtC 4315). A third sample taken from a test core (GD94) at a depth of 308 cm was dated to 4807 ± 38 BP (UtC 3798). By comparing palynological results this sample can be correlated with core GD95-1 at a depth of approximately 180 cm. However, as

sedimentology suggests a deeper position within the core, and a possible contamination of the sample caused by the hand corer technique cannot be excluded, the above correlation should be considered with caution.

The fossil pollen record

The sediment core provides a pollen record of 295 cm, covering a time span from approximately 9600-3400 BP. The uppermost 110 cm of the core are devoid of well preserved pollen, presumably because the upper sediments became regularly desiccated and are deeply weathered. Three major pollen zones can be distinguished:

Zone I (403-375 cm, around 9000 B.P.):

Around 9000 B.P. an open savanna with only very few trees predominated in the Manga Grasslands. This is indicated by high pollen percentages of *Poaceae* and a very low presence of arboreal pollen. Main woody taxa are *Combretaceae*, *Hyphaene* and *Alchornea*. Furthermore, zone I is characterized by a remarkable low diversity of pollen taxa. High percentages of *Typha* and *Cyperaceae* in the lowest part of the diagram indicate a relatively low lake level with shore marsh habitats. Pioneer plants such as many species of the family *Amaranthaceae*/*Chenopodiaceae* colonized these disturbed areas.

Zone II (375-115 cm, mid Holocene)

For the mid-Holocene period the pollen diagram shows an increase of Sudano-Guinean elements and a relatively high diversity of pollen taxa. Despite a significant rise of tree pollen percentages, high *Poaceae* values still indicate the presence of an open savanna. Pollen of several aquatic plants like *Nymphaea*, *Laurembergia* etc. points to open water conditions during that time.

Although most of the pollen taxa cannot be identified to species level and therefore no ultimate statement concerning species-specific habitat requirements can be made, the pollen assemblage strongly suggests that the Sudano-Guinean elements were mainly restricted to the edge of the former lake. Most of the abundant arboreal taxa of the pollen diagram can be found in species lists of modern swamp and riverine plant communities. A similar extrazonal community is described by LEEUW & TULEY (1972) from the Kerri-Kerri Plateau/Nigeria containing species like *Alchornea cordifolia*, *Syzygium guineense*, *Macaranga schweinfurthii*, *Irvingia smithii*, *Mitragyna ciliata* and *Elaeis guineenses*. Other genera with similar habitat requirements predominating in Zone II are *Uapaca* and *Morelia.*

Zone II can be divided into three subzones:

Zone II A is characterized by a sharp increase of *Alchornea* followed by rising percentages of *Uapaca*, *Syzygium* and *Combretaceae*. A parallel de-

crease of *Typha* and *Amaranthaceae/Chenopodiaceae* points to a rising lake level.

In Zone II B arboreal pollen taxa reach their highest values. *Alchornea* is an exception in showing a sharp decline, probably indicating a replacement by *Syzygium* and *Uapaca*.

Zone II C is characterized by a general decline of tree pollen. Whereras *Uapaca* and *Syzygium* are almost absent, *Alchornea* again shows a contrary pattern with a second peak. This asynchronous development is probably caused by different ecological amplitudes of these taxa. Aubréville (1959) and Trochain (1940) emphasize the pioneer character of *Alchornea*, which can be found along the watercourses also in the Sahelian zone. A change towards drier environmental conditions is also suggested by the slight increase of *Typha* and the constant presence of herbal taxa indicating disturbed habitats (*Mitracarpus*, *Chenopodiaceae/Amaranthaceae*, *Borerria*).

The distinct increase of charcoal particles in the uppermost part of Zone II is of special interest. The charcoal particle curve shows two peaks, each followed by a sharp decrease of *Cyperacae* and tree pollen and a rise of *Poaceae*. It is conceivable that regular fires in the vicinity of the lake destroyed the fringing vegetation. This emphasized the influence of *Poaceae* pollen from the surrounding grasslands on the pollen rain. At this stage it is not clear whether the increase of the frequency of fire was caused by a general trend towards drier environmental conditions or if these fires were the result of anthropogenic burning for improved access to the lake. The latter interpretation was postulated for two Saharan lakes by SCHULZ (1994) and HAYNES et al. (1989).

Zone III (115-110 cm, after 3400 B.P.)

Zone III is characterized by an extremely low diversity of pollen taxa and a predominance of *Poacae* pollen reaching values of about 98 %. Even taxa that represent the littoral zone are almost absent in the pollen diagram. This pollen assemblage points to a monotonous vegetation type, which is dominated by *Poaceae*.

Discussion

The palynological data from the Manga Grassland basically agree with the results given by MALEY (1981) and LÉZINE (1987). The pollen diagram from Lake Chad basin (MALEY 1981) shows a significant increase in arboreal pollen during the mid-Holocene with a major role of Sudano/Guinean elements between 8000-7000 B.P. Discussing the large catchment area of the palaeolake Chad, MALEY (1981) emphasized the role of fluvial transport from

the south for the occurence of Sudano/Guinean taxa. In contrast, a fluvial input can be excluded for the closed interdunal depressions of the Manga Grasslands. Hence, the pollen spectra prove the presence of Sudano-Guinean elements in this region indicating more humid conditions during the middle Holocene. Nevertheless, it should be considered that the distribution of these elements were probably restricted to the dune depression. Therefore, the pollen diagram does not provide much information about the composition of the surrounding savanna. However, it can be asserted that this savanna had an open structure as indicated by high *Poaceae* pollen percentages. Increasing pollen percentages of *Combretaceae*, furthermore, lead to the conclusion that species of this family played a more important role during mid-Holocene. Anthracological data point to the presence of a dense woodland around 5500 B.P. with *Combretaceae* (e.g. *Anogeissus leiocarpus, Terminalia sp.*) and Sudano-Guinean taxa (e.g. *Detarium, Afrormosia laxiflora*) at the Lantewa dune field, which is situated about 100km to the south (BALLOUCHE & NEUMANN 1995).

The pollen spectra from Niayes (LÉZINE 1989) also show an increasing presence of Sudano-Guinean elements after 9000 B.P. However, in contrast to these spectra, which indicate an abrupt change to modern Sahelian conditions at 2000 B.P., the diagram from the Manga Grassland points to a slow change towards drier environmental conditions starting before c. 4000 B.P. This corresponds to hydrological data from an interdune depression in southern Niger (GASSE et al.1990) showing a general climatic deterioration from 6400 B.P. onwards after a period of stable humid conditions between 9300-6400 B.P.

For the period around 3500 B.P., the pollen diagram indicates a vegetation cover similar to the modern one. At present, the pollen spectra do not provide much evidence for human activity. Nevertheless, the early presence of humans in this region has been shown by the discovery, in the sediments of the Komadugu Gana, of a canoe 8000 years old (BREUNIG in press). For the Sahelian zone of Burkina Faso and Nigeria, Neumann et al. (in press) assume an almost synchronous beginning of agriculture around 3000 B.P. However, in many cases the influence of climatic changes and human impact are hard to separate solely by pollen analysis. The interpretation of Sahelian pollen diagrams faces the dilemma that anemogamous *Poaceae* - in comparison to the abundant zoogamous trees- are steadily overrepresented. Therefore additional ecological indicators are needed. For the Manga Grasslands the distinct rise in charcoal fragments before 3500 B.P. might be an indicator for human activity. A further interpretation of the pollen spectra in terms of palaeo-climatic changes and vegetation zones is extremely difficult. The main taxa of the diagram are restricted to lakes an rivers with a wide range of distribution in extrazonal habitats and/or have a strong pioneer character. Therefore an interpretation based on a strict classification of these taxa in phytogeographical groups (e.g. Sudano-Guinean/Guineo-Sudanian) is rather impossible. More information about the ecological amplitude and habitat re-

quirements of single species is needed, to provide a more detailed picture about environmental changes during the Holocene period.

Lake Tilla: first results

The second study site is situated in the Sudanian zone of NE-Nigeria on the Biu Plateau which is mainly composed of basaltic rocks of Pliocene and Quaternary age (TURNER 1978). Mean annual rainfall is about 1000 mm/a (AITCHINSON et al. 1972). Today the vegetation of the plateau is characterized by large agricultural areas with few scattered trees, which were mainly planted in the vicinity of villages (eg. *Azadirachta indica*, *Adansonia digitata*). *Isoberlinia doka* shrubs occur in high number as a fallow regrowth, sometimes forming pure stands.

Lake Tilla - the largest lake of the Biu plateau was chosen for paleoecological studies (10°23'N, 12°08'E). At an altitude of 710 m, the lake occupies an explosion crater or maar with about 800 m diameter and no visible inlet or outlet. The inside walls of the crater are composed of massive columnar-jointed basalt and overlaying tephra rings with fragments derived from the older underlaying rocks, both basalt and granite (TURNER 1978). Until the early seventies the crater was permanently filled with water - today Lake Tilla regularly desiccates in the last months of the dry-season.

A 16 m core (LT95-4) was taken from the lake covering a time span of at least 20000 years. Three radiocarbon dates were obtained from this core giving an age of 3188 ± 37 B.P. for 297 cm (UtC 4316), 10295 ± 59 B.P. for 798 cm (UtC 4207) and 19920 ± 130 B.P. for 1500 cm (UtC 4122). The first 900 cm of the core are composed of black silts which are rich in well preserved pollen. Below 900 cm the sediments are characterized by a more or less chaotic layering of sandy silts with pebbles, clays and carbonatic fine sands.

Only a few samples from the upper 700 cm have been analyzed so far. The preliminary pollen spectra show a clear dominance of grass pollen even during the middle Holocene and low tree pollen percentages mainly characterized by Sudanian elements. With the exception of increasing *Cyperaceae* and *Typha* in the uppermost part of the core documenting the recent silting up of the lake, the pollen spectra give no evidence for a major change in vegetation during the mid-Holocene period.

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