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THE SOUTHERN MARGIN OF SAHARA IN THE CHAD REPUBLIC. VEGETATION , SOIL, AND PRESENT POLLEN RAIN

Les marges méridionales du Sahara en République du Tchad. Végétation, sols et pluie pollinique actuelle

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RESUME

La végétation du Nord tchadien montre une double transition dans sa répartition contractée et diffuse. Dans le Tibesti, au dessus de 3000 m d'altitude, on reconnait un changement caractéristique des semi-déserts marqué par l'extension d'une végétation de type Artemisia-Ephedra. *Dans les régions de basses altitudes, la transition est enregistrée par l'extension des unités contractées d'*Acacia-Panicum. *Cette transition est localisée entre les latitudes 14°N et 15°N. L'aspect typique de ce changement dénote de la densification des rangers d'*Acacia-Maerua-Capparis. *En somme, les changements observés dans les savanes sahariennes et sahéliennes vers la latitude 14°N dépendent largement du substratum. En outre, on note que l'extension de la zone des achabs coincide avec celle des régions qui recoivent régulièrement des précipitations d'hiver au contact de la mousson et de l'harmattan. Sinon, la dynamique actuelle des sols se restreint au développement des structures péllicullaires de surface et leur superposition et des vertisols dans les plaines d'inondations.*

Les mesures des pluies polliniques effectuées sur des filtres en mars-avril 1997 enregistrent une bonne représentativité de ces transitions. Les résultats retiennent une nette corrélation entre les spectres polliniques des arbres. La zone des achabs est caractérisée par les maximas d'éléments de longues distances, tel que Alnus, Betula, Pinus ,Ephedra, Artemisia ou Celtis, Diospyros *et Combretaceae.*

ABSTRACT

The North of the Chad republic exposes a double transition from the contracted vegetation of the desert to diffuse vegetation types. The first is situated in the high mountain region of the Tibesti above 3000 m's altitude as a change to the semidesert of the Artemisia-Ephedra-*type. The second represents the transition within the* Acacia-Panicum- *units from linear to diffuse repartition. This takes place between 15°N and 16°N. The extended zone of transition is characterized by the densified linear* Acacia-Maerua-Capparis-*units, their change to the saharan savannas and finally to the savannas of the Sahel at about 14°N. Within this region there is a large belt of achabs, receiving regular precipitations out of the contact between the monsoonal and haramattan air masses.*

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The present dynamic of soil formation is restricted to the development of pellicular surface structures and their superposition whereas vertisol activities characterize the center of large inondation plains.

*Mesurements of the present pollen rain was done in march and april 1997 with help of soil and air filters. The results show a clear representation of the several transitions of the plant cover by the elements of the tree vegetation. The zone of the frequent achab floras is characterised by the maxima of the elements of the long distance transport both from the North (*Artemisia, Alnus, Betula, Picea*) as from the South (*Celtis, Diospyros *andt Combretaceae)*

INTRODUCTION

Even the question of desertification is less confused now with an extension of the desert (HELLDEN 1991) the main question on its dynamics is still open. Is there a clear cut change from desert to savanna as reported from Niger (SCHULZ & HAGEDORN 1994) or could there be a modified model of this transition? Moreover, are these boundaries also documented in the present vegetation useful to take them as a model for palaeoenvironments? A joint expedition of the universities of Hohenheim, Gießen, Trier and Würzburg to the northern Chad during march and april 1997 allowed observations and mesurements of vegetation and present pollen rain in the desert-savanna transition zone. The present dynamic of pedology was studied parallely aswell.

VEGETATION.

The desert in the Sahara is characterized by the restriction of permanent vegetation to wadis and depressions where groundwater is available (MONOD 1954, QUEZEL 1965). The boundaries of the desert are sharp. In Niger this transition is visible as the change from the linear to the diffuse type of the *Acacia-Panicum*-vegetation representing the saharan desert and savanna aswell. South of the small belt of the saharan savannas the second change leads to the sahelian savannas of the *Acacia-Commmiphora-* type with an annual grass cover (SCHULZ & HAGEDORN 1994). Fig. 1 explaines these changes which occure in northern and northeastern Niger.

The vegetation of the Chad region is descibed hitherto by GASTON (1991), GILLET (1968), QUEZEL (1964,1965) and PIAS (1970). The North of the Chad republic exposes the change from the contracted vegetation of the desert to diffuse formations is a doubble way. Fig 2 shows the region between the Tibesti Mts. and the Bodelé depression. In the high mountain zone of the Tibest a transition from the *Acacia-Panicum* vegetation of the desert to the semideserts of the *Artemisia-Ephedra*-type is performed (QUEZEL 1964,1965). Own observations on the vegetation along the transect N'Djamena / Salal / Faya / Ain-Galaka / Kichi-Kichi showed that the transition in the lowland is different compared to that of the Niger. South of the Erg of Djourab (at about 16°15'N) isolated tree lines start to density. This is performed in an area which is characterized by the repeated change of substratum. Vegetation less inondation plains of silt, clay orf diatomites ared divided from another by sandridges and dunes settled by trees and bushes. At about 15°30'N a thin sand cover becomes continous but is still intercalatred by sandridges and dunes. These ridges are more and more colonised by dense tree lines of *Acacia, Balanites, Maerua* and *Capparis*.

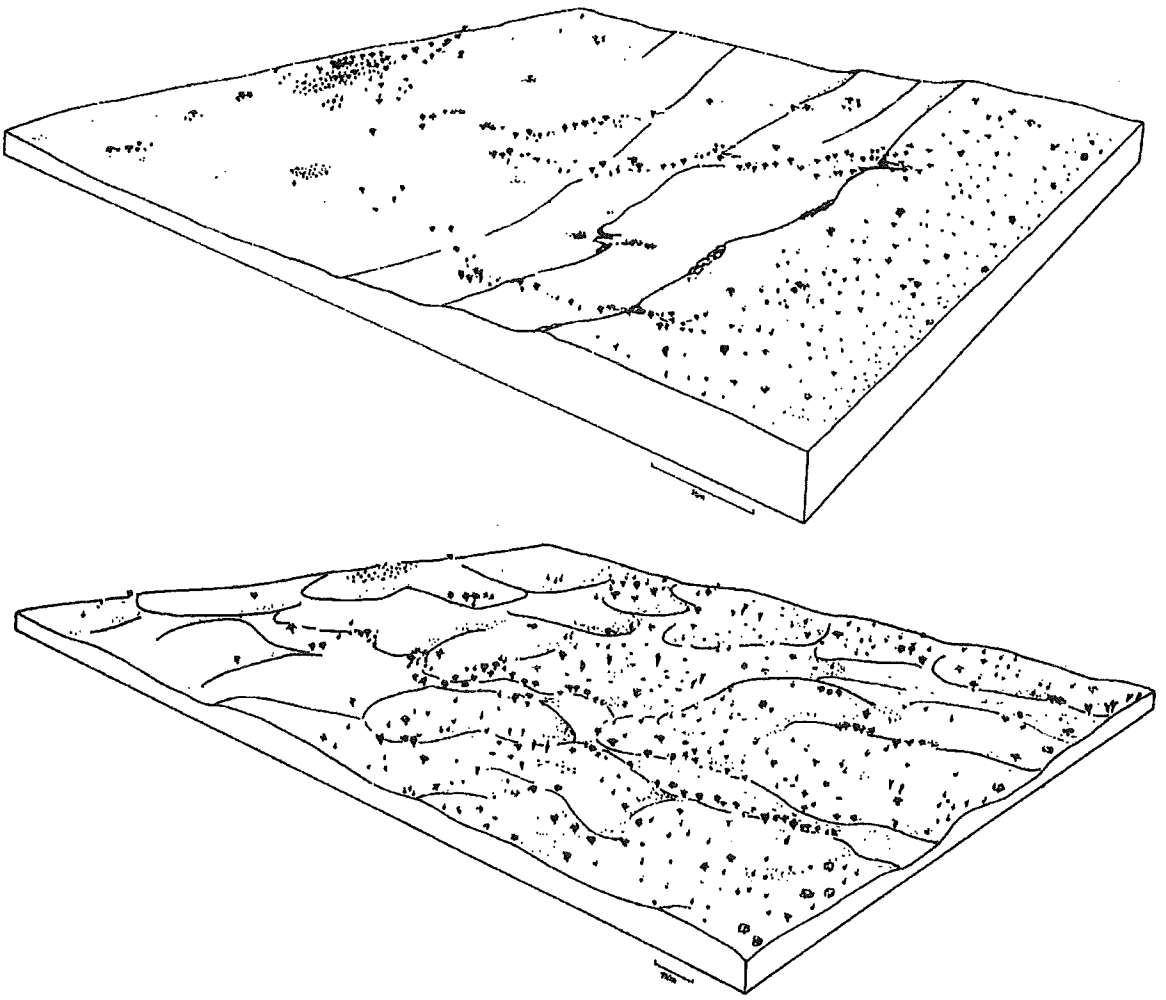


Fig. 1. The southern margin of the Sahara in Niger. Above the linear change at about 150 km south of Agadez at the Tigidid-cuesta, below in the Erg of Bilma.

At about 14°15′N the tree lines coalesce and change into saharan savannas. Inondation plains in the southern part of this belt often expose *Cordia sinensis* -thickets in their center. Whithin this transition zone there is a belt of short time therophyte floras - achabs - between 15°35′N and 14°50′N. These achabs are alimented by regular rainfalls in winter (december-march) caused by the contact of monsoonal amd harmattan air masses.

The southern position of the desert-savanna boundary - compared to ist position in Niger (16°30′N) certainly depends an the substratum mosaic in the central part of Chad.

At about 14°N the transition to the sahelian savannas takes place. This is performed in the extended palaeodune areas again characterized by dunes and large inondation plains. Contrary to the situationin eastern Niger, the *Commiphora-Acacia*-savannas are lacking. The vegetation mainly consists of acacias (*A. raddiana, A.senegal* and *A. albida* in the South. Other important elements

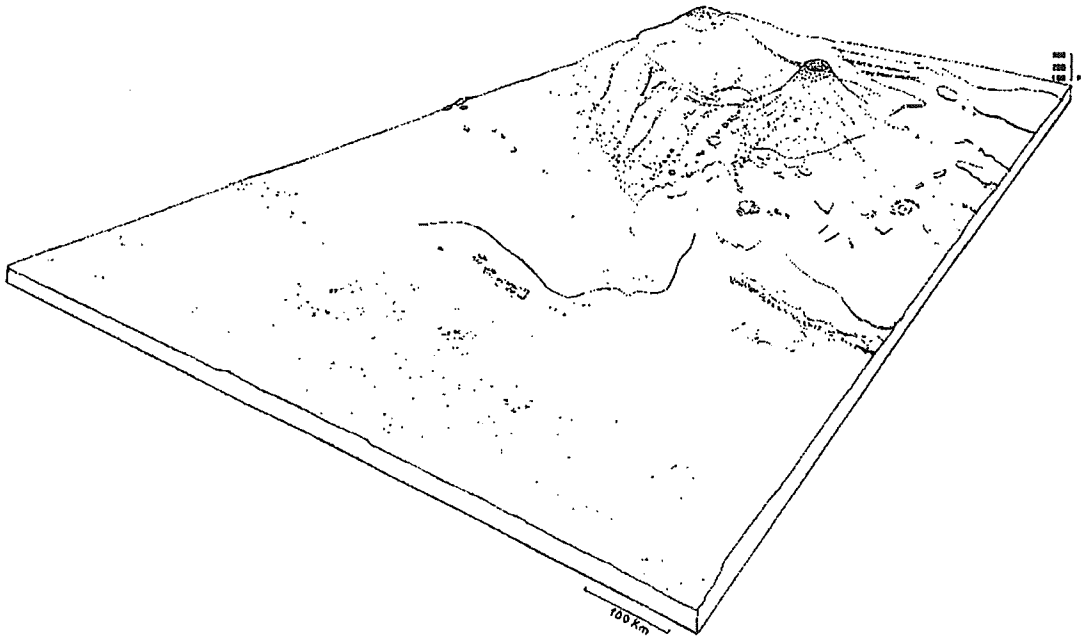


Fig. 2 The region between the Tibesti Mts and the Bodelé depression. The semidesert at the High Mts. zone. Oasises in the depression.

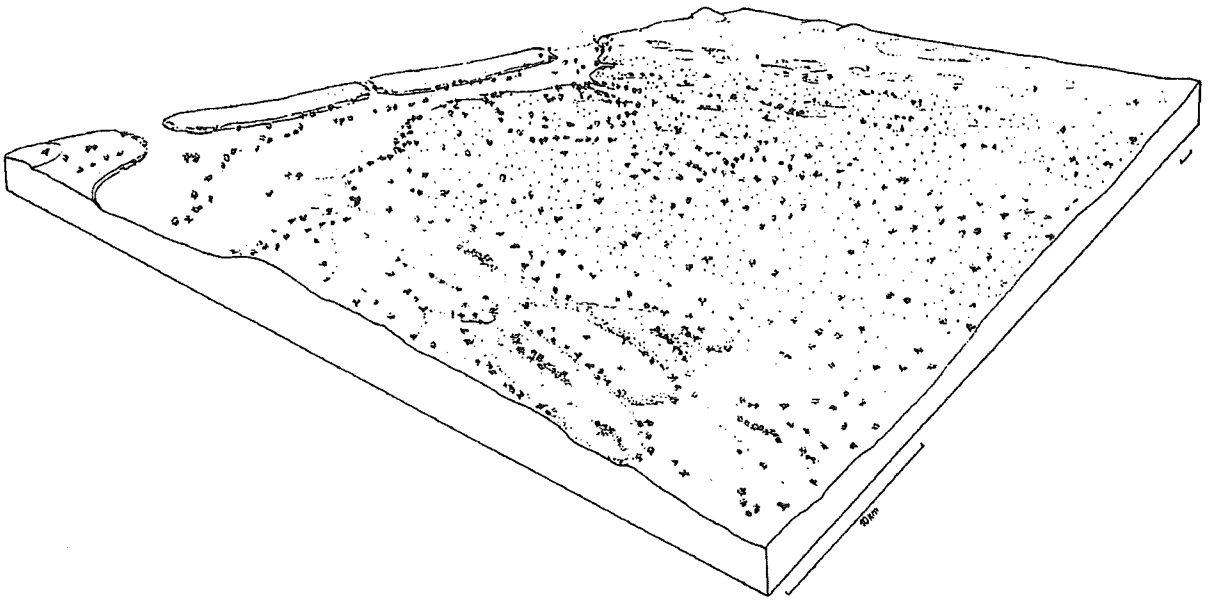


Fig. 3. The transition zone of the southern Sahara in Chad. The densification of tree lines and sandrigdes, the region of achabs, the change to the saharan savannas and the large valley of the Bahr el Ghazal are visible.

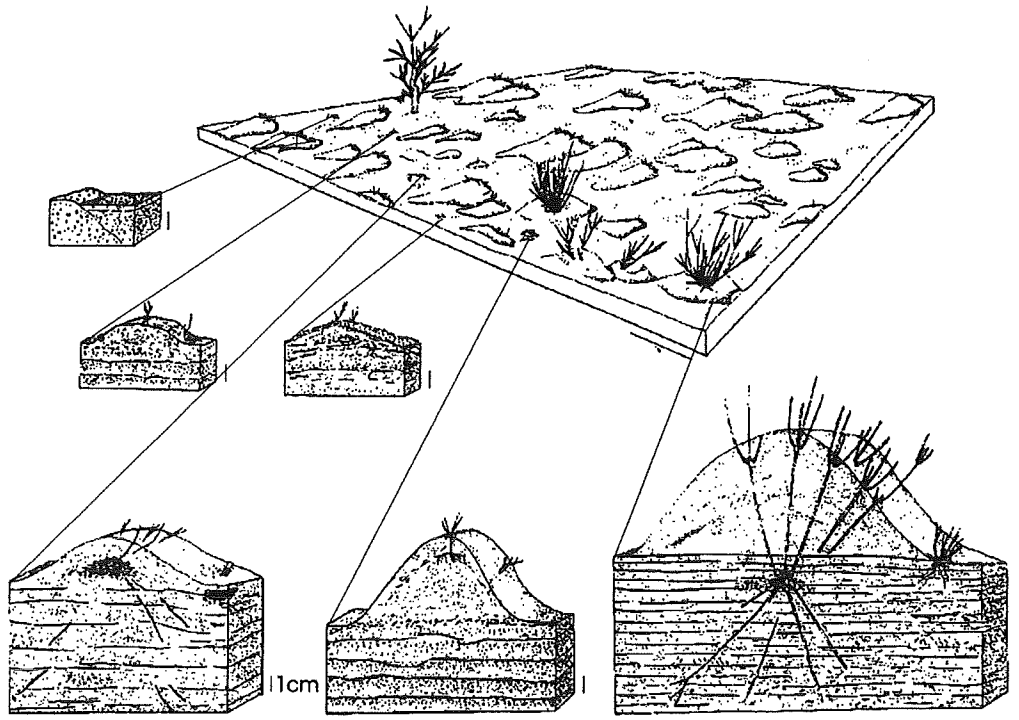


Fig. 4 The soil surface structure in the achab zone north of Salal. The system is stabilized by the root carpet of the grasses. The difference of the loose and the clay /fine sand layers of the palaeodunes is the base of the moisture storage.

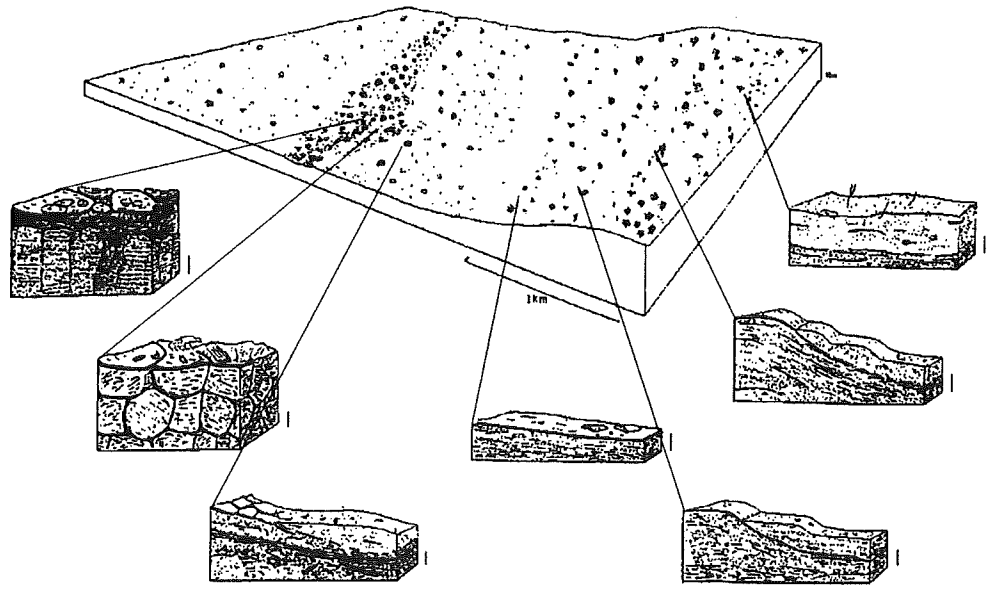


Fig. 5 System of the palaeodunes and inondation plains north of Mussoro. Remains of Acacia-Balanites -savannas of the slopes. Loose Acacia seyal - Boscia senegalensis- bush in the outer part of the depression and thickets of Cordia sinensis in the center. The upper soil layers are characterised by the pellicular surfaces and the cracking vertisols in the center.

are *Balanites aegyptiaca* and *Capparis decidua*.. Shrubs are less important. *Boscia senegalensis and Salvadora persica* are notable but *Aerva javanica* forinstance is very rare. Annual grasses and herbs are very rare also due a severe overgrasing. The plant cover is differenciated into the open *Acacia-Capparis-Balanites* savannas or parks on the dunes and on the outer part of the inondation plains aswell as into the *Cordia sinensis-Acacia seyal-Acacia nilotica*- thickets in the center of the inondantion plains (Fig.5). It is interesting to note, that saharan, south saharan-north sahelian elements like *Panicum turgidum, Balanites aegyptiaca* or *Capparis decidua* are regularly present down to the South of the Sahel. In its southern part the remains of former park savannas become more frequent and with the appearence of *Lannaea acida-Acacia albida* -savannas and parks one observes the transition to the north sudanian savannas visible.

The regeneration potential of the saharan and sahelian savannas was demonstrated by the situation of the tree pasture. The tree vegetation showed excellent conditions and above of the camels reach there are remarkable growing rates of *Acacia, Balanites* and *Capparis*. These savannas were traditionally part of the camel pasture (LE ROUVREUR 1989) but were abandoned during the long lasting civil war. With the end of the civil war the camel herders returned to use the exellent pasture conditions. The transition from saharan to sahelian savannas is also performed as an altitudinal change in the Ennedi massiv (GILLLET 1968 QUEZEL 1964). Here the *Acacia-Panicum*-savannas characterize the sourrounding lowlands whereas the plateaus of the sandstone massiv are colonised by *Acacia senegal- Seddera-Indigofera* -savannas. This transition is also comparable to the altitudinal vegetation of the Air-Mts. in northern Niger (SCHULZ & ADAMOU 1988).

PEDOLOGY

The present dynamic of the soil development in the desert-savanna transition zone aswell as in the sahelian savannas apparently is restricted to the formation of pellicular surface organisations (cf. CASENAVE & VALENTIN 1989). These processes may act as a stabilisatation in a certain counterbalance to the everpresent deflation and overgrazing. The zone of regular achabs serve as a good example to the stabilisation processes at the southern boundary ot the Sahara (Fig 4) . Moisture is stored by clays and silts of the underlying paleodunes as a sponge beneath the upper sand layers which are fixed by a root carpet.

The palaeodune regions of the southern saharan savannas regularly show a catena of these surface organisations to the predominance the vertisols in the center of the inondation plains. It goes parallel with the presence of *Acacia-Balanites-Maerua-Capparis*-savannas of the sandy areas and the *Cordia-Salvadora*-thickets in the inondation plains.

THE PRESENT POLLEN RAIN

The present pollen precipitation was mesured with help of soil and air filters (COUR 1974). The frames were fixed above and behind of vehicles. The soil filters were taken every 50 km for a distance of about 10 kms. Air filters were exposed 24 h each. Soil surface samples were collected too.

These investigations ared based on two main questions:

is there an expression of the vegetation boundaries in the pollenspectra as a modern model for the vegetation history ?

how far reaches the long distance transport from the North and from the South and which elements are characteristic for this phenomenon?

The filters were prepared in the classical combination of HF-HCl-acetolysis treatment. Counting of pollen grains was done to the point of consistancy of the spectra.

The pollendiagrams of the filters were arranged according to therir latitudinal position (Fig. 6).

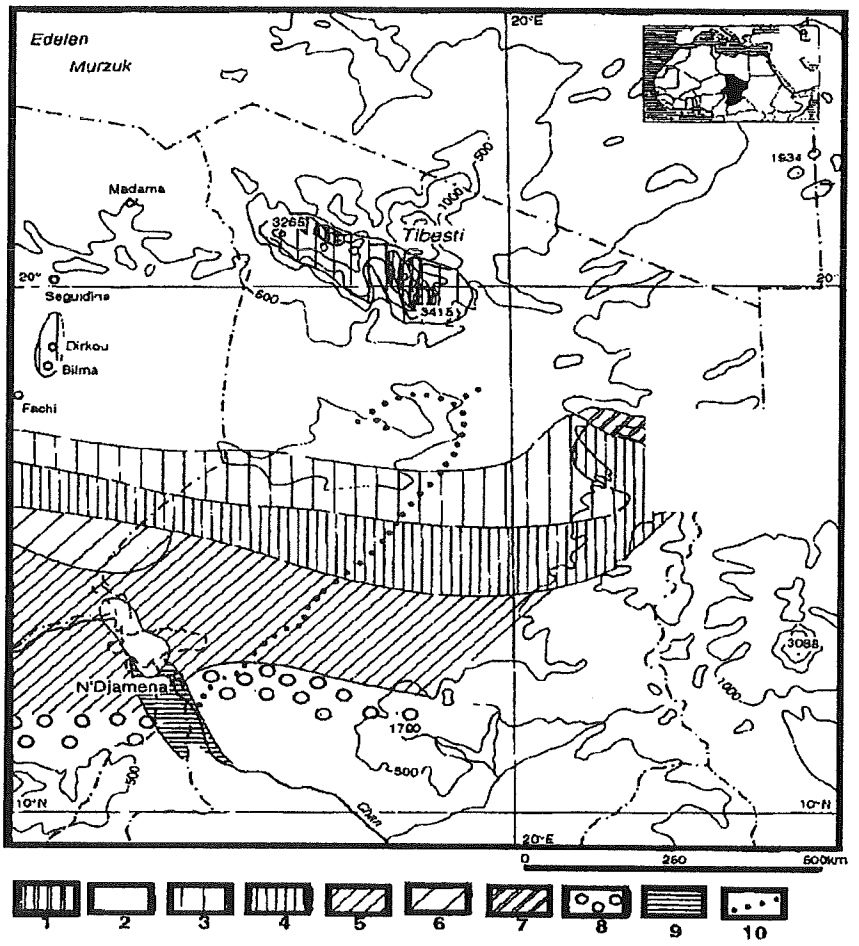
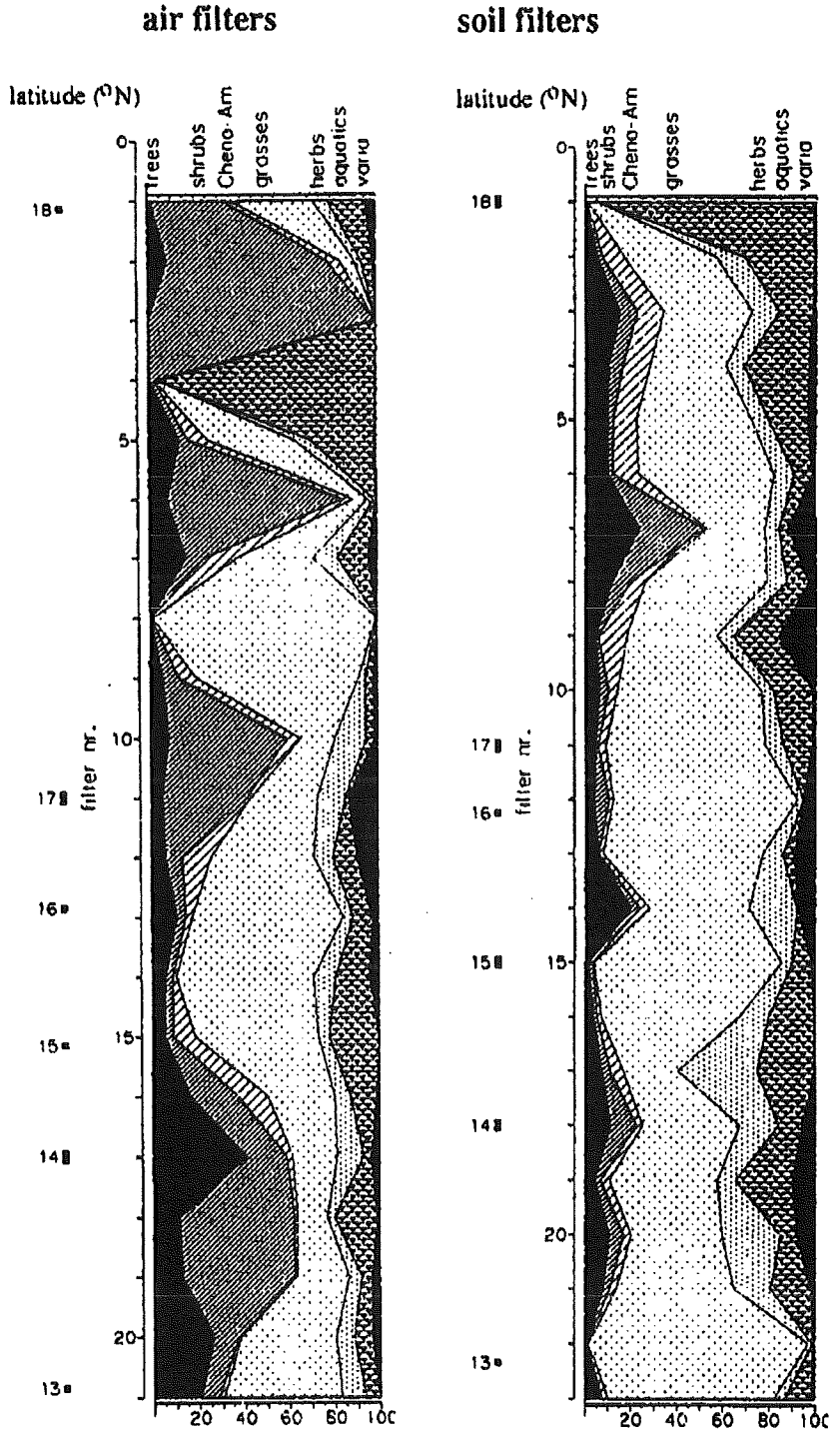


Fig. 6 Synthetic diagrams of the soil and air filter transects and schematic vegetation map of the northern and central Chad (after gaston 1981, Pias 1970, Quezel 1964 and own observations).

1. *Artemisia-Ephedra-Pentzia* -semidesert
2. therophyte and/or isolated tree vegetation
3. contracted *Acacia-Capparis-Maerua-Stipagrostis-Pani cum* - vegetation, oasis vegvetation
4. *Aacacia-Capparis-Maerua-Panicum* -savannas
5. *Acacia-Balanites-Capparis-Cordia-* savannas
6. *Acacia-Commiphora-* savannas
7. *Acacia-Seddera-Indigofera-* savannas
8. *Acacia-Balanites-Lannaea-* savannas.
9. riparian vegetation along the Chari and Logone
10. itinary



The spectra are generally not very rich. They are dominated by grasses, of Cyperaceae and of *Typha*. The next important group is made of tree and shrub elements. It is noteworthy that the lements of the long distance transport such as *Alnus, Betula, Pinus, Olea* or *Piliostigma, Celtis, Combretum* are concentrated for the region of frequent winter rain and regular achabs. *Cassia, Rhizinus* are locally overrepresented.

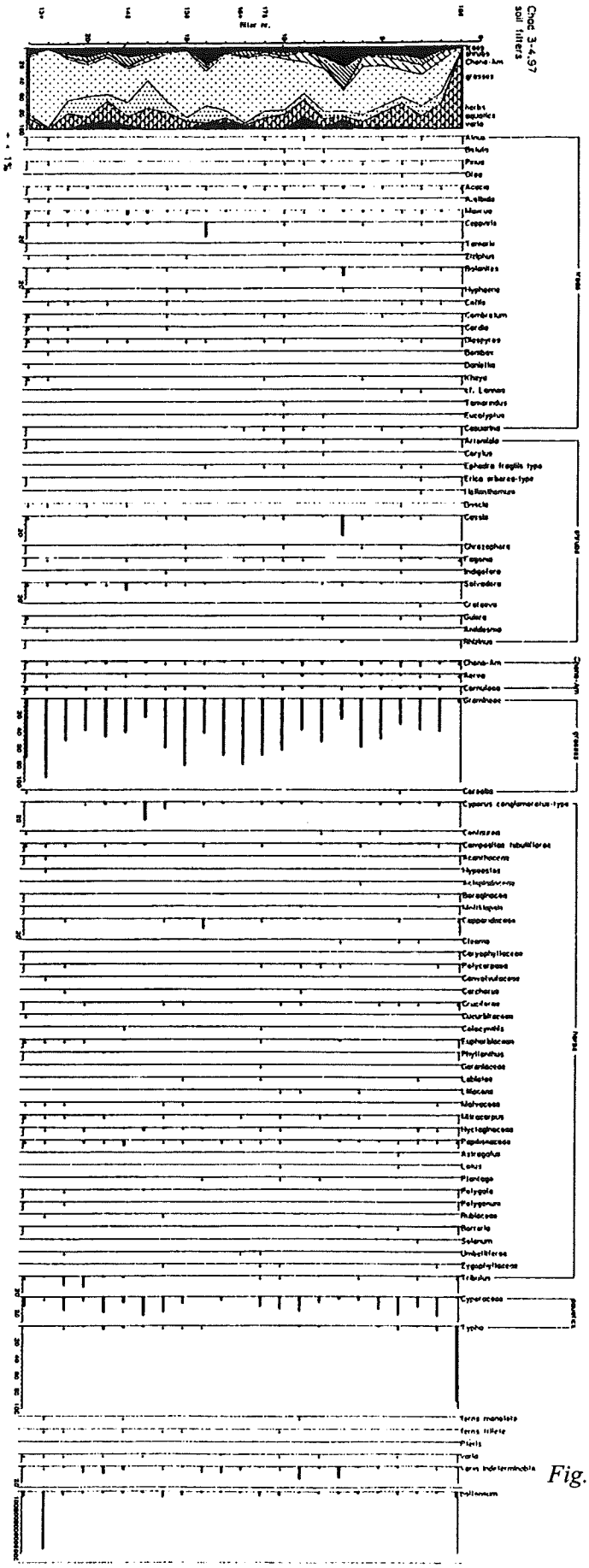


Fig. 7. Pollen diagram of the soil filter transect.

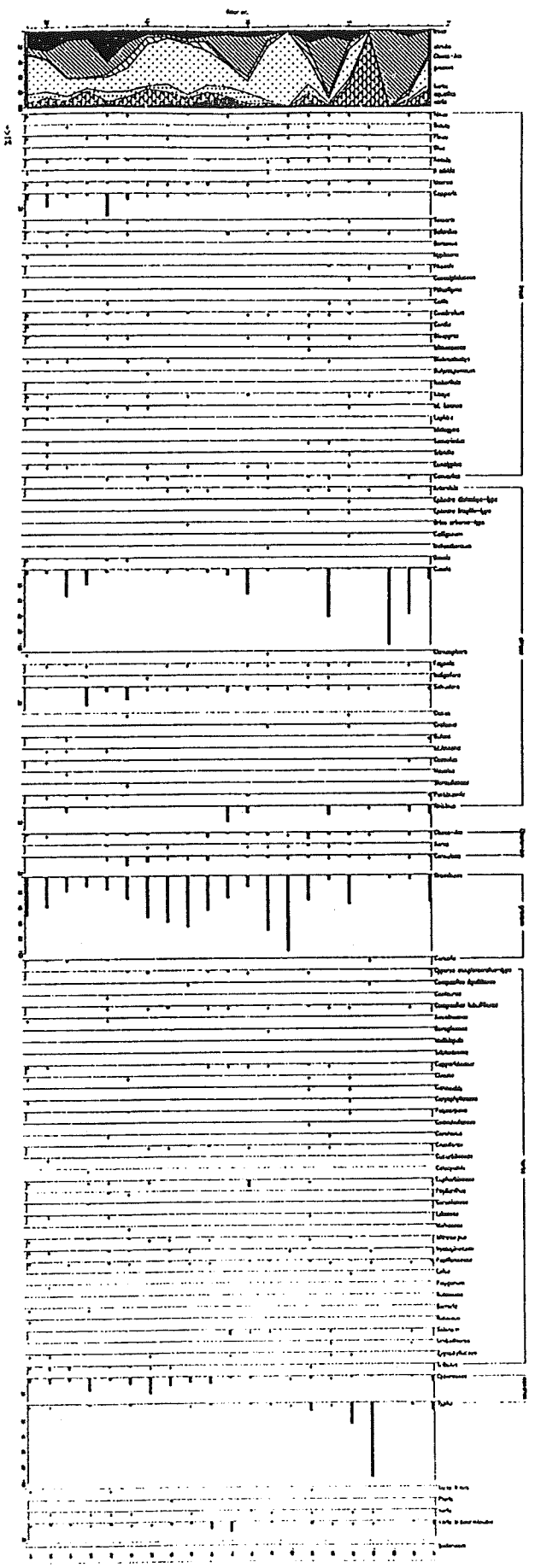


Fig. 8 Pollen diagram of the air filter transect.

The desert-savanna boundary is clearly indicated by the tree elements (*Capparis, Mearua, Balanites, Acacia*). This differs from teh dune areas of eastern Niger, where the combined peaks of Gramineae and Cyperaceae indicate the transition zone (SCHULZ 1990). These general traits are for both soil and air filters. The soil filters (Fig.7) differ from the air filters by their more regular composition The desert savanna boundary is indicated by the *Capparis* -peak. Local overrepresentations are more prominent in the air filters (Fig.8). In both filter types the part of the indeterminable pollen increases in the erg regions were they are mecanically destroyed.

First investigations of the soil samples resulted in a principal accordance to the filters samples. The important deflation in the North caused difficulties so filtermeasurements seem to be more adapted to these regions.

CONCLUSION

Observations and investigation at the southern boundary of the Sahara in Chad confirm the general type of the transition from the linear to the diffuse repartion within the *Acacia-Panicum* -vegetation. They also show the important influence of the substratum. The repeated change between inondation plains and dune ridges created a broad belt of transition.

The present pollen rain reflects well the repartition of the vegetations types and their boundaries. The long distance transport is mostly documented in the region of regular winter precipitation and achabs.

The abandonment of the region during the long lasting civil war caused a remarkable recreation of the tree vegetation. Also the formation of pellicular surface organisations underlines the regeneration potential and tendency towards stabilisation of these ecosystems.

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