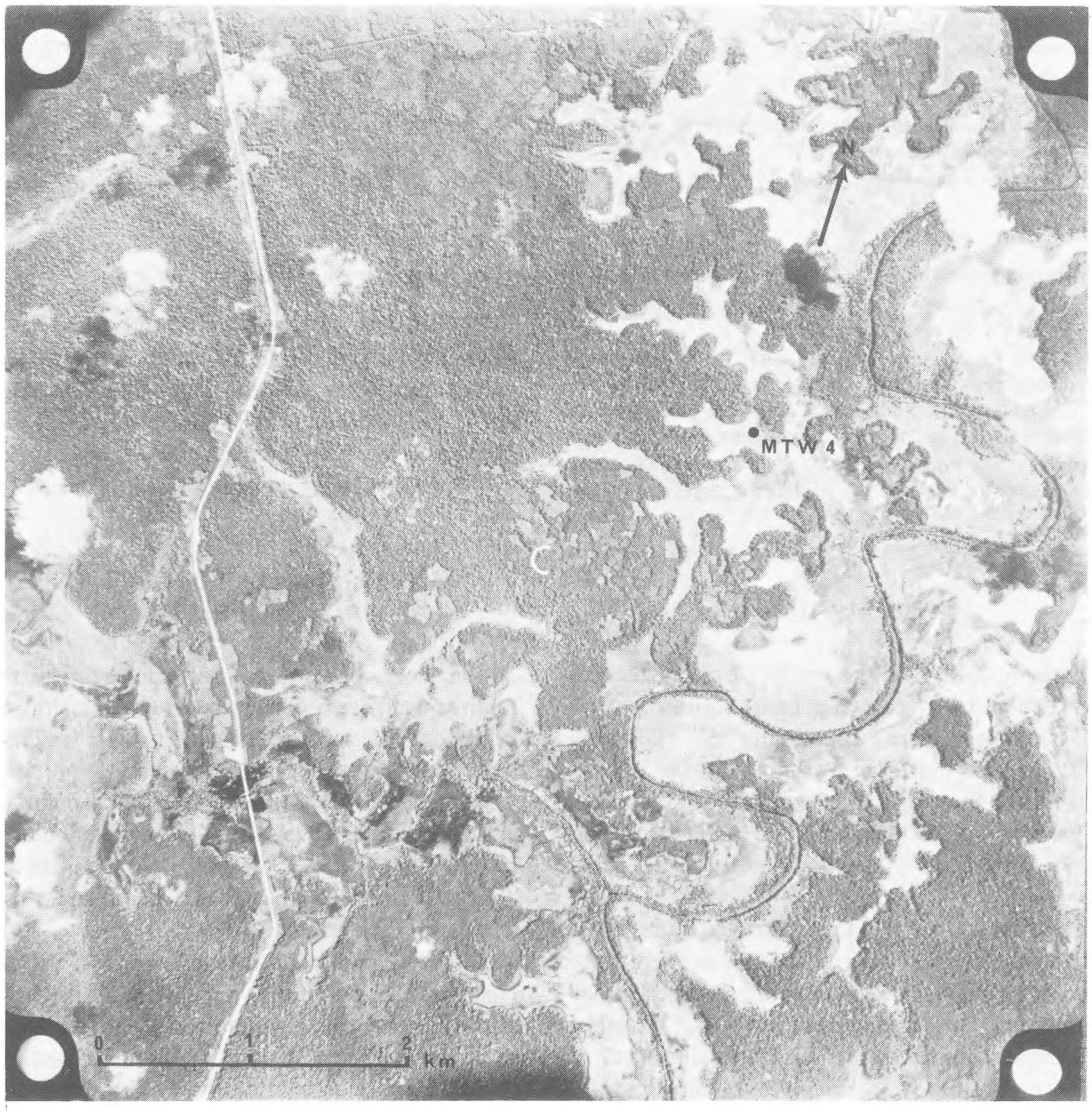
GEOLOGIE EN MIJNBOUW VOLUME 48 (2), p. 215-224 1969

POLLEN ANALYSIS OF TWO SECTIONS IN THE YOUNG COASTAL PLAIN OF SURINAM.

W. ROELEVELD[1])



Copyright Centraal Bureau Luchtkartering Aerial photograph of a part of the Matawaribo area.

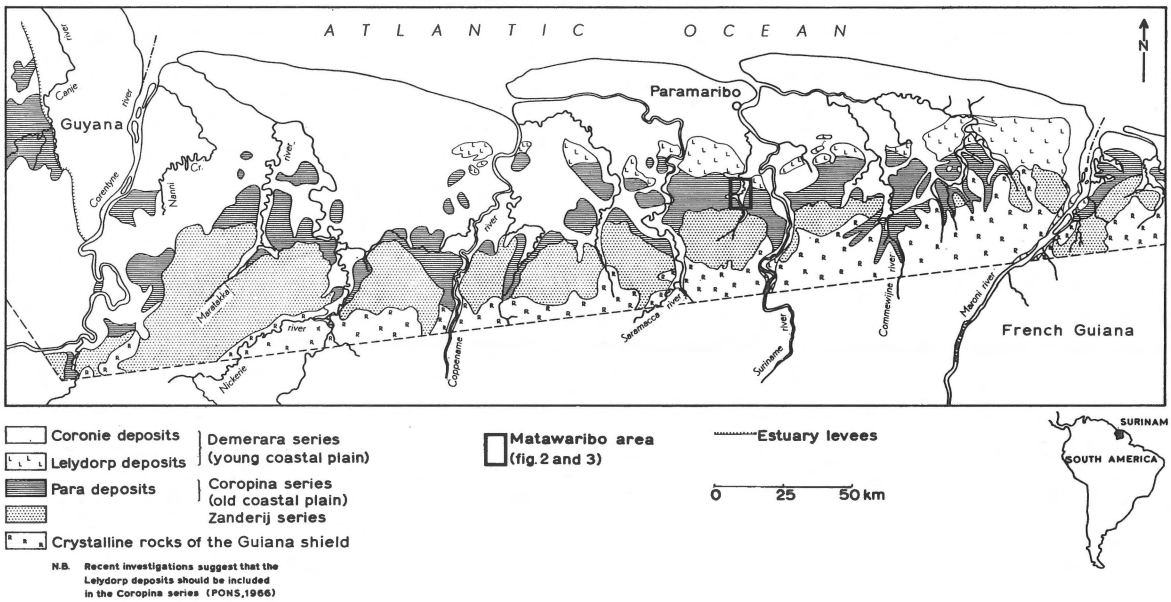


Fig. 1
Map of the sediments in the coastal plain of Surinam (simplified after Brinkman and Pons, 1964)

SUMMARY

Pollen diagrams have been made of two sections in the young coastal plain of Surinam (S. America). According to C 14 dates the clayey and peaty sediments have an early Holocene age. The pollen diagrams clearly show the changes of the vegetation caused by the postglacial ingression of the sea.

INTRODUCTION

This paper deals with the results of pollen analysis of two sections in the coastal plain of Surinam.

The samples were submitted in 1963 by Dr. L.J. Pons, at that time working with the Department of Soil Survey in Surinam. They were taken from borings in the Matawaribo area, about 35 km south of Paramaribo (see fig. 1 and 2 and aerial photograph).

The author wishes to express his gratitude to the Department of Soil Survey in Surinam for the permission to publish the maps of the surface geology and the vegetation of the area, to Dr. J.C. Vogel of the Physical Laboratory of the State University at Groningen for his co-operation to obtain the C 14 datings, and to Mr. P. Geurtsen for correcting the English text.

The research has been carried out at the Palynological Department of the Rijksmuseum van Geologie en Mineralogie in Leiden, under the supervision of Dr. T. van der Hammen. To him and to Mr. F.J.J. van Heyst and Mr. T.A. Wymstra I am indebted for their help and stimulating interest.

GEOLOGY AND GEOMORPHOLOGY (fig. 1 and 2)

The coastal plain of Surinam belongs to the sedimentary basin which is situated north of the crystalline rocks of the Guiana Shield. It is subdivided into two major geomorphological units: the old coastal plain in the south and the young coastal plain in the north. Both of them are mainly built up of marine clay. To the south of the coastal plain lies the Zanderij area, consisting of sandy sediments of Plio-pleistocene age.

The stratigraphy of the sediments in the coastal plain is not yet fully understood, although our knowledge has rapidly increased in the last few years. In a summarizing paper Brinkman and Pons (1964) give a classification of the Holocene sediments, with age determinations, supported by some C 14 datings.

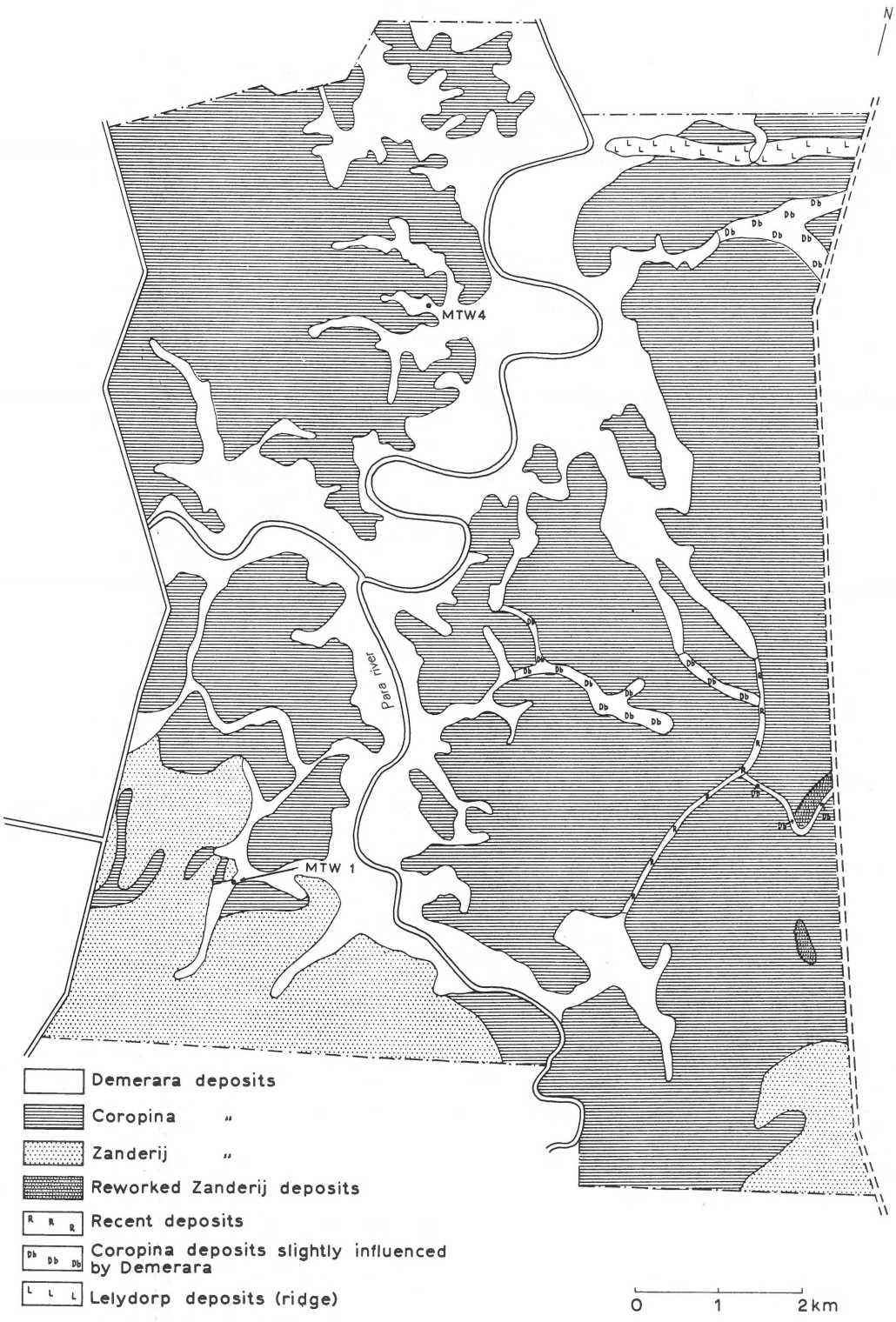


Fig. 2
Surface geology of the Matawaribo area (after Goedendorp) and location of the sections

The old coastal plain has an elevation of 2 to 7 m above mean sealevel; the highest parts are found in the south near the edge of the Zanderij area. The deposits were strongly dissected by erosion, probably during the Würm-glacial, when sealevel dropped about 100 m below to-day's. The sediments of the old coastal plain belong to the Coropina Series; they probably have an Eemian age. The young coastal plain has an elevation of 0 to 3 m above mean sealevel, except for the sandy ridges which can attain heights of 12 m. At its southern border the young coastal plain extends into the erosion gully system, developed in the old coastal plain. The sediments belong to the Demerara Series and are of Holocene age; however, according to recent investigations (P o n s, 1966) it seems that the Lelydorp deposits (see fig. 1) should be included in the Coropina Series.

THE VEGETATION

For this short description of the vegetation types we use the terminology of L i n d e m a n and M o o l e n a a r (1959). They distinguish between wet and dry vegetation types and rainforest. The wet vegetation type is subdivided into mangrove forest, several types of swamp vegetation and marsh (or seasonal swamp) forest. In the dry degetation type the savannah vegetation types are taken together.

Mangrove forest occurs along the coast, in swamps and along rivers. Its extension is more or less restricted to the occurrence of brackish water. The most important species are *Rhizophora mangle* and *Avicennia nitida*. Both of them may form forests. *Avicennia*-forest occurs on firm more settled mud, along the coast and on the levees along the rivers. *Rhizophora*-forest is found on soft mud. In the undergrowth *Acrostichum aureum* may be important.

Swamp vegetation is growing on spots that are moist to wet throughout the year. The vegetation may be herbaceous (with i.a. *Cyperus giganteus*, *Typha angustifolia, Sagittaria* and grasses) or a forest (with *Virola surinamensis, Symphonia globulifera, Bombax aquaticum, Pterocarpus officinalis, Triplaris, Euterpe* and *Bactris*).

Marsh forest occurs in periodically inundated areas. Important species are: *Eschweilera, Tabebuia, Ilex martiniana, Carapa* and the palms *Maximiliana, Euterpe, Mauritia, Bactris* and *Astrocaryum*. In the lower parts the vegetation may have a more swampy character.

Savannah vegetation develops where the soil dries out completely during a part of the year. Dependent on the duration of the water shortage period, the savannah vegetation is more open or denser. There are also differences between savannahs on sandy permeable soils and on clayey soils with impeded drainage. On clayey soils the herb-layer is somewhat richer and *Mauritia flexuosa* occurs along water courses. The savannah wood vegetation consists of relatively few, often xeromorphic species, with i.a. *Clusia fockeana, Bombax flaviflorum, Curatella americana* and *Byrsonima crassifolia*. Savannah forest sometimes shows two storeys. In the lower storey the species of the savannah wood are found. The upper storey consists of trees belonging to the rainforest, like *Loxopterygium sagotii* and *Plantonia insignis*.

The remaining forests on never inundated and well-drained soil are combined under the term rainforest. At present this type of forest is found south of the Matawaribo area.

The investigated area is situated in the border region of the open and scrub savannahs and the marsh forest. Along river courses and in depressions there is a swamp vegetation with herbs and shrubs. Fig. 3 shows the vegetation map of the area.

POLLEN TYPES AND POLLEN SEDIMENTATION

The recent and fossil distribution of the plants which are represented by the pollen types in the diagrams, was briefly described before (v a n d e r H a m m e n, 1963). From this description follows that there are only very few indicator species for the different vegetation types. *Symphonia globulifera* is found exclusively in swamps or in very wet marsh vegetation. *Byrsonima* in general is indicative of savannah vegetation. *Didymopanax* seems to belong to a dry type of rainforest.

Pollen sedimentation in this region has been studied scarcely; van der Hammen mentions the most important facts in his paper of 1963. It should be remembered that transport by water may play an important part (M u l l e r, 1959). Further it must be stressed that very high percentages of *Rhizophora* (over 50%) have only been found on the shelf off the coast, and in mangrove forest.

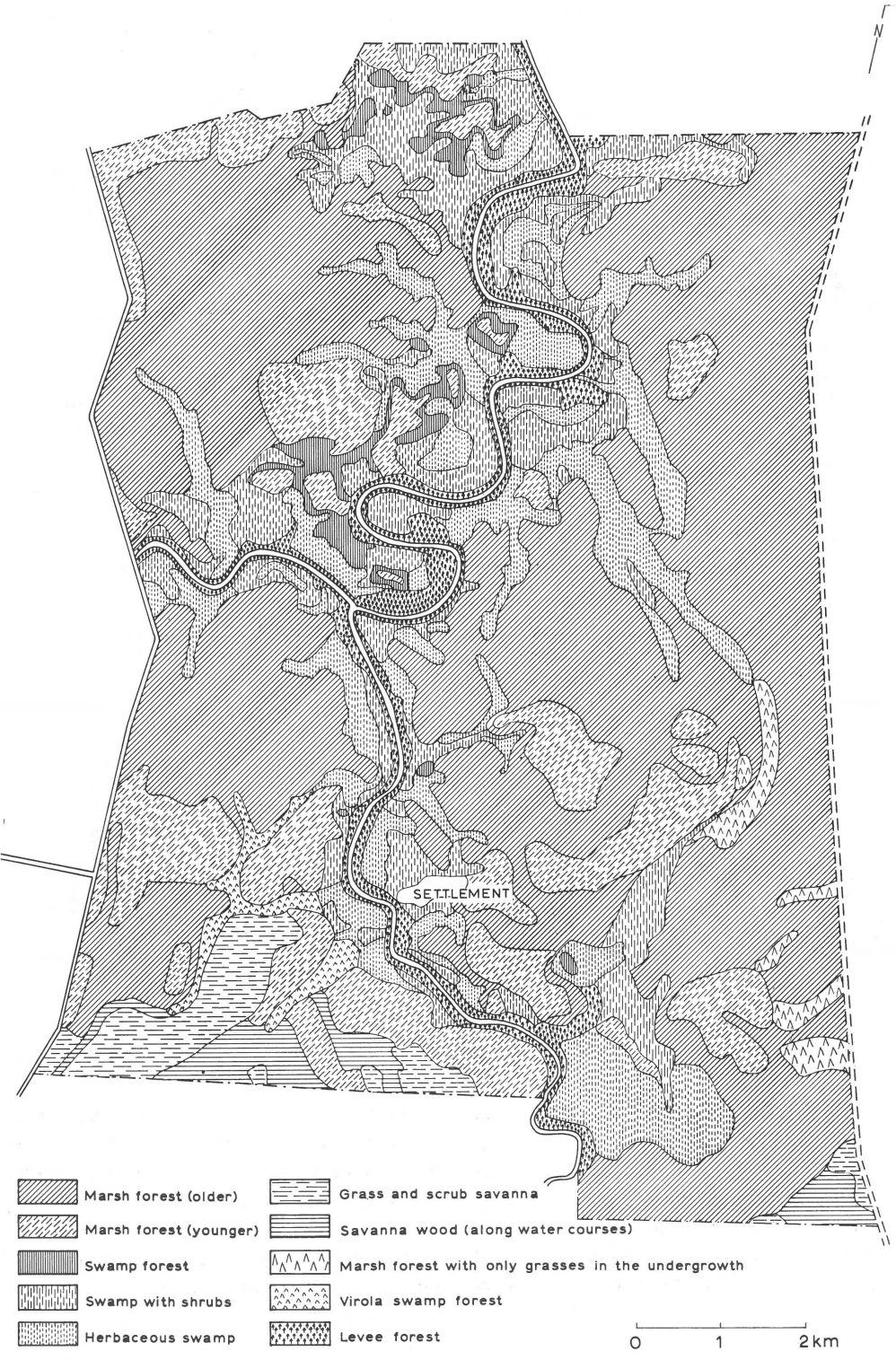
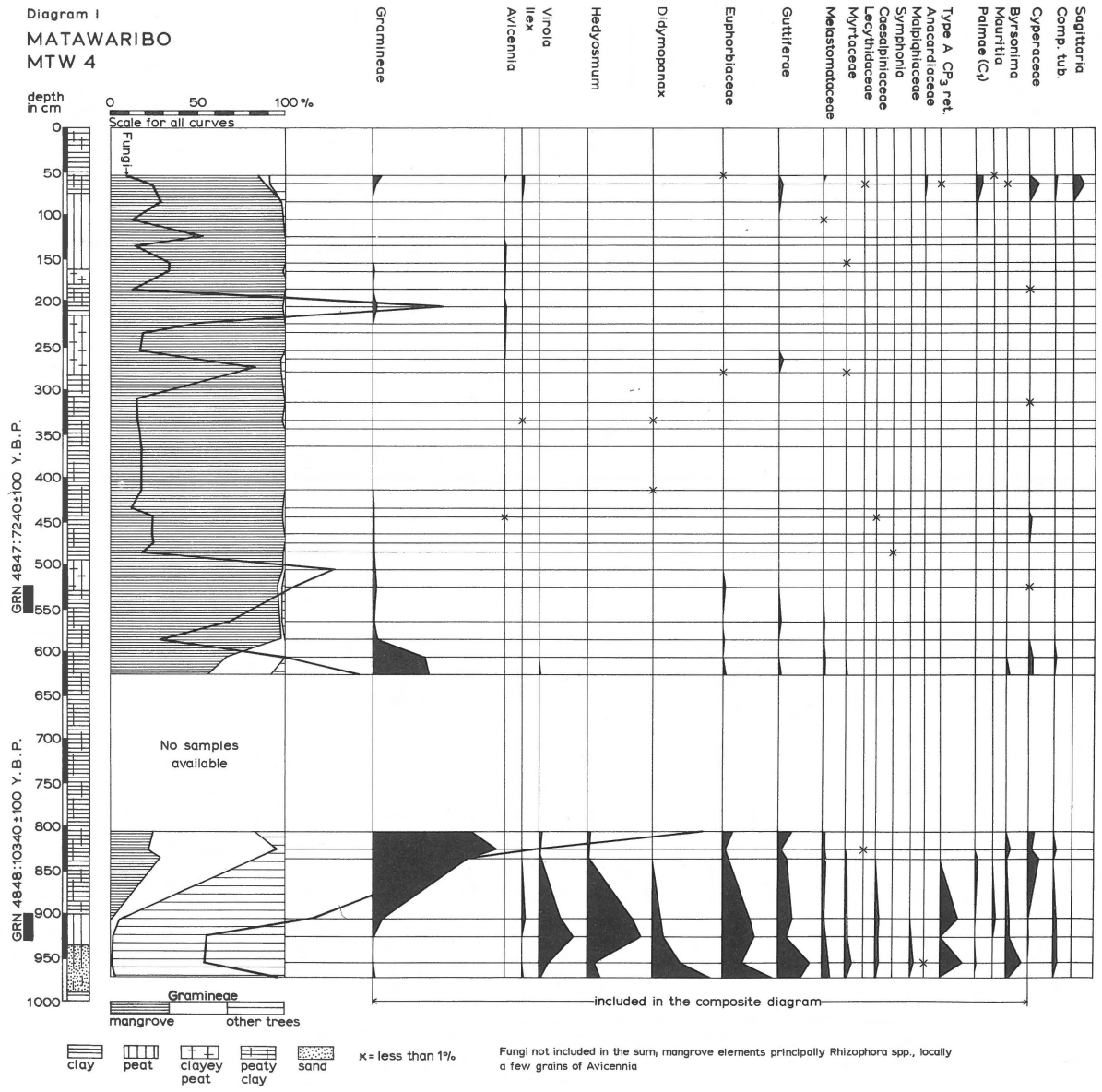


Fig. 3
Vegetation of the Matawaribo area (after Goedendorp)



DISCUSSION OF THE DIAGRAMS AND C 14 DATES

The diagrams are composed of a composite diagram and several separate curves. In the composite diagrams three groups of pollen grains are represented:

Mangrove elements *(Rhizophora, Avicennia)*

Grasses

Trees other than mangroves

In the pollen sum used for the construction of the diagrams only these elements are included.

For each spectrum 150 pollen grains were counted. Spores have not been counted, except for fungal spores. The Fungi-curve is shown as a thick line. All samples have been treated in the same way: they were boiled briefly with KOH, after that subjected to acetolysis (Erdtman), followed by a gravitative separation in a bromoform-alcohol mixture.

Section MTW 4 (diagram I)

This profile has been taken from an erosion gully in the Coropina landscape, filled in with Demerara

sediments. The surface at the spot is a little above mean sealevel. Pons gives the following description and interpretation of the profile:

depth (cm)	material	interpretation
0- 10	pegasse (peat)	
10- 30	black peaty clay	very young cover D3
30- 35	grey clay	
35- 50	black clay	transition D2/D3
50- 75	peaty clay	younger Demerara clay D2
75-160	peat	transition D1/D2
160-175	clayey peat	older Demerara clay D1
175-215	peaty clay	
215-280	clayey peat	
280-500	peaty clay	
500-530	clayey peat	
530-900	peaty clay	
900-930	strongly compressed layered peat	eustatic peat
930-960	peat containing some sand	
960-990	coarse sand with peat fragments	fluviatile deposit
990	Coropina clay	marine Pleistocene

The sandy deposit on the bottom of the old gully must be considered as a lag deposit from a period when the gully was still active as a drainage channel, obviously at a much lower sealevel than today. The peatlayer at the base of the Demerara clays strongly suggests a development comparable to that of the western part of the Netherlands. This peatlayer should in that case be the equivalent of the "peat-at-greater-depth" in the Netherlands, that was formed under conditions of a rising groundwater table caused by the (relative) rise of the sealevel. However, this interpretation is not in agreement with the C 14 dating (see below).

The pollen diagram can be subdivided into three major units: at the base an interval with a strong dominance of "other trees", followed by a Gramineae maximum, while from about 600 cm upward *Rhizophora* dominates almost completely.

The 970-900 cm interval seems to reflect the influence of the wet vegetation (*Virola*) in the gully and on the neighbouring floodplain of the Para river, and of a savannah wood vegetation (*Byrsonima*) with a possible tendency to rainforest conditions (*Didymopanax*) on the higher Coropina landscape.

From 9 m upward the deposits consist of peaty clay. In the diagram the percentages of *Rhizophora* and grasses are increasing, while the influence of the other trees decreases. Unfortunately there were no samples available of the 800-630 cm interval, but the diagram suggests a development towards a situation of almost 100% *Rhizophora*.

It is difficult to decide whether the high Gramineae percentages are caused by a grass-savannah on the Coropina and Zanderij landscape nearby, or by a wet herbaceous swamp vegetation in the gully, or by both. An extension of the grass-savannahs implies a more marked annual period of water shortage, probably caused by a climatic change. So far no indications for such change have been found in this region. As we also find this Gramineae maximum in diagram II, but on a higher (younger) level, the pollen has probably been produced by a grass vegetation in the inundated gully. Moreover, when looking at the present distribution of the vegetation belts, we see that the herbaceous swamps are most common in between the mangrove fringe and the swamp- and marsh forest. The diagram probably gives a vertical record of the shifting of these horizontal belts.

The interval 585-85 cm should represent brackish conditions with *Rhizophora* growth in situ. The very high *Rhizophora* percentages suggest that water transport of pollen grains may have taken place. It is evident that we are not concerned with shelf sediments, but the possibility of pollen transport by estuarine currents remains. To decide whether this was the case or not, we considered the following facts:

a The profile is developed as peaty clay. This indicates plant growth at the spot; most probably this must have been a mangrove vegetation, for in case of another vegetation one should expect any reflection of it in the pollen diagram. Even the pure peaty parts of the section contain about 100% *Rhizophora* pollen, that cannot be supplied by estuarine currents.

b Throughout the section, polyads of *Rhizophora* pollen grains were found, indicating a very short distance of transport.

c An analysis has been made in three samples of the relative percentages of the *Rhizophora* species. The results, shown in table I, show a notable increase of the percentages of *Rhizophora mangle* s.s. (the most salt tolerant species) upward. That means that, as one should expect, salt water conditions are more pronounced at a higher sealevel. So these spectra reflect the changes in vegetation in the region quite regularly, which probably would not

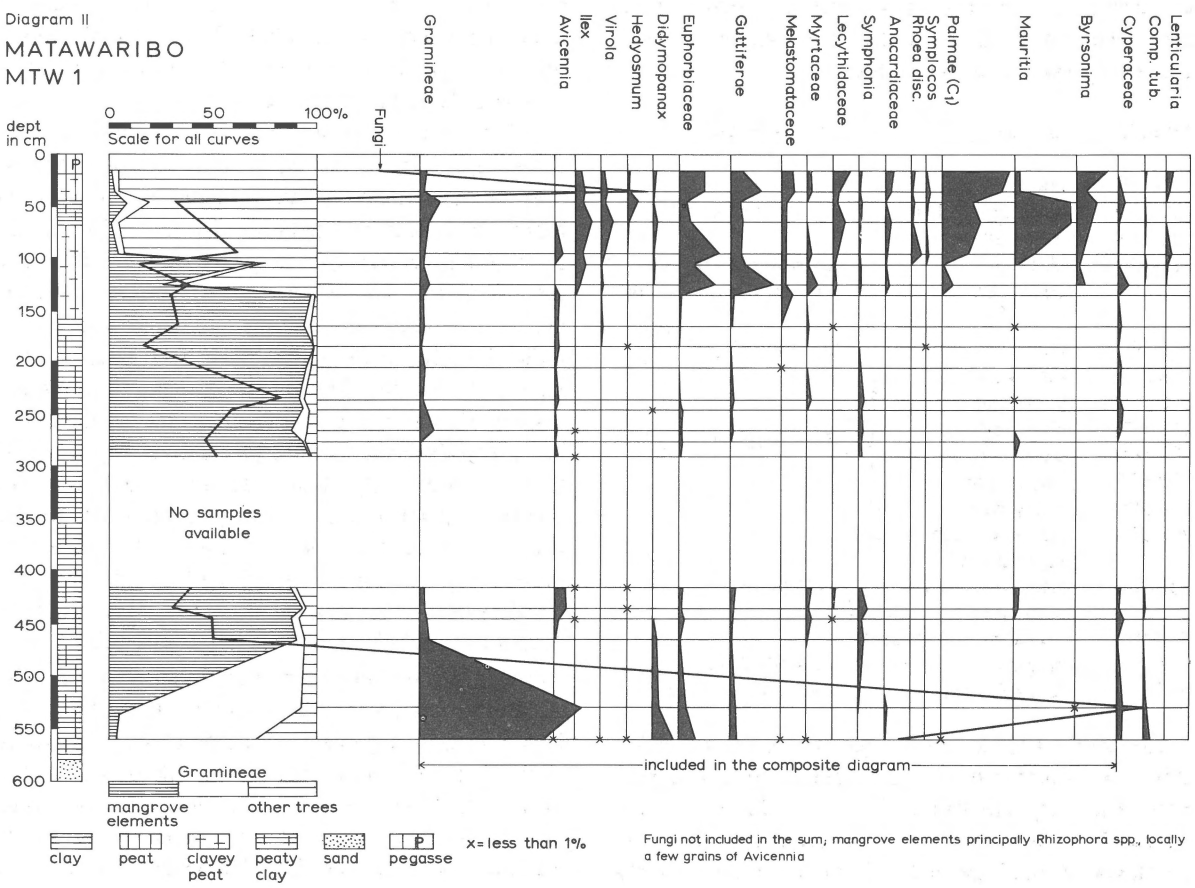


TABLE 1

Frequency of *Rhizophora* species in some samples of section MTW 4

Depth (cm)	*Rh.racemosa*	*Rh.harrisonii*	*Rh.mangle* s.s.	*Rh.*type
105	10.1%	49.5%	32.5%	8.1%
315	9.4%	58.1%	24.3%	8.1%
585	8.3%	65.5%	18.6%	7.6%

be the case if the pollen grains were transported by water. Moreover, in the three spectra, *Rhizophora harrisonii* is by far the most important. However, it has the biggest pollen grains of the three *Rhizophora* species and in the case of water transport one should expect a sorting out in favour of the smaller *Rhizophora mangle* and *Rhizophora racemosa* grains.

Concluding, we can say that the facts mentioned above, are in favour of the opinion that there must have been *Rhizophora* growth at the place, and that the transport of the *Rhizophora* pollen has mainly taken place in the air.

Muller (1959) and van der Hammen (1963) give *Rhizophora* percentages, varying between 30% and 95%, in samples taken in recent mangrove forests. In our diagram we find percentages that are even higher over a long interval. According to Brinkman and Pons (1964) the present day situation with a nearly stable sealevel is not comparable with the past. They state that at times of a rather quickly rising sealevel a vast swamp area may have existed, constantly inundated by brackish water and covered by a dense mangrove vegetation. It is likely that the nearly 100% *Rhizophora* frequencies in the diagram are, at least partially, caused by such an extensive mangrove forest nearby. It is also possible that conditions today are not optimal for

Rhizophora, and that the flowering of the species was more abundant in the past. Gonggrijp and Burger (1948) state that the *Rhizophora*-forest today shows a poor development and that the rejuvenation is bad.

Even in the pure peat (160-75 cm), that should represent a regression stage, *Rhizophora* reaches values of nearly 100%. This means that the mangrove forest continued to grow on the spot, possibly with reduced depth of the water (as indicated by the maxima of the Fungi-curve). This could explain why the D2 sedimentation phase had no distinct influence on the pollen spectra. The 0.55 cm interval contained too little pollen to be counted. So it was not possible to study the regression stage D2/D3 and the D3 sedimentation phase. Only the two uppermost spectra show a slight decrease of the percentage of *Rhizophora*, which probably can be correlated with the *Rhizophora* drop at 95 cm in diagram II.

The Fungi-curve shows the greatest variations. Although the meaning of the maxima is not quite clear, it seems that the presumption of van der Hammen (1963), that they occur when the vegetation becomes unstable, is supported by this diagram. There is a very high maximum at the transition towards mangrove forest. The less pronounced peaks are often related to lithological changes, but seem to lag a little behind. High maxima of Fungi in peat may also indicate a lower water-table, or seasonal drying up of a swamp.

C 14 dates. – The diagram is dated by two C 14 analyses:

GrN 4847 – peaty clay at 530-555 cm – 7240 ± 100 yr. B.P.
GrN 4848 – compressed peat at 900-930 cm – 10,340 ± 100 yr. B.P.

As various authors do agree that at the transition from Pleistocene to Holocene (about 10,000 years ago), sealevel was at least 25 m below todays, it seems that there is no connection between the late-Pleistocene and early-Holocene rise of sealevel and the development of the basal peat at the bottom of the gully at a depth of about 9 m.

The dating of 7240 years B.P. for the sedimentation of peaty clay (under marine influence) at a depth of about 5.5 m, corresponds fairly well to the sealevel curve according to Fairbridge (see Brinkman and Pons, 1964). It is this peaty clay that apparently corresponds to the time of final inundation.

From the two dates it is clear that the sedimentation of the basal peat is Late-glacial and that the deposition of the clay started in early Holocene times. According to Pons (1966) the sedimentation of this older Demerara clay was finished about 6000 years ago. The D2 and D3 sedimentation phases must be younger. However, it should be mentioned that no signs of a hiatus in the sedimentation are present in the pollen diagram.

Section MTW 1 (diagram II)

Like the other, this profile has been taken in an erosion gully in the Coropina landscape. The gully, situated at the southern edge of the Coropina clay area, is about 6 m deep and has been filled in with Demerara sediments. The surface at the spot is a little above mean sealevel.

Description and interpretation of the profile according to Pons:

depth (cm)	material	interpretation
0- 20	pegasse (clayey)	very young cover D3
20- 45	clayey brown peat	
45- 70	black peaty clay	younger Demerara clay D2
70-130	black layered clayey peat	transition D1/D2
130-160	brown layered clayey peat	older Demerara clay D1
160-580	greyish brown peaty clay	
580-600	sand	fluviatile deposit

The pollen diagram fits in well with diagram I. The Gramineae maximum and the interval with *Rhizophora* dominance can be easily correlated, although there will probably be some difference in age. At the base a part seems to be missing. It is possible that the basal peat with very high "other trees" percentages has been eroded or was never deposited. On the other hand the diagram gives a better picture of the upper metre. After some fluctuations *Rhizophora* almost disappears and is replaced by other trees, among which palms are very important. The presence of *Byrsonima, Ilex* and many palms points towards a savannah wood and marsh vegetation, which fits in well with the actual situation. The high *Mauritia* percentages at about 75 cm may have been caused by a *Mauritia* fringe along the creek.

It is not impossible that the *Rhizophora* fluctuations represent the influence of the younger sedimentation phases D2 and D3. Whether the *Rhizophora* peak at 105 cm can be correlated with the D2 phase

distinguished by Pons is doubtful. The small peak at 45 cm could be connected with the D3 transgression; the Fungi peak at 35 cm too seems to point in this direction. As in diagram I, there is also a very high Fungi maximum at the Gramineae peak. Finally, *Rhizophora* and *Avicennia* reach values of about 90%, somewhat lower than in the other diagram. Obviously, the mangrove forest at this place has been less dense and extensive, because of the location farther from the coast. However, polyads of *Rhizophora* show that mangrove has been growing on the spot.

CONCLUSIONS

The diagrams clearly show the changes of the vegetation caused by the ingression of the sea during the postglacial rise of sealevel. When the environment becomes increasingly brackish, the initial savannah and marsh vegetation is gradually replaced by a mangrove forest. Only the upper part of the diagrams indicates a decrease of marine influence in the younger part of the Holocene.

It should be remembered that the vegetational changes, recorded in the pollen diagram, are due to a changing intensity of marine influence and not directly to climatic phenomena. From publications by Brinkman and Pons (1964) it is known that during the quick rise of sealevel in early Holocene times (until about 6000 yr. B.P.), an extensive swamp area existed, covered by an almost pure *Rhizophora* vegetation. It seems that under such conditions exceptionally high values of *Rhizophora* in the pollen diagrams can be achieved. Whenever in the Holocene coastal diagrams from the Guianas these very high *Rhizophora* frequencies are found over a longer interval, it might be considered as an indication that we are concerned with the early Holocene deposits.

Although our diagrams apparently do not reflect very clearly eventual minor transgression and regression phases, sections nearer to the coast give a more pronounced reflection. In that region transgressions and regressions are represented by a shifting of the coastline. The *Avicennia* belt along the coast is then reflected in the pollen diagrams fairly well (see in this respect the coastal diagrams from Guyana (van der Hammen, 1963) and from Surinam (Laeyendecker-Roosenburg, 1966).

REFERENCES

Brinkman, R. and L.J. Pons (1964) – A classification and map of the Holocene sediments in the coastal plain of the three Guianas. Publication of The Soil Survey Institute, Wageningen. (An up-to-date version of this publication is in preparation)

Goedendorp, B. (1963) – Verslag van de studiekartering "Matawaribo"-Suriname. Unpublished report, Department of Soil Survey, Paramaribo.

Gonggryp, J.W. and D. Burger (1948) – Bosbouwkundige studiën over Suriname. Publ. v.d. Stichting "Landbouw Exportbureau 1916-1918", no. 32.

Hammen, T. van der (1963) – A palynological study on the Quaternary of British Guiana. Leidse Geologische Mededelingen, 29, p. 125-180.

Laeyendecker-Roosenburg, D.M. (1966) – A palynological investigation of some archaeologically interesting sections in northwestern Surinam. Leidse Geologische Mededelingen, 38, p. 31-36.

Lindeman, J.C. (1953) – The vegetation of the coastal region of Surinam. The vegetation of Surinam, I, 1.

Lindeman, J.C. and S.P. Moolenaar (1959) – Preliminary survey of the vegetation types of northern Surinam, The vegetation of Surinam, 1, 2.

Muller, J. (1959) – Palynology of recent Orinoco delta and shelf sediments. Reports on the Orinoco Shelf Expedition, 5. Micropaleontology, 5, 1, p. 1-32.

Pons, L.J. (1966) – Geogenese en pedogenese in de jong-Holocene kustvlakte van de drie Guyanas. Tijdschr. Kon. Ned. Aardr. Gen., Tweede Reeks LXXXIII, 2, p. 153-172.