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POST-GLACIAL TO HOLOCENE TRANSITION IN A PEATLAYER OF LAKE JACARE (RIO DOCE BASIN, BRASIL)

by E. VAN OVERLOOP (*)

INTRODUCTION.

The studied area is situated on the mid-current of the Rio Doce stream between 19°30' and 20° Southern latitude (Fig. 1).

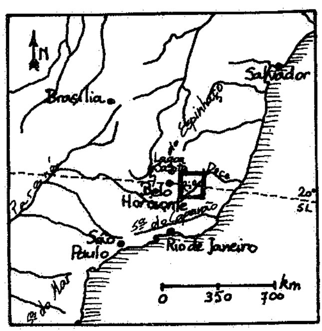

Fig. 1

☐ Studied area

It is contoured in the North by the "Serra Negra" and the "Serra das Safiras", in the West by the "Serra do Espinhaco", in the South by the "Serra do Caparao" and in the East by the "Serra dos Aimores". The mean altitude of the plateau is 500 m.

The Rio Doce is 700 km long of which 20 kilometers on both sides of the river are accompanied by a series of lakes. The latter all dominating by about twenty meters in height the flood-plain of the Rio Doce. The surrounding hills seldomly reach higher positions than 200 m.

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The regional climate is warm and the mean yearly temperature varies between 20° C and 22° C. Precipitation goes up to an average of 1.350 mm per year.

Until the beginning of the 20 th century the whole region has been covered by tropical-atlantic to cerrado transitional vegetagion which in some cultivated areas changed into elephant-grasses; in the swampy regions a typical swamp vegetation has been growing staedily (AB'SABER, 1969 and PFLUG, 1968).

Today human activities broke down this vegetation and changed it into Eucalyptus plantations as well as grassland for cattle.

The Lake Jacaré is one of the several lakes that occur in the natural park called "Parque Florestal". They have formerly been studied by Prof. Dr. M. R. M. DE MEIS and collaborators by means of airphotography, which formed the base of a preliminary mapping of the aggradation levels, the Holocene terraces and the dry lakes (Fig. 2).

In 1965 DE MEIS and BIGARELLA gave birth to the theory of the "rampa". By this is meant a "rampa de coluvio" to describe light concave valley bottom surfaces from the geomorphological point of view. From the geological point of view it points to sediments of Upper Pleistocene and Holocene age which are interfingering with fluviatile and-or lacustrine deposits of the same age (Fig. 3); together they build the so-called rampa or better "rampa complex" (Fig. 4).

Following the "rampa" theory, the lakes of the natural park have been established by the damming of the secondary valleys of the Rio Doce.

The study of the interfingering lake and slope sediments must allow us to provide ample information about the palaehydrological evolution of the area as a whole.

RECENT FIELD WORK.

Several drillings have been carried out in such sediments along the shores of the Lake Jacaré (DE MEIS, 1976 and VAN OVERLOOP, 1978) (Fig. 5).

DE MEIS, 1978, established a first stratigraphical approach of the aggradation area of the Lake Jacaré and subdivided the lithological section into several lithological units which have been partly taken over in a detailed lithological section (VAN OVERLOOP, 1981) (Fig. 6).

DESCRIPTION OF THE LITHOLOGICAL SECTION (Fig. 6).

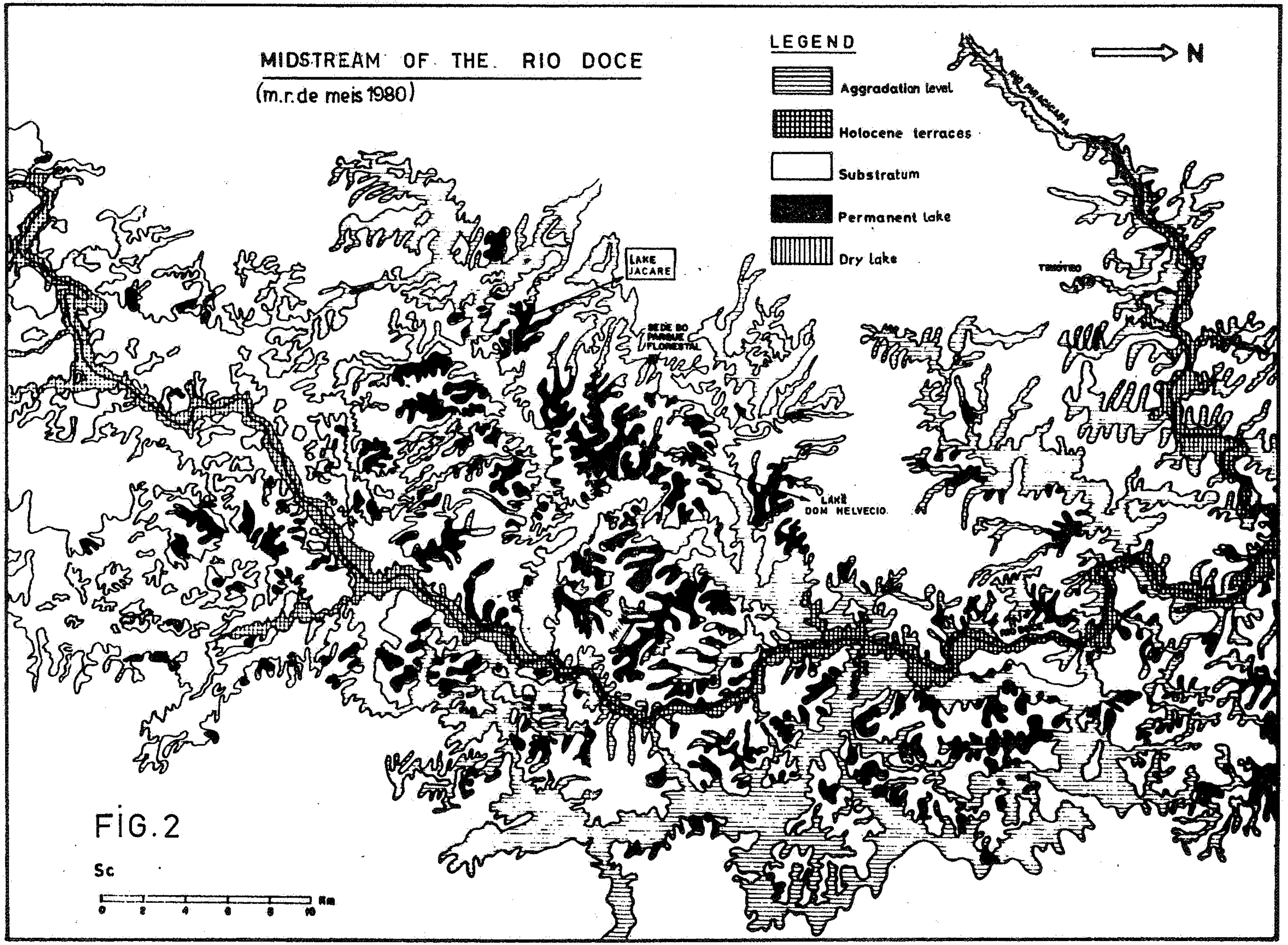
Unit 1 represents the weathered bedrock.

Unit 2 is built up of silty clay. According to DE MEIS, this unit gives a withness of older rampa activities, maybe of Middle Pleistocene age.

Unit 3 consists of silt with angular quartz nodules. This sediment has got all the properties of a structureless rampa-sediment and has been classified by DE MEIS amongst the Middle Pleistocene rampa generation. This rampa is here called rampa e.

Unit 4 is a layer of angular quartz nodules, clearly residual of the unit 3 sediments. It finds its origin in the washing out of a part of unit 3. Unit 4 can be called an erosional surface.

Unit 5 is a thick sandy body with irregular alternation



MIDSTREAM OF THE RIO DOCE
(m.r.de meis 1980)

FIG. 2

LITHOLOGICAL SECTION OF A "RAMPA"

transition from actual aggradation areal to actual degradation areal.

(M.R.M. de Meis, 1978)

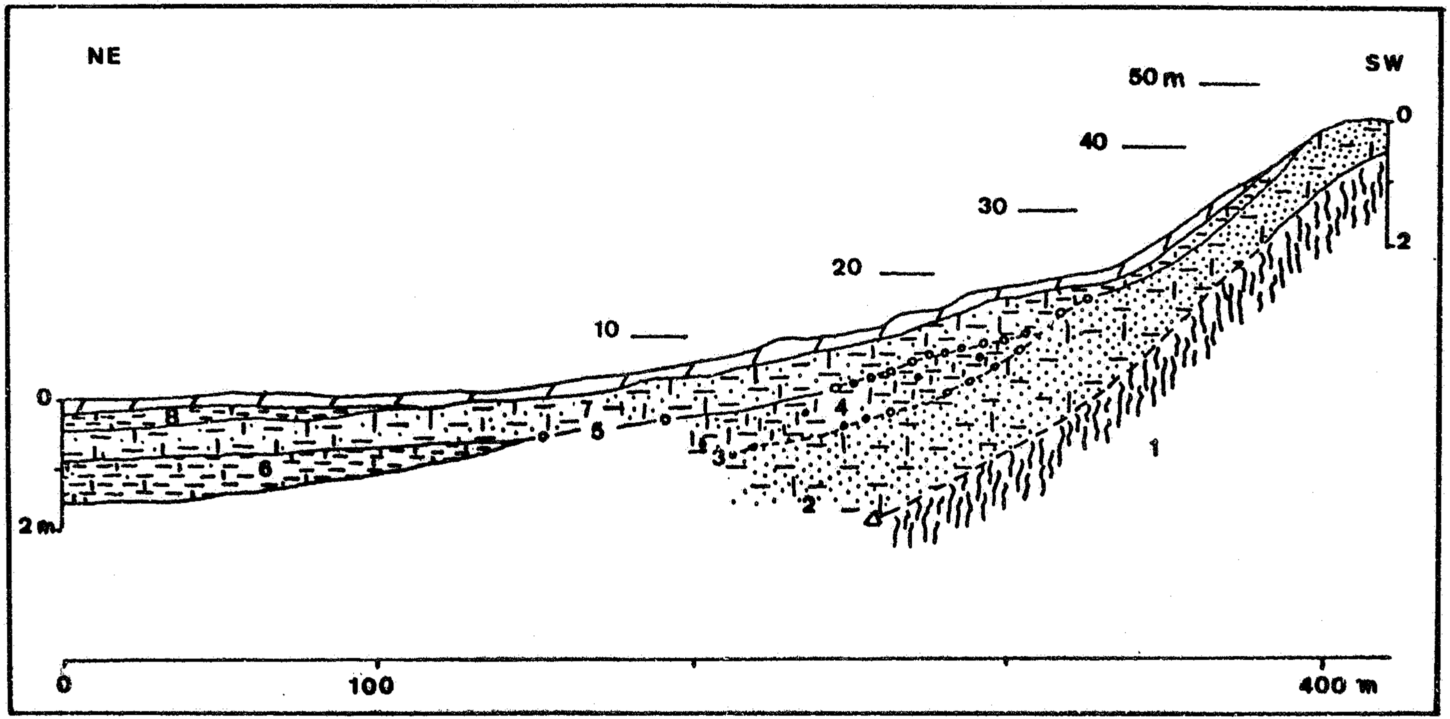


FIG.3

DETAIL of a RAMPA AREAL (M.R.M. de Meis, 1978)

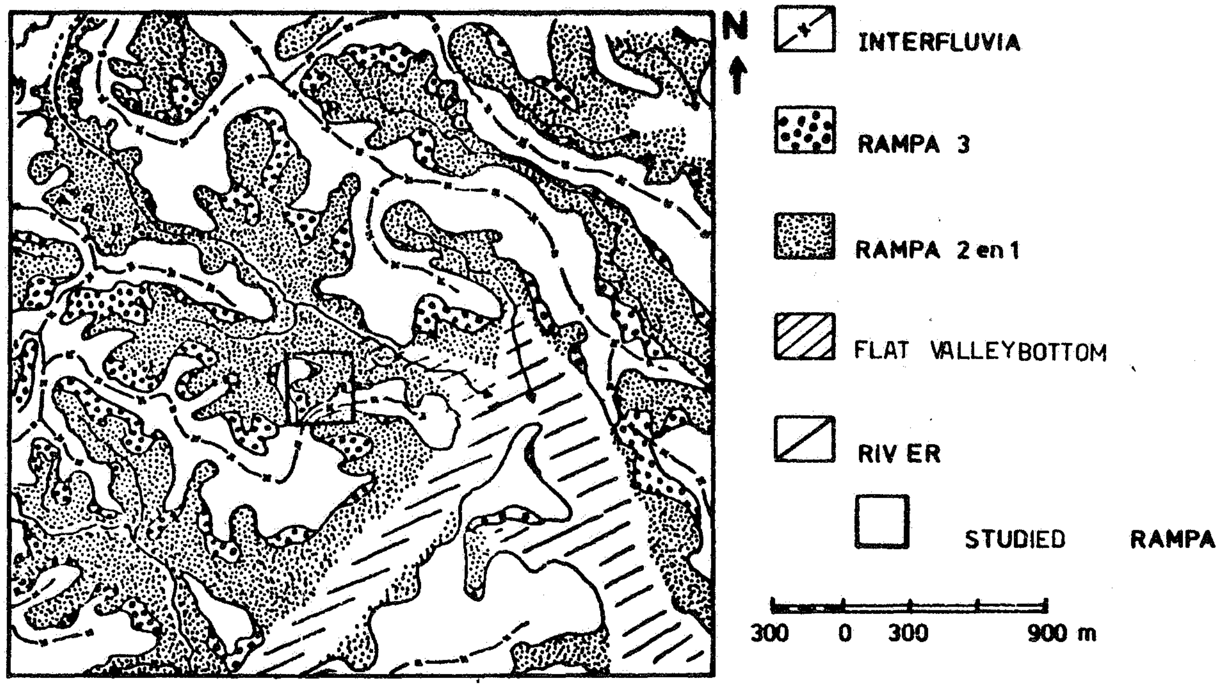


FIG.4

DETAIL OF THE JACARE LAKE BASIN AND LOCALISATION MAP OF THE DRILLINGS.

(M.R.M.DE MEIS.1978)

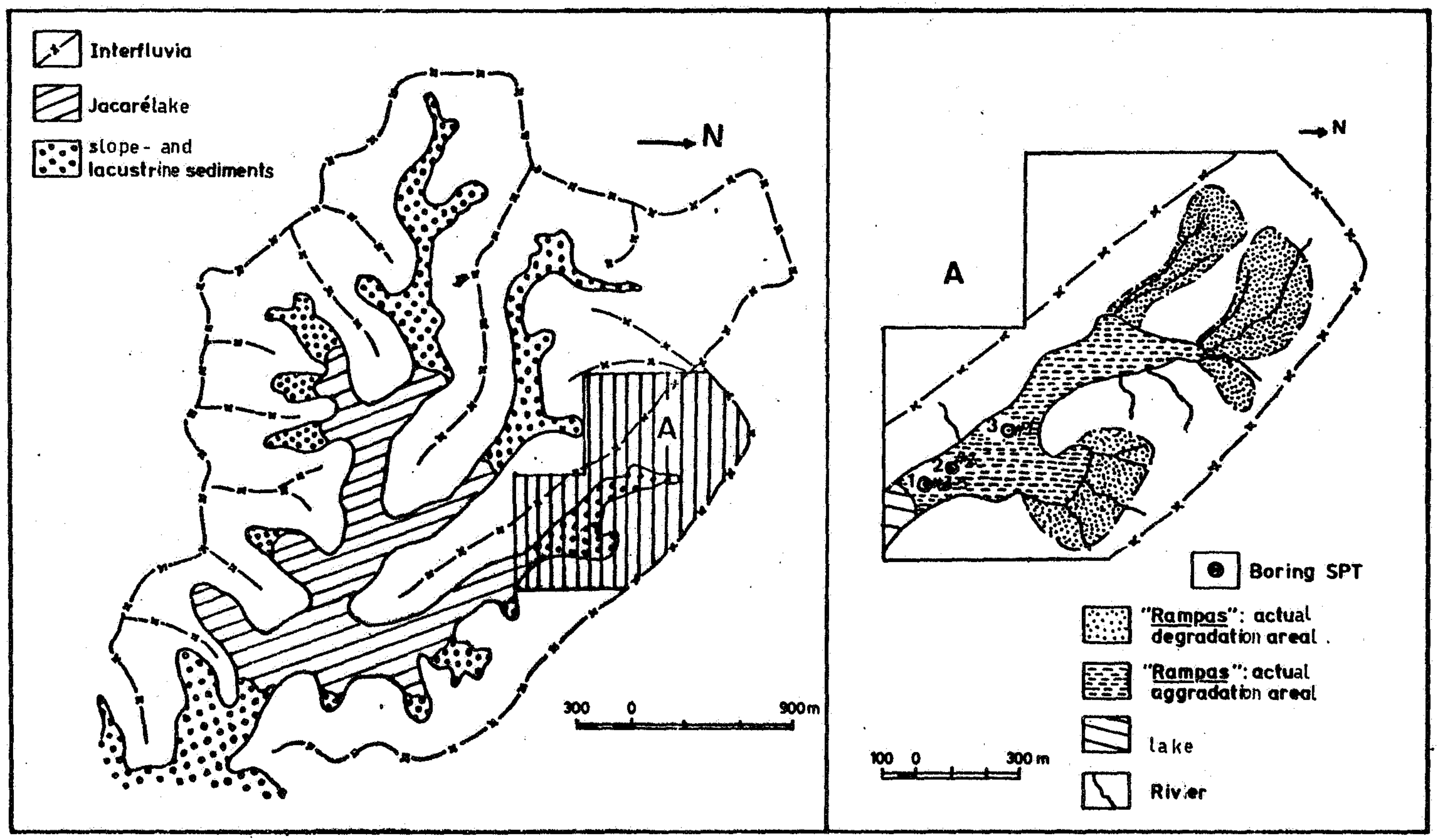


FIG.5

of silty, clayey and coarse sand layers. According to DE MEIS, 1978, this 5 to 7 m thick unit corresponds to the early Holocene upfilling phase, already mentioned by PFLUG, 1978, see later. It corresponds also with a new rampa generation, DE MEIS's "rampa 2" generation, called here rampa d. At the end of unit 5, an erosional phase seems to have taken place. A short period of standstill of processes must have occured, since a small soil formation appears, say unit 6.

The standstill was followed by a new erosional phase, which took away a part of the soil.

Unit 7 shows first very organic gyttya, followed by a well developed peat layer. This peat layer has been investigated for pollen and spores. The palynology showed that this peat was the beginning of a transgression of the Lake Jacaré. Its base has been C-14 dated by DE MEIS, 1978, giving an age of 9840 ± 220 BP.

Unit 8 is built up from very well sorted sand. The base is composed of coarse sand, followed by fine sand and ending in silt. This unit appears as a new rampa, which has been formed during the existance of the lake (see further in the palynological part.) We call her "rampa c". The rampa filled up the lake for a great deal.

Next unit n° 9 is again composed of gyttya followed by peat. This peat layer is supposed to be the end of the extension of the lake; which regressed again. It has been dated by DE MEIS, at the base on 9840 ± 250 BP and at the top on 3365 ± 155 BP. The lake seems to have extended from about 9800 BP untill about 3300 BP.

The sediments of unit 10 seem again to represent a rampa phase. They are coarse sand.

Follows fine alluvial clay (unit 11) with an intercalation of the very youngest rampa cycle, rampa a which is represented by unit 12, consisting of alternations of coarse, gravelous and fine sand.

CONCLUSIONS :

The lithology shows a clear alternation of rampa-, lake- and alluvial sediments. There are three Holocene rampa cycles, of which one occurs during the full existance of the lake.

There seems to have been a standstill of processes around the transition of the Pleistocene into the Holocene (unit 6).

Further on, the palynology will outline more details about the existance of the lake.

THEORIES ON THE ORIGIN OF THE LAKES.

PFLUG (1968) explained the damming of the tributary secondary valleys of the Rio Doce as follows :
after incision of these valleys into the bedrock during the Last Glacial Stage filling up of the Rio Doce with very coarse clastic materials started and thus heightened the floodplainlevel to about 20 m. Though the same happened in the large valleys coming from the mountains, it did not occur in the small tributary valleys which therefore have been dammed. An analysis of the damming sediments showed a semi-arid climate, whereas a 14-C datation of some organic material of this terrace yielded an age of 14.160 ± 500 BP.

The damming of the valleys also caused the origin of the lakes, which therefore are estimated to be Late Glacial or Early Holocene in age.

The transition of the very coarse upper glacial sediments that caused the damming, into the finer ones preluding a new transgressive phase has been dated : 10.340 ± 190 BP and 10.220 ± 225 BP. (DE MEIS, 1978).

It points to the fact that whilst from the beginning of the Holocene the Dio Doce started to incise her own sediments, the "Upper Pleistocene" lakes went on to exist in an allmost unchanged ecological system. The interfingering of rampa, lake- and fluviatile sediments shows nevertheless a changing of the environment as a whole.

DE MEIS (1978) explains in her "rampa" theory the detailed evolution during the Holocene in the dammed tributary valleys. River aggradation corresponds to high rates of slope erosion and river degradation i.e. incision to low rates of slope erosion. For the lakes the contrary seems to be true. High rates of slope erosion go together with lake regression and low rates of slope erosion with lake transgression. The whole system responds very well to the changing palaeohydrological conditions.

From several drillings that have been carried out (see fig. 7) drilling SPT 3 has been selected for sampling of the peat layer (Unit 7) for pollen analysis.

THE PREPARATION OF THE POLLEN SAMPLES.

The pollen have been treated in the Hugo de Vries laboratory, Amsterdam, the Netherlands.

The preparation went over cooking with KOH, 10 % solution (FAEGRI & IVERSEN, 1975) acetolysis (ERDTMAN, 1960), ultrasoning for less than 5 minutes and floating by Bromophorm-alcohol mixture. Thirteen samples (numbered from 1 -13) have been taken out from the drilling respectively at the following depths in cm :
522 - 534 - 550 - 560 - 575 - 592.5 - 617.5 - 637.5 - 657.5 - 682.5 - 702.5 - 722.5 - 742.5.

We stated that all pollen from lake sediments and peats accumulated in situ whereas pollen of rampa sediments may partly be reworked.

THE CONSTRUCTION OF THE POLLEN AND SPOREDIAGRAM (FIG. 7).

Per sample, 750 to 1.300 pollen and spores have been counted. Very little arbor pollen have been counted with regard to the amount of spores and grasspollen. Therefore no separate AP diagram has been established. All pollen and spores are included in the pollensum. In order to clearly distinguish characteristics of the vegetation assemblages a subdivision into families and species is provided, say : *Wood elements; Water plants; Compositae and Plantago; Gramineae; Cyperaceae; Ferns* (monolete and trilete spores); other spores and ascopores.

Each vegetation group is further subdivised into the representing families and species in addendum. The diagram will not provide us with direct palaeoclimatic indications, but gives a clear picture of the local palaeoecological and soil-conditions.

Because of their general small amount of pollen, families and species of the vegetation groups I, II, III and the

Gramineae are drafted on a scale which is 5 times the scale of the general diagram. The scale used for plotting out the *Cyperaceae* and the spores is half the scale of the general diagram, because of their abundance.

The general diagram is accompanied by a detailed lithological section with a depth indication for which each interval of 20 cm corresponds to the 10 % interval on the pollendiagram.

The pollen and sporediagram is subdivided into four local pollenzones : A, B1, B2 and C.

Pollenzone C is defined by the existence of cooler and drier wood elements, and the maximum extent of *Gramineae*.

Pollenzone B1 and B2 shows the appearence of *Palmae*, the maximum extent of nonfern spores and *Salicaceae*.

Pollenzone A in general points to an increase of the warm wood and water elements and a quick decrease of non-fern spores.

DETAILED DESCRIPTION AND INTERPRETATION OF THE POLLEN ZONES.

In this chapter detailed description of each of this pollen Zones will be given in normal chronological sequence i.e. from oldest to youngest in order.

For each of the Zones concerned will be aimed at an ecological interpretation.

ZONE C :

This is the lowermost Zone situated at the very start of the Holocene which shows besides a very large amount of nonfernspores, high rates of *Trilete* fernspores, *Gramineae*, *Compositae ulifloraetub* and woodelements. The amount of waterplants and *Cyperaceae* is relatively now.

The special aspect of this zone is represented by rather high amounts of *Ericaceae*, *Byrsonima*, *Compositae tubuliflorae* and *Gramineae*.

Ericaceae are shrubs which nowadays are found in the very South and South-East of Brasil, at an altitude of more than 2.100 m and on the highest mountains of the subtropical Serra's at an altitude of minimum 1.350 m., where night temperatures down to -4°C may be observed (BARROSO 1978, WETTSTEIN 1970).

Byrsonima is the only species of the family of the *Malpighiaceae* which grows under dry conditions and has been defined to be a typical savannah-member. V.d. HAMMEN, 1961, stated that *Byrsonima* was commonly growing on natural fireburnt, very hard savannah soils in British Guiana during the last Glacial. Heavy thunderstorms occures in the (very dry) dry season. The lightings caused natural fires. (V. d. HAMMEN, 1966, ABSY, 1978 and WETTSTEIN, 1970).

In the actual cerrados of Brasil, *Byrsonima* takes 17 % of the total amount of *Malpighiaceae* (WARMIMG and FERRI, 1973). The cerrado is known as being the vegetation type of the cooler and drier areas in the inner country of Minas Gerais (Brasil).

The *Compositae* are often highly represented in the vegetation types of the high mountain zones of the coastal Serra's (KLEIN, 1961-1975) and of the savannahs of Southern Brasil (WETTSTEIN, 1970). These latter plants prove, together with the very high amount of *Gramineae*, the presence of a shrub savannah, growing most probably under drier and much cooler conditions than today.

The surprising high amounts of *Liliaceae* , a family which has nowadays disappeared from the cerrado region in Minas Gerais (WARMING and FERRI, 1973), points to the presence of a different but drier vegetation.

Furthermore the presence of *Ranunculaceae* (which grow today maintly in the Southern and high altitudinal Western provinces of Brasil (BARROSO, 1978), of *Salicaceae* wich also today are lacking in the Cerrado in Minas Gerais, (WARMING and FERRI, 1973) and which are mainly growing today in the temperate and subtropical regions of the world (LANJOUW, 1968) i.e. in the very North and South only of Brasil are all witnessing of cooler conditions.

During the last Glacial in British Guiana (V.d.HAMMEN, 1966) a very dry season alternated with strong rains in the wet season. The very hard savannah soil was thus innundated.

There must have been left marshy patches of standing water in the shrub savannah because of the presence, although restricted, of *Typhaceae, Hydrocharitaceae, Plantago and Onagraceae,* and of ferns. *Salicaceae* also could grow on these humid places.

Towards the end of Zone C, the appearance of two taxa may be observed : *Palmae* and *Compositae liguliflorae.* Some very small amounts of *Myrtaceae, Araliaceae, Onagraceae* and especially the arrival of *Palmae* seem to prove altogether that temperature was steadily rising. Actually these plants are known to be mainly of tropical and subtropical origin.

In addition to the above one may wonder if human influence was not already preponderant, for which following points are to be considered :

1° Plantago occupies only the cultivated areas of the cerrado of Minas Gerais (WARNING and FERRI, 1973);

2° *Ranunculaceae* are found in most of the culture crops of the cerrado;

3° *Compositae* liguliflorae in the cerrado are for 66 % cultivated;

4° *Byrsonima* is a common invader of the so-called "queimadas" (fire burnt surfaces of the South of Brasil) (WETTSTEIN, 1970).

ZONE B :

Zone B may be subdivided into a lower Zone B1 and an upper Zone B2.

Zone B1 corresponds with the bottom of the very peat layer. In this Zone many taxa disappear. This is the case for the *Myrtaceae* ,, the *Liliaceae,* the *Ranunculaceae,* the *Ericaceae, Byrsonima,* the *Araliaceae, Platycarya,* the *Hydrocharitaceae* and *Plantago,* of which only the *Myrtaceae* will reappear in the upper Zone. *Byrsonima* and *Salicaceae* are still present in this Zone. The *Compositae tubuliflorae* are extinguishing after a small uprise. At the end of Zone B1 a maximum extension of non-fern spores is outlined.

Zone B2 corresponds with the end of the very peat layer. It shows a diminishing of the non-fernspores in favor of the fernspores and the *Cyperaceae.* The amount of *Palmae* is almost constant. The taxon of *Salicaceae* provides its maximum extension whereafter it disappears. *Byrsonima* and *Compositae tubuliflorae* disappear entirely together with the *Gramineae* at the end of the Zone. The taxon of the *Onagraceae* reappears as well as the *Polygonaceae. Rosaceae* and *Campanulaceae* are poorly represented.

Generally, the Zones B1 and B2 show a moistening of the soil. It goes along with an extension of the non-fern spores amongst which *Algae* could be recognized. When the non-fern spores are regressing they make space for fern spores and *Cyperaceae* pollen. The *Salicaceae* attain now their maximum extension. These factors point to swampy conditions, during which humidity seems to have been so high that plants such as *Byrsonima*, *Gramineae* and *Compositae* hardly could stand.

The air temperature must still have been lower than today, since there are still *Salicaceae*, this time together with *Campanulaceae*, which latter also grow mainly in the temperate and subtropical regions (LANJOUW 1968). Moreover, there is even no extension of the *Palmae*. Towards the top of the Zone B2, soil conditions still grow wetter, as proved by the rise of *Onagraceae* and *Polygonaceae* together with *Cyperaceae*.

The lack of pollen in Zone B as a whole may be due to very bad (basic peat) conservation conditions in the peat, or to the very poor pollen rain on this very spot in relation to the growth of the peat.

ZONE A :

This part of the pollen diagram shows a very rapid expansion of the woodelements, the water plants, *Compositae*, especially the *tubuliflorae*, *Plantago*, fern spores, and towards the end of the Zone, also of *Gramineae* and *trilete* fern spores. The taxon of non-fernspores regresses quickly and constantly, whilst at the end of the Zone there is a regression of the *monolete* fernspores and *Cyperaceae*.

A notaciable expansion is made by the *Palmae*, the *Labiatae*, the *Hydrocharitaceae*, *Hedyosmum*, *Nympheae*, *Compositae tubuliforae*, *Gramineae* and *trilete* spores.

The impressive and sudden progress of water elements such as *Hedyosmum*, *Hydrocharitaceae*, *Onagraceae*, *Nymphae*, and even *Scrophulariaceae* and *Polygonaceae* prove the presence of an open lake with standing water. The swampy conditions disappeared to a great extent which may readily be seen from the regression of non-fernspores and *Cyperaceae*.

The good representation of the families and species of *Palmae*, *Onagraceae*, *Proteaceae*, *Myrtaceae*, *Hedyosmum* and *trilete* spores (these spores represent the tree-ferns) seem to indicate warmer and more humid environmental conditions. The whole assemblage of plants points to a tropical-atlantic rain-forest although it seems still to be drier at the end of Zone A where *Gramineae*, *Compositae*, *tubuliflorae* and *Myrtaceae* develop abundantly. If such evolution is to continue, climatic conditions may become drier and warmer, say an evolution towards an open park savannah, where *Palmae* are dominant.

CONCLUSIONS.

The diagram shows a definite change of the vegetation before and after the formation of the peat layer.

The drier and cooler taxa of pollenzone C represent a vegetation that is nowadays commonly growing in the very South and the southern mountaineous areas of Brasil, make place in pollenzone A for families and species now present in a tropical to subtropical rain forest.

It may be stated that on the transition from Preboreal to Boreal the environment changed from cooler and drier than today to warmer, and more humid conditions almost similar to the present ones. This goes along with a change in vegetation from a cool shrub savannah into a vegetation allmost similar to a warm-humid subtropical atlantic rainforest. It is quite feasible that a period of draught occurred towards the end of the Boreal (end of pollen Zone A).

It has been proved that the start of deposition of the peatlayer is not contemporaneous of the installation of the lake itself; it has only been a wettening of the soil into a marshy swamp. Indeed, the very transgression started at the end of the peat layer development where the pollen of the water plants are found, to form a Boreal lake. The 14-C datation at the bottom of the peat layer yields an age of 9840 BP (DE MEIS, 1978), so that the very lake could only come into being during the Boreal.

Before the formation of the lake, relicts of the Post-Glacial Stage could survive changing environmental conditions at the beginning of the Holocene but most probably moistening of the soil has chased them out of the region definitively.

With regard to the rampa theory as developed by DE MEIS (1978 - 1980) - (see higher), stating that lake transgression coincides with the end of rampa formation it is concluded that this very end of the Post Glacial rampa cycle (rampa d, see fig. 6) should be placed in the beginning of the Boreal.

ACKNOWLEDGEMENTS.

In the first place the author feels profoundly indebted to Prof. M. Regina Mousinho DE MEIS, Head of the Dept. for Geomorphology of the Universidade Federal do Rio de Janeiro for her invitation for a joint project in the Rio Doce Basin. Second, it is with a feeling of profound gratitude that the help of Prof. van der HAMMEN and of members of his Laboratory is hereby remembered.

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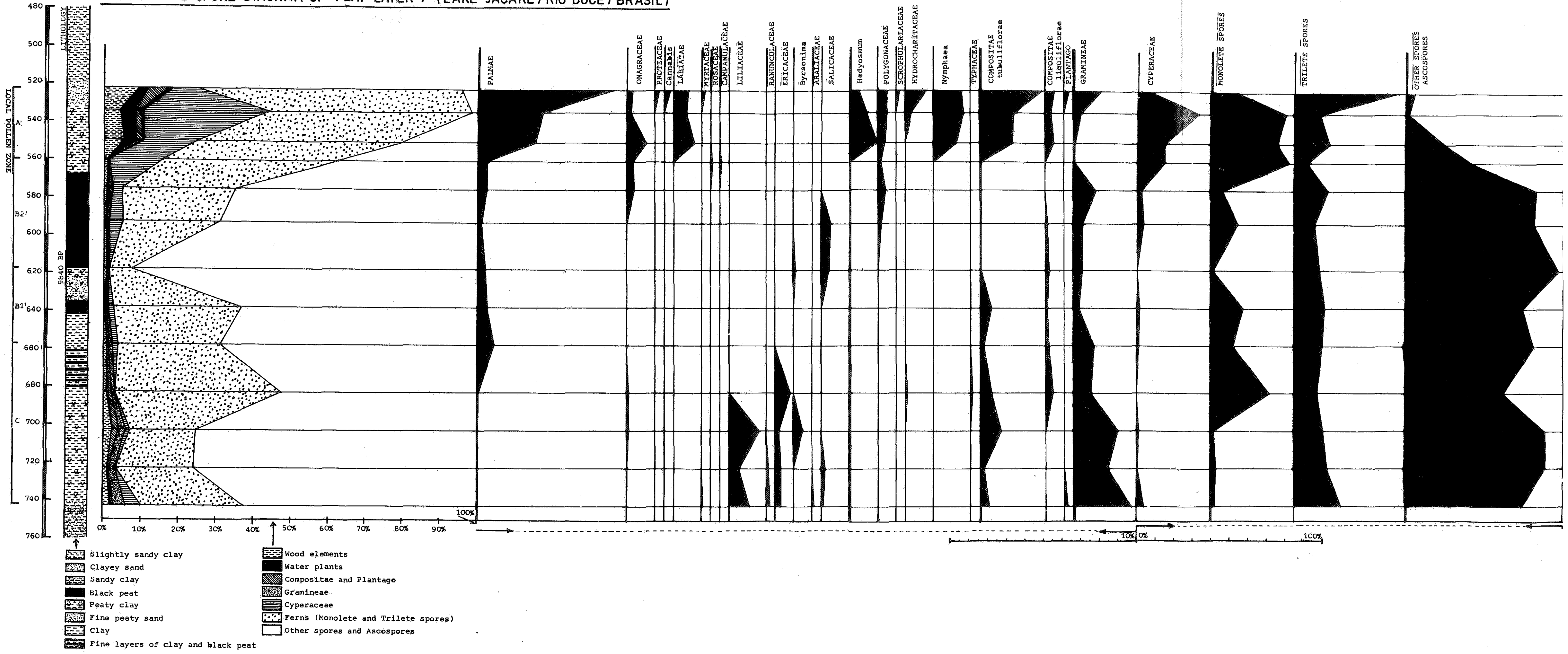
FIG.7 POLLEN AND SPORE DIAGRAM OF PEAT LAYER 7 (LAKE JACARÉ / RIO DOCE / BRASIL)



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