ATTEMPT AT A POLLEN CHRONOLOGY IN QUATERNARY FLUVIATILE DEPOSITS

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(Received 1. Mar 1965.)

The bore samples analysed derive from the site of one of the alternatives of the Tiszalök Storage Dam Project. In this area a number of prospect holes 25 m deep aligned in the axis of the prospective short-cut and 5 not aligned ones about 60 m deep were penetrated into the ground. These latter were selected for analysis because prospect holes of such depth have been uncommon in the Hungarian Great Plain. The fossil wood-remains from these boreholes were treated and published in the present journal by P. GREGUSS and J. MATUSZKA (1957). The layout of the boreholes is presented in Fig. 1.

Some of the boreholes studied (Nos I, IV, V) were located on a Pleistocene surface covered by loess where the latter is overlain only in some places by Holocene flood-plain deposits or by meadow soil. Two boreholes (No II, and No III) were, in turn, penetrated in the territory of an old basin which in the Holocene had first been eroded and then filled nearly up to the level of the Pleistocene surface. The spacing of the boreholes varied between 200 and 300 m.

The pollen material was recovered from the bore samples by ERDTMANN—ZÓLYOMI's method of separation by specific weight using zinc chloride.

The results of the analysis of the samples from the 60 m boreholes are represented in diagrams, where the figures for each borehole are given at proper height above sea level. The left-hand column of each diagram shows the lithofacies of the sediment penetrated, the central one the arbor pollen spectrum (AP=arbor pollen), the right-hand one the percentage composition of the non-arbor pollen (NAP=non-arbor pollen), while the right margin indicates the density of pollen grains in an opposite direction (from the right to the left). In the centre of this column the signs of the defined or supposed climatic phases have been given. The numbers on the right margin of the central column indicate the total amount of pollen grains counted in the respective layer. This is devoted to checking the reliability of the pollen patterns. Any statistics based upon the frequency distribution of the specimens analysed provides reliable information only above a certain number of observations, the information obtained from a very small number of observations being rather biased. Nevertheless, for lack of a sufficient number of data, the percentages obtained from very limited numbers of pollen grains have also been indicated, though such a composition has to be handled with precaution. The areas of completely sterile deposits have been left blank.

In the pollen diagrams the individual plant species are grouped according to their role as climatic indices. On the left-hand side the eurythermous deciduous trees are indicated, starting with the forms requiring a rather balanced and humid climate, first of all with *Abies*, a genus requiring the highest humidity. In the centre the coniferous species most tolerant of cold and drought, on the right-hand side the deciduous trees requiring little heat, but more humidity than the conifers, are represented. This order of succession is most clearly reflected by the legend. Accordingly, the levels characterized by a greater abundance of deciduous trees are roughly indicative of a more oceanic, milder climate, while those enriched in pollen grains of conifers indicate a more continental and colder climatic phase. Owing to the unproportionately higher pollen production of the conifers and to the higher resistance of their pollen-tubes to any attaque, the quantitative ratio of the deciduous trees to the conifers in the pollen spectrum is even for the mild climatic phases smaller than it must have been in the original association of trees. Thus, the interglacials and interstadials are indicated in many cases merely by the absolute presence of the eurythermous deciduous trees, irrespective of their ratio to the conifers.

The signs and symbols of fossil wood-remains determined by GREGUSS and MATUSZKA (1957) have been placed to the left of the depth scale on the left-hand margin of each bore column. Those finds of fossil wood which are indices of the same climate (e.g. *Pinus montana* and *P. silvestris)* and which can not be separated convincingly on the basis of their fabric either (e.g. *Picea* and *Larix*), have been united.

The distribution of wood remains corresponds in most cases quite well to the nature of the climatic phase determined on the basis of pollen content. In a few cases a contrast appears to exist between the two, chiefly when the pollen spectrum has been plotted by relying on very poor information. In these cases the authors had to resort to fossil wood finds which required to modify the original conclusions drawn merely from the pollen spectrum.

Of course, the fossil wood remains alone did not permit to determine climatic phases, the less so to trace their boundaries, since wood remains were found in particular beds only. However, apart from a few exceptions, pollen grains were present in every stratum, therefore, the changes in the climatic phases could be continually traced. Where there were many sterile layers, the age symbols were omitted.

In the diagrams of boreholes penetrating to 25 m depth the percentage ratio of the secondary pollen assemblage to the total of tree pollen grains are indicated in the areas showing pollen density. The redeposited Late Tertiary species such as *Pinus haploxilon* are members of *Juglandaceae* and *Ulmaceae*.

STRATIGRAPHIC SUBDIVISION

Pollen patterns of Holocene deposits

The profile constructed on information from the aligned 20 to 25 m boreholes shows lithofacies quite different from those of the Pleistocene. Thus it is clear that the Holocene alluvium reaches down to 10—20 m depth.

The Holocene is made up predominantly of finer-grained sediments which are commonly free of carbonates, in contrast with the Pleistocene represented by coarse-grained sands, gravels and in the upper horizons mostly by carbonate sediments. The differences in sedimentation and/or the boundary between the Pleistocene and Holocene beds are unambiguously reflected by the pollen spectrum, too.

The changes in the patterns of vegetation since the last glaciation are known in detail from data furnished by the palynological study of Hungarian peat bogs and particularly of bottom samples from Lake Balaton (12) and can be well correlated with occurrences outside Hungary (4). A correlation with these data permits even to give a detailed chronology of the Holocene series of these two boreholes.

X. Age of utilized and cultivated forests (present sub-Atlantic). This level is characterized, along with the present forest patterns, by the occurrence of cultivated *Gramineae*. In borehole No II the conifers are stock-forming, which is due to the limited amount of pollen grains.

IX. Beech Age (early sub-Atlantic). Along with the predominance of *Fagus*, some eurythermous deciduous trees such as *Carpinus*, *Quercus*, and *Tilia* are represented by high percentages. At the lower boundary of this level the ratio of *Abies*, a form adapted to continental climate, also becomes considerable, attaining about 10 per cent.

VIII. Age of Oak-Beech forests (subboreal). The afforestated areas must have been very extensive, since the relative amount of non-arbor pollen grains is small, the ratio of *Gramineae* being subordinate even within this group. As regards cultural layers, this level coincides with the Late Neolithic and the Bronze Age, its bottom being dated from about 2500 B. C.

VII. Younger age of mixed Oak (Atlantic). However, as to the Oak Age, the beds under consideration appear to represent its upper part only, as the representatives of hazel-nut, a form that should have to play a remarkable role in the earlier part of this age are completely lacking here. The same holds true of the representatives of the Hazel-Nut and Pine — Birch Ages. Below the Late Holocene deposits, through a great lacune, the boundary level of a glaciation is found, which is underlain by the deposits of an interstadial. Accordingly, in the deeper, northern reaches of the channel of the ancient Tisza the accumulation must have begun not earlier than in a later phase of the Oak Age, while in its shallower, southern parts it took place in the Beech Age.

Pollen patterns of the Pleistocene series

As noted above, the Pleistocene surface is made up everywhere of loess deposited during the last glaciation. Because of the rapid accumulation of fluviatile sediments, the material of the older loess levels is quasi „lost" within the sediments deposited in river water, just the same way as found to be the case with most of the Trans-Tisza Region. Owing to its low position, this last loess level was also covered by a thin blanket of flood-plain clay during the floods of the Tisza in most recent times.

The pollen patterns of the Wurmian glaciation are far from being uniform. In the uppermost glaciation stage W_{III} the amount of pollen grains is reduced, compared to their abundance in the Holocene. And where the profile begins with these sediments, the stock is represented almost entirely by Scotch fir pollen with some pollen grains of spruce. The subarctic coniferous tundra phase W_{II} is represented by the high percentage of *Selaginella*, along with an otherwise rather poor grass vegetation. In the subarctic coniferous association of W_{II} *cembra* pine also appears.

Between W_{III} and W_{II} there are birch groves with willow indicative of a very short subtropic influence which was not even able to melt the ice of W_{III}. The stadial of W_{I} is indicated by the consistent occurrence of *cembra* pine added to *Pinus silvestris*. In this part of the profile *cembra* pine is largely represented among wood remains, too. This period appears to have been the most severe of all the Wurmian stadials.

Thereafter a change of the climate for the better is readily shown by the appearance of *Carpinus*, along with *Quercetum mixtum* e.g. in borehole I where this very fact, together with the high pollen density, clearly indicates the presence of the R—W interglacial.

After this long interglacial phase, the subsequent glacial one of R_{II} is readily recognizable in the rich pollen spectrum consisting of the representatives of *Conifera* either purely or with a slight admixture of birch, suggesting more humidity. R_{I}, a glaciation phase of short duration like R_{II}, differs from the foremr only by that its pollen spectrum suggests the subarctic coniferous vegetation to have included some grassy thicket, too. The diagrams clearly indicate the possibility of an acclimatization of mixed forest in the period between the two glaciations.

The stratigraphic column of the 60 m boreholes ends by the mixed forest spectrum of the M—R interglacial which seems to extend beyond the depth range penetrated.

Thus, in the whole series exposed a total of five levels with glacial pollen spectra have been found which are added to by subglacial ones.

Theoretically, a subglacial climate ought to appear immediately before and after a glaciation which is found, indeed, to be true for a few cases, e.g. for that between the last and next to the last glaciations in borehole No I. *Divergencies from the rule seem to be mainly due to the fact that a fluviatile sequence is never complete,* as the river depositing its waste *sometimes acts as an erosive agent* even in case of a sedimentation of lower course type. Consequently, *following the cases, it is either the lower or the upper part of the sequence of glacial or subglacial pollen pattern that has been* preserved. Yet, incomplete as it is, it indicates well the presence of a cold phase.

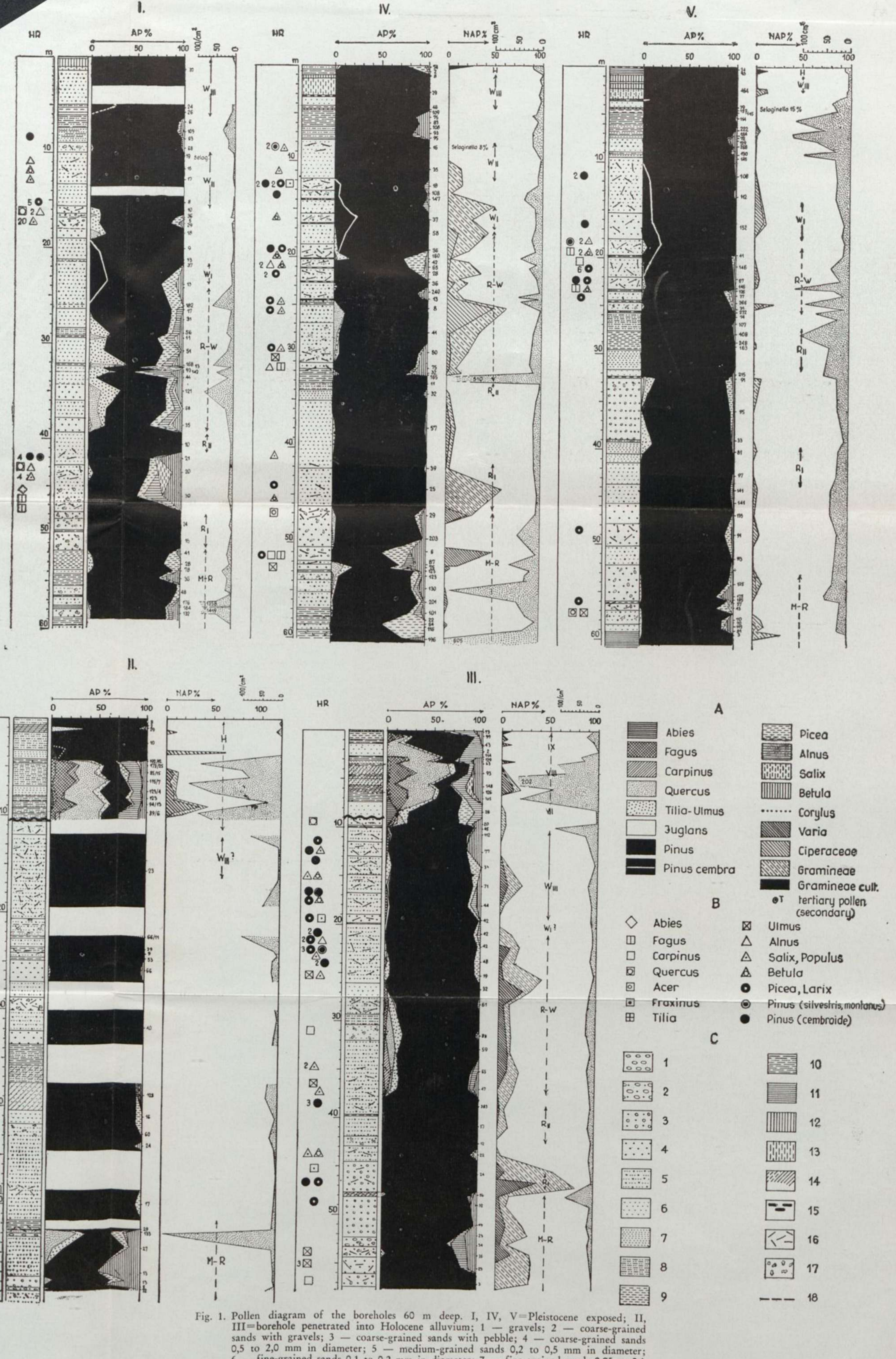

Fig. 1. Pollen diagram of the boreholes 60 m deep. I, IV, V=Pleistocene exposed; II, III=borehole penetrated into Holocene alluvium; 1 — gravels; 2 — coarse-grained sands with gravels; 3 — coarse-grained sands with pebble; 4 — coarse-grained sands 0,5 to 2,0 mm in diameter; 5 — medium-grained sands 0,2 to 0,5 mm in diameter; 6 — fine-grained sands 0,1 to 0,2 mm in diameter; 7 — fine-grained sands 0,05 to 0,1 mm in diameter; 8 — fine-grained silty sands; 9 — silt with fine-grained sands; 10 — clayey silt; 11 — clay; 12 — loess; 13 — sandy loess; 14 — humic layers; 15 — peaty layers; 16 — layers with vegetal remains; 17 — calcareous concretions; 18 — groundwater table.

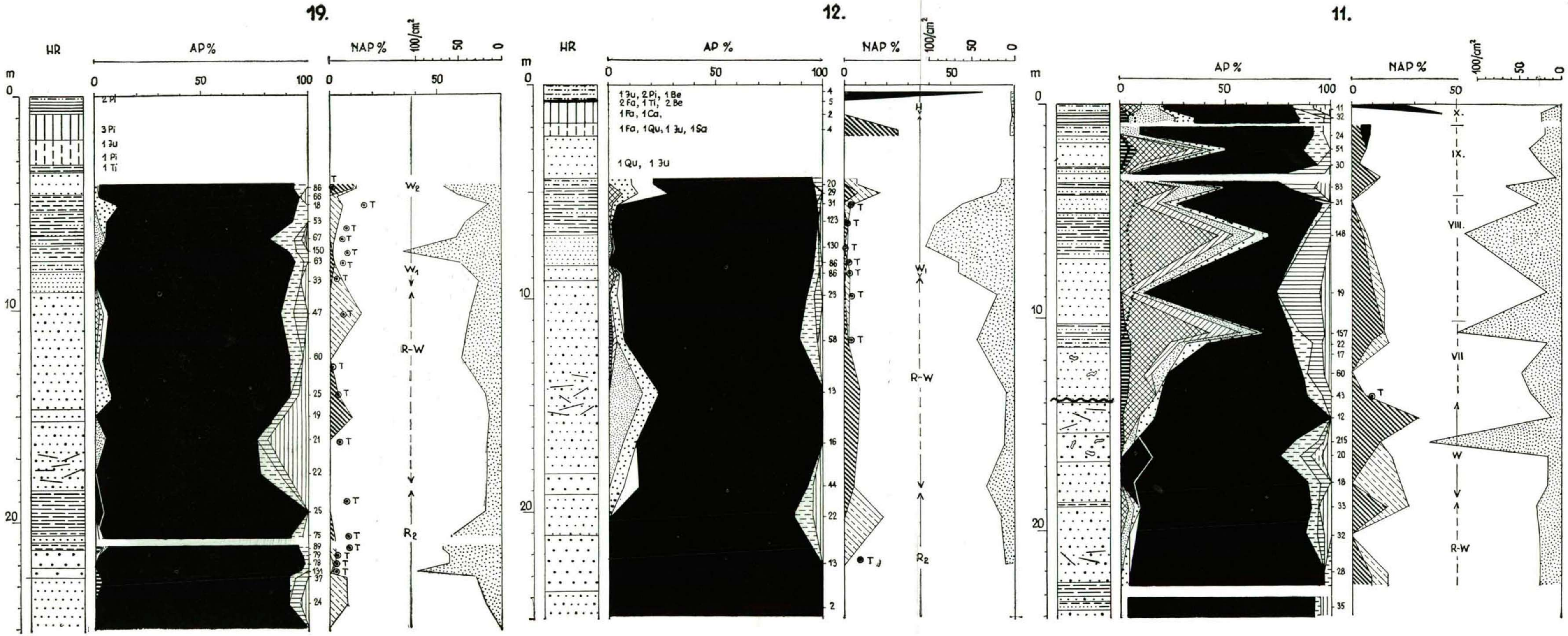

Fig. 2. Pollen diagrams of boreholes Nos 19, 12, 11 within the geological section A_2.

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