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THE PROBLEM OF FLORISTIC BOUNDARY BETWEEN PLIOCENE-PLEISTOCENE IN WESTERN CARPATHIANS MTS. ON THE BASIS OF PALYNOLOGICAL EXAMINATION

(Figs. 1–3)

A b s t r a c t. A detail pollen analysis of samplex from Upper Pliocene and Pleistocene gave results important for the differentiation of Upper Pliocene and Pleistocene, in addition to stratigraphical data. It has been stated that there is a certain climatic boundary between Pliocene and Pleistocene, not, though, so conspicuous as in Western Europe. With respect to palaeoclimatology, the authoress present the probable climatic curve between Pontian and Riss-Würmian. The climatic curve at the beginning of Pleistocene does not display such a conspicuous deviation as that of Western Europe (W. H. Z a g w i j n). According to the decrease or extinction of some Pliocene species certain cooling of climate may be also supposed in our region.

Р е з ю м е: Подробным пильцевым анализом образцов из верхнего плиоцена и плейстоцена были достигнуты результаты не только стратиграфические, но и важные результаты в вопросах отличия верхнего плиоцена от плейстоцена. Обнаружилось, что существует определенное климатическое розграничение между плиоценом и плейстоценом, хотя оно не так выразительно как в Западной Европе. Исходя из палеоклиматического состояния я предлагаю правдеподобную климатическую кривую начиная понтом по рисс-вюрм. Климатическая кривая вначале плейстоцена не показывает так выразительное отклонение как в Западной Европе (по В. Г. Загвиину). Однако исходя из убывания или исчезновения некоторых плиоценовых видов можно предполагать определенное охлаждение и в нашей области.

Introduction

The Pliocene-Pleistocene boundary from the view of palynology has been examined mainly in Western Europe, partially in Poland, and very rarely in Hungary. In our country the problem has not been examined thoroughly mainly owing to the Pleistocene formation being freshwater in its character, and to the Pleistocene sediments containing too small an amount of fosils. The earlier Pleistocene is represented by loesses and fossile soils. Analyses of numerous samples offered positive results on red soils and brown soils referred to the Earliest Pleistocene (approximately pre-Tegelenian-Tegelenian). Rich pollen material has been offered by clayey beds in southwestern Slovakia (Marcelová — Dvory) from the bore-hole VL-7. Faunistic material supported the reference of the beds to the Tegelenian. The younger pollen diagram has been gained from the soils of Central and Eastern Slovakia. These areas were rich in pollen material and the comparison with literature supports a supposition about the younger Lower Pleistocene of approximately Mindelian-Rissian interstadial. In our country, younger Pliocene

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is abundantly represented by clayey-marly beds containing numerous sporomorphs. The floristic boundary between Pliocene—Pleistocene should therefore be estimated basing upon floristic characteristics of the coloured-clay formation (Pontian of the Kolárovo formation (Rumanian) of red soils (Lower Villafranchian) of clays from Marcelová — Dvory (Villafranchian) and fossil red and grey-brown soils in Central Slovakia (Günz—Mindelian, Mindelian—Rissian). (Tab. 1.)

A	Gánovce — travertines	= Rissian-Würmian
Pliocene	Holsteinian	= Mindelian-Rissian
	clays-red fossil soils Cromerian	= Günz-Mindelian
	Waalian	= Upper Villafranchian
	Red soils = pre-Tegelenian	= Lower Villafranchian
B	Kolárovo formation = Rumanian	= Reuverian
Pleistocene	Coloured clays formation	= Pontian

I have used the comparative material of Reuverian and Tegelenian from the Netherlands. I have compared material with our results, having mainly used data by W. H. Z a g w i j n, who dealt with the problem in the Netherlands most thoroughly.

The present paper is divided into the following chapters:

1. A Brief Outline of Sediments Between Pliocene and Earlier Pleistocene.
2. The Results for Climatic Evaluation in Our Country and Their Correlation with the Results of West-European and Central-European Authors.
3. Conclusions.

Coloured-Clay Formation — Pontian

The pollen diagram of the coloured-clay formation including the results of the pollen analyses of samples from four bore-holes, led to the supposition of a sufficient palynological characteristics of the beds.

Cryptogame are rather poor as to species, although the *Polypodiaceae* family is quite numerous, less frequent being the genus *Osmunda.* In several samples spores of *Fungi,* of the family *Cyatheaceae,* of the genus *Lycopodium* and *Sphagnum* have been found. The Coniferae are predominantly represented by the genus *Pinus, Pinus Haploxylon* surpassing *Pinus silvestris* in number. Abundant is the genus *Tsuga, T. diversifolia, T. canadensis* and *Tsuga* with an extremely wide fringe. In every sample *Taxodiaceae* are constantly present. The majority of samples contain the genus *Cedrus,* some of them even in higher number. Among *Conijerae* the families *Cupuliferae, Abietaceae, Sciadopitys* are abundnat, *Larix* being rare. Most abundant is the class of *Angiospermae.* High percent representation is that of the genus *Alnus,* very abundant

almost in all the samples of the coloured-clay formation studied. Numerous are *Carya, Pterocarya, Carpinus, Ulmus, Corylus, Quercus, Myricaceae* also occur. In the samples examined also *Ericaceae, Typha,* and *Cornus* are present. A low percent of the genus *Sabal* among palms occured. Usually palms occur in Earlier Miocene, yet *Sabal* lasted up to the initial glaciation. The youngest *Sabal* representatives have been found in the (variegated series) coloured-clay formation in our country. Among other woody plants important for age determinations are the genera *Castanea, Juglans, Rhus* without permanent occurrences, yet in a comparatively great number in several samples. Woody forms predominate over the herbaceous. Among the latter most abundant were *Asteraceae, Umbeliferae, Artemisia, Liliaceae, Graminae, Chenopodiaceae, Cyperaceae.*

Kolárovo-Formation — Rumanian

In our country, clayey beds of the youngest Pliocene mostly occur in the South-Slovakian region. The age of the formation was not quite clear; still the comparison with a pollen diagram from the type locality of Reuverian showed the age analogy of the horizons. The stage has been palynologically thoroughly studied in several bore-holes.

In the profiles of some bore-holes of these beds the family *Polypodiaceae,* the genus *Lycopodium* and the genus *Sphagnum* are quite abundant.

Among *Coniferae* the Pinus-type *Haploxylon* predominates over *Pinus silvestris. Taxodiaceae* are quite numerous in several samples. Among other *Coniferae* the genera *Abies, Picea, Cedrus, Tsuga Canadensis* and *Ephedra* are represented. Consequently, there are frigophilous herbaceous types mixed with the Pliocene ones.

Most abundant are *Angiospermae.* As in the coloured-clay formation, here also the genera *Alnus, Carpinus, Ulmus, Betula, Carya* predominate. Less abundant are: *Corylus, Nyssaceae, Pterocarya, Castanea* and *Liquidambar.*

In contrast to the coloured-clay formation the NAP per cent increased here; anbling qualitative determination of the boundary between the coloured-clay formation and the Kolárovo formation. By the presence of the family *Nyssaceae* and *Taxodiaceae* however, the Villafranchian (Tegelenian) age of these sediments is excluded. In accordance with these criterii, the Kolárovo formation displays stratigraphical position different from that of the coloured-clay formation and from the Lower Villafranchian. Among NAP very abundant are *Chenopodiaceae, Umbeliferae, Papaveraceae, Polygonaceae, Hedera, Artemisia, Caryophyllaceae, Urticaceae, Ericaceae, Cyperaceae, Phragmites, Lilaceae, Graminae.* Evidently, in the Kolárovo formation there are more numerous varieties of herbaceous forms in contrast to the coloured-clay formation.

W. H. Zagwijn (1957) qouted Reuverian (Rumanian) *Sequoia, Taxodium, Sciadopitys, Nyssa, Liquidambar, Castanea, Carya, Pterocarya, Tsuga, Eucommia;* lower per. cent of the genus *Picea,* higher — *Betula,* very high — the genus *Alnus* and *Quercetum mixtum,* Tertiary types (*Carya, Pterocerya,* etc.) represented by 30 % in several samples.

Lower Villafranchian (Pre-Tegelenian—Tegelenian) — Čermaň — Milanovce

Stratigraphical position of these red and brown soils has not been determined and has only been characterized palynologically so far.

Among the samples studied, losses of red and brown soils in Southern Slovakia have been referred to the Oldest Pleistocene. I have palynologically examined numerous

samples from these beds. Pollen analyses have showed that the sediments are not completely sterile as for sporomorphs. There has been found an association quoted in E. P l a n d e r o v á, (1969): spores of *Fungi, Polypodiaceae, Osmunda, Sphagnunt, Cyatheaceae, Pteris, Pinus* type *Haploxylon, Pinus silvestris, Cupressaceae, Betula, Alnus, Cayra, Fagus, Quercus, Corylus,* NAP, *Chenopodiaceae.*

It is, though, a poor association, but it is very difficult to get sporomorphs from such types of rocks. In contrast to the Kolárovo formation the plant association is more frigophilous, but some Tertiary types pass into this sedimentation period, too.

Among thermophilous plant elements *Carya, Castenae, Rhus* have been preserved to this period. More numerous were pollen grains of the genera *Alnus, Pinus, Betula, Corylus.*

In accordance with this I suppose that climate was colder during that sedimentation period, although it did not reach the subtropical character as quoted by W. H. Z a g w i j n (1959) from the Netherlands.

Lower Villafranchian (Tegelenian) VL—7.

The clayey beds from the bore-hole VL—7 — contain very abundant pollen material. In these beds vertebrate fauna occured Z. S c h m i d t, R. H a l o u z k a (1970), indicating the Tegelenian age of the sediments.

Very abundant are herbs, still among Tertiary elements there are *Castanea, Ostrya, Sciadopitys.* In contrast to Kolárovo formation the herbaceous component is more varied and more abundant with *Umbeliferae, Chenopodiaceae* and *Compositae* predominating. The asociation is a little bit different from the samples of the Kolárovo formation. Considerably varied are herbaceous elements, especially *Artemisia, Umbeliferae, Asteracea, Chenopodiaceae, Cyperaceae, Graminae, Poaceae, Polygonaceae.*

In accordance with this pollen pattern I suppose that these beds are younger than red soils in Čermaň and Milanovce. Miocene plant elements have been reduced only to some types as *Ostrya, Sciadopitys,* cf. *Castanea.* Other woody plants might also have grown under colder climate and occur in younger Pleistocene, too. But the climatic curve did not return to the same position as during Rumanian (Reuverian). In this stage an association of mixed foliaceous forests predominates, an association of hydrophilous forests including the main component represented by the genus *Alnus,* being preserved. The Pliocene marshy forest is only represented by the genus *Sciadopitys* as a relict.

Among thermophilous woody plants requiring relatively dry substratum, *Quercus, Fraxinus, Ostrya, Corylus* have been found. Thermophilous woody plants requiring humid substratum are represented by the genus *Alnus.*

Günz/Mindel'an—Mindelian/Rissian/Cromerian—Holsteinian
(localities Srdiečko, Betliar, Muráň, Kláštor)

Cryptogamae are most abundantly represented by the family *Polypodiaceae.* Another numerous group is that of the spores of *Fungi.* In some samples there are abundant genera *Lycopodium, Sphagnum, Pteris.* Abundant tissues of *Algae* have also been found. Among *Coniferae* numerous is *Pinus silvestris* highly predominating over *Pinus* type *Haploxylon.* The genus *Abies* occured only in one sample. *Angiospermae* represent the most numerous group in the pollen diagram. Very frequent are the genera *Betula, Alnus, Ulmus* and *Quercus.* Less frequent are *Carpinus, Tilia, Popolus, Ilex, Acer,*

Corylus, Fagus. All the other genera and families belong to NAP. Such are *Nuphar, Ranunculaceae, Asteraceae, Chenopodiaceae, Gramínae, Centaurea, Artemisia, Lilaceae, Eleagnus, Angelica, Urticaceae.*

The pollen pattern shows that the sediments are younger than Tegelenian, yet older than Holsteinian. The same is showed by a comparison with the flora of Gánovce. I have examined the material for the comparison, although it was already published by V. Knebloá (1960).

Palaeoecological Evaluation of Plio-Pleistocene Sediments

The results of pollen analyses beginning with the coloured-clay formation to the younger Pleistocene give us a plastic pattern of climatic evoluation in our country in that period.

In the coloured-clay formation the climate was still relatively warm, yet when compared with older beds it could be characterized as mild: there appeared *Myricaceae,* rare *Engelhardtia* extinguishing at the end of the period. So we may say it was mild climate with relicts of Miocene plant elements.

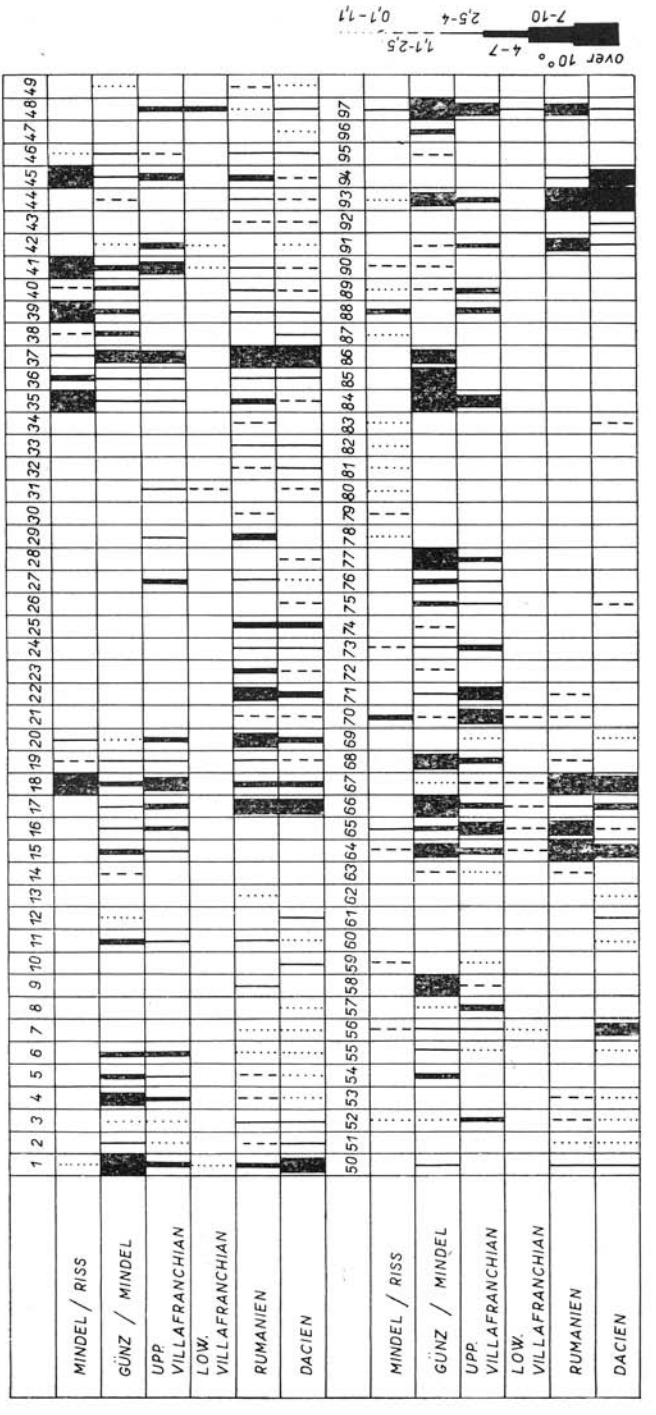
Since the Kolárovo formation is referred to Pliocene on the basis of correlation with Reuverian sediments, we may state some it only caused percentual decrease of Tertiary woody plants and increased the amount of the NAP component.

Practically, the gradual cooling was indicated by greater variety of herbacaous plant elements and by extinguishing family *Myricaceae* and the genus *Engelhardtia.* Similarly, pollen of the genus *Sabal* have also been found in the coloured-clay formation, as quoted by A. Rónai (1959) between Pliocene and Pleistocene. According to Szafer's (1952) opinion, Pliocene flora still contains exotic plant elements which are absent in Pliocene.

According to U. Rein (1955) the genera *Castanea, Cedrus, Sciadopitys* pass into Tegelenian with the note of interrogation. In that sedimentation period very frequent are the genera *Quercus, Corylus, Eucommia, Ulmus, Fraxinus.* Among *Coniferae* best represent are *Pinus* and *Picea,* among NAP mainly *Graminae, Papaveraceae, Hedera, Rubiaceae, Ericaceae, Cyperaceae, Phragmites, Liliaceae.* As showed by this pollen diagram, the climate is colder than in Pliocene. In Western Europe this stage is preceded by pre-Tegelenian, represented in our country most probably by red soils from Milanovce and Čermaň. This pre-Tegelenian represents a climatic break in floristic representation. In our country the cooling of climate was not so conspicuous as in Western Europe. This is also proved by the flora of red soils, still including some Tertiary elements. Pollen analyses from these sediments will be discussed later on. Now I only want to note that according to the analyses of Old-Pleistocene sediments here, too, appeared some effects of the initial West-European glaciation.

Pollen patterns by Central- and West-European authors give palynological results from type localities studied mainly by W. H. Zagwijn, the results of A. Alehenger (1959) and F. Lona's (1950) works. This is why I support my work with quotations of these authors.

In W. H. Zagwijn's (1959) opinion, woody plants between Reuverian (Rumanian) and pre-Tegelenian (Lower Villafranchian) decreased in amount, still in Tegelenian their number increased to the original state. Between Reuverian and Tegelenian the family *Ericaceae* increased in number W. H. Zagwijn has found that elements typical of Pliocene, such as *Sequoia, Taxodium, Sciadopitys, Nyssa, Liquidambar,* do not occur in Tegelenian, only in Reuverian. The boundary between the Cenozoic and Quaternary


over 10°
4-7
7-10
1,7-2,5
2,5-4
0,7-1,7
MINDEL / RISS
GÜNZ / MINDEL
UPP. VILLAFRANCHIAN
LOW. VILLAFRANCHIAN
RUMANIEN
DACIEN

was placed between Reuverian and Tegelenian on the Congress in London in 1948. In our country that is between Rumanian and Lower Villafranchian according to stage denominations amployed. Approximately the same data as W. H. Zagwijn (1959) gave also U. Rein (1955) on the occurrences of woody forms between Pleistocene and Tegellenian. The genera *Nyssa, Sciadopitys* and *Castanea* are referred to Tegelenian with the note of interrogation.

V. Knebloyá (1960) described Upper-Pliocene flora from Gánovce, that I have emploed as comparative material. She found greater number of woody forms in contrast to the herbaceous as showed also by the material from the same locality which I have used for the determination of boundary between Pliocene and Pleistocene.

Van G. Brelie et comp. (1959) recorded Pleistocene flora from Frommersdorf, mainly from the Rissian-Würmian interglacial with only rare occurrences of Tertiary pollen. Among woody plants most frequent are *Alnus, Keteleeria, Pinus, Betula, Corylus,* from NAP, *Cyperaceae, Graminae, Compositae.*

I. Niklewski (1966) presented Pleistocene pollen profile from Koniecpole in Poland. It is a pity he did not give more precise age in Pleistocene. The pollen diagram contains typical Old-Pleistocene association in addition to a small number of Tertiary pollen, absent in younger Pleistocene according to other authors. Such are mainly *Sequoia, Nyssa, Tsuga, Sciadopitys, Carya.*

W. H. Zagwijn (1957) deals very detaily with the problem of older Pleistocene, particularly with the period of Reuverian and Tegelenian as well as with interglacial higher than Waalian (Upper Villafranchian) and Cromerian (Günz-Mindelian interstadial).

Fig. 1. Explanatory notes: 1 — *Polypodiaceae.* 2 — *Laevigatisporites* sp. 3 — *Osmunda* sp. 4. — *Spores of Fungi.* 5 — *Verrucatosporites* sp. 6 — *Lycopodium* sp. 7 — *Cingulatisporites* sp. 8 —*Laevigatisporites pseudomaximum.* 9 — *Laevigatisporites neddeni.* 10 — *Triplanosporites.* 11 — *Sphagnum* sp. 12 — *Cyatheaceae.* 13 — *Leiotriletes* sp. 14 — *Pteris* sp. 15 — *Algae.* 16 — *Pinus* sp. 17 — *Pinus typ Haploxylon.* 18 — *Pinus silvestris.* 19 — *Abies* sp. 20 — *Picea* sp. 21 — *Tsuga* sp. 22 — *Tsuga diversifolia.* 23 — *Tsuga canadensis.* 24 — *Taxodium* sp. 25 — *Cedrus* sp. 26 — *Sequoia* sp. 27 — *Sciadopitys* sp. 28 — *Larix* sp. 29 — *Cupressaceae.* 30 — *Ephedra* sp. 31 — *Rhus* sp. 32 — *Carya* sp. 33 — *Pterocarya* sp. 34 — *Caryophyllaceae.* 35 — *Carpinus* sp. 36 — *Ulmus* sp. 37 — *Alnus* sp. 38 — *Salix.* 39 — *Corylus.* 40 — *Tilia* sp. 41 — *Betula* sp. 42 — *Cupuliferae.* 43 — *Nyssaceae.* 44 — *Juglans* sp. 45 — *Quercus* sp. 46 — *Ericaceae.* 47 — *Tricolporopoll.* sp. 48 — *Castanea* sp. 49 — *Tricolpopoll.* sp. 50 — *Tricolporopollenites asper.* 51 — *Sabal* sp. 52 — *Ilex* sp. 53 — *Liquidambar* sp. 54 — *Acacia* sp. 55 — *Fagus* sp. 56 — *Acer* sp. 57 — *Eleagnus* sp. 58 — *Popolus* sp. 59 — *Fraxinus* sp. 60 — *Cyrilla* sp. 61 — *Myricaceae.* 62 — *Monocolpopollenites* sp. 63 — *Oeonotheracenae.* 64 — NAP. 65 — *Compositae.* 66 — *Graminae.* 67 — *Nympheaecae,* 68 — *Chenopodiaceae.* 69 — *Sanguisorba* sp. 70 — *Artemisia* sp. 71 — *Umbeliferae.* 72 — *Nuphar* sp. 73 — *Ranunculaceae.* 74 — *Centaurea.* 75 — *Typha* sp. 76 — *Urticaceae.* 77 — *Liliaceae.* 78 — *Saxifraga* sp. 79 — *Daucaceae.* 80 — *Silenaceae,* 81 — *Rosaceae.* 82 — *Brassicaceae.* 83 — *Sparganium* sp. 84 — *Phragmites* sp. 85 — *Angelica* sp. 86 — *Mohraceae.* 87 — *Frangula* sp. 88 — *Poaceae.* 89 — *Cyperaceae.* 90 — *Lamiaceae.* 91 — *Ovoides* sp. 1. 92 — *Ovoides* sp. 2. 9 3 — *Fresh-water Planktion.* 97 — Varia.

According to the decision of the Pliocene komision for the stratigraphie in central Europe, it have to use for coloured clay formation and kohlen formation the term „Pontian" instead of tern „Dacian". (Explanation to the fig. 1, 2, 3.)

To the Reuverian he ascribed warm climate with very abundant genus *Alnus* and with Tertiary plant types such as *Sequoia, Carya, Nyssa, Sciadopitys, Taxodium, Tsuga, Eucommia, Liquidambar, Castanea.* In pre-Tegelenian the author supposed cold climate and in Tegelenian — warm.

Important data on Upper-Pliocene and Lower-Pleistocene gave A. Altehenger (1959). The author traced the frequency curve of stratigraphically important genera in Upper Pliocene and Lower Pleistocene. Basing upon this, the author characterizes the fluctuation of humidity and temperature of climate.

Tegelenian flora has been examined in detail by W. H. Zagwijn (1963). In pollen diagrams the author gave percentual representation of pollen in the whole profile of Tegelenian clays. Among woody plants very abundant are *Quercus, Alnus, Carya, Pterocerya, Picea, Pinus,* among NAP, *Graminae, Cyperaceae* and *Artemisia.*

B. Menke (1969) recorded also the family *Myricaceae* from Old Pleistocene, absent in our Rumanian (the Kolárovo formation). The pollen spectrum according to B. Menke's data on Old Pleistocene displays more numerous Tertiary plant elements. Although sediments rich in Tertiary elements are referred to Lower Villafranchian, it is contradictory to the results given by W. H. Zagwijn and U. Rein, who found more numerous Tertiary woody plants *(Carya, Pterocarya, Myricaceae, Ostrya)* only up to the end of Reuverian (Rumanian), i. e. to the initial glaciation. Our results are in accordance rather with W. H. Zagwijn (1959), Tiergart (1954), G. Brelie's (1959) results. These authors gave also the correlation of the results of pollen analyses concerning Western Europe with the Central-European.

Palaeoecological Evaluation of Plio-Pleistocene Sediments in the Region of West Carpatians Mts.

The floristic history between Upper Pliocene and Old Pleistocene will be briefly outlined now.

The pollen diagram shows that Tertiary woody plants have had quite a high percentual representation in the coloured-clay formation. Herbs were not so varied as for species, at least, as showed by the results of examination of about 100 samples from Southwestern Slovakia.

Shallow marshy areas in Pliocene, occupied with marshy woody plants of the *Taxodiaceae-Nyssaceae, Myricaceae, Carya,* type desintegrated in the coloured-clay formation. *Taxodiaceae* were gradually replaced by the genus *Alnus. Myricaceae* were only preserved in protected areas, and *Nyssaceae* displayed only a part of their original amount. Subtropical plants extinguished completely.

In that period the following types of forests have been distinguished:

a) Humid marshy forests with high representation of the genus Alnus and with the relicts of the families *Taxodiaceae, Myricaceae* and *Nyssaceae.*

b) More arid coastal forests represented by the genera *Pinus* and *Betula.*

c) A forests zone with moderate requirements of humidity, represented by the genera *Ulmus, Carpinus, Ilex,* with some occurrences of the genus *Ephedra.* In this zone also fern and other herbs are supposed to have existed as well as *Coniferae* from the genera *Picea* and *Cedrus.*

In the Kolárovo formation forests of the type resembling that of the coloured-clay formation may be found, only in the hydrophilous forest the family *Myricaceae* is missing. Other Plio-Pleistocene plant elements still occur, without, however, representing any substantial component of flora. They are slowly extinguishing and they might

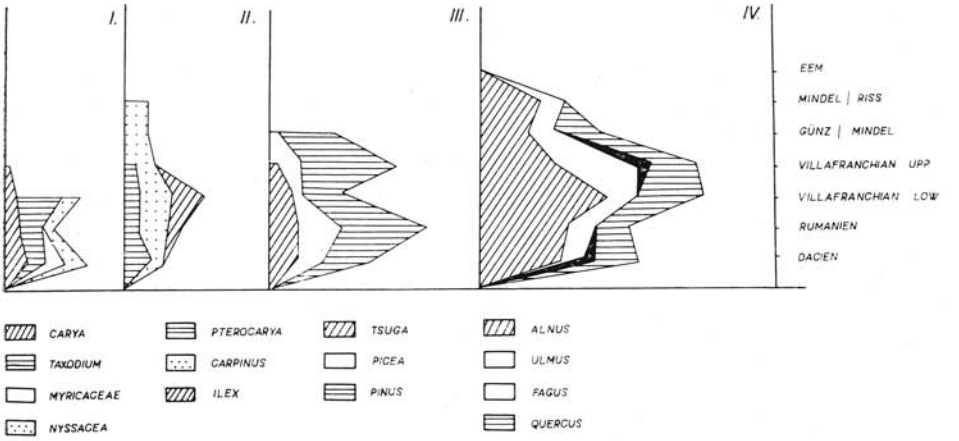


Fig. 2. Percentual Representation of some ecologically important sporomorphs.

have been preserved only in relicts. In the Kolárovo formation, flora has been as follows:

Moors have been desintegrated, and lakes have arisen, — as proved by water plants. The moors zone has been reduced. The genus *Alnus* increased in number when compared with the coloured-clay formation, yet it was not any substantial increase. In that sedimentation period approximately four floristic units may be distinguished according to humidity requirements:

1. Aquatic environment with *Algae* represented by *Nymphaeceae* and *Nuphar*.
2. Near-shore marshy forests, the substance of which represented *Alnus* and relicts of Tertiary woody plants formed mainly of *Taxodiaceae, Sequoia, Carya, Nyssaceae,* sporadical *Sabal* occurrences.
3. Xerophilous mixed foliaceous-coniferous forests represented approximately the same elements as in the coloured-clay formation.

Spores of the genus *Sphagnum* prove that in the coloured-clay formation and in the Kolárovo formation there were bog-peats. In higher levels xerophilous woody plants and herbs grew. *Ephedra* shared substantially the forming of flora. *Ephedra* indicate dry climate. I suppose that *Ilex* grew in a drier environment.

In accordance with the results of the pollen analysis I suppose there was mild climate, warm enough, sufficiently humid.

According to G. Brelie (1959) quantitative difference between Pontian and Reuverian (Rumanian) is more conspicuous. In Pontian the author found still high per. cent of Tartiery woody plants, while in Reuverian these species considerably decreased in number. In our countries differences between Pontian and Reuverian are not so great. Qualitative difference is mainly in appearance of numerous herbaceous types which have not occured in the coloured-clay formation (Pontian).

From the view of climate, the occurrence of Tertiary plant elements indicates the cooling of climate in Reuverian, yet not so substantial as to evoke decrease of thermophilous plant elements. In our country, the earliest Quaternary sediments are represented by red and brown sediments. It has already been mentioned that they are poor in sporomorphs. This is why they can only be qualitatively evaluated and the floristic pattern of that sedimentation period constructed. The pollen pattern of

that period is poor, mainly without Miocene plant elements. They are, however, pollen of the genera *Carya, Castanea, Rhus* and *Pterocarya,* that may still be considered for floristic relicts preserved from Reuverian. The rest of flora was frigophilous, represented by the genera *Betula, Alnus, Pinus* and *Herbs.*

I suppose the cooling of climate in comparison with Reuverian (the Kolárovo formation) evoking considerable increase of Tertiary plants. So consequent to the sedi-

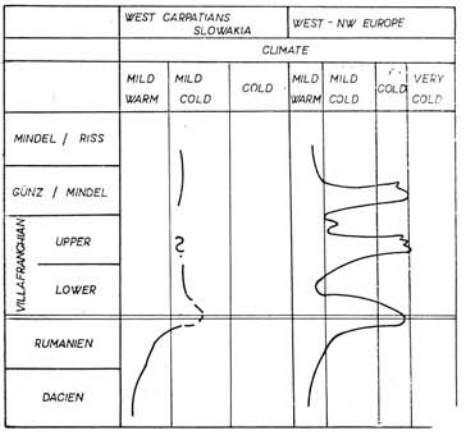


Fig. 3. Postulated climatic curve from the period of the end of Pliocene to Middle Pleistocene in the West-Carpathian region (E. Planderová) and in Western Europe (W. H. Zagwijn).

mentation of the Kolárovo formation, in our country, too, there was the cooling of climate represented by a cold period on the basis of Quaternary.

Ecological Evaluation of Villafranchian Sediments

In the course of sedimentation of the Lower-Villafranchian clays from the view of ecology, the following ecological situation may be observed:

1. In aquatic environment the *Algae — Ovoidites* lives, considered a freshwater plankton.
2. Coastal marshy plants represented mainly from woody plants of the genus *Alnus.*
3. More arid mixed coniferous-foliaceous forest, *Pinus* consisting predominantly from the species *Pinus silvestris.*
4. Woody plants of higher levels around moors, including *Pinus* and *Sciadopitys.*

A considerably numerous component of the Villafranchian plant association is represented by herbs of the types of *Artemisia* and *Umbeliferae,* indicating the cooling of climate in that period when compared with Reuverian.

The climatic curve shows that in this country the profile between Dacian and Rissian-Würmian interglacial was not continuous, and the curve of the climatic situation supposed could therefore only be constructed partially. There are still numerous connecting parts missing to complete the curve. And it is probable that in our situation — with only fragmentary Pleistocene sediments, it will not even be possible to complete the curve. The transition between Pliocene and Pleistocene is, however, clear in sediments I have examined on the basis of Pleistocene. The temperature curve is equal with that in Western Europe to a certain extent. The only difference rests in the fact *that* while in Western Europe in Tegelenian it shows falling tendency, from mild warm to very cold climate, in our country only mild — cold climate flora has been found.

May be that the appearance of some beds favourable for pollen analyses of the earliest Pleistocene facilitate the completing of the missing climate periods. Some cooling of climate may also be supposed in Lower Villafranchian, in consequence of which in the upper part of the Lower Villafranchian only a small number of Tertiary plant elements have been preserved.

Upper-Villafranchian sediments are missing, still in fossil soils Cromerian-Holsteinian have been found, giving quite a clear pattern of the climate in that period. Since the present report is to give the characteristics not of the whole Pleistocene, but only of the earliest, I shall not deal more in detail with the upper horizons.

Conclusion

A detail pollen analysis of Upper Pliocene and Pleistocene samples gave results of stratigraphical as well as palaeoecological character.

1. Stratigraphical position of the so-called Kolárovo formation has been determined. After floristic comparison with Reuverian it may be referred to this stage, i. e. to the Uppermost Pliocene (Pontian.)

2. Probable stratigraphical position of red soils from Milanovce and Čermaň has been determined in the Earliest Villafranchian.

3. Stratigraphical position of the samples VL—7 has been determined in the Lower Villafranchian.

4. Criterii for the differentiation of Pliocene and Pleistocene have been determined. Comparison and determination of a greater number of samples have showed that there is a certain climatic boundary between Pliocene and Pleistocene, not though, so conspisuous one as in Western Europe. (Figs. 1, 2.)

5. Basing upon correlation with palynological results the age of red fossil soils from numerous localities in Slovakia has been determined as Günz/Mindelian or Mindelian/Rissian interglacial.

6. From the view of palaeoecology I have drawn the climatic curve (Fig. 3) between the coloured-clay formation and Middle Pleistocene according to the samples evaluated. After the comparison with the palynological results concerning Western Europe, I have found that climatic curve in Old Pleistocene had a little different course. The climatic break during the inital glaciation was not so sharp as in Western Europe.

Although very numerous samples have been examined in order to solve the problem in our country, I cannot consider the problem solved. I intend to follow occurrences of Old and Middle Pleistocene and to complete the missing data in climatic and stratigraphical evaluation.

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