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The Ferdynandów Interglacial in Poland

During the removing of the overburden in the western face of the Bełchatów mine, the Quaternary lacustrine and boggy sediments named "Buczyna pod brukiem" have been exposed. The pollen analysis of these sediments has shown, that they have represented the same pollen succession which has been illustrated by the pollen diagram from Ferdynandów. Owing to the characteristic pollen spectra from the interglacial climatic optimum it may be stated, that the floras of Ferdynandów and "Buczyna pod brukiem" are of the same age. The sediments of Ferdynandów Interglacial at Białobrzegi on Pilica river, Sosnowica and Podlodów have also been taken into account.

INTRODUCTION

The paper "Flora of the Mazovian Interglacial at Ferdynandów" (Z.Janczyk-Kopikowa, 1975) requires presently some comments. In the sixties, owing to the detailed analyses of the material (J.Rzechowski et al., 1966; J.Rzechowski, 1967; J.E.Mojski, 1969), the geological situation of the interglacial sediments at Ferdynandów appeared to be fully precised. The interglacial sediments have been situated between the South-Polish Glaciation and Middle-Polish Glaciation. In the earlier stratigraphic schemes (S.Z.Różycki, 1964, 1967; E.Rühle, 1965; A.Środoń, 1960 et al.) the stratigraphic unit between two glaciations ensuing one after the other, that is between South-Polish Glaciation and Middle-Polish Glaciation, was called Mazovian Interglacial. The sediments documented palaeobotanically (with strictly determined pollen succession), as well as sediments lacking in floral remains, for instance very thick fluvial series of sandy sediments, were included in the Mazovian Interglacial.

The author, writing about the flora from Ferdynandów, had in mind mainly its stratigraphic position (between the South-Polish Glaciation and Middle-Polish Gla-

ciation), nevertheless stressing strongly the differences between the pollen successions at Ferdynandów, and at Nowiny Żukowskie (J.Dyakowska, 1952), Ciechanki Krzesimowskie (M.Brem, 1953) and other floras of the same ages, which are generally called floras of the Mazovian Interglacial. The difference between the ages of those floras and the age of flora from Ferdynandów was doubtless, but their mutual relationship remained an open question (Z.Janczyk-Kopikowa, 1975). The essential floral differences between them were the basis for the distinguishing of two different interglacials by A.Środoń (1969) — that is the Mazovian and Lublin interglacials.

The stratigraphic position of the floras spoken about caused a broad discussion. Controversial opinions were formulated by many authors (K.Erd, 1978; L.Lindner, 1981; J.Łyczewska, 1977; S.Z.Różycki, 1978; E.Rühle, 1976; H.Ruszczyńska-Szenajch, 1978; M.Sobolewska, 1969; A.Środoń, 1969; L.N. Voznyachuk, 1978 et al.).

The palaeobotanical and geological proofs and detailed analysis of full material allowed to formulate an opinion, that the flora from Ferdynandów represents a new interglacial in Polish stratigraphic scheme of the Quaternary (Z. Janczyk-Kopikowa et al., 1981). It is presently called Ferdynandów Interglacial (*l.c.*). According to the rule of priority, the term Mazovian Interglacial was saved for the interglacial, for which the pollen successions at Nowiny Żukowskie, Ciechanki Krzesimowskie and others of the same age are characteristic. As it is accepted, both interglacials occupy the stratigraphic position between South-Polish (San) and Middle-Polish (Odra) glaciations with the reservation, that the Ferdynandów Interglacial is situated below Mazovian Interglacial (*l.c.*; J.E.Mojski, 1985) and is set apart by a distinction of Wilga Glaciation.

The floral characteristics of both interglacials are different. For Mazovian Interglacial, it was discussed many times (W.Szafer, 1953; J.Dyakowska, 1952; A.Środoń, 1972 et al.). The pollen succession of Ferdynandów is most fully illustrated by the pollen diagram from Ferdynandów. Similar type of floral development was confirmed also in other sites mentioned below.

THE SITES OF FERDYNANDÓW INTERGLACIAL IN POLAND

M.Sobolewska (1969) published a pollen diagram from Łuków, stating that the developments of floras at Łuków and Ferdynandów (Z.Janczyk-Kopikowa, 1963) were similar. This statement found strong confirmation after the detailed working-out of the sediments from Ferdynandów; the diagrams from Ferdynandów and Łuków were acknowledged as beeing of the same age (Z.Janczyk-Kopikowa, 1975).

The flora from Podgórze (I.Jurkiewiczowa et al., 1973) was also accepted as beeing of the same age as Ferdynandów (Z.Janczyk-Kopikowa et al., 1981). J.E.Mojski (1985) correlated the corresponding pollen spectra from Podgórze with the lower and upper climatic optimum at Ferdynandów.

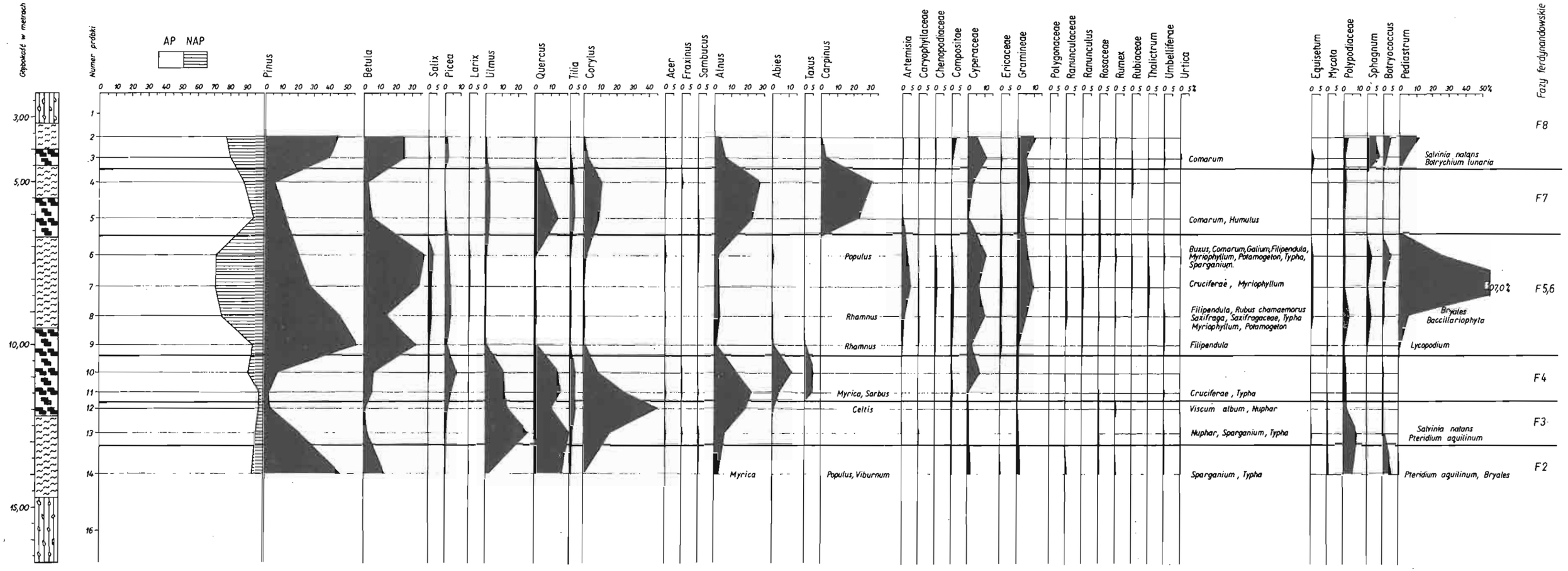

Fig. 1. Pollen diagram of the Ferdynandów Interglacial in Białobrzegi, profile 71
1 – peats; 2 – silts; 3 – tills; AP – trees and shrubs; NAP – herbs
Diagram pyłkowy interglacjału ferdynandowskiego w Białobrzegach, profil 71
1 – torfy; 2 – mułki; 3 – gliny zwałowe; AP – drzewa i krzewy; NAP – rośliny zielne

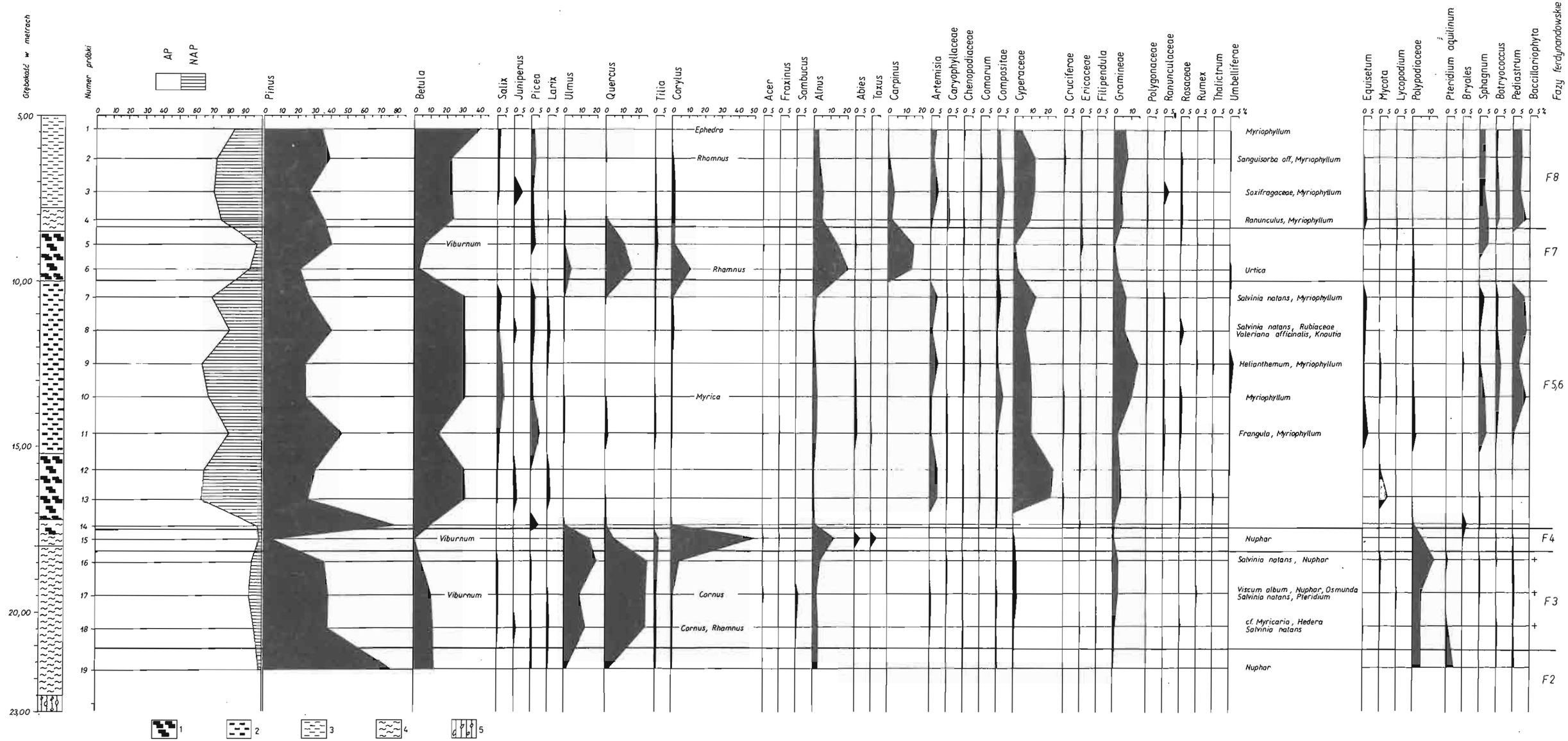

Fig. 2. Pollen diagram of the Ferdynandów Interglacial in Białobrzegi, profile 84
1 – peats; 2 – gyttjas; 3 – clays; 4 – silts; 5 – tills; AP – trees and shrubs; NAP – herbs
Diagram pyłkowy interglacjału ferdynandowskiego w Białobrzegach, profil 84
1 – torfy; 2 – gytie; 3 – iły; 4 – mułki; 5 – gliny zwałowe; AP – drzewa i krzewy; NAP – rośliny zielne

In the seventies, the fossil flora at Białobrzegi on Pilica river was worked-out (Z.Janczyk-Kopikowa, 1981). The samples were taken from the boreholes made by "Geoprojekt" of Warsaw, situated at the right bank of Pilica beyond its valley. The boreholes penetrated the upper strata of soil and sands and then the upper, not very thick horizon of till, under which the lacustrine and boggy sediments (with thickness reaching about 19 m) lay. These formations in turn lay on the lower horizon of till. Full data about the Pleistocene sediments below the interglacial series are lacking, because none of the boreholes cut through the Quaternary.

It is evident from the *Geological Map of Poland* 1:200 000, sheet Skierniewice (A.Makowska, 1970) that Tertiary sediments were overlaid by the till of the South-Polish Glaciation, the fluvioglacial sands and gravels, and the upper till (Middle-Polish Glaciation — two horizons). More precise definition of the ages of these two horizons of glacial till is controversial.

It results from the detailed geological data for the Quaternary sediments (E.Ciuk, E.Rühle, 1952) for the area lying about 2 km west of the localization site of the "Geoprojekt" boreholes, that the till on the Warta Glaciation occurs to the north of Pilica valley only.

The age of tills of the Middle-Polish Glaciation in the vicinity of Białobrzegi was not strictly defined in the *Geological Map of Poland* 1:200 000 (A.Makowska, 1970); they remained there undivided. The presence at this area of till of the Warta Stage was accepted by M.D.Baraniecka (1971) and Z.Sarnacka (1988).

Taking into account all statesments given above, it is difficult to accept an unequivocal age for the till covering the interglacial sediments at Białobrzegi; the sequence of deposits underlaying the interglacial series is also unkown.

The age of the interglacial series was determined using the palaeobotanical criteria. The pollen succession at Białobrzegi can be unequivocally referred to that of Ferdynandów.

The pollen analysis at Białobrzegi was done in three boreholes (Białobrzegi 71 — Fig. 1; Białobrzegi 82 — Fig. 2 ; Białobrzegi 98 — Fig. 3). The fullest image of the pollen succession was achieved in the profile 98. The pollen diagram shows here the development of flora, beginning with the boreal coniferous forests with preponderance of pine (*Pinus*). Later the preponderance of birch (*Betula*) with traces of light-demanding shrubs *Ephedra* and *Helianthemum* was noted with a minimal increase of herbaceous plants (NAP). The diminishing of the amount of birch (*Betula*) and pine (*Pinus*), and the appearance of the thermophilous deciduous trees (*Quercus, Ulmus, Tilia*) began the phase of prevailing mixed forests. After their decay, the deciduous forests developped. Oak (*Quercus*) and elm (*Ulmus*) acieved the amounts of 21.1 and 19.9%; linden (*Tilia*) of 5.0% and hazel (*Corylus*) 44.0%. The share of alder (*Alnus*) approached 20%; hornbeam (*Carpinus*) was not found. This phase may be connected with the third phase of development of flora at Ferdynandów — the phase of the climatic optimum.

In the profile 98 at Białobrzegi the next phase of Ferdynandów — the fourth phase with *Abies* — is lacking. This phase is shown at the diagram (Fig. 1 and 2), where the share of fir is distinctly marked.

After the fourth phase all diagrams from Białobrzegi show the cooling of the climate expressed by the dominant birch-pine forests and the increase of the amount of the herbaceous plants (with maximum up to 37.0% in the profile Białobrzegi 84). The diagrams depict the renewed warming and the come-back of the deciduous forests (phase seven at Ferdynandów): *Quercus, Ulmus, Tilia, Corylus* and *Alnus*. The showing-up of *Carpinus* for the first time in the diagrams (reaching the maximum value of 31.0%) is especially worth mentioning in the profile Białobrzegi 71 (Fig. 1).

After this warming, in Białobrzegi the come-back of boreal pine-birch forests was noted, connected with the increase of the share of the herbaceous plants to 29.2% (Białobrzegi 84 — Fig. 2). This reigning of pine-birch forests ends the interglacial development of flora at Białobrzegi.

The interglacial lacustrine-boggy series at Białobrzegi are especially worth noticing because of their full development and geological situation. Unfortunately the technique of boring used by "Geoprojekt" in the year 1974 gave no possibility for taking of sufficient amounts of samples for the pollen analysis. The distances between samples generally equaled 0.5–1.0 m, what allowed for obtaining of only approximate data. However, the interglacial pollen succession at Białobrzegi can be unequivocally referred to the pollen succession at Ferdynandów. Nevertheless, it would be suitable to make a thorough, universal work-out of the interglacial sediments at Białobrzegi.

The type of the pollen succession, similar to given above, is noted in the histogram from Sosnowica in the district of Lublin (Fig. 4). The lacustrine-boggy sediments lie here at the depth of 13.50–18.35 m between two horizons of tills (L.Dolecki et al., in print). The development of flora begins with the domination of tundra. The share of the herbaceous plants amounts to 64.0%, among which *Gramineae* are reaching 11.0%, *Cyperaceae* and *Artemisia* to 16.0% each. *Chenopodiaceae* and *Ranunculaceae* are rather plentiful. The boreal pine-birch forests, reigning after the tundra, give place to the deciduous forests with *Quercus* up to 21.6%, *Ulmus* up to 20.0%, *Tilia* up to 5.6% and *Corylus* up to 26.7%. The phase of dominant deciduous forests at Sosnowica corresponds to the third phase at Ferdynandów. It is the climatic optimum.

The fourth phase, in which significant is the share of *Abies* reaching 30%, is conspicuous in the diagram at Sosnowica.

The cooling after the climatic optimum is also distinctly marked and represented through the reigning of pine-birch forests. At the top of the profile the decrease of the amounts of *Pinus* and *Betula*, and the increase of amount of the thermophilous deciduous forests (*Quercus, Ulmus, Tilia, Corylus*) can be noticed. *Carpinus* appears for the first time in the profile. It seems, that pollen spectra of three highest samples can be connected with the seventh phase, that is with the renewed warming in the profile of Ferdynandów.

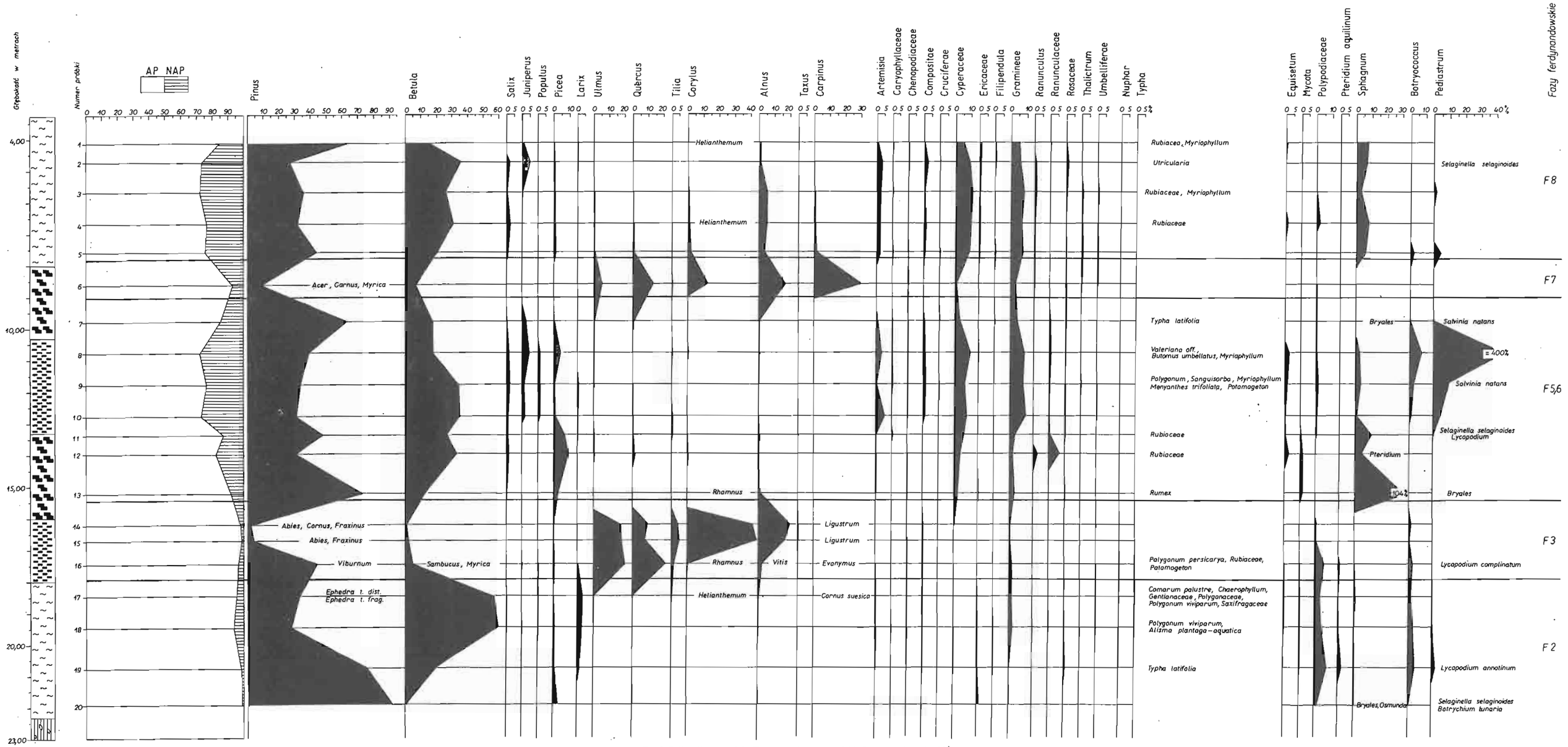

Fig. 3. Pollen diagram of the Ferdynandów Interglacial in Białobrzegi, profile 98
Explanations as in Fig. 2
Diagram pyłkowy interglacjału ferdynandowskiego w Białobrzegach, profil 98
Objaśnienia jak na fig. 2

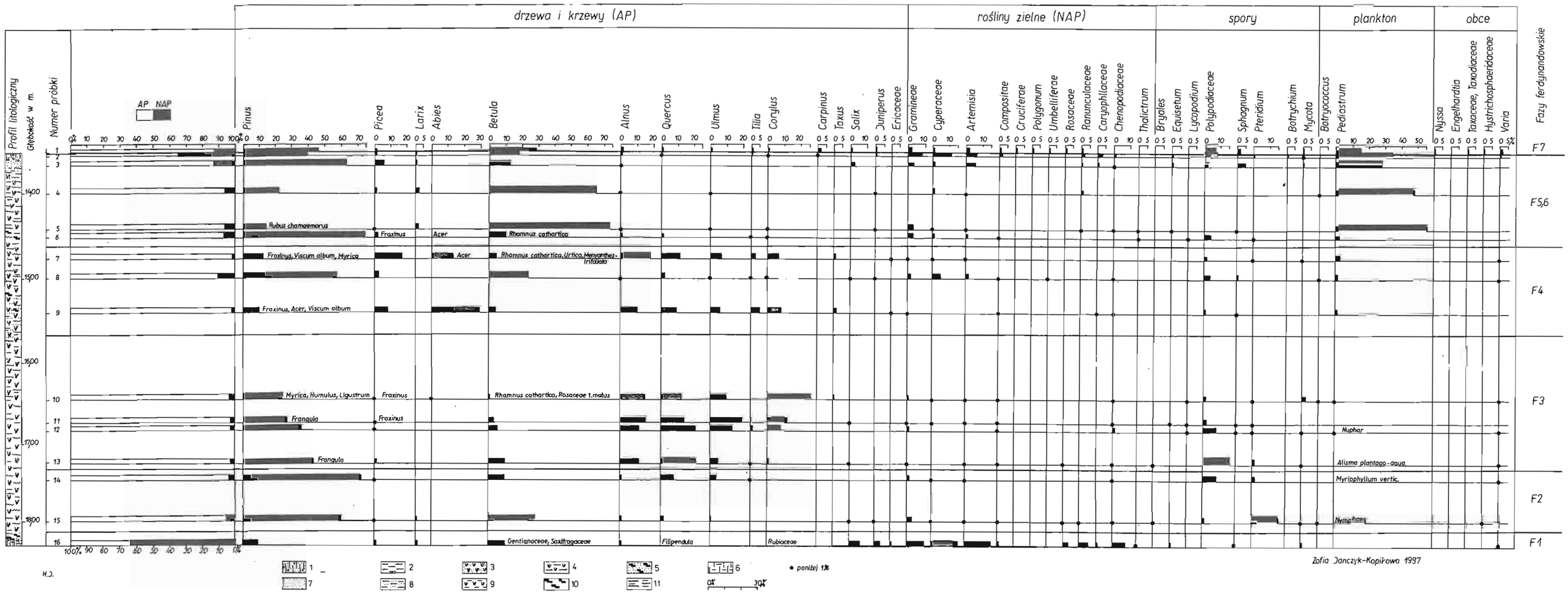

Fig. 4. Pollen diagram of the Ferdynandów Interglacial in Sosnowica

1 – sandy clay loams, with gravels; 2 – silts; 3 – arenaceous gyttjas; 4 – silty gyttjas; 5 – arenaceous peats; 6 – argillaceous clays; 7 – sands; 8 – argillo-arenaceous silts; 9 – argillaceous gyttjas; 10 – peats; 11 – argillaceous silts

Diagram pyłkowy interglacjału ferdynandowskiego w Sosnowicy

1 – gliny piaszczysto-ilaste ze żwirami; 2 – mułki; 3 – gytie piaszczyste; 4 – gytie mułkowate; 5 – torfy piaszczyste; 6 – gliny ilaste; 7 – piaski; 8 – mułki ilasto-piaszczyste; 9 – gytie ilaste; 10 – torfy; 11 – mułki ilaste

The pollen succession at Sosnowica ends with the image of the thermophilous deciduous forest with hornbeam (*Carpinus*). It seems, that lack of the boreal forests in the end of the interglacial is the result of destroying (by erosion) of the highest part of the interglacial sediments.

At Podlodów in the district of Lublin the pollen spectra from the climatic optimum seem to belong to the Ferdynandów Interglacial. This profile is still beeing worked-out.

"BUCZYNA POD BRUKIEM"

The sediments in the profile "Buczyna pod brukiem" were described by M.D.Baraniecka and A.Hałuszczak (1982). They lie in the central part of the western exploitation face in Bełchatów. The samples were taken for the pollen analysis from the mineral and mineral-organic series found there at the height of 160.25 up to 162.20 m above sea level. Their depth amounts to 2.20 m. 29 samples were taken for the pollen analysis, mainly with the distance between the samples of 5 cm, more seldom of 10 cm, and in one case the distance was 25 cm.

The profile "Buczyna pod brukiem" is lithologically diversified. The sandy sediments are overlaid by lacustrine silts containing peat at the top, then by silty peat, in parts containing sand; they are in turn overlaid by silts. These silts were incised by the pavement at the place of sampling (M.D.Baraniecka, A.Hałuszczak, 1982).

The sediments from the site "Buczyna pod brukiem" belong to the lower structural horizon of Quaternary and lie (at the place of profiling) in its upper part on the sandy beds, below which the horizon of till occurs.

The pollen diagram of the site "Buczyna pod brukiem" (Fig. 5) depicts the dominant tundra or forest-tundra. The herbaceous plants (41.6%) consisted mainly of *Artemisia* — 18.0%, *Gramineae, Cyperaceae, Rosaceae, Compositeae* and others, for instance *Saxifraga, Gentiana, Caryophyllaceae, Chenopodiaceae* . Among shrubs, *Salix, Juniperus* and *Helianthemum, Hippophaë, Ericaceae*. This type of flora can witness the presence of subarctic climate, typical for the glaciation. The diminishing of the share of herbaceous plants to about 10% and high amount of birch (*Betula*) in the pollen spectrum of sample 27 allows to suppose the warming of climate, allowing for the development of thickets, or birch forest. The warming disappears higher for some time (what can be seen from the pollen spectrum of sample 26), giving place for the second time to the development of herbaceous plants of the open plains.

It can be accepted, that the lower part of the diagram from "Buczyna pod brukiem" shows the climatic changes during the end of the glaciation preceding the Interglacial at Buczyna.

Beginning from the site of taking of the sample 25, the full reigning of arborescent plants is observed — the pine-birch trees with spruce (*Picea*) and larch (*Larix*). The amount of herbaceous plants is diminishing, the climate becomes boreal.

The showing-up of *Quercus* and *Ulmus* announces the time of deciduous forests, that is the climatic optimum of the interglacial. Characteristic for this optimum are high values for elm (*Ulmus*) — 14,5%, oak (*Quercus*) — 20.0%, and hazel (*Corylus*) — 39.3%. Linden (*Tilia*) achieves the value of 7.7% and alder (*Alnus*) about 30.0%. Fir (*Abies*) also shows-up, achieving in the highest sample 3 the value of 5.9%. The presence of *Carya* and *Celtis* pollen deserves special notice. These trees do not belong to the present-day flora of Poland and were not found on the Eemian Interglacial. The presence of such thermophilous trees, as: *Buxus*, *Taxus* , *Ligustrum* and *Hedera* is also worth stressing. Characteristic is the complete lack of *Carpinus*. The climate of the optimum was moderate with tendencies to beeing moderately warm, what allowed for the presence of trees: *Celtis* and *Carya*, unknown in the flora of present-time Poland.

At the site "Buczyna pod brukiem", the floral succession after the climatic optimum cannot be observed, because the upper part of sediments was destroyed (M.D.Baraniecka, A.Haluszczak, 1982). Nevertheless, the pollen succession of the remaining part of the existing interglacial sediments allows in this case for unequivocal correlation of "Buczyna pod brukiem" Interglacial with Ferdynandów Interglacial.

CONCLUSIONS

The data collected till now for the Ferdynandów Interglacial allow to state its floral peculiarity. The characteristic pollen succession, repeating in several profiles spoken about, allows for the precising of its features, from which most important are:

1. Small role of spruce (*Picea*) in the whole interglacial.
2. The climatic optimum, expressed by the reigning of thermophilous deciduous forest, mainly of oak (*Quercus*) and elm (*Ulmus*) in more or less equal amounts (about 20%). The culmination of hazel (*Corylus*) amounting to several tens per cent after the maxima for oak and elm. Small amount of linden (*Tilia*). Sporadic or lacking hornbeam (*Carpinus*).
3. The early spreading-out of alder (*Alnus*).
4. Short-lasting, but significant role of fir (*Abies*) together with insignificant share of yew (*Taxus*).
5. The warming of climate for the second time in the upper part of the profile, expressed through the reigning of deciduous forest with the significant amount of hornbeam (*Carpinus*).

It is accepted, that the correlation of the sites of Ferdynandów Interglacial is unequivocal, if we take the palaeobotanic criteria as a base. The stratigraphic position of this interglacial is still not quite clear because the uniform opinion, resulting from the interpretation of geological materials about the sequence of Mazovian and Ferdynandów interglacials is still lacking. The comparison of geological data and TL dating for the profile of Ferdynandów (Z.Janczyk-Kopikowa et al., 1981; J.E.Mojski.

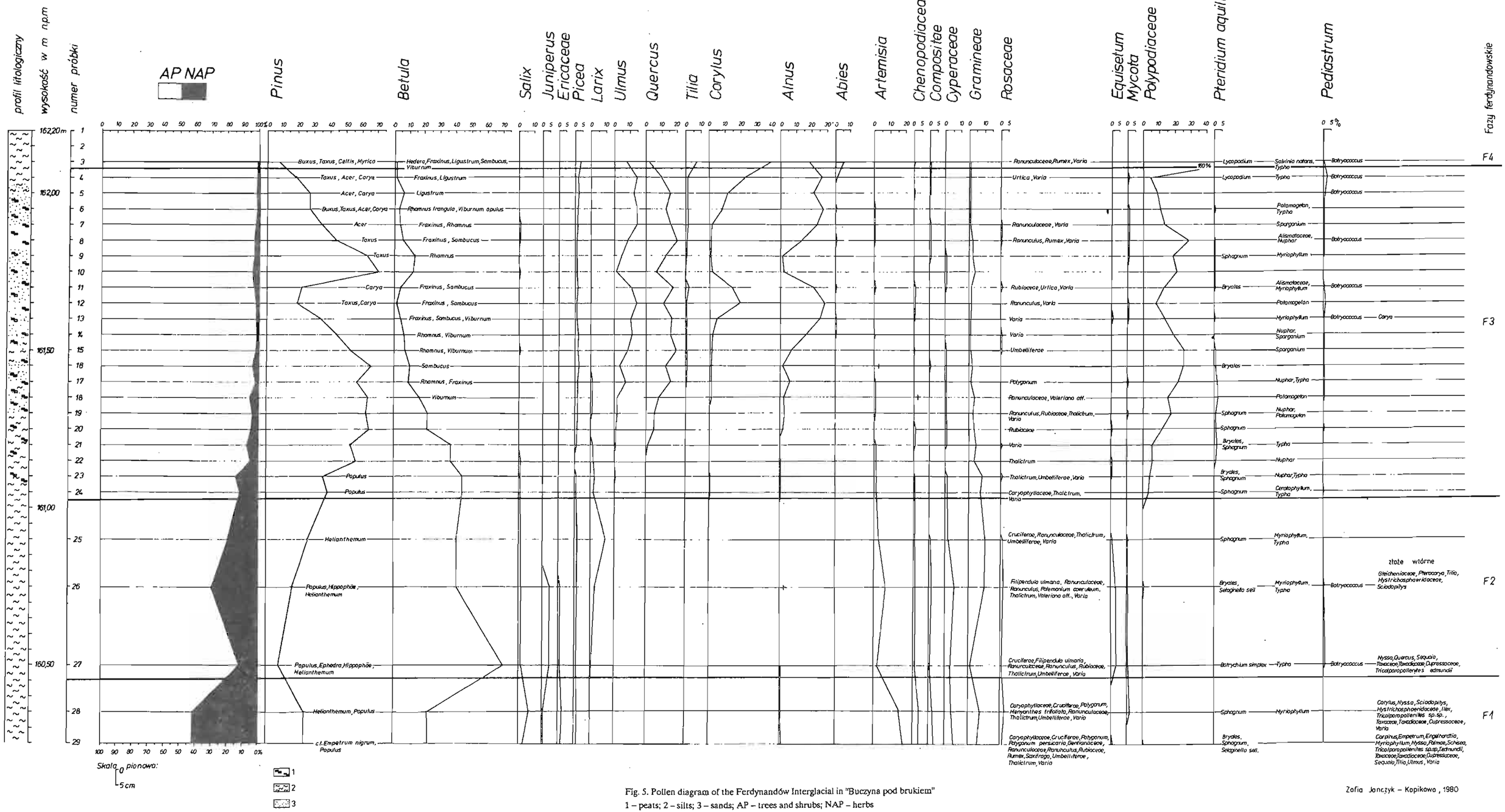

Fig. 5. Pollen diagram of the Ferdynandów Interglacial in "Buczyna pod brukiem"
1 – peats; 2 – silts; 3 – sands; AP – trees and shrubs; NAP – herbs
Diagram pyłkowy interglacjału ferdynandowskiego w "Buczynie pod brukiem"
1 – torfy; 2 – mułki; 3 – piaski; AP – drzewa i krzewy; NAP – rośliny zielne

Zofia Janczyk – Kopikowa, 1980

1985) for the sites of "Buczyna pod brukiem" and Podgórze (L.Lindner, 1988) induce to the opinion that Ferdynandów Interglacial is older than Mazovian Interglacial.

However, as it was pointed out, it can be said from the interpretation of the geological profile in Łuków, that the interglacial sediments of Łuków lie higher than Mazovian Interglacial.

Interglacial pollen succession of Łuków and Ferdynandów are identical and there is no possibility whatever (without complete overlooking of the palaeobotanical criteria) of accepting different ages for these floras.

On the other hand, the character of the pollen and macroscopic flora (existing taxons, their succession and share in per cent) of the Ferdynandów and Mazovian interglacials do not give, according to the author, sufficient basis to determine which of these floras is older.

The palaeobotanical correlation of Ferdynandów Interglacial with the interglacials of the Russian Plain (for which the stratotype lies in the Nizhniynskiy Rov in Byelorussia), although simple and certain, does not at present solve the problem, because the stratigraphic position of this interglacial in the stratigraphic schemes of USSR is equivocal. G.J.Goriecki et al. (1987) supposes that this interglacial is younger than Likhvin Interglacial, but O.P.Kondratiene and A.F.Sanko (1985), L.N.Voznyachuk (1978) and others situate the sediments of Shklov (Nizhniynskiy Rov) below Likhvin Interglacial. So, the mutual relation of Mazovian and Ferdynandów interglacials remains an open question.

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INTERGLACJAŁ FERDYNANDOWSKI W POLSCE

Streszczenie

Stanowisko osadów interglacjalnych "Buczyna pod brukiem" (fig. 5) stwierdzone zostało w odkrywce kopalni węgla brunatnego w Bełchatowie. Diagram pyłkowy pozwala na jednoznaczną korelację osadów z tego stanowiska z osadami z Ferdynandowa (Z. Janczyk-Kopikowa, 1975).

Na podstawie diagramu z Ferdynandowa, "Buczyna pod brukiem", Białobrzegów (fig. 1–3), Sosnowicy (fig. 4) i innych można wnioskować o odrębności tych flor od flor interglacjału mazowieckiego i eemskiego. Powtarzająca się w omawianych diagramach interglacjalna sukcesja pyłkowa jest charakterystyczna (odrębna od eemskiej i mazowieckiej) i pozwala na sprecyzowanie jej cech, z których ważniejsze to:

1. Niewielka, w całym interglacjale, rola świerka (*Picea*).

2. Optimum klimatyczne wyrażone panowaniem drzew liściastych ciepłolubnych, głównie dębu (*Quercus*) i wiązu (*Ulmus*) w mniej więcej równych ilościach (ok. 20%). Kilkudziesięcioprocentowa kulminacja leszczyny (*Corylus*) po maksimach dębu i wiązu. Niewielkie ilości lipy (*Tilia*). Brak lub sporadyczne występowanie graba (*Carpinus*).

3. Wczesne rozprzestrzenienie się olszy (*Alnus*).

4. Krótkotrwała znacząca rola jodły (*Abies*) łącznie z nikłym udziałem cisa (*Taxus*).

5. Powtórne ocieplenie w stropowej części profilu wyrażone panowaniem lasów liściastych, ze znaczącym udziałem graba (*Carpinus*).

Poza obszarem Polski diagramy o sukcesji pyłkowej typu ferdynandowskiego znane są powszechnie z terenu Białorusi, gdzie ich stratotyp znajduje się w miejscowości Niżniński Rów.