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THE FERDYNANDÓW INTERGLACIAL AT STANISŁAWICE NEAR KOZIENICE (CENTRAL POLAND)

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ABSTRACT. The occurrence of a series of lacustrine and marshy deposits referred to the decline of the San 2 Glaciation and Ferdynandów Interglacial was found in the profile at Stanisławice in the eastern part of the Radom Plain. The results of a palynological study of this series are presented in a pollen diagram. Three local pollen zones have been distinguished in the Late Glacial and four pollen periods in the interglacial. The absolute age of the deposits corresponding to the interglacial optimum has been determined by the TL method at 508 000 BP. Deposits of the Odra Glaciation overlie the interglacial layers. The Quaternary formation is here reduced to a great extent.

KEY WORDS: Ferdynandów Interglacial, lithostratigraphy, palinostratigraphy

INTRODUCTION

In an exploratory borehole made at Stanisławice for the purposes of the detailed Geological Map of Poland to a scale of 1: 50 000, sheet Kozienice (Żarski 1992), a series of lake and marsh deposits of the Ferdynandów Interglacial, with a pollen succession different from that of the Eemian and Mazovian-Holstein Interglacials, was evidenced by the results of palynological studies. The absolute age of the series under discussion was also determined and the results of lithological-petrographical studies are being prepared. The nearest localities of the Ferdynandów Interglacial are at Białobrzegi on the river Pilica, about 40 km west of the site under study, and at Ferdynandów, situated east of the borehole.

GEOGRAPHICAL SITUATION AND GEOLOGY OF THE PROFILE

The Stanisławice borehole is situated in the southern part of the Mazovian Lowland, about 100 km south of Warsaw (Fig. 1), near the town of Kozienice. In the physico-geographic division of Poland, according to Kondracki (1978), the study area is included in the mesoregion of the Radom Plain. The borehole is located on the postglacial upland, at an altitude of 149 m a.s.l., at a distance of about 1 km from its edge descending mildly towards the valley of the Vistula River (Figs 2 and 3). The surface of the upland is flat, diversified by dunes, several to more than ten metres in height. It is for the most part covered by tills and fluvioglacial sands of the Odra Glaciation

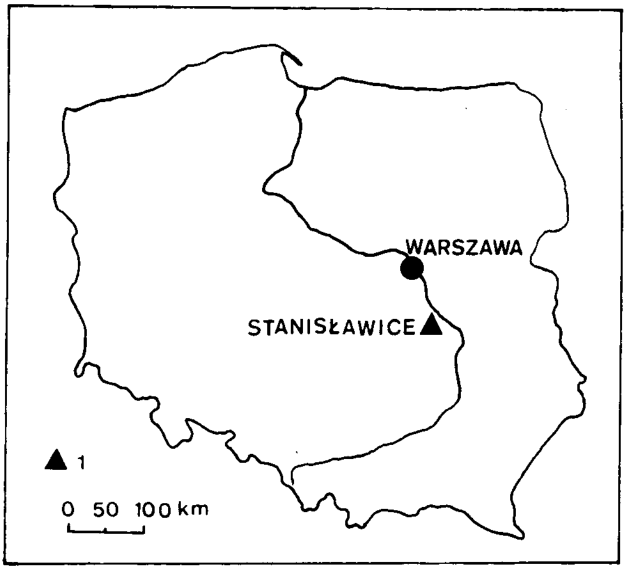

Fig. 1. Sketch map showing the location of the borehole. 1 – borehole

(Fig. 3). The borehole under study is situated at the foot of a small dune, in a small longitudinal depression without outflow.

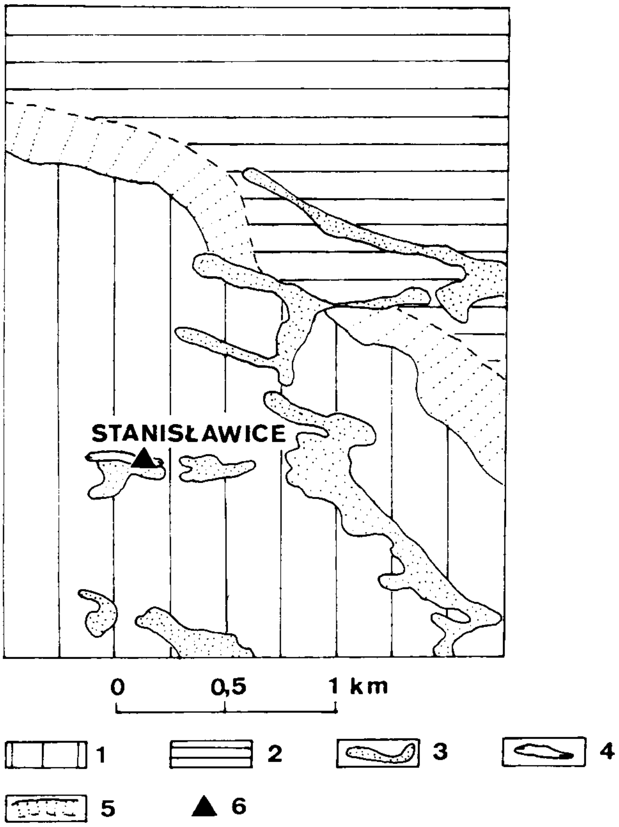

Fig. 2. Simplified geomorphological sketch. 1 – postglacial upland, 2 – supraflood terrace of the Vistula River, 3 – dunes, 4 – depressions void of outflow, 5 – mild edges of the postglacial upland, 6 – borehole

DESCRIPTION OF PROFILE

Lithological description

0.00–2.00	dusty sand with silty intercalations and peat inserts -HCL (H)
2.00–8.08	brown-grey loamy till, sandy at the bottom +++HCL (O)
8.08–8.15	grey-black clay -HCL (F)
8.15–9.30	brown-black peat with many wood pieces; in places detritus gyttja -HCL (F)
9.30–10.50	well-decomposed black peat, clayey, in places silty -HCL (F)
10.50–11.80	detritus gyttja with wood remains ++HCL (F)
11.80–12.30	calcareous gyttja (Sz)
12.30–12.60	dark-grey sandy silt ++HCL, with intercalations of yellow silt -HCL (Sz)
12.60–13.50	dark-grey silt with light intercalations -HCL (Sz)
13.50–13.80	grey-blue silt with intercalations of light-grey fine-grained sand -HCL (Sz)
13.80–20.60	beige-brown and blue-greenish fine-grained sand with intercalations of silts and dusty sands -HCL, with gravel at the bottom (Sr)
20.60–25.00	fine- and medium-grained quartz sand with dusty- sand intercalations -HCL (Rb)
25.00–28.00	grey clayey silt -HCL (Ra)
28.00–32.20	light-grey fine- and medium-grained sand -HCL (Ra)
32.20–37.50	coal clay passing into black silt -HCL (M_2)
37.50–41.30	grey fine-grained sand with silty intercalations -HCL (M_2)
41.30–46.20	grey-greenish dusty sand -HCL (Ol_1)
46.20–48.00	grey silt -HCL (Ol_1)

Stratigraphic description, TL examination

Boring at Stanisławice was finished in dusty sands and grey silts of the Lower Oligocene (Ol_1) (Słodkowska 1992). Here the Oligocene deposits reach several tens of metres in thickness and are underlain by Palaeocene marls (Pc) (Fig. 3). The 10-metres-thick Middle Miocene deposits (M_2), in the form of carbonaceous sands passing into silts and clays, occur above the Oligocene formations (Słodkowska 1992). The Miocene strata are overlain by a series of preglacial deposits (R), 11 m in thickness. These are of fluvial origin and occur in two accumulation cycles, (Ra) and (Rb), and in two facies: a channel facies and an extra-channel one. The formations of cycle (Ra) begin with a 4-metres-thick layer of quartz sands and end with a 3-metres-thick layer of clay with silt intercalations. These are extra-channel pollen free deposits. The age determined by the TL method is 800000 BP Lub-2470 (Butrym 1992). All the remaining TL datings were also performed at the Lublin Laboratory. Cycle (Rb), 4.5 m thick, is composed of quartz sands with an admixture of gravels and silt intercalations.

At the surface of the ground the preglacial deposits outcrop in the bank of the upland in the village of Stanisławice (Fig. 3). They belong to the so-called Kozienice layer, described and studied by Kosmowska-Ceranowicz (1966). Fluvial deposits associated with the San 2 Glaciation (Sr), with their bottom at an altitude of 128.4 m a.s.l., come above that layer. They are extraglacial deposits of a slowly flowing river, consisting of fine-grained sand, 6.8 m in thickness, with silt and silty sand intercalations. This formation is horizontally stratified. These deposits are in very bright and diversified colours: beige, brown,

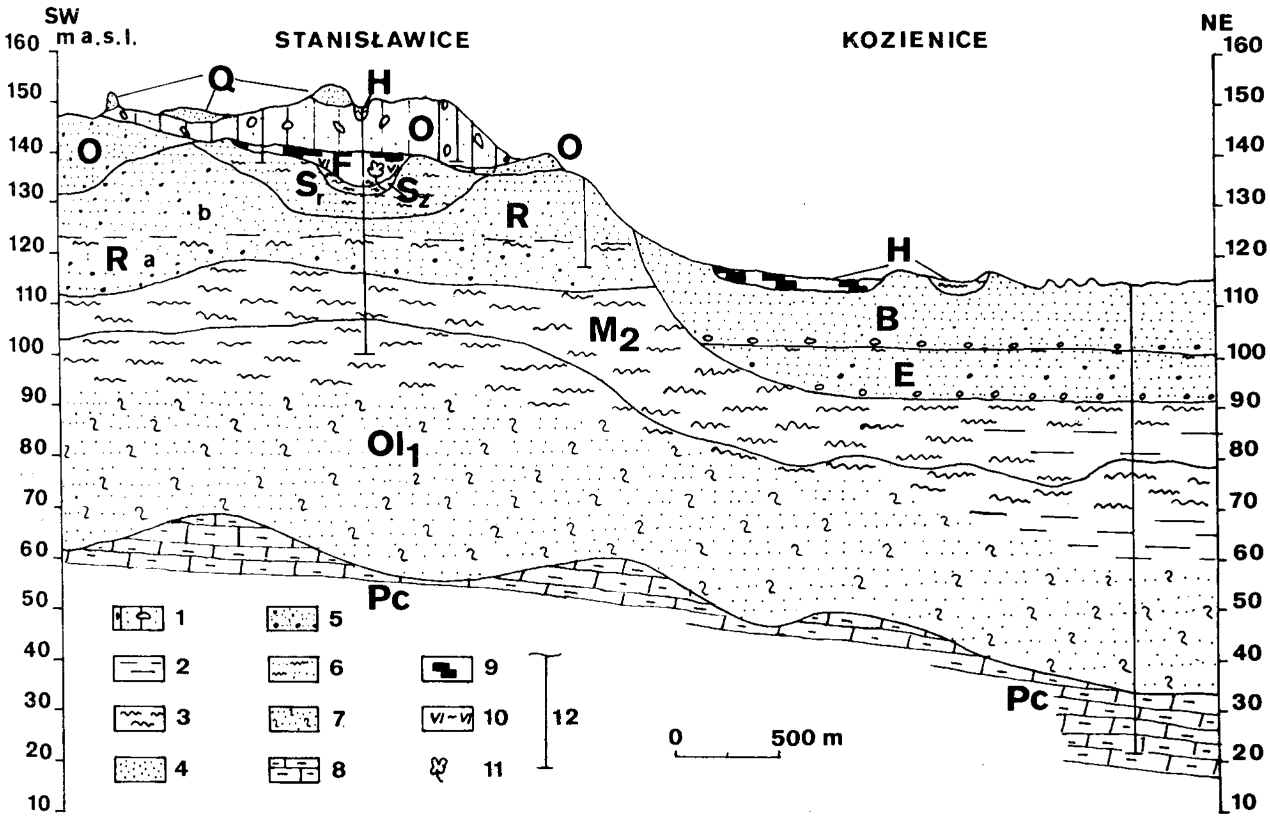

Fig. 3. Geological section. 1 – tills, 2 – clays, 3 – silts, 4 – sands, 5 – sands and gravels, 6 – dusty sands, 7 – glauconitic sands, 8 – marls, 9 – peats, 10 – gyttja, 11 – fossil flora, 12 – borings, Pc – Lower Palaeocene, Ol_1 – Lower Oligocene, M_2 – Middle Miocene, Ra – preglacial (cycle a), Rb – preglacial (cycle b), Sr – Southern Polish Glaciation (San 2), river facies; Sz – Southern Polish Glaciation (San 2), stagnant-water facies; F – Ferdynandów Interglacial, O – Odra Glaciation, E – Eemian Interglacial, B – Baltic Glaciation, Q – undivided Quaternary

black, blue and green. Such colours evidence a constant humidification of deposits. The processes of reduction of ferric compounds to ferrous ones occured in anaerobic conditions. As a result, the beige-brown colours changed into greenish blue. These deposits do not react with HCL. Their top was dated by the TL method at 564000 ± 84000 BP, Lub-2469 (sample from a depth of 14.0 m). A pollen analysis carried out by Janczyk-Kopikowa (1992) for a sample taken at a depth of 14.2 m and belonging to the fluvial series, showed the presence of *Pinus, Betula, Quercus* and other deciduous trees. Since the pollen proceeded from deposits of the channel facies, it may be supposed that it had been brought in washes. Above the fluvial formation of the San Glaciation there come glacilacustrine deposits (Sz), which pass without any sedimentational gaps into lacustrine deposits of the Ferdynandów Interglacial. The bottom of the glacilacustrine series lies at a depth of 13.8 m and the top at 11.8 m. These deposits begin with grey-blue calcareons-free silt. The TL age of this silt was determined at 537000 ± 80000 BP, Lub-2780 (sample from a depth 13.0–13.3 m) (Fig. 4). The top of this silt layer coincides with the lower boundary of local pollen assemblage zone St-1. The foregoing silt is followed by a layer of dark-grey silt, 0.30 m thick, with yellow silt intercalations; it corresponds with pollen zones St-1 and St-2, and the overlying mineral gyttja, 0.5 m thick, with zone St-3. Here, the lithological boundaries quite agree with the boundaries of pollen zones determined by climatic changes. The lacustrine series of the Ferdynandów Interglacial (F) begins with detritus gyttja, the bottom of which occurs at a depth of 11.8 m (137.2 m a.s.l.). It is 1.3 m thick and corresponds with pollen period I. The TL date of this deposit (sample from a depth of 11.0–11.3 m) is 519000 ± 78000 BP (Lub-2799). The gyttja is overlain by well-decomposed peat, somewhat clayey, in places silty. Its thickness is 1.2 m and it coincides with pollen periods II and III, which comprise an interglacial optimum. The absolute age of the sample from a depth of 9.80–10.1 m is 508000 ± 76000 BP

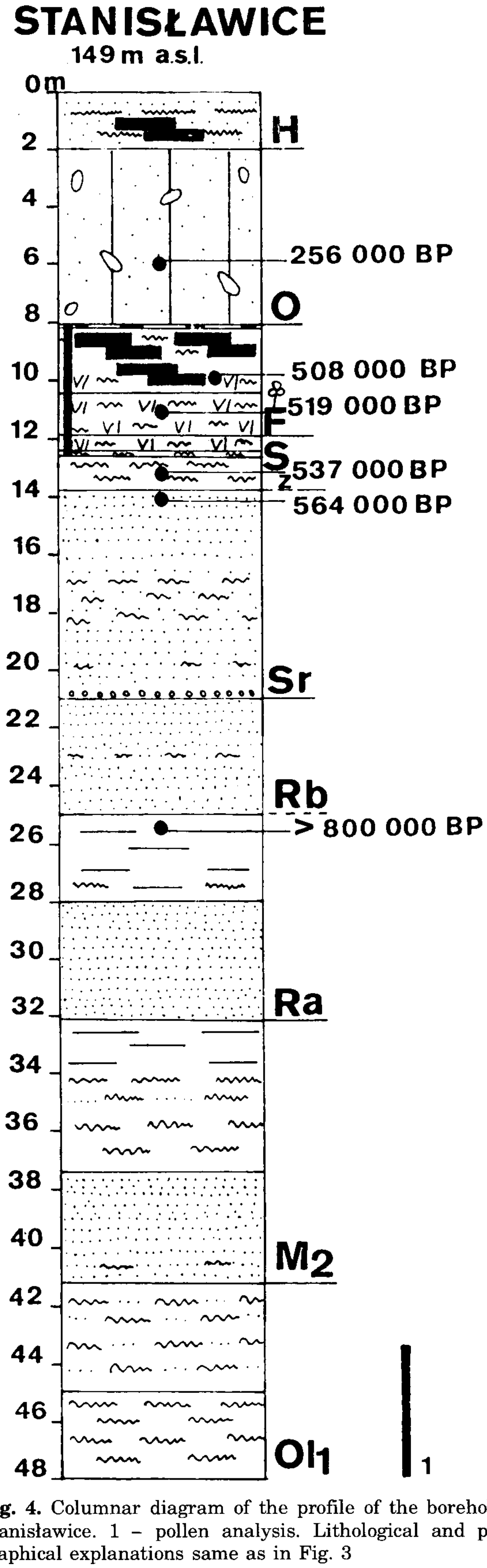

Fig. 4. Columnar diagram of the profile of the borehole at Stanisławice. 1 – pollen analysis. Lithological and petrographical explanations same as in Fig. 3

(Lub-2778) – (pollen period II). The interglacial series at Stanisławice ends with peat and interbeddings of detritus gyttja, which is 1.15 m thick and passes upwards into black clay. This layer corresponds with pollen period IV. The upper part of the series was cut off by later glaciations and in consequence the deposits from the second interglacial optimum, characteristic of the Ferdynandów succession, are missing. The lacustrine-and-marshy series of the Ferdynandów Interglacial at Stanisławice is 3.7 m in thickness. The interglacial series is covered by 2-metres-thick layer of till of the Odra Glaciation (O), dated by the TL method at 256000 ± 38000 BP (Lub-2468 – sample from a depth of 6 m) and a two-metres-thick series of Holocene sandy and peaty muds (H).

POLLEN ANALYSIS

Pollen analysis has been carried out for 49 samples taken at 8.09–12.60 m of the Stanisławice profile. The samples were macerated with 10% HCL, 7% KOH, heavy liquid (aequeous solution of CdJ_2 + KJ) and acetolysis. The results of the pollen analysis are presented in a pollen diagram (Fig. 5). The basic sum for percentage calculations consisted of pollen of trees, shrubs and dwarf shrubs (AP), and also terrestrial herbaceous plants (NAP). The pollen of aquatic plants, spores, plankton and forms strange to the Quaternary were not included to the basic sum. Their percentages were calculated in relation to the basic sum. The state of preservation of pollen grains was good.

The pollen diagram (Fig. 5) presents the pollen succession of the Late Glacial of the preceding glaciation and that of the interglacial. Three local assemblage zones have been distinguished in the Late Glacial, whereas only periods, i.e. biostratigraphical units of a higher rank than the zones, have been separated in the interglacial (Janczyk-Kopikowa 1987, Zasady 1988).

Fig. 5. Pollen diagram for the late glacial and Ferdynandów Interglacial at Stanisławice. For explanations see Fig. 3

LATE GLACIAL

Zone St-1, *Juniperus*-NAP, samples 48–49, depth 12.50–12.60 m. In this zone *Juniperus* reaches a maximum of 8.5%, *Salix* 4.8%. *Pinus* and *Betula* pollen occurs in equal parts, about 20% either. The NAP values reach 31.0% and 44.0% with the dominance of Cyperaceae 21.5%, Gramineae 8.4%, *Artemisia* 9.2%.

The upper boundary of the zone is placed at the distinct fall in the NAP values.

Zone St-2, *Betula-Pinus*, sample 47, depth 12.30–12.50 m. This zone is based on the findings from only one sample. Its significant feature is the common occurrence of *Pinus* (44%) and *Betula* (48.8%). *Juniperus* and *Salix* are declining. The NAP values fall to 5.6%.

The upper boundary of this zone is marked by the distinct rise in the NAP values.

Zone St-3, *Artemisia-Betula*, samples 44–46, depth 11.9–12.3 m. In this zone the NAP values range from 27.2 to 48.8%. *Artemisia,* with a maximum of 23.2%, is dominant among them. Cyperaceae reach 11.6%, Gramineae 5.6% and Chenopodiaceae 4.4%. As regards AP, *Betula*, which forms 44.0%, prevails. *Pinus* reaches 22.0%. *Salix* and *Juniperus* reappear.

The upper boundary of this zone lies at the rapid fall in NAP to 5.2%. It is, at the same time, the floristic boundary between the Late Glacial and the interglacial (depth – 11.80 m).

Distinct changes in the vegetation and climate are observed in the Late Glacial at Stanisławice. Initially (zone St-1) the dominant vegetation is treeless, with abundant Cyperaceae and with Gramineae and *Artemisia.* Noteworthy are also the light-loving *Juniperus*, having the maximum of its occurrence here, and *Helianthemum*. The proportion of *Salix* is significant. It may well be that amidst the treeless vegetation there were patches of forest-tundra, with *Pinus* and *Betula.* The subarctic-boreal climate is characteristic of the cool phase of the decline of glaciation.

Zone ST-2 shows a clear change in the nature of vegetation. The treeless vegetation had been replaced by close pine-birch forest, with an admixture of *Larix*. *Nuphar* appears amid the aquatic vegetation. *Typha latifolia* is also present. Here, we may speak about a distinct warming of the climate, which was of the boreal nature and characteristic of the interphase of the Late Glacial.

A re-withdrawal of the forest and the domination of tree-less vegetation are observed in zone St-3. The tundra-type vegetation, with Gramineae, Cyperaceae, Chenopodiaceae and *Selaginella selaginoides*, comprised steppe elements, as evidenced by a large proportion of *Artemisia*. Light-loving *Juniperus, Helianthemum* and *Hippophaë* are noteworthy. The persisting *Betula* and *Salix* may have formed small thickets. The vegetation of zone St-3 suggests a severe climate and is characteristic of the cold phase of the Late Glacial.

The continuous presence of *Picea* in a proportion of about 1% throughout the Late Glacial deserves to be emphasized.

INTERGLACIAL

Four pollen periods have been distinguished in the interglacial pollen succession (FI, FII, FIII, FIV).

FI is characterzized by the prevalence of boreal pine-birch forests. The dominance of *Betula* (max. 55.2%) and later that of *Pinus* (max. 68.4%) are noted at the onset of period FI. *Larix* and *Picea* also go to the making of the forest, *Alnus* is present, and the thermophilous deciduous trees *Ulmus* and *Quercus* appear in the middle of the period. Herbs (NAP) occur in proportions beneath 5% and they are of no major importance. The rise in the pollen values of *Quercus* and *Ulmus* and the fall of those of *Pinus* mark the upper boundary of period FI.

In **FII** thermophilous deciduous trees are dominant. The proportions of *Quercus* (max. 20.8%) and *Ulmus* (max. 17.6%) are similar, more or less uniform throughout period FII. At the beginning of the period the significance of *Pinus* and *Betula* is still great, whereas from the mid-period onward *Corylus* begins to dominate and reaches its maximum of 46.0% towards the end of FII. *Alnus* is present, its mean proportion being about 15%.

Large numbers of such shrubs as *Sambucus, Viburnum, Rhamnus* and *Cornus* occur in the dominant mixed deciduous forests with an admixture of *Tilia, Acer* and *Fraxinus.* Attention should be given to the occurrence of *Vitis* and *Ligustrum*, and in waters, thermophilous *Salvinia natans*. The herbaceous vegetation appears vestigially, (NAP below 3%). This is a period of interglacial climatic optimum. The climate is defined as temperate to warm temperate.

The upper boundary of period FII is placed at the rapid fall of the *Corylus* values and the increase in the values of *Picea* and *Abies*.

In **FIII** coniferous trees, like *Picea* (max. 14.8%) and *Abies* (max. 30.4%), play an important role. *Taxus*, reaches its not very high maximum of 2.6% in this period too. Thermophilous deciduous trees – *Quercus, Ulmus* and *Tilia* (the last one reaching a maximum of 5.8%) and *Corylus* – persist in the forests. These are mixed forests of the temperate climate with humidity higher than in period FII.

The upper boundary of the FIII period coincides with the rapid rise in the proportion of *Pinus*.

FIV is distinguished by the domination of pine forest with spruce and birch. The proportion of *Pinus* is high, max. 70.4%, *Picea* 10.4%. *Betula* reaches high pollen values (50.8%) only in the youngest part of period FIV. A small proportion of thermophilous deciduous trees is still to be seen in its older part. The herbaceous plants (NAP) in general persist about a level of 10% and only in the top portion of the profile their proportion reaches to 19.2%. The domination of pine-birch forests closes the succession of the interglacial at Stanisławice.

This succession bears certain characteristic features, e.g. the occurrence of *Quercus* and *Ulmus* in more or less equal quantities in the climatic optimum, the culmination of *Corylus* (about 45%) following the maxima of *Quercus* and *Ulmus*, the values of *Tilia* below 10% and the early expansion of *Alnus*. The dominance of *Abies*, with not very abundant *Picea* and a small proportion of *Taxus*, was short-lived but significant. The lack of *Carpinus* is worth emphasis.

A succession of similar traits has been presented by Janczyk-Kopikowa (1991a) as characteristic of the Ferdynandów Interglacial. It differs from the Eemian and Mazovian (Holstein) successions. In the foregoing work the author also mentions some other sites, whose pollen successions bear features of the Ferdynandów succession. In the stratotype profile at Ferdynandów (Janczyk-Kopikowa 1975) the FIV period is followed by a warming of the climate reflected by the domination of mixed deciduous forest with a high proportion of *Carpinus*. In the Ferdynandów succession *Carpinus* does not enter into the composition of the forests before the second warming. That is so not only in the Ferdynandów profile but also at Białobrzegi and Sosnowica (Janczyk-Kopikowa 1991b) and at Podgórze (Jurkiewiczowa et al. 1973) . Unfortunately, there are no deposits at Stanisławice that would evidence the second warming within the interglacial and its decline phase.

GEOLOGICAL AND PALAEOGEOGRAPHICAL RECAPITULATION

The retreat of the San glacier from the area at issue was followed by an accumulation of river deposits – stratified sands and silts and, at the very bottom, gravels, giving evidence of erosional processes. There was a small river here, the width of which did not exceed 1 km. The river flow was very slow, in the course of time it declined and a small water basin was formed in the river channel. At first calcium-free grey silts were deposited to pass next into calcareous gyttja, which constituted a transitional sediment between the Late Glacial and the interglacial. The prevailing climate was cool, boreal. Gyttja was accumulated at the onset of the interglacial. The overgrowing of the basin with vegetation led to peat formation in the period of the greatest warming. The following cooling of the climate was also reflected in the peat layer. The absolute TL age of the interglacial series under study, corresponding to the Ist and IInd pollen periods, lies within an interval between 519 000 and 508 000 BP. The samples from the IIIrd and IVth pollen periods were not subjected to dating because the deposit was not suitable for this type of study. The deposits of the Ferdynandów Interglacial are overlain by glacial deposits of the Middle Polish Glaciation. There is a big stratigraphic gap here, which makes it impossible univocally to define the stratigraphical position of the lacustrine deposits as they can be defined in the stratotype profile at Ferdynandów (Rzechowski 1987). It can be ascertained in the borehole at Stanisławice that the lacustrine deposits of the Ferdynandów Interglacial are older than the Odra Glaciation (Solawa Glaciation) and younger than the preglacial and extraglacial deposits referred to the San 2 Glaciation (Elstera Glaciation). The area in which the boring was made is characterized by reduced quaternary layers, which reduction was due to intense erosional processes. These processes may have been in turn strongly influenced by the uplift of the deeper substratum brought about by tectonic movements, probably also in the Pleistocene.

REFERENCES

BUTRYM J. 1992. Wyniki datowań termoluminescencyjnych próbek osadów czwartorzędowych z arkusza Kozienice, szczegółowej mapy geologicznej Polski w skali 1: 50 000., Arch. PIG, Warszawa.

JANCZYK-KOPIKOWA Z. 1975. Flora interglacjału mazowieckiego w Ferdynandowie (summary: Flora of the Mazovian Interglacial at Ferdynandów). Biul. Inst. Geol., 290: 5–94.

– 1987. Uwagi na temat palinostratygrafii czwartorzędu (summary: Remarks on palynostratigraphy on the Quaternary). Kwart. Geol., 31 (1): 155–162.

– 1991a. Palynostratigraphy of the Pleistocene in Poland and the problem of the age of deposits from Besiekierz (Central Poland). Ann. Univ. M. Curie - Skłodowska, sec. B, 46: 111–128.

– 1991b. The Ferdynandów Interglacial in Poland. (Interglacjał ferdynandowski w Polsce). Kwart. Geol., 35 (1): 71–80.

— 1992. Interglacjał ferdynandowski w Stanisławicach, ark. Kozienice 1: 50 000. MS., Arch. PIG, Warszawa

JURKIEWICZOWA I., MAMAKOWA K. & RÜHLE E. 1973. Utwory środkowego plejstocenu na południe od Wyśmierzyc koło Nowego Miasta nad Pilicą. (summary: Middle Pleistocene deposits south of Wyśmierzyce, near Nowe Miasto on the Pilica River). Folia Quat., 43: 1–18.

KONDRACKI J. 1978. Geografia fizyczna Polski. PWN, Warszawa.

KOSMOWSKA-CERANOWICZ B. 1966. Osady preglacjalne dorzecza środkowej Wisły. (summary: Preglacial-sand gravel sediments in the Middle – Vistula Basin). Prace Muzeum Ziemi, 9: 223–297.

RZECHOWSKI J. 1987. Problemy formalnej litostratygrafii czwartorzędu w Polsce. (summary: The questions of formal lithostratigraphy of the Quaternary in Poland). Kwart. Geol., 31 (1): 125–138.

SŁODKOWSKA B. 1992. Wyniki badań palinologicznych osadów trzeciorzędowych z profilu Stanisławice. MS, Arch. PIG, Warszawa.

ZASADY POLSKIEJ KLASYFIKACJI, terminologii i nomenklatury stratygraficznej czwartorzędu. Państw. Inst. Geol., Instrukcje i metody badań geologicznych, 1988, 47.

ŻARSKI M. 1992. Szczegółowa mapa geologiczna Polski w skali 1: 50 000, ark. Kozienice z objaśnieniami tekstowymi. MS, Arch. PIG, Warszawa.