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Organogenic deposits of the Mazovian Interglacial (Mindel *II*/Riss *I*) in the middle Vistula basin, compared to coeval European localities

ABSTRACT: Deposits representative of two climatic optima of the Mazovian Interglacial (Mindel *II*/Riss *I*) occur in post-glacial paleolakes (Ferdynandów, Podgórze) and paleovalleys (Syrniki) in the middle Vistula basin. As judged after their paleogeomorphologic and lithostratigraphic analysis, the lower optimum of the Mazovian Interglacial can be correlated with the lower part (Lh_1) of the Likhvin Interglacial, and the upper optimum with the Holstein Interglacial. Younger organogenic deposits, underlying the till of the Odranian Glaciation (Riss *I*), are attributed to the anaglacial part of that glaciation.

INTRODUCTION

The present paper is aimed to discuss the geological setting of the most important outcrops of deposits representative of the Mazovian Interglacial (Mindel *II*/Riss *I*) in the middle Vistula basin, Central Poland (Text-fig. 1). A special attention is paid to those localities (Ferdynandów, Podgórze) with interglacial organogenic deposits preserved in post-glacial lakes of the Sanian (Mindel *II*) age, overlain by the till of the Odranian Glaciation (Riss *I*). An attempt has been undertaken to recognize the position of those organogenic deposits relative to the alluvial series filling up the interglacial valleys of pre-Wieprz river (*cf.* Ruszczyńska-Szenajch 1978b) and pre-Pilica river (*cf.* Różycki 1964, 1972).

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LITHOSTRATIGRAPHIC AND PALEOGEOMORPHOLOGIC POSITION OF DEPOSITS OF THE MAZOVIAN INTERGLACIAL

SECTION AT FERDYNANDÓW

Organogenic deposits at Ferdynandów by Kock were subjected to several palynologic (Janczyk-Kopikowa 1963, 1975), as well as geologic investigations (Mojski 1969; Gronkowska 1972; Łyczewska 1977; Rusz-

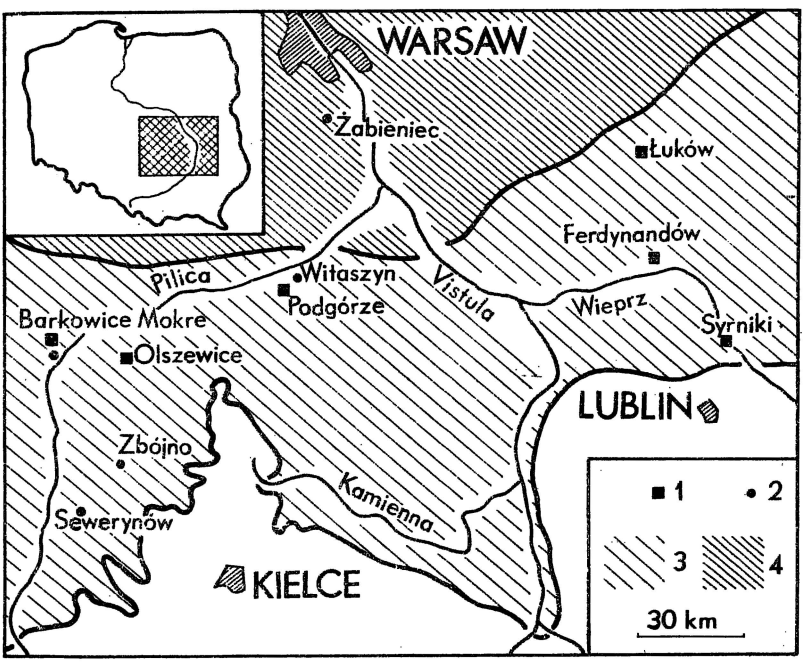


Fig. 1. Location map of the investigated organogenic deposits in Central Poland *1* localities of the Mazovian Interglacial (Mindel *II*/Riss *I*); *2* localities of the anaglacial part of the Odranian Glaciation (Riss *I*); *3* area covered by the icesheet of the Odranian Glaciation (Riss *I*); *4* area covered by the icesheet of the Vartanian Glaciation (Riss *II*)

czyńska-Szenajch 1978a, b). Most of the cited authors were of the opinion that those deposits are representative of the Mazovian Interglacial (Mindel *II*/Riss *I*), except for Łyczewska (1977) who assigned them to the Lublinian Interglacial (Riss *I*/Riss *II*). In turn, Rühle (1970) attributed them to the pre-maximum interstadial (Łuków Interstadial) of the Odranian Glaciation (Riss *I*); Sobolewska (1969) to the Podlasian Interglacial (Günz/Mindel *I*); and Erd (1978) and Mojski & Rzechowski (*in* Janczyk-Kopikowa & *al.* 1980) to the Voigtstedt-Warmzeit (Elster *I*/ /Elster *II* = Mindel *I*/Mindel *II*) called by Polish authors as the Kozi Grzbiet or Małopolanian Interglacial (Głazek & *al.* 1976a, 1977; Lindner 1978; Różycki 1978).

Paleogeomorphologic characteristics of the lower Wieprz basin were presented by Ruszczyńska-Szenajch (1978b) who claimed that the organogenic deposits of Ferdynandów (layer 2 in Text-fig. 2) had accumulated in a lake developed in the axial part of a glaciogenic depression formed by the icesheet of the Sanian Glaciation (Mindel II). The icesheet is indeed evidenced by a till (layer *1* in Text-fig. 2) overlying deposits of the glaciogenic depression (*dgl* in Text-fig. 2).

Deposits of the Mazovian Interglacial (layer *2* in Text-fig. 2) are represented by silts, sandy silts, and an organogenic series including peats, gyttjas, lake marls, bituminous shales, and diatomaceous earth in boreholes located in the vicinity of Ferdynandów. According to Janczyk-Kopikowa (1975), the organogenic series presents 11 floristic phases, with two climatic optima included. The lower optimum is at the phase 3. It is characterized mostly by *Ulmus*, *Quercus*, and *Corylus*, and represents a temperate to warm temperate climate. The upper optimum is at the phase 7. It is characterized mainly by *Carpinus* and *Alnus*, being representative of temperate climatic conditions.

The large amounts of thermophilous deciduous trees in the phase *3* of Janczyk-Kopikowa (1975) have considerably hampered any attempts to correlate the organogenic series of Ferdynandów with other organogenic deposits overlain by the till of the Odranian Glaciation (Riss *I*), and especially with those claimed to be representative of the Mazovian Interglacial (Mindel *II*/Riss *I*). The only palynologic localities resembling the organogenic series of Ferdynandów are those at Łuków (*cf.* Sobolewska 1969) and Podgórze (cf. Jurkiewiczowa & *al.* 1973), both of them representative of deposits accumulated in post-glacial lakes developed at morainic plateaux of the Sanian Glaciation (Mindel *II*).

From the geological standpoint, a similar bi-optimal interglacial period is represented by the organogenic deposits recorded in a borehole by Odintsovo, the Soviet Union, with the upper optimum being palynologically close to various localities of the Likhvin Interglacial, and the lower optimum resembling the Roslav Interglacial (Breslav & *al.* 1979).

The palynologic data, as well as the paleogeomorphologic characteristics of the lower Wieprz basin (see Ruszczyńska-Szenajch 1978b) permit a conclusion that the twofold alluvial series (layer *3* in Text-fig. 2) found in a paleovalley west-southwest of Ferdynandów and partly overlying the interglacial organogenic deposits is younger than the latter. According to Ruszczyńska-Szenajch (1978b), that series is equivalent to the third and fourth alluvial series recorded in the section at Barkowice Mokre on Pilica (*see* Text-fig. 1). The accumulation of the latter series is to be attributed (*cf.* Różycki 1972) to a climatic cooling marking the beginning of the anaglacial part of the Odranian Glaciation (Riss *I*).

In the neighborhood of Ferdynandów the alluvial series is overlain by a till (layer *4* in Text-fig. 2), tripartite here and there. Most authors assigned that till to the Riss Glaciation; Mojski (1969) and Ruszczyńska-Szenajch (1978b) to the Odranian Glaciation (Riss *I*), and Łyczewska (1977) to the Vartanian Glaciation (Riss *II*).

SECTION AT PODGÓRZE

Organogenic deposits recorded at Podgórze by Wyśmierzyce in the lower Pilica basin (layer *9* in Text-fig. 3*B*) have been assigned by Jurkiewiczowa & *al.* (1973) to the Mazovian Interglacial (Mindel *II*/ /Riss *I*).

The oldest Quaternary deposits in that area are the tills (layer *1* in Text-fig. 3*B*) of the Nidanian Glaciation (Mindel *I*). The tills are cut by a paleovalley filled up with alluvial sands (layer *2* in Text-fig. 3*B*) representative of the Malopolanian Interglacial (Mindel *I*/Mindel *II*). The overlying sands and silts (layer *3* in Text-fig. 3*B*) have been recognized for accumulated in an ice-dammed lake during the anaglacial part of the Sanian Glaciation (Mindel *II*). The presence of the icesheet of that glaciation is documented by a till (layer *4* in Text-fig. 3*B*) cut by a paleovalley filled up with alluvial sands (layer *5* in Text-fig. 3*B*) representative of the post-maximum interstadial of the Sanian Glaciation. The overlying silts and sands (layer *6* in Text-fig. 3*B*), and the successive till (layer *7* in Text-fig. 3*A*—*B*) are attributable to the post-maximum stadial of that glaciation.

The above described sedimentary sequence is overlain at Podgórze by a sandy-silty series (layer *8* in Text-fig. 3*B*) reflecting a lacustrine sedimentation during the decline of the icesheet of the post-maximum stadial of the Sanian Glaciation. The overlying organogenic deposits (layer *9* in Text-fig. 3*B*), found both at Podgórze and at Podlesie, are to be attributed to the bi-optimal Mazovian Interglacial (Mindel *II*/Riss *I*). As indicated by the palynologic diagram obtained by Mamakowa (*in* Jurkiewiczowa & *al.* 1973) for the section of Podgórze, the lower optimum (samples *23—24*) is characterized by predominance of *Alnus, Corylus, Quercus,* and *Ulmus,* accompanied by *Acer*. At the upper optimum (samples *13—15*), the dominant deciduous trees and/or shrubs were *Alnus* and *Corylus*. In the neighboring section at Podlesie (*see* Text-fig. 3*B*) the interglacial organogenic deposits cover directly the till, and represent only a part of the upper climatic optimum.

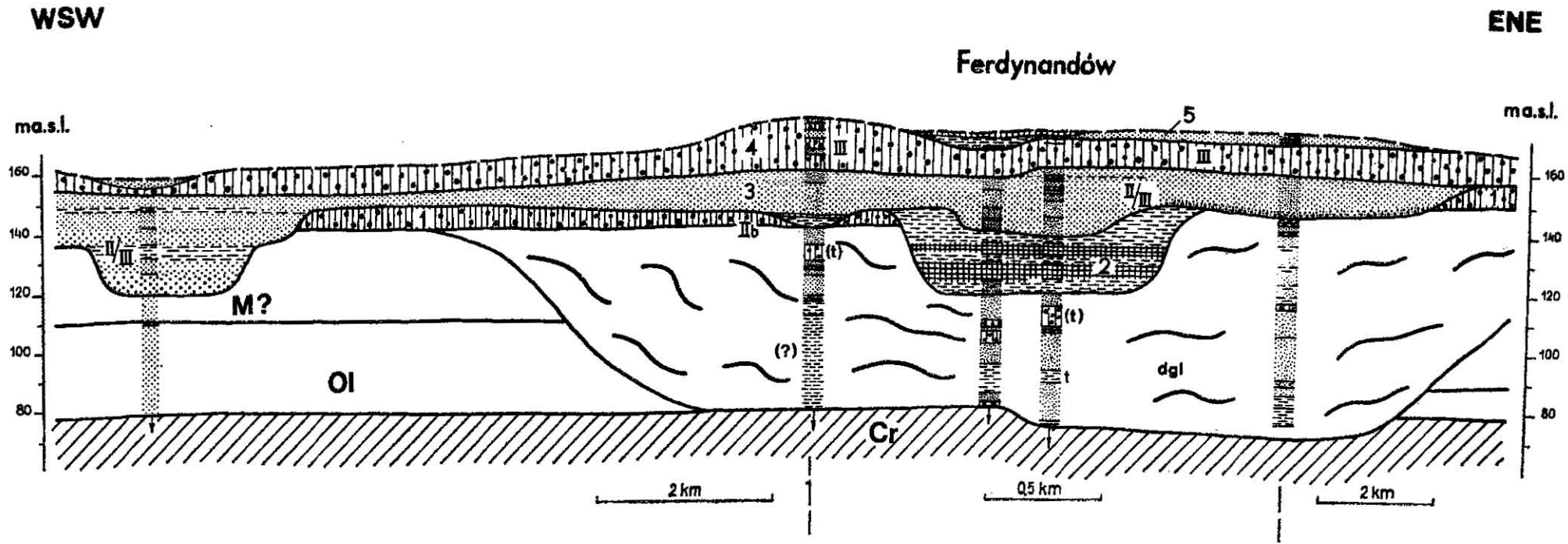
According to Różycki (1964, 1972), tills of the Sanian Glaciation (layer 7 in Text-fig. 3*A*) are cut by a deep paleovalley at Witaszyn on Pilica, some 6 km northwest of Podgórze. The paleovalley is filled up with four alluvial series, the lower two of which (layer *10* in Text-fig. 3*A*) are representative of the Mazovian Interglacial (Mindel *II*/Riss *I*). The lowermost series reflects the lower climatic optimum (Sulejów optimum), and the overlying one the upper optimum (Olszewice optimum) of the interglacial.

The lower optimum (Sulejów optimum) remains thus far incompletely documented floristically. As indicated by the analysis of plant remains preserved in the lower alluvial series of Barkowice Mokre (*see* Text-fig. 1), that optimum was characterized (Sobolewska & Supniewska *in* Rühle 1952) by co-occurrence of coniferous (*Abies*) and deciduous trees or shrubs (*Alnus, Corylus, Acer*). Presumably, it is equivalent to the lower interglacial optimum recorded at Ferdynandów and Podgórze, as it may be the case also with the lower climatic optimum found at Syrniki (*cf.* Karaszewski 1954, Rühle 1973). One may suppose that this holds also for the lower (interstadial?) optimum reflected at Gościęcin (*cf.* Środoń 1957) by organogenic-mineral deposits overlying the till of the Sanian Glaciation.

In turn, the upper climatic optimum (Olszewice optimum) recognized by Sobolewska (1956a) within the Pleistocene alluvial series of Olszewice is characterized chiefly by *Carpinus* accompanied by considerable amounts of *Alnus,* and seems to be equivalent to the upper interglacial optimum of Ferdynandów and Podgórze.

The upper two alluvial series found in the paleovalley at Witaszyn (layer *11* in Text-fig. 3*A*) were attributed by Różycki (1972) to the anaglacial part of the Odranian Glaciation (Riss *I*). Organogenic deposits preserved at Barkowice Mokre at the top of the lower one of the two series are indicative of predominance of coniferous forests at that time (Sobolewska 1952), which is the case also with the deposits described by Jurkiewiczowa & Mamakowa (1960) from Sewerynów. In turn, the plant-bearing silts (layer *12* in Text-fig. 3*A*) recorded at Witaszyn

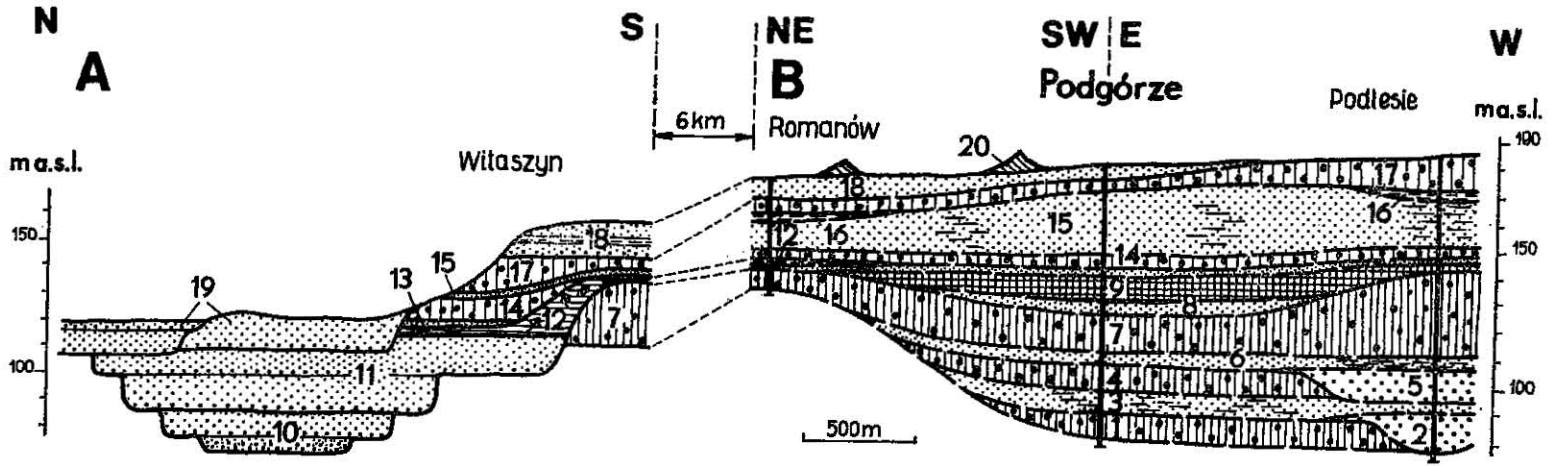
Geological section of the glaciogenic depression at Ferdynandów (*after* Ruszczyńska-Szenajch 1978b)



Cr Cretaceous (marls, limestones, and gaizes, with chalk or limy clays in places); *Ol* Oligocene (clays and fine- to medium-grained sands); M Miocene (fine- to medium--grained sands and clays); *dgl* glaciogenic depression filled up with Quaternary and older deposits; *t* Tertiary material

SANIAN GLACIATION (MINDEL *II*): *1* till of the maximum stadial
MAZOVIAN INTERGLACIAL (MINDEL *II*/RISS *I*): **2** silts, sandy silts, and organogenic lacustrine deposits. ODRANIAN GLACIATION (Riss *I*): **3** alluvial gravels, sands, and silts; *4* till intercalated with sands of the Radomka Stadial; *5* sands and silts
Stratigraphic symbols are as *in* Różycki (1972)

Geological sections: A — southern part of the Pilica valley by Witaszyn (*after* Różycki 1964), B — Podgórze region (data taken *from* Jurkiewiczowa & *al.* 1973)



NIDANIAN GLACIATION (MINDEL *I*): *1* till. MALOPOLANIAN INTERGLACIAL (MINDEL *I*/MINDEL *II*): *2* sands with gravel and fine boulders. SANIAN GLACIATION (MINDEL *II*): *3* sands and silts; *4* till of the maximum stadial; *5* interstadial sands with gravel and fine boulders; *6* sands and silts; *7* till of the post-maximum stadial; *8* silts and sands of lacustrine origin. MAZOVIAN INTERGLACIAL (MINDEL *II*/RISS *I*): *9* gyttja, clayey shale, and sandy silt of lacustrine origin, with sands at the top; *10* alluvial sands and gravels. ODRANIAN GLACIATION (RISS *I*): *11* alluvial sands and gravels of the Liwiec Stadial; *12* plant-bearing silts and clays of the Liwiec Stadial; *13* alluvial sands of the Zbójno Interstadial; *14* till of the Krzna Stadial; *15* sands intercalated with silts of the Podlesie Interstadial; *16* clays and silts of the Podlesie Interstadial; *17* till of the Radomka Stadial; *18* fluvioglacial sands intercalated with silts of the Radomka Stadial. POST-ODRANIAN DEPOSITS: *19* alluvial sands, gravels, and muds; *20* dunes

at the top of the uppermost alluvial series make the evidence for a climatic cooling (*cf.* Środoń *in* Ciuk & Rühle 1952) and may even be suggestive of the occurrence of the icesheet of a pre-maximum stadial of the Odranian Glaciation (Riss *I*) northeast of Warsaw (Różycki 1972). Mamakowa (in Jurkiewiczowa & *al.* 1973) recorded up to 90% of *Pinus* pollen accompanied by minor amounts of various herbaceous-plant pollen in the ice-dammed lacustrine deposits of that age at Romanów. A similar palynologic diagram was obtained for the section at Żabieniec (Janczyk-Kopikowa *in* Sarnacka 1977). This climatic cooling has been recently called as the Liwiec Stadial of the Odranian Glaciation (Lindner & Brykczyńska 1980).

The plant-bearing silts are cut at Witaszyn by a paleovalley of a dozen or so meters in depth, with sandy deposits at the bottom (layer *13* in Text-fig. 3*A*). The development of that paleovalley is to be attributed to a considerable climatic amelioration during the Zbójno Interstadial (Lindner & Brykczyńska 1980).

The till (layer *14* in Text-fig. 3*A*—*B*) overlying the above described paleovalley deposits of Witaszyn and Romanów, as well as the interglacial deposits of Podgórze and Podlesie, represents the Krzna Stadial of the Odranian Glaciation (Rühle 1970, Jurkiewiczowa & *al.* 1973, Lindner 1979). Higher in the section, there are sands intercalated with silts (layer *15* in Text-fig. 3*A*—*B*) and clays and silts (layer *16* in Text-fig. 3*B*) representative of the Podlesie Interstadial defined palynologically by Mamakowa (*in* Jurkiewiczowa & *al.* 1973) in the section at Podlesie. The overlying till (layer *17* in Text-fig. 3*A*—*B*) makes the evidence for the occurrence of the icesheet of the maximum stadial (Radomka Stadial) of the Odranian Glaciation in that area (Różycki 1964, 1972; Jurkiewiczowa & *al.* 1973; Lindner 1979). The melting of that icesheet resulted in accumulation of fluvioglacial sands intercalated with silts (layer *18* in Text-fig. 3*A*—*B*).

A TENTATIVE LITHOSTRATIGRAPHIC CORRELATION WITHIN THE MINDEL *II*/RISS *I* INTERGLACIAL IN EUROPE

The characteristics of the Pleistocene organogenic deposits of the middle Vistula basin permit a comparison of their stratigraphic position to that of other organogenic sequences attributable to the Great Interglacial (=Holstein Interglacial), the latter being most commonly meant as the time interval between the maximum development of the icesheet of the Sanian Glaciation (Mindel *II*) and that of the Odranian Glaciation (Riss *I*). The obtained results corroborate the earlier claims (Różycki 1961, 1964, 1967; Rühle 1969, 1973) that the considered time interval presented actually a number of alternating cool and warm periods, out of which only the warmest two (the Sulejów and Olszewice optima) are to be attributed to the Mazovian Interglacial (Mindel *II*/Riss *I*); whereas the fossil floras of Barkowice Mokre (*B* = upper organogenic deposits), Sewerynów, Witaszyn, Żabieniec, Romanów, Zbójno, and Podlesie are attributable to the anaglacial part of the Odranian Glaciation (Riss *I*).

As indicated by the history of the alluvial sedimentation in paleovalleys during the anaglacial part of the Odranian Glaciation (Riss *I*), it was controlled mainly by a gradual deterioration of the climate resulting in a decline of the flora, which caused in turn an increase in

supply of clastic material derived from the slopes of paleovalleys. An additional factor contributing to the accumulation of the third and fourth alluvial series in the valleys of pre-Vistula, pre-Wieprz, and pre-Pilica rivers could be the occurrence of an icesheet in the north-eastern part of the Mazovian Lowland (Różycki 1972, Rühle 1973). This is the reason for recognition of the considered time interval for the Liwiec Stadial, separated by the Zbójno Interstadial from the subsequent Krzna Stadial (Lindner & Brykczyńska 1980). The Krzna Stadial was succeeded by the Podlesie Interstadial and the Radomka Stadial, the latter being the time of the maximum extent of the icesheet of the Odranian Glaciation (Riss *I*) in Central Europe (Text-fig. 4).

The proposed subdivision of the anaglacial part of the Odranian

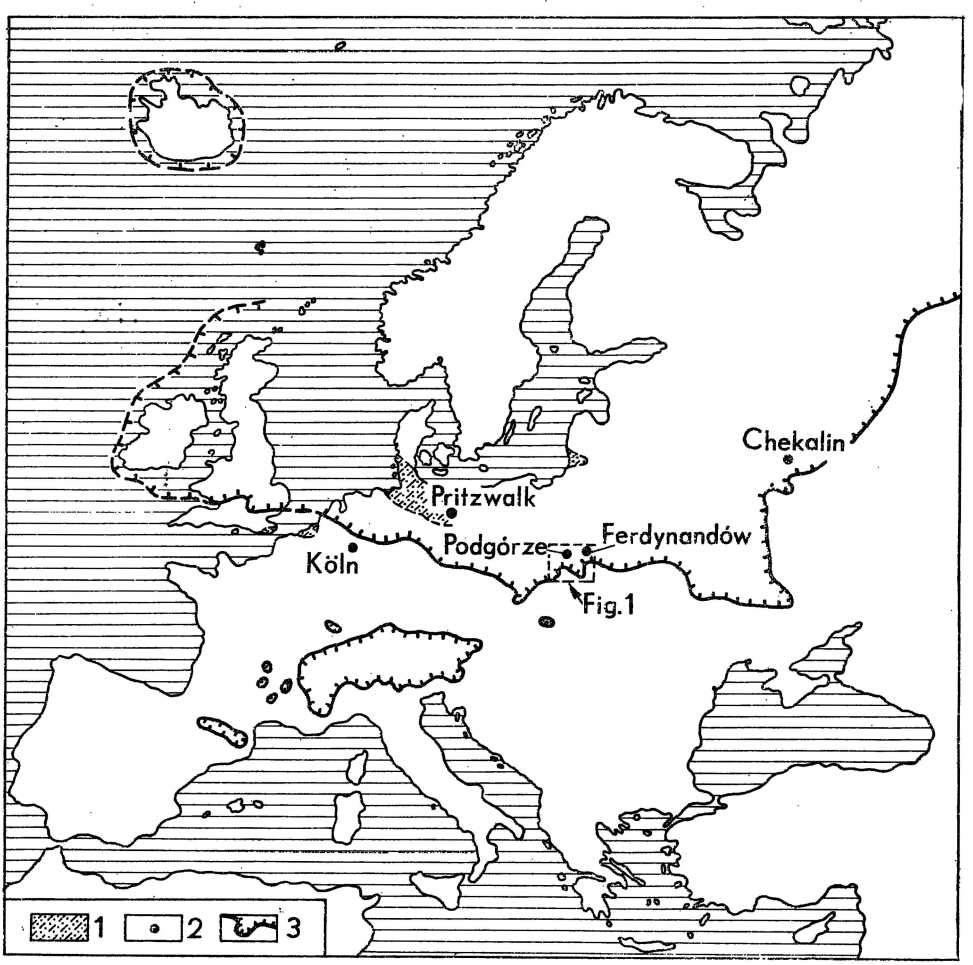


Fig. 4. The investigated localities of the Mindel *II*/Riss *I* Interglacial against the maximum extent of the Riss *I* Glaciation in Europe

1 marine deposits of the Mindel *II*/Riss *I* Interglacial; *2* the investigated organogenic deposits of the Mindel *II*/Riss *I* Interglacial; *3* maximum extent of the Riss *I* Glaciation (*after* Krasnov 1964, Velitchko 1977)

Glaciation (Riss *I*) and the recognition of the stratigraphic position of organogenic deposits of the Mazovian Interglacial (Mindel *II*/Riss *I*) permit an attempt to correlate the investigated localities with the most important sections of interglacial intermorainic deposits in the Soviet Union and the German Democratic Republic.

The most representative section attributable to the considered interglacial in the Soviet Union is that at Chekalin (formerly Likhvin) on the Oka river (Text-fig. 4), which was the subject of comprehensive paleobotanic and geologic investigations (Ushko 1959, Gritchuk 1961, Kriger & Moskvitin 1961, Sudakova 1973, Sudakova & Aleshinskaya 1974). According to the most recent chronostratigraphic interpretation of that section (Text-fig. 5*B*), deposits overlying the till of the Oka Glaciation (Mindel *II*) and underlying that of the Dnieper Glaciation (Riss *I*) represent three distinct time intervals of the Likhvin Interglacial (*Lh_1, Lh_2, and Lh_3*).

The oldest subunit of the Likhvin Interglacial (*Lh_1*) is represented by sands and gravels overlain by organogenic deposits. The palynologic diagram obtained for lacustrine deposits making part of that sequence differs from those recorded in other localities (Big Kosha, Bulatovo) attributed to the same interglacial in a higher proportion of pollen of coniferous trees, and especially *Abies* (Vishnevskaya & *al.* 1970). One may suppose that the lowermost part of the Chekalin section, dated for 459,000±56,000 BP after the thermoluminescence method, is representative of the pre-optimum and optimum phases of the Likhvin Interglacial and may be a lithostratigraphic equivalent of the lower climatic optimum of the Mazovian Interglacial (Text-fig. 8).

The overlying two sandy-gravel series, each of them ended with basinal deposits and paleosols, have been designated for the middle part of the Likhvin Interglacial (*Lh_2*) in the Chekalin section (Text-fig. 5*B*). As judged after their lithostratigraphic position and absolute time attribution (453,000±52,000 to 371,000± ±43,000 BP after the thermoluminescence method), the basinal deposits and paleosols preserved at the top of the lower one of the two series may be equivalent to the upper climatic optimum of the Mazovian Interglacial, which was dated at Draby, Central Poland, for 320,000 to 440,000 BP after the FCl/P method (*cf.* Głazek & *al.* 1976b). In turn, the upper series was dated for 349,000±45,000 and 336,000±41,000 BP, and the lithostratigraphic evidence appears indicative of its equivalence to the alluvial sedimentation during the anaglacial part of the Dnieper Glaciation (Riss *I*). When referred to the middle Vistula basin, the latter series can be correlated with the alluvial and basinal deposits of Barkowice Mokre and Witaszyn (series *3* of Różycki 1964) and Ferdynandów (lower part of the twofold alluvial series of Ruszczyńska-Szenajch 1978b), as well as with the alluvial sands of Wąchock dated for 352,000 BP after the thermoluminescence method (Lindner & Prószyński 1979). Hence, they may be correlated with the initial part of the Liwiec Stadial (Lindner & Brykczyńska 1980).

The lower part of the *Lh_3* unit of the Chekalin section includes loessy deposits with frost wedges and a poorly developed paleosol (Text-fig. 5*B*). It may be time equivalent to the series *4* of Barkowice Mokre and Witaszyn (*sensu* Różycki 1964), and the upper part of the twofold alluvial series of Ferdynandów as meant by Ruszczyńska-Szenajch (1978b). Thus, it may reflect a decline of the Liwiec Stadial (Text-fig. 8). The overlying paleosol, dated in the Chekalin section for 324,000±35.000 BP after the thermoluminescence method (Ivanovo Interglacial

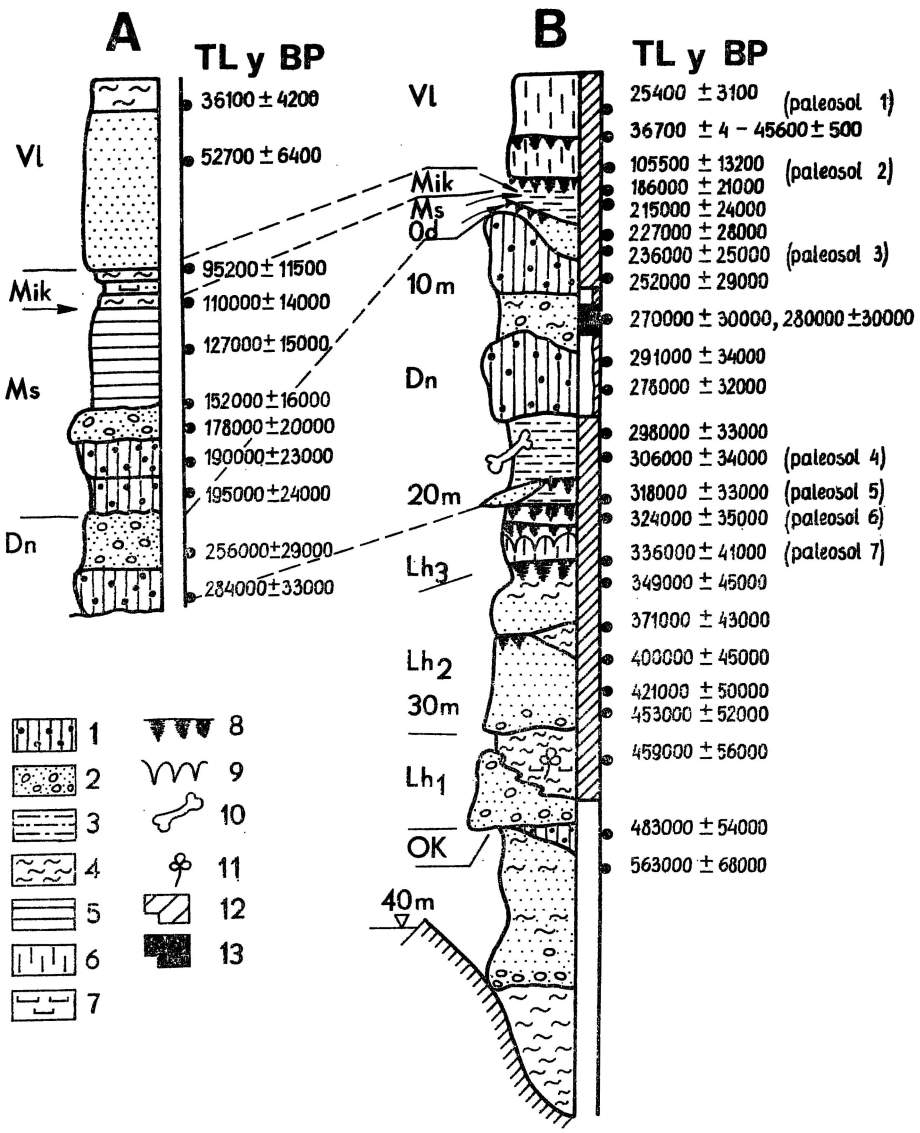


Fig. 5. Geological sections of the Pleistocene of the central part of the Russian Plain (*after* Sudakova & Aleshinskaya 1974): **A** Nero lake, **B** Chekalin (formerly Likhvin)

Absolute datings by the thermoluminescence method *after* V. A. Iljichev & V. N. Shelkoplyas; paleomagnetic data *after* V. I. Trukhin & S. S. Faustov

1. tills; *2* boulders, gravels, and sands; *3* silts; *4* loams and clays; *5* varved clays; *6* loessy sediments; *7* lime bog; *8* paleosols (numbered 1 to 7); *9* frost wedges; *10* mammoth and lemming remains; *11* organogenic deposits of the optimum of the Likhvin Interglacial; *12* normal polarization; *13* reverse polarization

OK Oka Glaciation (Mindel); **Lh** Likhvin Interglacial (Mindel *II*/Riss *I*); **Dn** Dnieper Glaciation (Riss *I*); **Od** Odintsovo Interglacial (Riss *I*/Riss *II*); **Ms** Moscow Glaciation (Riss *II*); **Mik** Mikulino Interglacial (Riss *II*/Würm); **Vl** Valdai Glaciation (Würm)

of Moskvitin 1977), may be time equivalent to the warm Zbójno Interstadial. The basinal deposits covering that paleosol were dated for 318,000±33,000 BP after the thermoluminescence method and can be recognized for equivalent to the Krzna Stadial. Finally, the paleosol developed at those basinal deposits can be correlated with the Podlesie Interstadial.

The discussed deposits are overlain at Chekalin by silts with mammoth and lemming remains, and a till attributable to the Dnieper Glaciation (Riss *I*). The till was dated for 280,000±32,000 BP after the thermoluminescence method and may be correlated with the maximum stadial (Radomka Stadial) of the Odranian Glaciation in the middle Vistula basin (Text-fig. 8).

In the German Democratic Republic the considered interglacial period (Mindel *II*/Riss *I*) is most completely represented in the section of Pritzwalk (Text-fig. 6). As shown in the geological section given by

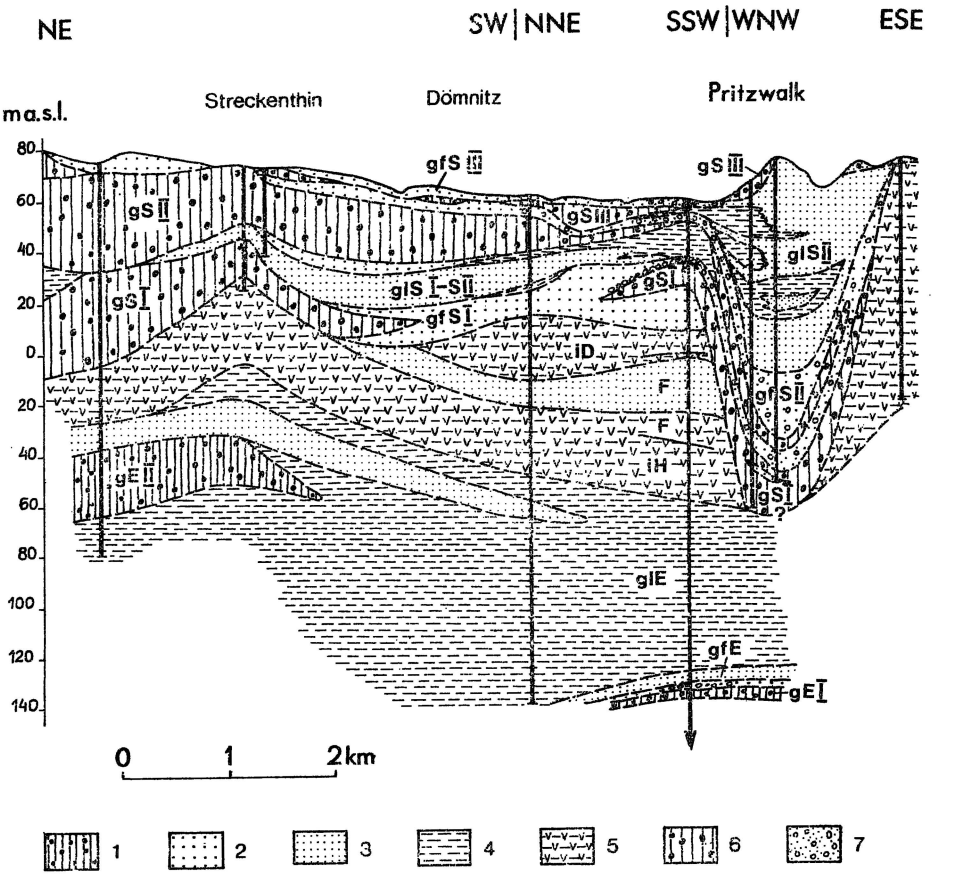


Fig. 6. Geological section of the Quaternary in the Pritzwalk region (*after* Cepek & *al.* 1975)

1 tills of the Elster Glaciation (Mindel); *2* fine- to coarse-grained sands intercalated with gravels; *3* fine- to medium- grained and silty sands; *4* silts and clays, varved in places; *5* silts intercalated with clays; *6* tills of the Saale Glaciation (Riss); *7* sands and gravels *gf* glaciofluvial facies; *gl* glaciolimnic facies; *g* glacial facies

S III Lausitzer-Kaltzeit (Saale *III*); **S II** Fläming-Kaltzeit (Saale *II*); **S *I*** Saale-Kaltzeit s. str.; **iD** Dömnitz-Warmzeit **F** Fuhne-Kaltzeit; **iH** Holstein-Warmzeit; **E** Elster-Komplex (**E I** and **E II**)

Cepek & *al.* (1975), the oldest Quaternary deposit in that area is the till of the Elster *I* Glaciation (layer *gEI* in Text-fig. 6). The till is covered by sands and gravel (layer *gfE* in Text-fig. 6) overlain in turn by fine-grained sands and silts passing upwards into a thick silty--clayey series (layer *glE* in Text-fig. 6). The latter series is overlain by the till of the Elster *II* Glaciation (layer *gEII* in Text-fig. 6) covered in turn by fine-grained sands.

The above sequence is overlain at Pritzwalk area by a thick series of silts intercalated with clays. As shown by a palynologic analysis of those deposits (Erd 1973), the lower part of that series is representative of the Holstein Interglacial (layer *iH* in Text-fig. 6), with a distinct optimum characterized by *Abies* and *Carpinus* at the phase *5* equivalent to the phase *III* of Szafer (1953). The latter phase can be attributed to the climatic optimum recorded at Olszewice (*cf.* Sobolewska 1956a) and Syrniki (*cf.* Sobolewska 1956b). Furthermore, the mollusk and ostracode fauna of Syrniki shows much affinity to those attributed in the German Democratic Republic to the Holstein Interglacial (Diebel 1961). One may therefore claim that the brackish-limnic deposits of the Holstein Interglacial recorded in the Pritzwalk section may be time equivalent to the upper climatic optimum of the Mazovian Interglacial (Text-fig. 8). The results of Müller's (1974) work suggest that this was a rather short time interval, approximating only some 15,000 to 16,000 years.

According to Erd (1973), a distinct cooling recorded in the upper part of the silts of Pritzwalk is equivalent to the Fuhne-Kaltzeit. However, Cepek & *al.* (1975) attributed also the overlying sandy deposits (layer *F* in Text-fig. 6) to the latter period. The palynologic characteristics of deposits representative of the Fuhne-Kaltzeit found both in the Pritzwalk section and at Wuthenow (Cepek & Erd 1975) are indicative of a considerable cooling reflected by a decline of coniferous trees, out of which only *Pinus* amounts to 25% in the pollen diagrams. Possibly, this cooling is time equivalent to the Liwiec Stadial (Text-fig. 8). One may suppose that this is the case also with the upper part of the Lh_2 series of the Chekalin section.

Higher up in the Pritzwalk section occurs a silty-clayey series (layer *iD* in Text-fig. 6) demonstrated palynologically to reflect a climatic warming (Erd 1973). This warming (Dömnitz-Warmzeit) is characterized by early predominance of *Alnus* (up to 30%) and *Quercus* (up to 15%) among the deciduous trees, associated with an increasing proportion of *Corylus*, *Carpinus*, and *Taxus* later on. The stratigraphic position of deposits of the Dömnitz-Warmzeit seems to be suggestive of a time equivalence to the warm Zbójno Interstadial in Central Poland (*cf.* Lindner & Brykczyńska 1980) and to the so-called Ivanovo Interglacial in the Chekalin section (*cf.* Moskvitin 1977) included recently to the Lh_3 series (Sudakova & Aleshinskaya 1974).

According to Cepek & *al.* (1975), the three tills (layers *gSI*, *gSII*, *gSIII* in Text-fig. 6) overlying the silty-clayey series in the Pritzwalk section represent three successive stadials of the Saale Glaciation. They are separated from one another by glaciofluvial (layers *gfSI* and *gfSII* in Text-fig. 6) and glaciolimnic deposits (layer *glSI—glSII* in Text-fig. 6). The oldest one of these three stadials (Saale *I*) can be correlated with the maximum stadial (Radomka Stadial) of the Odranian Glaciation in Poland, the maximum development of the Dnieper Glaciation in the Soviet Union, and the Riss *I* Glaciation in the Alps (Kukla 1977).

When considering organogenic deposits of the Mindel *II*/Riss *I* Interglacial in Poland, much attention is to be paid to the Rhine terraces north of Cologne (*cf.* Brunnacker & *al.* 1978). The terraces occur out of the maximum extent of the icesheet of the Riss *I* Glaciation, and bear various interglacial deposits (Frimmersdorfer Interglacial, Holstein Interglacial and possibly Efferen Interglacial) which allows to restore the Pleistocene history of the lower Rhine valley (Text-fig. 7), and especially to decipher the position and nature of deposits of the Holstein Interglacial represented by the "Kempen-Krefelder Schichten" (*cf.* Kempf 1966).

The "Kempen-Krefelder Schichten" of the lower Rhine valley (*see* Text-fig. 7) include lake marls, gyttja, peats, and humus muds overlying sands and gravels of the alluvial series called as the middle terrace *MT IIIa* (Mittelterrasse *IIIa*), and underlying the successive alluvial series *MT IIIb* (Mittelterrasse *IIIb*). The series *MT IIIa* may have accumulated not only during the final part of the Mindel *II* Glaciation (Brunnacker & *al.* 1978), but also during the pre-optimum phase and possibly even the earlier interglacial climatic optimum which caused complete disappearance of the Alpine glaciers of the Mindel *II* Glaciation.

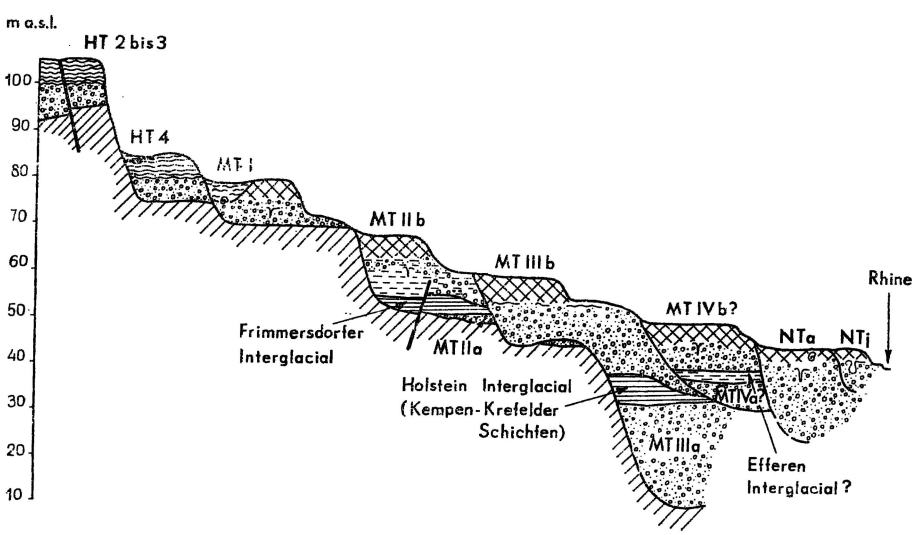


Fig. 7. Synthetic geological section of the Rhine terraces north of Cologne (*after* Brunnacker & *al.* 1978)

***HT2 bis 3, HT4*: upper terraces; *MT I, MT IIa, MT IIb, MT IIIa, MT IIIb, MT IVa?, MT IVb?*: middle terraces; *NTa, MTj*: lower terraces (older and younger, respectively) Frimmersdorfer Interglacial = Mindel *I*/Mindel *II* (?); Holstein Interglacial = Mindel *II*/Riss *I*; Efferen Interglacial (?) = Riss *I*/Riss *II* (?)**

The organogenic deposits preserved in the Cologne area ("Krefelder Schichten" and "Kempen Schichten") may be a lithostratigraphic equivalent of the organogenic deposits attributable to the upper climatic optimum of the Mazovian Interglacial (Mindel *II*/Riss *I*) found in paleovalleys of that age in the middle Vistula basin. As indicated by palynologic data, deciduous and coniferous trees occurred in more or less equal proportion during the accumulation of the lower part of the "Krefelder Schichten" (Kempf 1966). Higher up in the section, the

pollen of coniferous trees begin to prevail over those of deciduous trees (*Pinus* up to 55%, *Abies* up to 40%, *Picea* up to 5%; and on the other side, *Alnus* up to 35%, *Quercus* up to 15%). The pollen of *Pinus* and *Alnus* are dominant also in the "Kempen Schichten" (up to 43% and 78%, respectively). In addition, both the lithostratigraphic units yielded a rich assemblage of plant macrofossils (*Azolla interglacialica, Vitis silvestris, Stratiotes intermedius,* among others), as well as abundant mollusks and ostracodes typical of the Holstein Interglacial (Kempf 1966).

The accumulation of the overlying alluvial series of the terrace *MT IIIb* (Text-fig. 7) has been attributed to a climatic cooling (Brunnacker & *al.* 1978) supposedly during the anaglacial part of the Saale Glaciation (Kukla 1978). One may suppose that the advance of the Scandinavian icesheet of the Drenthe Stadial of the Saale Glaciation (Riss), which dammed and later on covered the lower Rhine valley, did also considerably contribute to the alluvial accumulation at the terrace *MT IIIb*.

CONCLUSIONS

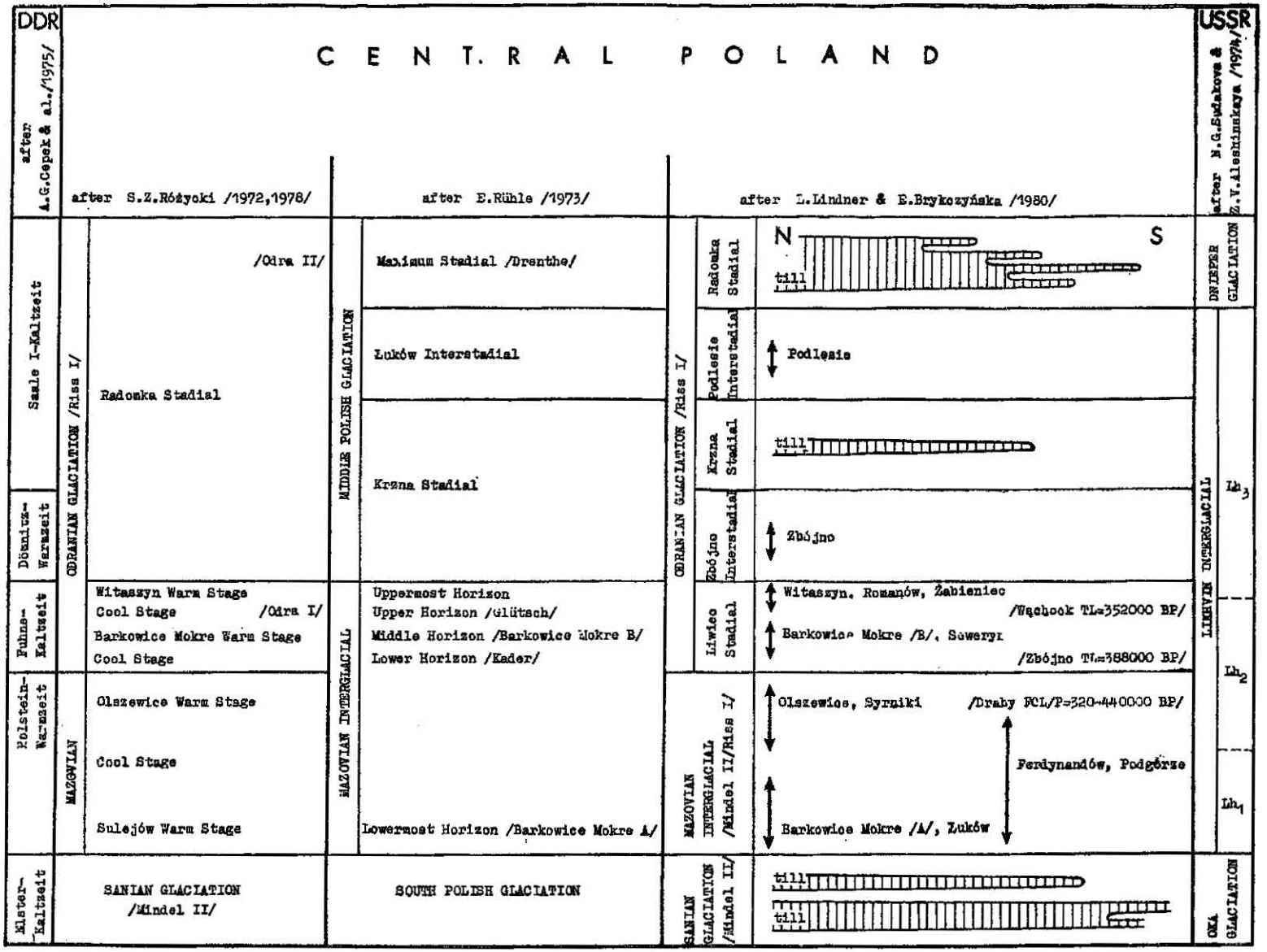
The presented data indicate that the Mazovian Interglacial (Mindel *II*/ /Riss *I*) included two climatic optima (the earlier Sulejów Warm Stage and the later Olszewice Warm Stage) in the middle Vistula basin. The two optima are palynologically documented in paleolakes of Ferdynandów and Podgórze developed at the morainic plateau of the Sanian Glaciation (Mindel *II*). The later optimum is well evidenced also by paleovalleys of Olszewice and Syrniki.

From the geological standpoint, deposits representative of the earlier optimum of the Mazovian Interglacial are to be conceived of as equivalent to the lower part of the Likhvin Interglacial (Lh_1), and being of older age than the Holstein Interglacial. In turn, the upper optimum of the Mazovian Interglacial is to be correlated with the Holstein Interglacial and the lower part of the Lh_2 series.

Therefore, the organogenic deposits recorded at Barkowice Mokre, Sewerynów, Witaszyn, Romanów, Zbójno, Żabieniec, and Podlesie are to be assigned to the anaglacial part of the Odranian Glaciation (Text-fig. 8). One may suppose that deposits representative of the Fuhne--Kaltzeit and Dömnitz-Warmzeit, as well as those of the upper part of Lh_2 and the entire Lh_3 series also are of that age.

With the above cited datings after the thermoluminescence method of Middle Pleistocene deposits of the European continent taken into account, one may claim that the warming recognized in England for the Cromerian Interglacial and dated after the $^{230}Th/^{234}U$ method for 350,000 BP (Waltham & Harmon 1977) is to be correlated with the Mindel *II*/Riss *I* Interglacial. In turn, the warming recognized in England for the Hoxnian Interglacial and dated after the $^{230}Th/^{234}U$ method for 245,000+35/—25,000 BP at Clacton and over 275,000 BP at Swanscombe (Szabo & Collins 1975, Shotton & *al.* 1977), and for

Diverse stratigraphic subdivisions of the Mindel *II*/Riss *I* Interglacial and the anaglacial part of the Riss *I* Glaciation in Poland and adjacent countries



225,000+75/—45,000 BP in the Yorkshire Dales (Waltham & Harmon 1977) appears equivalent to the Riss *I*/Riss *II* Interglacial (Odintsovo or Lublinian Interglacial, or Rügen-Warmzeit). The latter interpretation is corroborated by the recent dating of the famous archeologic locality at Bilzingsleben by Erfurt, German Democratic Republic (228,000+ +17/—12,000 BP after the $^{230}Th/^{234}U$ method; Głazek & *al.* 1980), which was previously attributed to the Holstein Interglacial.

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REFERENCES

BRESLAV S. L., VALUEVA M. N. & MAUDINA M. I. 1979. New data on Odintsovo stratotypic section. *Dokl. AN SSSR*, **248** (1), 161—166. Moskva.

BRUNNACKER K., BOENIGK W., DOLEZALEK B., KEMPF E. K., KOČI A., MENTZEN H., RAZI RAD M. & WINTER K. P. 1978. Die Mittelterrassen am Niederrhein zwischen Köln und Mönchengladbach. *Forschr. Geol. Rheinl. u. Westf.*, **28**, 277—324. Krefeld.

CEPEK A. G. & ERD K. 1975. Das Holstein-Interglazial im Raum Neuruppin — ein neus pollenstratigraphisches Richtprofil und seine quartärgelogische Bedeutung. *Zt. Geol. Wiss.*, **9**, 1151—1178. Berlin.

— , HELLWIG D., LIPPSTREU L., LOHDE H., ZIERMANN H. & ZWIRNER R. 1975. Zum Stand der Gliederung des Saale-Komplexes im mittleren Teil der DDR. *Zt. Geol. Wiss.*, **3**, 1049—1075. Berlin.

CIUK E. & RÜHLE E. 1952. Two sections across the Pilica valley in the environs of Białobrzegi. *Biul. PIG*, **68**, 199—274. Warszawa.

DIEBEL K. 1961. Ostracoden des Paludinenbank-Interglazials von Syrniki am Wieprz (Polen). *Geologie*, **10** (4/5). Berlin.

ERD K. 1973. Pollenanalytische Gliederung des Pleistozäns der Deutschen Demokratischen Republik. *Zt. Geol. Wiss.*, **1**, 1087—1103. Berlin.

— 1978. Pollenstratigraphie im Gebiet der skandinavischen Vereisungen. *Schriftenr. Geol. Wiss.*, **9**, 99—119. Berlin.

GŁAZEK J., HARMON R. S. & NOWAK K. 1980. Uranium-series dating of the hominid-bearing travertine deposit at Bilzingsleben, G.D.R., and its stratigraphic significance. *Acta Geol. Polon.*, **30** (1), 1—14. Warszawa.

— , LINDNER L. & WYSOCZAŃSKI-MINKOWICZ T. 1976a. Interglacial Mindel *I*/Mindel *II* in fossil-bearing karst at Kozi Grzbiet in the Holy Cross Mts. *Acta Geol. Polon.*, **26** (3), 377—393. Warszawa.

— , SULIMSKI A., SZYNKIEWICZ A. & WYSOCZAŃSKI-MINKOWICZ T. 1976b. Middle Pleistocene karst deposits with *Ursus spelaeus* at Draby near Działoszyn, Central Poland. *Acta Geol. Polon.*, **26** (3), 451—466. Warszawa.

— , KOWALSKI K., LINDNER L., MŁYNARSKI M., STWORZEWICZ E., TUCHOŁKA P. & WYSOCZAŃSKI-MINKOWICZ T. 1977. Cave deposits at Kozi Grzbiet (Holy Cross Mts, Central Poland) with vertebrate and snail fauna of the Mindelian *I*/Mindelian *II* interglacial and its stratigraphic correlations. *Proc. 7th Intern. Speleolog. Congress*, 211—214. Sheffield.

GRITCHUK V. P. 1961. Iskopaemye flory kak paleontologicheskaja osnova stratigrafii chetvertichnykh otlozhenij severo-zapada Russkoj ravniny. *Akad. Nauk SSSR k VI Kongressu INQUA v Varshave*, 25—71. Moskva.

GRONKOWSKA B. 1972. Deposition in the Ferdynandów basin during the Mazovian Interglacial. *Kwart. Geol.*, **16** (1), 183—191. Warszawa.

JANCZYK-KOPIKOWA Z. 1963. Pollen analysis of the Quaternary deposits from Ferdynandów. *Kwart. Geol.*, **7** (4), 639—645. Warszawa.

— 1975. Flora of the Mazovian Interglacial at Ferdynandów. *Biul. IG*, **290**, 5—96. Warszawa.

— , MOJSKI J. E. & RZECHOWSKI J. 1980. Position of the Ferdynandów Interglacial, Middle Poland, in the Quaternary stratigraphy of the North European Plain. *In*: Rept. 6 on Brno session, IGCP Project *73/1/24*, Quaternary Glaciations in the Northern Hemisphere.

JURKIEWICZOWA I. & MAMAKOWA K. 1960. The interglacial at Sewerynów near Przedbórz. *Biul. IG*, **150**, 71—104. Warszawa.

— , — & RÜHLE E. 1973. Middle Pleistocene deposits south of Wyśmierzyce near Nowe Miasto on the Pilica river. *Folia Quatern.*, **43**, 1—26. Kraków.

KARASZEWSKI W. 1954. About the presence of two older interglacial formations in the Syrniki on Wieprz profile. *Biul. IG*, **69**, 167—176. Warszawa.

KEMPF E. K. 1966. Das Holstein-Interglazial von Tönisberg im Rahmen des Niederrheinischen Pleistozäns. *Eiszeit. u. Gegenw.*, **17**, 5—60. Öhringen.

KRASNOV I. I. 1964. Evropa — Chetvertichnye otlozheniya. *In*: Fiziko-geograficheskiy atlas mira. Moskva.

KRIGER N. J. & MOSKVITIN A. I. 1961. A survey of Pleistocene studies of the Russian Plain in the territory of the RSFSR. *In*: Czwartorzęd Europy środkowej i wschodniej, część I. *Prace IG*, **34**, 499—584. Warszawa.

KUKLA G. J. 1977. Pleistocene land-sea correlations. I. Europe. *Earth-Sci. Rev.*, **13**, 307—374. Amsterdam.

— 1978. The classical European glacial stages: correlation with deep-sea sediments. *Trans. Nebraska Acad. Sci.*, **6**, 57—93.

LINDNER L. 1978. Palaeogeomorphologic evolution of the western part of the Holy Cross region in Pleistocene. *Roczn. Pol. Tow. Geol.* (*Ann. Soc. Géol. Pologne*), **48** (3/4), 479—508. Kraków.

— 1979. Stratigraphic position and extent of tills in the central part of the Małopolska Upland. *Biul. Geol. Uniw. Warsz.*, **23**, 59—77. Warszawa.

— & BRYKCZYŃSKA E. 1980. Organogenic deposits at Zbójno by Przedbórz, western slopes of the Holy Cross Mts, and their bearing on stratigraphy of the Pleistocene of Poland. *Acta Geol. Polon.*, **30** (2), 153—163. Warszawa.

— & PRÓSZYŃSKI M. 1979. Geochronology of the Pleistocene deposits exposed at Wąchock, northern part of the Holy Cross Mts. *Acta Geol. Polon.*, **29** (1), 121—131. Warszawa.

ŁYCZEWSKA J. 1977. The estimation of the interglacial from Ferdynandów at the background of facial evolution of Pleistocene deposits from the forefield of the Lublin Upland. *Kwart. Geol.*, **21** (1), 119—140. Warszawa.

MOJSKI J. E. 1969. Stratigraphy of Meso-Pleistocene glacial deposits. *Kwart. Geol.*, **13** (2), 385—407. Warszawa.

MOSKVITIN A. I. 1977. Stratigraphy of the Pleistocene period of the Russian Lowland. *Studia Geol. Polon.*, **52**, 325—345. Warszawa.

MÜLLER H. 1974. Pollenanalytische Untersuchungen und Jahres schichtenzählung an der holstein-zeitlischen Kieselgur von Munster-Breloh. *Geol. Jb.*, **A, 21**, 107—140. Hannover.

RÓŻYCKI S. Z. 1961. Sub-stages of the Great Interglacial Stage. *In*: S. Z. RÓŻYCKI (*Ed.*), Prace o plejstocenie Polski Środkowej, pp. 13—34. Warszawa.

— 1964. Les oscillations climatiques pendant le "Grand Interglaciaire". *Repts. VIth Intern. Congress INQUA*, **2**, 211—225. Łódź.

— 1967. The Pleistocene of Middle Poland, 251 pp. PWN; Warszawa.

— 1972. Plejstocen Polski Środkowej, 2nd ed. 315 pp. PWN; Warszawa.
— 1978. From Mochty to a synthesis of the Polish Pleistocene. *Roczn. Pol. Tow. Geol.* (*Ann. Soc. Géol. Pologne*), **48** (3/4), 445—478. Kraków.
RUSZCZYŃSKA-SZENAJCH H. 1978a. Glacitectonic origin of some lake-basins in areas of Pleistocene glaciations. *Polskie Archiwum Hydrobiol. PAN*, **25**, 373—381. Warszawa.
— 1978b. Glacigenic series and buried river valleys of Middle Pleistocene age in Kock region. *Kwart. Geol.*, **22** (2), 339—359. Warszawa.
RÜHLE E. 1952. Geological profile of the Quaternary in Barkowice Mokre near Sulejów. *Biul. PIG*, **66**, 219—243. Warszawa.
— 1969. The section of Quaternary deposits at Łuków in Podlasie. *Biul. IG*, **220**, 81—103. Warszawa.
— 1970. Les nouvelles unités stratigraphiques de la glaciation de la Pologne Centrale — Riss sur la territoire entre la moyenne Vistule et la Bug. *Acta Geogr. Lodz.*, **24**, 399—412. Łódź.
— 1973. Stratygrafia czwartorzędu Polski. *In*: Metodyka badań osadów czwarotrzędowych, pp. 31—78. Warszawa.
SARNACKA Z. 1977. Organic sediments in Mazovian (Great) Interglacial fluvial series from Żabieniec south of Warsaw. *Kwart. Geol.*, **21** (1), 141—151. Warszawa.
SHOTTON F. W., BANHAM P. H. & BISHOP W. W. 1977. Glacial-interglacial stratigraphy of the Quaternary in Midland and Eastern England. *In*: F. W. SHOTTON (*Ed.*), British Quaternary Studies, pp. 267—282. Oxford.
SOBOLEWSKA M. 1952. Interglacial at Barkowice Mokre near Sulejów. *Biul. PIG*, **66**, 245—284. Warszawa.
— 1956a. Pollen analysis of the interglacial deposits of Olszewice. *Biul. IG*, **100**, 271—289. Warszawa.
— 1956b. Pleistocene vegetation of Syrniki on the river Wieprz. *Biul. IG*, **100**, 143—192. Warszawa.
— 1969. Interglacial deposits at Łuków in Podlasie in the light of pollen analysis. *Biul. IG*, **220**, 105—114. Warszawa.
SUDAKOVA N. G. 1973. Stratigrafija Likhvinskogo (Chekalinskogo) opornogo razreza. *In*: V. A. ZUBAKOV (*Ed.*), Chronology of Pleistocene and climatic stratigraphy, pp. 138—147. Leningrad.
— & ALESHINSKAYA Z. V. 1974. Rannij i srednij pleistocen. *In*: V. A. ZUBAKOV (*Ed.*), Geokhronologija SSSR, vol. **3**, pp. 49—55. Leningrad.
SZABO B. J. & COLLINS D. 1975. Age of fossil bones from British interglacial sites. *Nature*, **254**, 680—682. London.
SZAFER W. 1953 (for 1952). Pleistocene stratigraphy of Poland from the floristical point of view. *Roczn. Pol. Tow. Geol.* (*Ann. Soc. Géol. Pologne*), **22** (1), 1—99. Kraków.
ŚRODOŃ A. 1957. Interglacial flora from Gościęcin near Koźle (Sudeten Foreland). *Biul. IG*, **118**, 7—60. Warszawa.
USHKO K. A. 1959. Likhvinskij (Chekalinskij) razrez mezlednikovykh ozernykh otlozhenij. *In*: Lednikovyj period na territorii Evropejskoj chasti SSSR i Sibiri, pp. 148—226. Moskva.
VELITCHKO A. A. 1977. Maximum glaciation in Eastern Europe — the age problem. *In*: Rept. 4 on Stuttgart session, IGCP Project *73/1/24*, Quaternary Glaciations in the Northern Hemisphere, pp. 167—179. Prague.
VISHNEVSKAYA E. M., KOLESNIKOVA T. D., MALAKHOVSKI D. B. & HOMUTOVA V. I. 1970. Novye dannye o razreze ozernykh srednepleistocenovykh otlozhenij u derevnii Bulatovo v rajone verkhnej Volgi. *In*: Istoria ozer, pp. 42—54. Vilnius.

WALTHAM A. C. & HARMON R. S. 1977. Chronology of cave development in the Yorkshire Dales, England. *Proc. 7th Intern. Speleolog. Congress*, 423—425. Sheffield.

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OSADY ORGANOGENICZNE INTERGLACJAŁU MAZOWIECKIEGO (MINDEL *II*/RISS *I*) W DORZECZU ŚRODKOWEJ WISŁY NA TLE RÓWNOWIEKOWYCH STANOWISK W EUROPIE

(Streszczenie)

Przedmiotem pracy jest analiza litostratygraficzna i paleogeomorfologiczna głównych stanowisk interglacjału mazowieckiego (Mindel *II*/Riss *I*) w dorzeczu środkowej Wisły (fig. 1). Szczególną uwagę poświęcono stanowiskom Ferdynandów i Podgórze, w których interglacjalne osady organogeniczne zachowane są w obrębie kopalnych jezior polodowcowych, a przykryte są glinami zwałowymi zlodowacenia Odry (Riss *I*). Podjęto próbę określenia położenia tych stanowisk względem osadów rzecznych interglacjału mazowieckiego (fig. 2—3) oraz ich stosunku do ważniejszych stanowisk osadów organogenicznych z tego okresu w Europie (fig. 4—7). Z analizy zebranych materiałów wynika, iż interglacjał mazowiecki charakteryzował się dwoma optimami klimatycznymi (por. Janczyk-Kopikowa 1975). Starsze optimum odpowiada najprawdopodobniej dolnej części interglacjału lichwińskiego (Lh_1), natomiast młodsze — interglacjałowi holsztyńskiemu i wyższej części interglacjału lichwińskiego (Lh_2). Stratygraficznie jeszcze młodsze osady organogeniczne zachowane w stanowiskach: Barkowice Mokre (*B*), Sewerynów, Witaszyn, Romanów, Żabieniec, Zbójno i Podlesie należy odnieść (fig. 8) do anaglacjalnej części zlodowacenia Odry (*Riss I*).
