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An outline of Pleistocene chronostratigraphy in Poland

ABSTRACT: The Quaternary in Poland consists of the Protopleistocene (1,870 000—950 000 y. BP), the Pleistocene (950 000 — 10 000 y. BP), and the Holocene (last 10 000 y. BP). Within the Protopleistocene the Otwock Cooling and the Celestynów Warming are distinguished. The Pleistocene includes 9 main glaciations (Narew, Nida, San, Mogielanka, Wilga, Liwiec, Odra, Warta, Wisła) separated by 8 interglacials (Przasnysz, Kozi-Grzbiet, Pilczyca, Ferdynandów, Barkowice-Mokre, Zbójno, Grabówka, Eemian). A climatic characteristics and ages of all these episodes are presented on the basis of paleomagnetic, thermoluminescence, FCl/P, and ^{14}C datings, which also enabled a chronostratigraphic correlation of the distinguished episodes with the equivalent units in the neighboring countries and in deep-sea sediments.

INTRODUCTION

Recent investigations of the Quaternary deposits in Poland have resulted in the recognition of climato- and chronostratigraphic succession, extents of Scandinavian glaciations and of separating interglacials (*see* Text-fig. 1).

The investigated sections have recently required, but paleontologic data, the absolute datings received by various methods (^{14}C, TL, FCl/P, and partly paleomagnetism). These data enable a chronostratigraphic correlation with the Quaternary units in Europe (Text-figs 8 and 9), and with deep-sea sediments that record a full sequence of Quaternary climatic changes (*cf.* Shackleton & Opdyke 1973, Kellogg 1980, Wysoczański-Minkowicz 1980, Zubakov & Borzenkova 1983).

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CLIMATO- AND CHRONOSTRATIGRAPHY OF THE QUATERNARY

A principal role in definition of the Quaternary and its subdivision in Poland is played by paleomagnetic data (Różycki 1978, 1980; Lindner 1978, 1980, 1982), similarly as in the other European countries (*cf.* Bowen 1978,

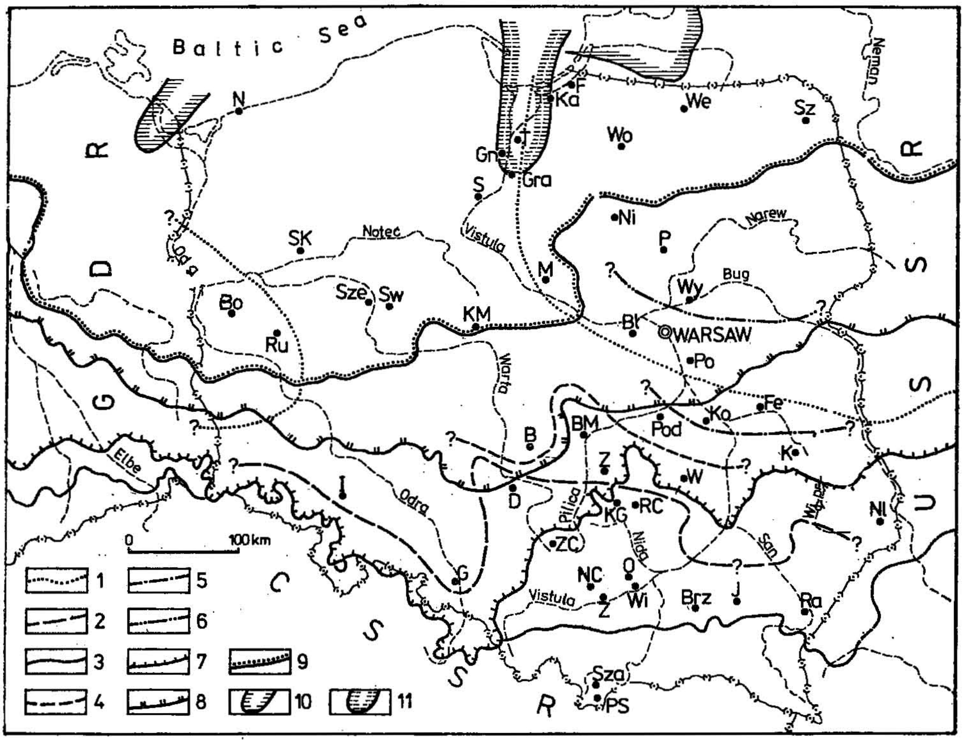


Fig. 1. Extents of the Scandinavian icesheets in Poland

1 — Narew Glaciation, 2 — Nida Glaciation, 3 — San Glaciation, 4 — Mogielanka Glaciation, 5 — Wilga Glaciation, 6 — Liwiec Glaciation, 7 — Odra Glaciation, 8 — Warta Glaciation, 9 — Wisła Glaciation

10 — sea bays during the Barkowice-Mokre (Mazovian = Holstein) Interglacial, 11 — sea bay during the Eemian Interglacial

Location of sites mentioned in the text:

LATE TERTIARY: Ko — Kozienice, Wi — Witów; OTWOCK COOLING and CELESTYNÓW WARMING: Po — Ponurzyca, ZC — Żabia Cave; PRZASNYSZ INTERGLACIAL: P — Przasnysz, Wy — Wyszków; KOZI-GRZBIET INTERGLACIAL: KG — Kozi Grzbiet, J — Jasionka, Sza — Szaflary; PILCZYCA INTERGLACIAL: B — Bełchatów; FERDYNANDÓW INTERGLACIAL: Fe — Ferdynandów, Pod — Podgórze, B — Bełchatów, M — Mochowo; BARKOWICE-MOKRE INTERGLACIAL: BM — Barkowice Mokre, D — Draby G — Gościęcin, K — Krępiec, We — Węgorzewo, Bo — Boczów, M — Mochowo; ZBÓJNO INTERGLACIAL: Z — Zbójno, K — Krępiec, Nl — Nieledew; GRABÓWKA INTERGLACIAL: Gra — Grabówka, F — Frombork, W — Wąchock, B — Bełchatów; EEMIAN INTERGLACIAL: T — Tychnowy, Gn — Gniew, Ka — Kadyny, Sz — Szwajcaria, Ru — Rusinowo, I — Imbramowice, Sze — Szeląg, Sw — Swarzędz, Ni — Nidzica, Bł — Błonie, Z — Zwierzyniec, O — Odonów, Nl — Nieledew, Ra — Radymno,, NC — Nietoperzowa Cave; Pre-maximum part of the WISŁA GLACIATION: SK — Stare Kurowo, KM — Konin Maliniec, S — Sartowice, NC — Nietoperzowa Cave, Z — Zwierzyniec, O — Odnów, W — Wąchock, Nl — Nieledew, RC — Raj Cave, Ra — Radymno; Post-maximum part of the WISŁA GLACIATION and the HOLOCENE: PS — Przedni Staw Lake, Brz — Brzozowica, Wo — Woryty, N — Niechorze

Bonifay 1980, Nikiforova & *al.* 1980, Wiegank 1982, Zubakov & Borzenkowa 1983). With reference to the scheme presented by Różycki (1980), the Quaternary of Poland starts with the Protopleistocene, comprising the time interval from 1,870 000 to 950 000 y. BP that is the whole middle part of the Matuyama Epoch, since the beginning of the Olduvai Event to the beginning of the Jaramillo Event (Mankinen & Dalrymple 1979). The Protopleistocene is followed by the Pleistocene, lasting from 950 000 to 10 000 y. BP. The latter is subdivided into three parts: the Early Pleistocene (950 000 to 730 000 y. BP), *i.e.* the youngest part of the Matuyama Epoch, since the beginning of the Jaramillo Event until the Matuyama/Brunhes boundary; the Middle Pleistocene (730 000 to 128 000 y. BP) which comprises the principal part of the Brunhes Epoch; and the Late Pleistocene (128 000 to 10 000 y. BP) which corresponds to the younger part of the Brunhes Epoch. The youngest part of this epoch, comprising the last 10 000 y. is defined as the Holocene.

PROTOPLEISTOCENE

In the territory of Poland the Protopleistocene supplies no evidences of any Scandinavian glaciations. The section at Ponurzyca near Warsaw (Text-fig. 1) yields a bipartite depositional sequence. Its older part represents the first Quaternary cooling, defined as the Otwock Cooling; the younger part proves a considerably warmer climate and is called the Celestynów Warming (Baraniecka 1975, Stuchlik 1975). Mojski (1982) defined these two parts of the Protopleistocene as the Krasnystaw Formation. In eastern and Central Poland it is composed of clastic deposits which usually fill deep river valleys incised in the Early Tertiary, and the Pliocene sediments of the Kozienice Formation (Text-figs 2—3).

OTWOCK COOLING

In the Ponurzyca section this cooling is recorded by lacustrine series that overlies the Tegelen silts. As compared with the Tegelen, this period showed a distinct climatic deterioration. The previous mesophilous deciduous forests were replaced by pine-spruce forests with numerous birch-trees. This interval corresponds to the Eburonian of West Europe. The floristic site at Kaznów, Lublin Upland, and sediments of the Żabia Cave, Polish Jura, with abundant vertebrate remains (Text-figs 1 and 8), are also of the same age. The Otwock Cooling can be correlated with the ^{18}O horizons *36—30* of deep-sea sediments.

REFERENCES: Baraniecka (1975), Stuchlik (1975), Janczyk-Kopikowa (1981), Mojski (1982), Bosák & *al.* (1982).

CELESTYNÓW WARMING

This warming is represented by sands and silts, underlain in the Ponurzyca section (Text-fig. 1) by the deposits of the Otwock Cooling and overlain by gravels and sands with Scandinavian material, correlated with the Narew Glaciation. From a floristic point of view, the Celestynów Warming is an equivalent of the Waalian Interglacial of the Netherlands. At that time Central Poland was densely forested, whilst in southern Poland the Połaniec gravels without any Scandinavian material

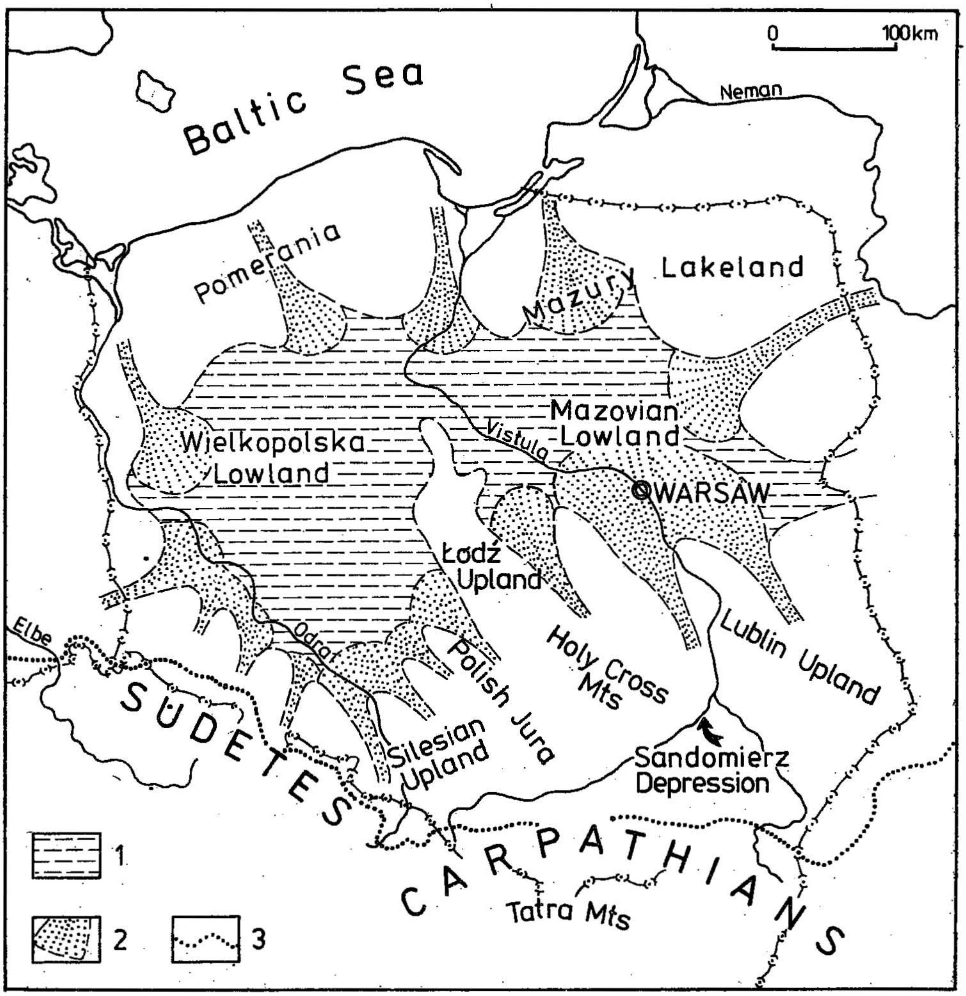


Fig. 2. Territory of Poland during the Pliocene

PLIOCENE: 1 — limits of variegated clays deposition, 2 — main alluvial fans; QUATERNARY: 3 — southernmost extent of the Scandinavian erratics were deposited. Similar gravels fill deep river valleys in the Holy Cross Mts. The warming lasted since about 1,350 000 to 950 000 y. BP and can be correlated with the ^{18}O horizons *29—25* of deep-sea sediments.

REFERENCES: Baraniecka (1975), Stuchlik (1975), Lindner (1980), Różycki (1980).

EARLY PLEISTOCENE

NAREW GLACIATION

During this glaciation the Scandinavian icesheet occupied north-eastern and partly western Poland (Text-fig. 1) and could even reach the Lublin Upland. The deposits of this glaciation are best evidenced in the northern and north-eastern Mazovian Lowland. Near Wyszków (Text-fig. 4) and Przasnysz they are represented by two or three tills, separated by silts and sands. The Narew Glaciation lasted since about 950 000 to 900 000 y. BP and can be correlated with the ^{18}O horizon *24* of deep-sea sediments.

REFERENCES: Michalska (1961), Straszewska (1968), Różycki (1972, 1980), Wojtanowicz (1983).

PRZASNYSZ INTERGLACIAL

This interglacial is represented by an almost 30 m thick fluvial series near Wyszków (Tex-fig. 4), filling a river valley incised in tills of the Narew Glaciation and in the underlying Miocene deposits. This series is composed of sandy-gravel deposits of several erosive-accumulative cycles.

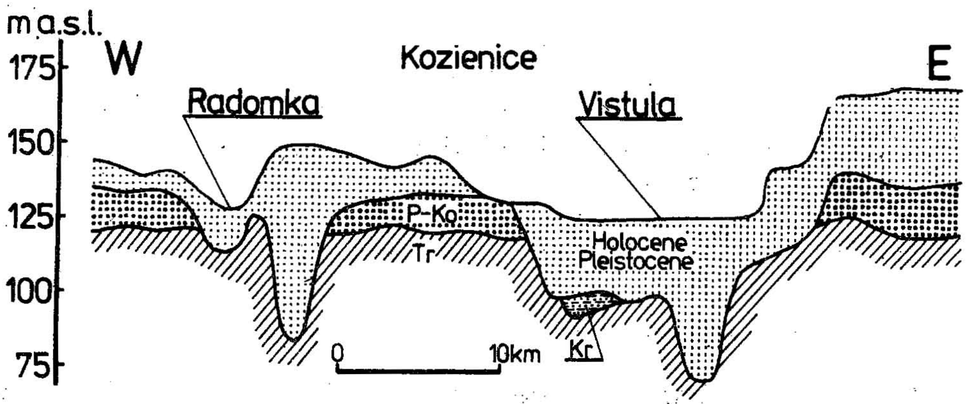


Fig. 3. Geological section of the Tertiary and Quaternary deposits near Kozienice (*adapted from:* Mojski 1982)

Tr — older Tertiary, **P-Ko** — Kozienice Formation of Pliocene age, **Kr** — Krasnystaw of Protopleistocene age

In the Przasnysz section (Text-fig. 1) this warming is documented by a 50 m thick silty-sandy sequence with pollens of dense deciduous forests which developed during a climatic optimum between two heights of *Abies*. According to some authors, the presence of fir-hornbeam and alder-spuce horizons and TL datings (686 000—615 000 y. BP) seem to refer this interval to a younger interglacial.

Fluvial sediments from the Brus section, Lublin Upland (TL dating: 785 500—761 500 y. BP), are also assigned to the Przasnysz Interglacial. This interglacial is correlated with the ^{18}O horizons *23—21* of deep-sea sediments.

REFERENCES: Selle (1960), Straszewska (1968), Różycki (1972), Bałuk (1983), Mamakowa (1983), Wojtanowicz (1983).

MIDDLE PLEISTOCENE

NIDA GLACIATION

During this glaciation, previously considered as the older South-Polish Glaciation, the Scandinavian icesheet reached the northern slopes of the Sudetes and of the Central Polish Uplands. The glacial lobes entered the Odra valley upstream Gościęcin and the northern part of the Sandomierz Depression. During a retreat the iceshet deposited a locally bipartite till, particulary distinct in the central and northern Holy Cross region, in the deeply incised valleys of the Lublin Upland, and throughout the western Sudetic Foreland.

Paleomagnetic determinations (Brunhes/Matuyama boundary) and FCl/P datings of bone remains at Kozi Grzbiet prove the maximum of the Nida Glaciation to have occurred about 730 000—640 000 y. BP. In the same time the earliest Polish loess was deposited (Text-fig. 8) in valleys of the Holy Cross region. In the Lublin Upland the ice-dam sediments of the middle part of this glaciation are known from Wólka Petryłowska (TL dating: 732 000—660 000 y. BP).

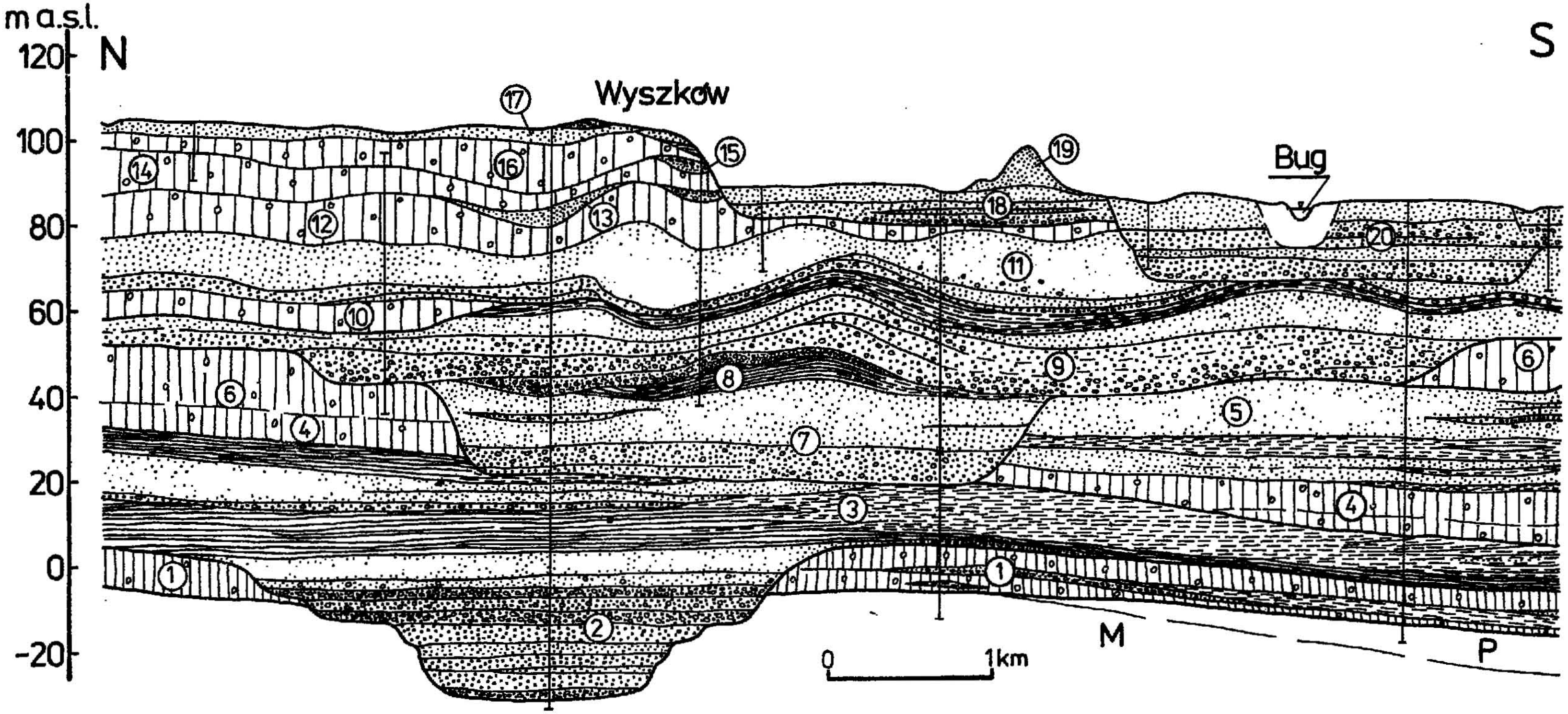
The Nida Glaciation is correlated with the ^{18}O horizon *20* of deep-sea sediments (dated for 729 000—706 000 y. BP).

REFERENCES: Czarnocki (1931), Mojski (1969), Łyczewska (1971), Różycki (1972, 1978, 1980), Głazek & *al.* (1976a, 1977) Lindner (1977a, 1980, 1982), Wojtanowicz (1983).

KOZI-GRZBIET INTERGLACIAL

This interglacial was identified due to studies over a karst site at Kozi Grzbiet in the Holy Cross Mts (Text-figs 1 and 8). Its speleothems contain, but faunsistic remains, feldspars and heavy minerals coming from glacifluvial sediments of the Nida Glaciation. A rich faunistic

Geological section of the Quaternary sediments near Wyszków (*adapted from*: Straszewska 1968)



M — Miocene; P — Pliocene; NAREW GLACIATION: *1* tills, sands and silts; PRZASNYSZ INTERGLACIAL: *2* fluvial sands and gravels; NIDA and SAN GLACIATION: *3* ice-dam clays and silts, glacifluvial sands, *4* tills; PILCZYCA INTERGLACIAL: *5* fluvial sands, gravels and silts; MOGIELANKA GLACIATION: *6* till; FERDYNANDÓW INTERGLACIAL: *7* fluvial sands and gravels; WILGA GLACIATION: *8* ice-dam clays and silts; BARKOWICE-MOKRE INTERGLACIAL: *9* fluvial sands, gravels and silts; LIWIEC GLACIATION: *10* till; ZBÓJNO INTERGLACIAL: *11* fluvial gravels and sands; ODRA GLACIATION: *12* till; GRABÓWKA INTERGLACIAL: *13* sands and gravels; WARTA GLACIATION: *14* till of the older stadial, *15* interstadial sands and gravels, *16* till of the younger stadial, *17* glacifluvial sands and gravels; EEMIAN INTERGLACIAL and WISŁA GLACIATION: *18* fluvial sands and gravels, *19* aeolian sands; HOLOCENE: *20* fluvial sands and gravels assemblage of the speleothems, yielding numerous snail shells, amphibian, reptilian and mammalian remains, proves their Late Cromerian age. A similar conclusion arises from the FCl/P dating of bones (700 000 — 550 000 y. BP), pointing out to the so-called Cromer *II* of the Netherlands. Paleomagnetic investigations of the speleothem show positive magnetic polarization (Brunhes), and therefore an age younger than the optimum of the Cromer Interglacial of the Netherlands (*cf.* Montfrans 1971).

A floristic characteristics of the Kozi-Grzbiet Interglacial is recorded by organogenic sediments of the Jasionka section near Rzeszów (Text-fig. 1). These sediments enclose pollens of a succession from pine through mixed forests (with small areas covered by deciduous forests) to a very short-lasting subarctic environment and the following, progressive expansion of the *Pinus*-dominated forests. Outside the extent of the Scandinavian icesheet, in the northern Tatra Foreland, this interglacial is represented by organogenic sediments at Szaflary near Nowy Targ (Text-fig. 1). In deep-sea sediments it is correlated with the ^{18}O horizon *19*, dated for 706 000—688 000 y. BP.

REFERENCES: Dąbrowski (1967), Laskowska-Wysoczyńska (1967), Birkenmajer & Stuchlik (1975), Głazek & *al.* (1976*a*, 1977), Lindner (1977*a*, 1982), Różycki (1978, 1980), Szyndlar (1981, 1984).

SAN GLACIATION

During this glaciation, previously considered as the younger South-Polish Glaciation, the Scandinavian icesheet reached the Sudetes and the Carpathians (Text-fig. 1) spreading upslope to about 450 m a.s.l. In southern Poland the icesheet deposited a till underlain by the till of the Nida Glaciation or separated from the latter by fluvial or glacifluvial sediments. In the Łódź and the Central Polish Uplands a bipartition of this till is noted. Its lower part occupies a smaller area and seems to represent the pre-maximum stadial. Such bipartition is exemplified by the section exposed over the Tertiary brown-coal mine at Bełchatów (Text-fig. 5) where the till is overlain by sands (TL dating: 558 000 y. BP). In the Holy Cross region the tills of the San Glaciation are underlain by loesses with malacofauna. In deep-sea sediments the bipartite San Glaciation is correlated with the ^{18}O horizons *18—16*, dated for 688 000 to 592 000 y. BP.

REFERENCES: Poliński (1927), Czarnocki (1931), Klimaszewski (1967), Mojski (1969), Baraniecka & Sarnacka (1971), Łyczewska (1971), Lindner (1977*a*, 1980, 1982), Różycki (1978, 1980), Hałuszczak (1982), Butrym & *al.* (1982), Wojtanowicz (1983).

PILCZYCA INTERGLACIAL

This interglacial separates the San Glaciation from the Mogielanka Glaciation and has been previously considered as an interstadial in the younger part of the San Glaciation. The borehole data, geomorphologic analysis of the area and paleosols under the tills allow to consider this interval as an interglacial warming. Such a conclusion arises also from correlations of the Quaternary climatic changes in Poland and in the neighboring countries (Text-fig. 8) as well as from TL dating for 588 000 y. BP of the supra-till sands in the Bełchatów section (Text--fig. 5). This interval is correlated in deep-sea sediments with the ^{18}O horizon *15*, defined as a distinct climatic warming from 592 000 to 542 000 y. BP. In the Lublin Upland this interglacial is called the Luszawa Warming.

REFERENCES: Mojski (1969), Lindner (1982), Butrym & *al.* (1982).

MOGIELANKA GLACIATION

During this glaciation, previously defined as the younger (post-maximum) stadial of the San Glaciation, the Scandinavian icesheet reached the northern slopes of the Central Polish Uplands and occupied the Bełchatów region, and Lower Wieprz drainage basin (Text-fig. 1). It deposited the youngest till of the South-Polish glaciations, noted under the tills of the Middle-Polish glaciations near Bełchatów, Podgórze, Ferdynandów and Syrniki on the Wieprz River. In the Lublin Upland (Wólka Petryłowska) the silts under this till were TL dated for 544 400—532 000 y. BP. In the western Holy Cross margins and in the Ferdynandów region a loess was deposited at that time (Text-fig. 8). In deep-sea sediments this glaciation is correlated with the ^{18}O horizon *14*, dated for 542 000—500 000 y. BP.

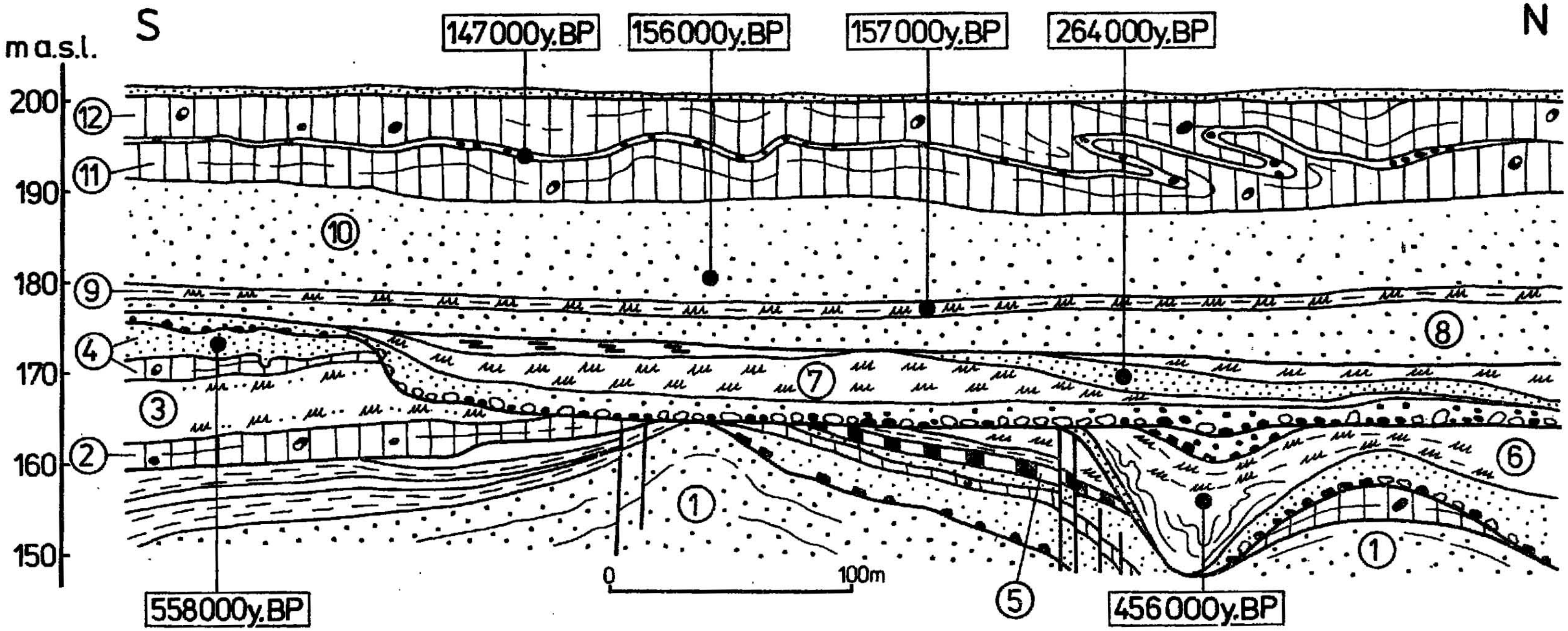
REFERENCES: Mojski (1969, 1982), Baraniecka & Sarnacka (1971), Jurkiewiczowa & *al.* (1973), Janczyk-Kopikowa & *al.* (1981), Haluszczak (1982), Lindner (1982).

FERDYNANDÓW INTERGLACIAL

This interglacial has been previously considered as an equivalent of the earliest, *i.e.* the optimum part of the Mavovian Interglacial. The organogenic sediments of this age occur *i.a.* at Ferdynandów, Podgórze, and Buczyna near Bełchatów (Text-fig. 1) and represent a bi-optimal floristic succession, quite different from that of the Barkowice-Mokre Interglacial (*see below*). Near Bełchatów (Text-fig. 5), the Ferdynandów Interglacial sediments overlie a till of the San Glaciation and the sands of the Pilczyca Interglacial (TL dating: 558 000 y. BP). They are covered there by ice-dam deposits (TL dating: 456 000 y. BP) of the Wilga Glaciation. In northern Poland (Mochowo) this period is represented by a sandy-clayey series (TL dating: 483 700 y. BP). In deep-sea sediments this in-

Geological section of the deposits in the western part of the brown-coal open-mine at Bełchatów

(adapted from: Haluszczak 1982) with the thermoluminescence dating *(after:* Butrym & al. 1982, and personal communication)



TERTIARY: *1* sands and silts; SAN GLACIATION: *2* till of the older stadial, *3* interstadial sands and silts, *4* till of the younger stadial with overlying sands of the Pilczyca Interglacial; FERDYNANDÓW INTERGLACIAL: *5* fluvial sands and silts with the Buczyna organogenic sequence; WILGA GLACIATION: *6* ice-dam sands and silts; GRABÓWKA INTERGLACIAL: *7* fluvial gravels, sands and silts; WARTA GLACIATION: *8* glacifluvial sands, *9* ice-dam clays and silts, *10* glacifluvial sands, *11* lower till, *12* upper till terglacial is recorded by the ^{18}O horizon *13* dated for 500 000—472 000 y. BP.

REFERENCES: Janczyk-Kopikowa (1975, 1980, & *al.* 1981), Różycki (1972, 1980), Lindner (1981), Lindner & Grzybowski (1982), Mojski (1982), Butrym & *al.* (1982), Lamparski (1983).

WILGA GLACIATION

During this glaciation the Scandinavian icesheet occupied north--eastern Poland and reached the Lower Wieprz and Lower Pilica drainage basic (Text-fig. 1). It deposited a till, a mineralo-petrographic composition of which differs much from those of tills of earlier glaciations. In the forefield of the icesheet, particularly within the northerly running river valleys, ice-dam lakes were formed at that time, the clays and silts (TL dating: about 456 000 y. BP) of which are noted *e.g.* in the Bełchatów section (Text-fig. 5). In the upper part of the Kozi Grzbiet section a winnowing of older glacifluvial sands occurred during this period (440 000—400 000 y. BP). In deep-sea sediments this interval is recorded by the ^{18}O horizon *12*, dated for 472 000—400 000 y. BP.

REFERENCES: Janczyk-Kopikowa & *al.* (1981), Różycki (1972, 1980), Lindner (1981), Lindner & Grzybowski (1982), Mojski (1982), Butrym & *al.* (1982).

BARKOWICE-MOKRE INTERGLACIAL

This interglacial, called also the Mazovian Interglacial, has been described from many sites of organogenic sediments *i.a.* from Barkowice Mokre, Ciechanki Krzesimowskie, Krępiec, Gościęcin, Węgorzewo, Boczów (Text-fig. 1).

In the Barkowice Mokre section the succession starts with pollens of birch-pine forests, followed by spruce-pine to the climatic optimum with fir-hornbeam forests. A similar succession was noted in the Krępiec section (Text-fig. 6A).

In cave deposits the interglacial optimum is represented by a bonebed with *Ursus spelaeus* Rosenmüller & Heinroth in the Draby section, Polish Jura (Text-figs 1 and 8), and FCl/P dated for 440 000—320 000 y. BP. In northern Poland (Mochowo) the river deposits were TL dated for 379 000—389 000 y. BP whereas in the Brus section, Lublin Upland, for 384 200 y. BP.

In deep-sea sediments this interglacial is correlated with the ^{18}O horizon *11*, dated for 400 000—367 000 y. BP. According to Müller (1974) it lasted 15 000—16 000 years.

REFERENCES: Sobolewska (1952), Szafer (1953), Różycki (1972), Rühle (1973), Głazek & *al.* (1976b), Janczyk-Kopikowa (1981), Lindner (1981), Lamparski (1983), Wojtanowicz (1983), Marciniak (1983).

LIJWIEC GLACIATION

The Scandinavian icesheet of this glaciation occupied north-eastern Poland and deposited a till to the north-east of Warsaw (Text--fig. 1), among others in the Wyszków area (Text-fig. 4). This till, previously considered for an evidence of the pre-maximum icesheet advance *(GIII-2)* during the Odra Glaciation, overlies the sands and gravels of the second alluvial cycle of the Mazovian Interglacial (as defined by Różycki 1972).

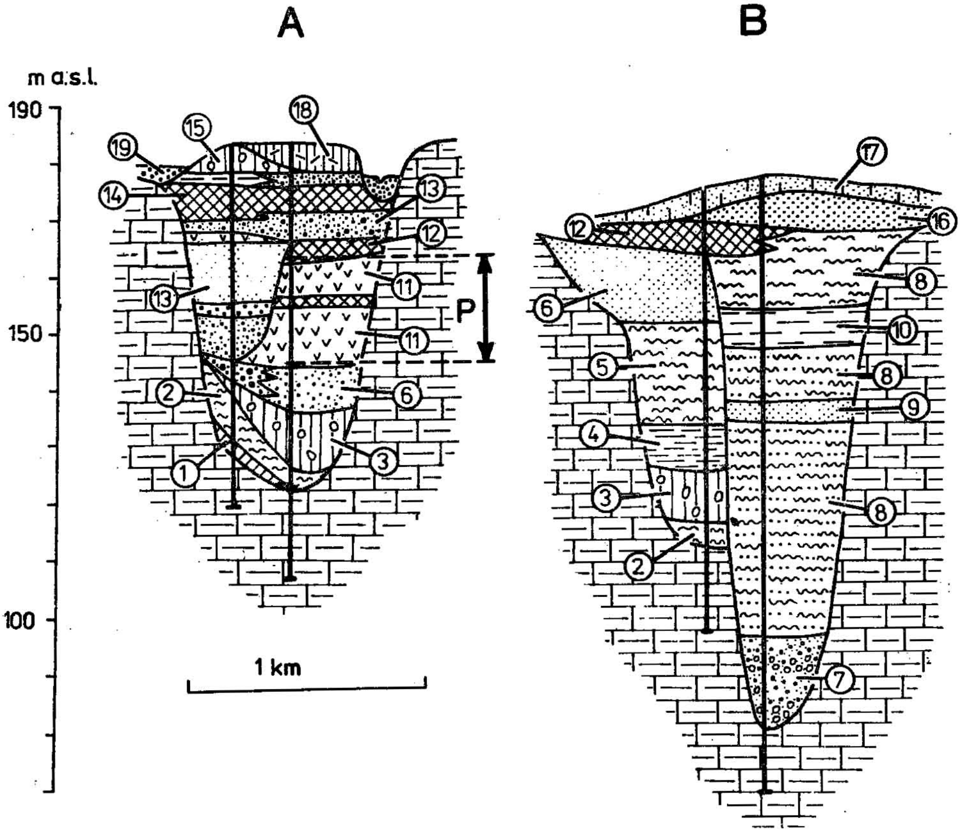


Fig. 6. Geological sections of the Quaternary deposits at Krępiec (A) and Ciechanki Krzesimowskie (B); *adapted from*: Harasimiuk & Henkiel (1981)

PROTOPLEISTOCENE: *1* regolith and weathering clays, *2* silts; SAN GLACIATION: *3* **till**, *4* varved clays; PILCZYCA INTERGLACIAL: *5* sandy silts, *6* fluvial sands; MOGIELANKA GLACIATION: *7* glacifluvial gravels; BARKOWICE-MOKRE INTERGLACIAL: *8* silts and sandy silts, *9* fluvial sands, *10* silts and clays, *11* diatomites, *12* peat and gyttja; ZBÓJNO INTERGLACIAL: *13* fluvial sands and gravels, *14* humus sands with peat intercalations; ODRA GLACIATION: *15* tills and glacial sands with gravels; EEMIAN INTERGLACIAL: *16* fluvial sands; WISŁA GLACIATION: *17* sandy-silty elluvial covers with aeolian components, *18* loess; HOLOCENE: *19* muds and peats

P — section with pollen (Janczyk-Kopikowa 1981) and diatomological (Marciniak 1983) analyses

The ice-dam silts deposited in the icesheet forefield (Zbójno section; Text-fig. 1) are TL dated for 380 000 y. whereas the alluvia in the Wąchock section (Text-fig. 1) for 352 000 y. BP. An accumulation of the oldest loess of the Nieledew section (Text-fig. 8) occurred also at that time (TL dating: 367 800±44 00 to 351 600±42 000 y. BP).

In deep-sea sediments this glaciation is correlated with the ^{18}O horizon *10* dated for 367 000—345 000 y. BP.

REFERENCES: Różycki (1972), Lindner & Prószyński (1979), Lindner & Brykczyńska (1980), Maruszczak (1980), Lindner & Grzybowski (1982), Butrym & Maruszczak (1983).

ZBÓJNO INTERGLACIAL

During this interglacial the erosion progressed locally through all the deposits of the Liwiec Glaciation down to the underlying sediments of the Barkowice-Mokre Interglacial (Text-fig. 6*A*).. The organogenic deposits are known in the Zbójno section where they are underlain by ice-dam silts (TL dating: 388 000 y. BP) and covered by a till of the Odra Glaciation. A palynological analysis of the Zbójno section proves that during the climatic optimum of this interglacial deciduous forests with *Tilia* (to 48%), *Corylus, Quercus* and *Picea* predominated. The organogenic sediments from the Konin-Marantów section seem to be also of the same age.

The TL datings of older loess in the Nieledew section indicate that the oldest paleosol (developed on the loess dated for 367 800 ± 44 000 y. BP) should be correlated with the Zbójno Interglacial. In deep-sea sediments this interglacial is represented by the ^{18}O horizon *9* dated for 347 000—297 000 y. BP.

REFERENCES: Borówko-Dłużakowa (1967), Lindner & Brykczyńska (1980), Harasimiuk & Henkiel (1981), Butrym & Maruszczak (1983).

ODRA GLACIATION

During this glaciation, defined also as the maximum Middle-Polish Glaciation, the Scandinavian icesheet reached the northern and western forelands of the Central Polish Uplands (Text-fig. 1). It spread upslope to 290—330 m a.s.l. and formed numerous end moraines and outwash plains. Further to the west it occupied a considerable part of the Silesian Upland, passed through the Moravian Gate and stopped at 500—600 m a.s.l. in the Sudetes. In the marginal zone during the maximum extent of the icesheet the glacial deposits were accumulated as the two series. The lower one occupies a smaller area and represents the Krzna Stadial whereas the overlying one corresponds to the Radomka—Kamienna stadial.

In the same time successive loess was deposited in southern Poland (Text-fig. 8). It is best preserved in the Odonów and Nieledew sections where its chronostratigraphic position is supported by the identified Chegan Event, dated for 260 000—298 000 y. BP. In deep-sea sediments this glaciation is represented by the ^{18}O horizon 8, dated for 297 000—251 000 y. BP.

REFERENCES: Jahn & Szczepankiewicz (1967), Rühle (1970), Różycki (1972, 1980), Jersak (1973, 1975), Śnieszko & Tucholka (1975), Tucholka (1977), Maruszczak (1980), Lindner & Grzybowski (1982), Lewandowski (1982), Mojski (1982), Butrym & Maruszczak (1983), Wojtanowicz (1983).

GRABÓWKA INTERGLACIAL

This interglacial, previously defined as the Pilica Interstadial or the Lublin Interglacial, separates the older part of the Middle-Polish glaciations (Odra Glaciation) from its younger part (Warta Glaciation). In the Bełchatów section (Text-figs 1 and 5) it is represented by lacustrine and fluvial series (TL dating: 264 000 y. BP), the same as in the Wąchock section (TL dating: 245 000 ± 45 000 y. BP). Sands of the Frombork section (TL dating: 260 000—240 000 y. BP) were supposedly deposited during the same time. In the Grabówka section (Text-fig. 7), the lake sediments between two tills record a relatively warm climate (several percent of *Corylus*, *Tilia*, *Abies*, *Ulmus*, and over 20% of *Quercus* in the pollen spectrum).

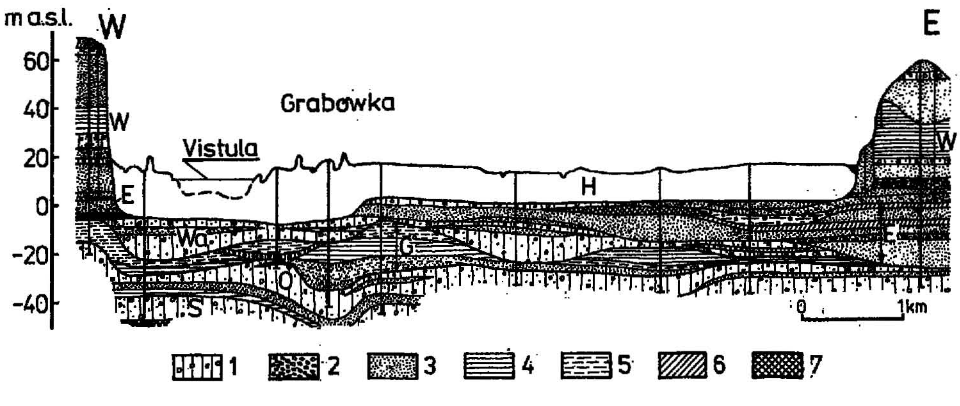


Fig. 7. Geological section of the Quaternary deposits in the Vistula Valley near Grabówka (*adapted from*: Makowska 1977)

1 till, *2* gravels, *3* sands, *4* clays, *5* silts, *6* clays, silts and gyttjas with organic matter, *7* marine clays and silts

S — deposits of the San Glaciation, **O** — deposits of the Odra Glaciation, **G** — deposits of the Grabówka Interglacial, **Wa** — deposits of the Warta Glaciation, **E** — deposits of the Eemian Interglacial, **W** — deposits of the Wisła Glaciation, **H** — Holocene deposits

In the Central Polish Uplands, the Odonów and Nieledew loess sections contain a paleosol of the Nieledew type. At Nieledew this soil is younger than 230 000—240 000 y. BP but older than 221 300 ± 27 000 y. BP.

In deep-sea sediments this interglacial is recorded by the ^{18}O horizon 7, dated for 251 000—195 000 y. BP.

REFERENCES: Baraniecka & Sarnacka (1971), Różycki (1972, 1980), Jersak (1973, 1975), Makowska (1977), Maruszczak (1980), Lindner & Grzybowski (1982), Hałuszczak (1982), Lindner & Prószyński (1979), Fedorowicz (1983), Butrym & Maruszczak (1983).

WARTA GLACIATION

During this glaciation Central Poland was occupied by the Scandinavian icesheet to the south of the Warsaw parallel (Text-fig. 1). In its marginal zone the icesheet deposited two tills of the older (pre-maximum) and younger (maximum) stadials, respectively (Text-fig. 8).

In the Bełchatów section (Text-fig. 5), the sands (TL dating: 147 000 y. BP) separate these tills which overlie the clastic deposits resulting from the icesheet advance during the Warta Glaciation (TL dating: 157 000 and 156 000 y. BP). In the Wąchock section, to the south of the maximum extent of this icesheet, there occur cover deposits (TL dating: 142 550 ± 3 650 y. BP) and in the Nieledew section the loesses (TL dating: 179 000 y. BP). The final part of this glaciation corresponds to the first man's appearance to the territory of Poland. The artifacts of the Levallois-Moustierian culture in the Zwierzyniec section (Text-fig. 1) were noted within the sands on which a soil of the Eemian Interglacial developed. Such artifacts in the Nietoperzowa Cave (Text-fig. 1) were also found in sediments that were the substrate for Eemian weathering processes.

In deep-sea sediments this glaciation is correlated with the ^{18}O horizon *6* dated for 195 000—128 000 y. BP, a maximum cooling of which occurred in the North Atlantic 150 000—130 000 y. BP.

REFERENCES: Różycki (1972), Chmielewski & *al.* (1977), Lindner & Prószyński (1979), Lindner & Grzybowski (1982), Madeyska (1982), Butrym & *al.* (1982), Butrym & Maruszczak (1983).

UPPER PLEISTOCENE

EEMIAN INTERGLACIAL

This interglacial is the only one during the Pleistocene when the sea entered the territory of Poland (Text-fig. 1). The sediments of this sea are known only in the Lower Vistula area. They are composed of two clayey-silty series (Text-fig. 7), among which the upper one is correlated with the Eemian optimum and delimits an extent of the Tychnowy Sea.

The Eemian Interglacial is characterized by rich vegetation, the relics of which are preserved under deposits of the Wisła Glaciation and outside the icesheet extent (sites at Rusinów, Szeląg, Swarzędz, Imbramowice, Błonie, Nidzica, Szwajcaria; *see* Text-fig. 1).

In the Central Polish Uplands the older loesses were capped by leached soils. At Wąchock, Odonów, Nieledew and Radymno such soils constitute the lower part of the Nietulisko-*I* horizon. In the Zwierzyniec section this soil is accompanied by artifacts of the Levallois-Moustierian culture, similarly as in the Nietoperzowa Cave.

The TL datings of the pre- and post-Eemian deposits prove that this interglacial started about 125 000 and ended about 108 000 y. BP. The TL dating of loesses overlying the interglacial soil at Nieledew suggests the interglacial continuation only until 110 000 y. BP. In deep-sea cores this warming is correlated with the ^{18}O horizon *5e* dated for 128 000—118 000 y. BP.

REFERENCE: Halicki (1950), Borówko-Dłużakowa & Halicki (1957), Jersak (1973), Karaszewski (1974), Chmielewski & *al.* (1977), Konecka-Betley & Straszewska (1977), Makowska (1979), Lindner (1980), Maruszczak (1980), Madeyska (1982), Butrym & Maruszczak (1983).

WISŁA GLACIATION

During this glaciation the Scandinavian icesheet occupied Pomerania, northern and central parts of the Wielkopolska Lowland and the Mazury Lakeland (Text-figs 1—2). There are one to three main tills, all of which become locally bipartite. These tills in the Lower Vistula valley (Text-

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Fig 8. Stratigraphic subdivision of the Quaternary in Poland, to show the main glacial (vertically hachured are the tills) and interglacial episodes, and an attempt of their regional correlation

GI, GII, GIII and GIV — glaciations, JI/II, JII/III and JIII/IV — interglacials after Różycki (1961)

Bełchatów, radiocarbon datings: **B1** — 14 350 BP, **B2** — 21 970 BP, **B3** — 25 200 BP; and thermoluminescence datings (*after* Butrym & *al.* 1982, and personal communication): **B4** — 139 000 BP, **B5** — 156 000 BP, **B6** — 264 000 BP, **B7** — 456 000 BP, **B8** — 558 000 BP

Thermoluminescence datings of the Wąchock section (*after* Lindner & Prószyński 1979; **W1** — 15 830 ± 1 830 BP, **W2** — 24 087 ± 2 587 BP, **W3** — 42 000 ± 1 500 BP, **W4** — 142 550 ± 3 650 BP, **W5** — 245 000 ± 45 000 BP, **W6** — 352 000 BP) and the Nieledew section (*after* Butrym & Maruszczak 1983: **N1** — 24 800 ± 3 000 BP, **N3** — 32 300 ± 4 000 BP, **N6** — 55 400 ± 7 000 BP, **N7** — 60 800 ± 7 500 BP, **N8** — 97 700 ± ± 12 000 BP, **N11** — 159 300 ± 19 000 BP, **N13** — 179 700 ± 22 000 BP, **N17** — 255 800 ± 31 000 BP, **N20** — 287 600 ± 36 000 BP, **N25** — 351 600 ± 42 000 BP, **N27** — 368 800 ± 44 000 BP)

-fig. 7) are the best developed due to oscillations of the iceshet. Two lowest tills are to be connected with the first advance of the Scandinavian icesheet onto the deposits of the Eemian Interglacial, and are dated 110 000—100 000 y. BP. In the same time an accumulation of the oldest loess of the Wisła Glaciation occurred, with the Blake Event symptoms preserved at Nieledew (TL datings: 101 300 ± 12 000 y. BP and 97 700 ± ± 12 000 y. BP).

A younger warming is evidenced in loesses by a chernozem of the Nietulisko-*I* horizon and by organogenic sediments at Stare Kurowo (Text-fig. 1), correlated with the Brørup Interstadial. In the Nietoperzowa Cave and neighboring caves the artifacts of the Levallois-Moustierian and Micoquo-Prondnikian cultures of this age were found.

The second icesheet advance of the Wisła Glaciation occupied much larger area. In the Lower Vistula valley it is documented by a till. The TL datings of deposits overlying this till in the Sartowice section (Text-fig. 1) define its age for over 51 000 y. and authorize its correlation with the icesheet advance at the worldwide climatic cooling, recorded in deep-sea sediments by the ^{18}O horizon *4* dated for 75 000—64 000 y. BP. This cooling is represented in the Zwierzyniec section by silts (TL datings: 71 700—67 600 y. BP) and by the loess at Nieledew (TL dating: 60 800 ± ± 7 500 y. BP).

A successive, younger warming during the same glaciation is represented at Sartowice by silts (TL datings: 51 000 ± 8 000 y. BP and 43 000 ± 7 000 y. BP) and by two beds of organogenic sediments in the Konin—Maliniec section (Text-fig. 1). The lower bed of these sediments (Maliniec *I*; radiocarbon dating 42 900 y. BP and 42 500 y. BP) contains floristic remains of a park tundra and corresponds probably to the Moershoofd Interstadial. The upper bed (Maliniec *II*; radiocarbon dating 22 230 ± 480 y. BP and 22 050 ± 450 y. BP) yielding remains of a brushy tundra, corresponds to the warming which preceded the maximum extent of the icesheet during the Wisła Glaciation. In southern Poland this warming is identified with the Interpleniglacial of the Netherlands, and it is represented by mid-loessic tundra paleosols (TL datings: 50 000—24 000 y. BP) as well as by a humus horizon in the Nietoperzowa Cave (radiocarbon dating 38 160 ± 250 y. BP). Within and above the latter there occur artifacts of the Jerzmanovician culture. In deep-sea sediments this warming is correlated with the ^{18}O horizon *3*, dated for 64 000—32 000 y. BP.

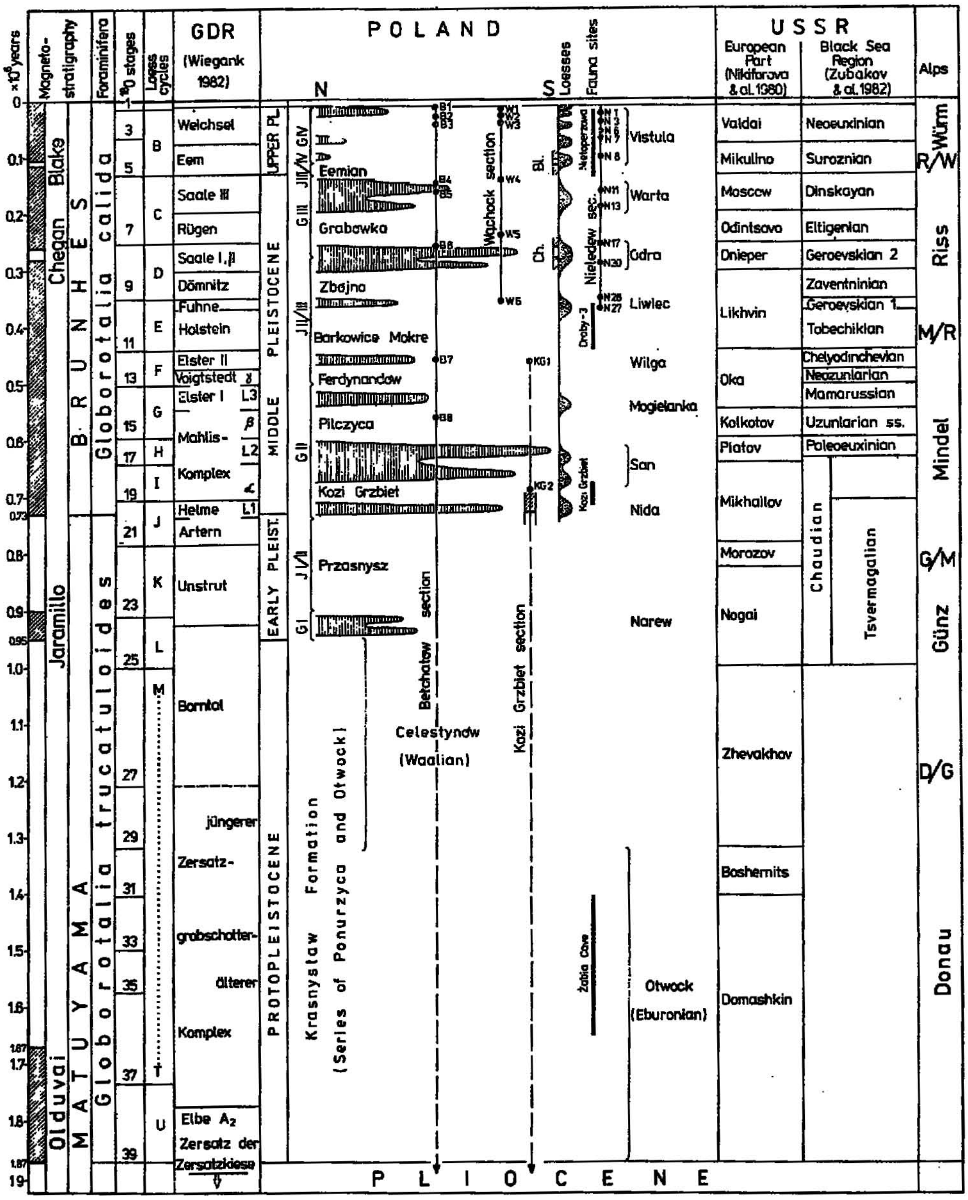
The third icesheet advance of the Wisła Glaciation (Text-fig. 1) is evidenced by two youngest tills. The lower one, correlated with the Leszno—Poznań Phase, delimits the maximum icesheet extent (about 20 000 y. BP). A retreat of this icesheet during the Mazury Interphase favored an organogenic deposition in the Mazury Lakeland (TL dating 17 800 ± 250 y. BP) and the formation of a paleosol in the Wąchock section (TL dating: older than 15 830 ± 1830 y. BP). The last of these dates defines the age of the youngest Wisła Glaciation loess in Poland and it is close to the icesheet-extent time during the Pomeranian Phase. The maximum development of the Wisła Glaciation in Poland is correlated in deep-sea sediments with the ^{18}O horizon 2, dated for 32 000—13 000 y. BP.

A deglaciation of the area during the Pomeranian Phase and the younger icesheet standstills are defined as the Late Glacial. In Poland this period is recorded by numerous sites with organogenic sediments (Witów, Mikołajki, Brzozowica, Przedni Staw Lake, Woryty, Niechorze; *see* Text-fig. 1). A palynological analysis proved that most Late Glacial — Holocene lacustrine and bog sediments had been deposited already before the Alleröd.

REFERENCES: Halicki (1960), Wasylikowa (1964), Ralska-Jasiewiczowa (1966), Środoń (1967), Jersak (1973), Marciniak (1973, 1979), Kopczyńska-Lamparska (1976), Chmielewski & *al.* (1977), Tuchołka (1977), Brykczyńska (1978), Prószyński (1978), Marks (1979), Tobolski (1979), Pazdur

BRITISH ISLES after Funnel & West /1977/, West /1977/	FRG after Brunnacker /1978/, & al. /1978/, Urban /1983/		CSSR after Macoun /1981/	GDR after Wiegank /1982/	POLAND	USSR after Nikiforova & al. /1980/
DEVENSIAN[3]	WEICHSELIAN	/Jb/	WEICHSELIAN[3]	WEICHSEL[3]	WISŁA[3]	VALDAI[3]
Ipswichian[1]	Eemian[1]		Eemian[1]	Eem[1]	Eemian[1]	Mikulino[1]
WOLSTONIAN[3]	WARTHE	/Ja/	WARTHE	SAALE III	WARTA[3]	MOSCOW[3]
Hoxnian[3]	Kärlicher		post-Saalian W.P.	Rügen[3]	Grabowka	Odintsovo[3]
ANGLIAN	DRENTHE	/H/	OLDRISOV	SAALE I,II	ODRA[3]	DNIEPER[3]
Carton Sands	Ariendorfer		Neplachovice	Dömnitz	Zbdjno	
CROMER TILLS		/Gb/	PLHANEC	FUHNE	LIWIEC[3]	[3]
Cromerian	Leutesdorfer		Jaktar	Holstein[1]	Barkowice M.[1]	[1] Likhvin
Beestonian		/Ga/	KRAVARE	ELSTER II	WILGA[3]	[3]
Pastonian	Frimmersdorfer		Otice	Voigtstedt[1]	Ferdynandow[1]	
Baventian		/F/	OPAVA	ELSTER I	MOGIELANKA[3]	[3] OKA
Antian		/E/	Slavkov	Mahlis-	Pilczyca	Kolkotov
Thurnian	Ville-	/C,D/	Late pre-gl. P.		SAN	Platov
Lundhamian			Koberice	-Komplex	Kozi Grzbiet	Mikhailov
pre-Lundhamian	-Komplex	/Bb/	Early pre-gl. P.	Helme[2]	NIDA[2]	
				Artern		
				Unstrut	Przasnysz	Morozov
		/Ba/			NAREW	Nogai
				Borntal	Celestynów	Zhevakhov
				Zersatz-		
		/A/		-grobschotter-	Otwock	Boshernits
				-Komplex		Domashkin

Fig. 9. Correlation of the Quaternary units in Europe, based on the 1 — biostratigraphic, 2 — paleomagnetic data, and 3 — absolute datings



Datings of deposits of the Kozi Grzbiet section by FCl/P (KG2 — 700 000—550 000 BP *after* Głazek & *al.* 1976) and thermoluminescence (KG1 — 440 000—400 000 BP *after* Lindner 1982) methods

& Walanus (1979), Stankowska & Stankowski (1979), Drozdowski (1980), Makowska (1980), Kozarski (1980, 1981), Kozarski & *al.* (1981), Galon (1982), Wysoczański-Minkowicz (1982), Madeyska (1982), Cieśla & Marciniak (1982), Marciniak & Cieśla (1983), Lindner & *al.* (1984), Krupiński (1984).

HOLOCENE

The Holocene is considered by some authors as the warming of the interglacial rank. This time favored the deposition of lacustrine-bog, fluvial, aeolian and slope sediments. Studies over these sediments laid the foundations for a subdivision of the Holocene into several phases with a climatic optimum of the Atlantic Period at 8 400—5 100 y. BP.

REFERENCES: Ralska-Jasiewiczowa (1966), Starkel (1968, 1977), Rosa (1968), Falkowski (1975), Lindner (1977b), Kozarski & Rotnicki (1978), Rudowski (1979), Pawlikowski & *al.* (1982), Szczepanek (1982), Jersak & Śnieszko (1983), Krupiński (1984).

CONCLUSIONS

The Ice Age in Poland starts in the Early Pleistocene with the Narew Glaciation (*GI* according to Różycki, 1961) and the following Przasnysz Interglacial (*J/III*). The three Middle Pleistocene glaciations (Nida, San, Mogielanka) together with the separating interglacials (Kozi-Grzbiet, Pilczyca) represent the climatic warmings and coolings of the South-Polish glaciations (*GII*). The successive Great Interglacial (*JII/III*) with its four climatic warmings distinguished by Różycki (1964), in the presented chronostratigraphical approach comprises three interglacials (Ferdynandów, Barkowice-Mokre, Zbójno), two glaciations (Wilga, Liwiec) and a warming of the lower rank (Podlesie) which took place already in the anaglacial part of the Odra Glaciation. The Middle-Polish glaciations (*GIII*) include the older (Odra) and the younger (Warta) glaciations, separated by the Grabówka Interglacial. The Upper Pleistocene is represented by the Eemain Interglacial (*JIII/IV*) and the following Wisła Glaciation (*GIV*).

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REFERENCES

BAŁUK A. 1983. Nowe profile czwartorzędu z okolic Przasnysza. *Kwart. Geol.*, 27 (2), 414—415. Warszawa.

BARANIECKA M. D. 1975. The Ponurzyca sequence and its implications for the origin and age of the Mazovia Preglacial. *Kwart. Geol.*, 19, (3), 651—665, Warszawa.

— & SARNACKA Z. 1971. The stratigraphy of the Quaternary and the paleogeography of the drainage basin of the Widawka. *Biul. Inst. Geol.*, 254, 157—270. Warszawa.

BIRKENMAJER K. & STUCHLIK L. 1975. Early Pleistocene pollen-bearing sediments at Szaflary, West Carpathians, Poland. *Acta Palaeobot.*, 16 (2), 113—146. Warszawa—Kraków.

BONIFAY M. F. 1980. Relations entre les données isotopiques et l'histoire des grandes faunes européennes plio-pleistocenes. *Quatern. Res.*, 14, 251—262. Washington.

BORÓWKO-DŁUŻAKOWA Z. 1967. Palaeobotanical studies of Late Pleistocene deposits (Brørup) in the Konin-Marantów area. *Prace Inst. Geol.*, 48, 81—136. Warszawa.

— & HALICKI B. 1957. Interglacial sections of the Suwałki region and of the adjacent territory. *Acta Geol. Polon.*, 7 (4), 361—401. Warszawa.

BOSÁK P., GŁAZEK J., HORÁČEK I. & SZYNKIEWICZ A. 1982. New locality of early Pleistocene vertebrates — Żabia Cave at Podlesice, Central Poland. *Acta Geol. Polon.*, 32 (3—4), 217—226. Warszawa.

BOWEN D. Q. 1978. Quaternary geology; a stratigraphic framework for multidisciplinary work. *Pergamon Press;* Oxford — New York — Toronto — Sydnep — Paris — Frankfurt.

BRUNNACKER K. 1978. Neuere Ergebnisse über das Quartär am Mittel- und Niederrheim. *Fortschr. Geol. Rheinld u. West.*, 28, 111—122. Krefeld.

— , BOENIGK W., DOLEZALEK B., KEMP E. K., KOČI A., MENTZEN H., RAZI RAD M. ,& WINTER K. P. 1978. Die Mittelterrassen am Niederheim zwischen Köln und Mönchengladbach. *Fortscher. Geol. Rheinld u. Westf.*, 28, 277—324. Krefeld.

BRYKCZYŃSKA E. 1978. An attempt to reconstruction Late Glacial and Holocene history of vegetational cover from the Niechorze area in Western Pomerania. *Kwart. Geol.*, 22 (2), 361—377. Warszawa.

BUTRYM J., BARANIECKA M. D., KASZA L., BRODZIKOWSKI K., HAŁUSZCZAK A., GOTOWAŁA R. & JANCZYK-KOPIKOWA Z. 1982. Datowanie bezwzględne osadów czwartorzędowych górnego piętra strukturalnego w strefach Piaski — Buczyna — Chojny odkrywki bełchatowskiej. *Mat. I Symp. „Czwartorzęd rejonu Bełchatowa"*, 150—157. *Wyd. Geol.;* Wrocław — Warszawa.

— & MARUSZCZAK H. 1983. Termoluminescencyjna chronologia lessów z profilu Nieledew. *Komitet Badań Czwartorzędu PAN, Sprawozd. z bad. nauk.*, 5, 114—117. Warszawa.

CHMIELEWSKI W. 1961. Civilisation de Jerzmanowice; 92 pp. *IHKM PAN;* Wrocław — Warszawa — Kraków.

— , KONECKA-BETLEY K. & MADEYSKA T. 1977. Palaeolithic site Cracow-Zwierzyniec in the light of investigations in 1972—1974. *Biul. Inst. Geol.*, 305, 13—30. *Warszawa.*

CIESLA A. & MARCINIAK B. 1982. Development of Late Glacial lacustrine deposits at Niechorze (western Pomerania) in the light of diatomological and geochemical data. *Kwart Geol.*, 28 (1), 191—215. Warszawa.

CZARNOCKI J. 1931. Diluvium der Święty Krzyż Gebirge. *Rocznik PTG (Ann. Soc. Géol. Pologne)*, 7, 85—105, Kraków.

DĄBROWSKI M. J. 1967. Pollen analysis of an interstadial profile from Jasionka near Rzeszów. *Acta Geol. Polon.*, 17 (3), 509—520. Warszawa.

DROZDOWSKI E. 1980. Chronostratigraphy of the Vistulian Glaciation on the lower Vistula River. *Quatern. Stud. Poland.*, 2, 13—20. Warszawa — Poznań.

FALKOWSKI E. 1975. Variability of channel processes of lowland rivers in Poland and changes of the valley floors during the Holocene. *Biul. Geol. Uniw. Warsz.* 19, 45—78. Warszawa.

BFEDOROWICZ S. 1983. Metodyka badań i dotychczasowe wyniki uzyskane w Laboratorium TL w Gdyni (referat na Symp. „Metody chronologii bezwzględnej" w Gliwicach).

FUNNEL B. M. & WEST R. G. 1977. Preglacial Pleistocene deposits of East Anglia. British Quaternary Studies (F. W. SHOTTON, *Ed.)*, 247—265. *Clarendon Press;* Oxford.

GALON R. 1982. On the stratigraphy and chronology of the last glaciation (Vistulian) in Poland. *Quatern. Stud. Poland*, 3, 37—48. Warszawa — Poznań.

GŁAZEK J., 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

faunas of the Mindelian I/Mindelian II Interglacial and their stratigraphic correlations. *Proc. 7 th Intern. Speleolog. Congr.*, 211—214. Sheffield.
— LINDER L. & WYSOCZAŃSKI T. 1976. Interglacial Mindel I/Mindel II in fossil-bearing karst at Kozi Grzbiet in the Holy Cross Mts. *Acta Geol. Polon.*, 26 (3), 376—393. Warszawa.
— , SULIMSKI A., SZYNKIEWICZ A. & WYSOCZAŃSKI-MINKOWICZ T. 1976. Middle Pleistocene karst deposits with *Ursus spelaeus* at Draby near Działoszyn, Central Poland. *Acta Geol. Polon.*, 26 (3), 451—466. Warszawa.
HALICKI B. 1950. La position stratigraphique des dépôts eemiens dans la region de la Basse Vistule. *Rocznik PTG (Ann. Soc. Géol. Pologne)*, 20 (3), 313—318. Kraków.
— 1960. The problem of the Mazurian Interstadial Period. *Zbiór Prac i Komunikatów Treści Geol., Inst. Geol., Muz. Ziemi*, 107—123. Warszawa.
HAŁUSZCZAK A. 1982. Zarys budowy geologicznej czwartorzędu w rejonach Piaski oraz Buczyna-Chojny. Mat. I Symp. „Czwartorzęd rejonu Bełchatowa", 14—35. *Wyd. Geol.*; Wrocław — Warszawa.
HARASIMIUK M. & HENKIEL A. 1981. Fossil valley forms in the vicinities of the Wieprz river system. *Kwart. Geol.*, 25 (1), 147—162. Warszawa.
JAHN A. & SZCZEPANKIEWICZ S. 1967. Osady i formy czwartorzędowe Sudetów i ich przedpola. Czwartorzęd Polski (R. GALON & J. DYLIK, *Eds*), 397—430. *PWN*; Warszawa.
JANCZYK-KOPIKOWA Z. 1975. Flora of the Mazovian Interglacial at Ferdynandów. *Biul. Inst. Geol.*, 290, 5—94. Warszawa.
— 1980. Paleobotanical foundations of the stratigraphy of the Lower and Middle Pleistocene of SE Poland. *Guide-book of field seminar „Stratigraphy and chronology of the loesses and glacial deposits of the Lower and Middle Pleistocene in SE Poland"*, 29—80, Lublin.
— 1981. Pollen analysis of the Pleistocene sediments at Kaznów and Krępiec. *Biul. Inst. Geol.*, 321, 249—258. Warszawa.
— , MOJSKI J. E. & RZECHOWSKI J. 1981. Position of the Ferdynandów Interglacial, Middle Poland, in the Quaternary stratygraphy of the North European Plain. *Rept 6 on the session IGCP Project 73 (1) 24, Quaternary Glaciation in the Northern Hemisphere*, 146—162. Prague.
JERSAK J. 1973. Lithology and stratigraphy of the loess on the Southern Polish Uplands. *Acta Geograph. Lodziensia*, 32, 1—142. Łódź.
— 1975. Profil lessowy w Odonowie II. *Przewodnik Konf. Teren. „Less i zróżnicowanie typologiczne gleb kopalnych na Wyżynie Małopolskiej"*, 40—43. Łódź.
— & ŚNIESZKO Z. 1983. Rozwój rzeźby miechowskiego i opatowsko-sandomierskiego płata lessowego w późnym vistulianie i holocenie. *Przewodnik Konf. „Późnovistuliańskie i holoceńskie zmiany środowiska geograficznego na obszarach lessowych Wyżyny Miechowskiej i Opatowsko-Sandomierskiej"*, 5—12. Katowice.
JURKIEWICZOWA I., MAMAKOWA K. & RÜHLE E. 1973. Middle Pleistocene deposits south of Wyśmierzyce near Nowe Miasto on the Pilica River. *Folia Quatern.*, 43, 1—26. Kraków.
KARASZEWSKI W. 1974. Age of the Warsaw ice-dammed lake sediments. *Bull. Acad. Polon. Sci., Sér. Sci. Géol. Géogr.*, 22 (3—4), 151—154. Warszawa.
KELLOGG T. B. 1980. Paleoclimatology and paleo-oceanography of the Norwegian and Greenland seas: glacial — interglacial contrasts. *Boreas*, 9 (2), 115—137. Oslo.
KLIMASZEWSKI M. 1967. Polskie Karpaty Zachodnie w okresie czwartorzędowym. Czwartorzęd Polski (R. GALON & J. DYLIK, *Eds*), 431—497. *PWN*; Warszawa.
KONECKA-BETLEY K. & STRASZEWSKA K. 1977. Palaeopedologic investigations of leess in the Sandomierz area on the ground of its stratigraphy. *Studia Geol. Polon.*, 52, 215—233. Waarszawa.
KOPCZYŃSKA-LAMPARSKA K. 1976. Radiocarbon datings of the Late Glacial and Holocene deposits of western Pomerania. *Acta Geol. Polon.*, 26 (3), 413—418. Warszawa.
KOZARSKI S. 1980. An outline of Vistulian stratigraphy and chronology of the Great Poland Lowland. *Quatern. Stud. Poland*, 2, 21—35. Warszawa — Poznań.
— , NOWACZYK B. & TOBOLSKI K. Results of studies of deposits from Stary Kurów near Drezdenko assigned to the Brørup Interstadial. *Przegląd. Geol.*, 4 (324), 210—214. Warszawa.

— & ROTNICKI K. 1978. Problems concerning the development of valley floors during Late-Würm and Holocene in the Polish Lowland. PTPN, *Prace Kom. Geograf.-Geolog.*, 19, 1—57. *PWN;* Warszawa — Poznań.

KRUPIŃSKI K. M. 1984. Evolution of Late Glacial and Holocene vegetation in the Polish Tatra Mts, based on a pollen analysis of sediments of the Przedni Staw Lake. *Bull. Acad. Polon. Sci., Sér. Sci. de la Terre (in press).*

LAMPARSKI Z. 1983. Pleistocene and its substrate in the northern part of the Middle Vistula Region. *Studia Geol. Polon.*, 76, 1—821. Warszawa.

LASKOWSKA-WYSOCZAŃSKA W. 1967. The interstadial of the Cracovian glaciation from Jasionka near Rzeszów. *Acta Geol. Polon.*, 17 (3), 495—507. Warszawa.

— 1971. Quaternary stratigraphy and palaeomorphology of the Sandomierz Lowland and the Foreland of the Middle Carpathians, Poland. *Studia Geol. Polon.*, 34, 1—109. Warszawa.

LEWANDOWSKI J. 1982. Extent of ice sheet of Middle-Polish Glaciation in the Silesian Upland. *Biul. Inst. Geol.*, 337, 115—142. Warszawa.

LINDNER L. 1977a. Pleistocene glaciations in the western part of the Holy Cross Mts, Central Poland. *Studia Geol. Polon.*, 53, 1—143. Warszawa.

— 1977b. The age of river flood-terraces from the Holy Cross Hts in the light of ^{14}C datings of the „black oak horizons". *Kwart. Geol.*, 21 (2), 325—334. Warszawa.

— 1978. Paleogeomorphologic evolution of the western part of the Holy Cross region in the Pleistocene. *Rocznik PTG (Ann. Soc. Géol. Pologne)*, 48 (3—4), 479—508. Kraków.

— 1980. An outline chronostratigraphy of the Quaternary of the Holy Cross Mts region. *Kwart. Geol.*, 24 (3), 698—707. Warszawa.

— 1981. Organogenic deposits of the Mazovian Interglacial (Mindel *II*/Riss *I*) in the Middle Vistula basin, compared to coeval European localities. *Acta Geol. Polon.*, 31 (1—2), 111—128. Warszawa.

— 1982. South-Polish glaciations (Nidanian, Sanian) in southern Central Poland. *Acta Geol. Polon.*, 32 (3—4), 163—177. 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.

— & GRZYBOWSKI K. 1982. Middle-Polish glaciations (Odranian, Wartanian) in southern Central Poland. *Acta Geol. Polon.*, 32 (3—4), 191—208. Warszawa.

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

— , MARKS L. & PĘKALA K. 1983. Quaternary glaciations of South Spitsbergen and their correlation with Scandinavian glaciations of Poland. *Acta Geol. Polon.*, 33 (1—4), 169—182. Warszawa.

— , & — 1984. Late Quaternary glacial episodes in Hornsund Region of Spitsbergen. *Boreas (in press).*

ŁYCZEWSKA J. 1971. The Quaternary of the Góry Świętokrzyskie. *Prace Inst. Geol.*, 64, 5—108. Warszawa.

MACOUN J. 1981. The significance of the north Moravian Pleistocene for stratigraphical correlation of the Central European Quaternary. *Rept 6 on the session IGCP Project 73 (1) 24, Quaternary Glaciations in the Northern Hemisphere*, 198—204. Prague.

MADEYSKA T. 1982. The stratigraphy of Palaeolithic sites of the Cracow Upland. *Acta Geol. Polon.*, 32 (3—4), 227—242. Warszawa.

MAKOWSKA A. 1977. Interglacial horizon in profile of the Middle-Polish Glaciation from the Lower Vistula River valley. *Kwart. Geol.*, 21 (4), 769—783. Warszawa.

— 1979. Eemian interglacial in valley of Lower Vistula River. *Studia Geol. Polon.*, 63, 1—90. Warszawa.

— 1980. Late Eemian with preglacial and glacial part of Vistulian Glaciation in the Lower Vistula region. *Quatern. Stud. Poland*, 2, 37—55. Warszawa — Poznań.

MAMAKOWA K. 1983. Wstępne wyniki badań palinologicznych osadów z Przasnysza. *Kwart. Geol.*, 27 (2), 415—418. Warszawa.

MANKINEN E. A. & DALRYMPLE G. B. 1979. Revised geomagnetic polarity time scale for the interval 0—5 m. y. BP. *J. Geophys. Res.*, 84 (2), 615—625. Washington.
MARCINIAK B. 1973. The application of the diatomological analysis in the stratigraphy or the Late-Glacial deposits of the Mikołajki Lake. *Studia Geol. Polon.*, 39, 1—159, Warszawa.
— 1979. Dominant diatoms from Late Glacial and Holocene lacustrine sediments in Northern Poland. *Nova Hedwigia*, 64, 411—426. Vaduz.
— 1983. Diatoms in the Mazovian Interglacial of the Lublin Upland. *Bull. Acad. Polon. Sci., Sér. Sci. de la Terre*, 30 (1—3), 77—85. Warszawa.
— & CIEŚLA A. 1983. Diatomological and geochemical studies on Late Glacial and Holocene sediments from the Przedni Staw Lake in the Dolina Pięciu Stawów Polskich (Tatra Mts). *Kwart. Geol.*, 27 (1), 123—142. Warszawa.
MARKS L. 1979. Foreland influence on ice-sheet movement during the Vistulian (Würm) Glaciation; the case of the Lubawa Elevation (Mazury Lakeland). *Bull. Acad. Polon. Sci., Sér. Sci. de la Terre*, 26 (3—4), 203—213. Warszawa.
MARUSZCZAK H. 1980. Stratigraphy and chronology of the Vistulian loesses in Poland *Quatern. Stud. Poland*, 2, 57—76. Warszawa.
MICHALSKA Z. 1961. Stratigraphy of the Pleistocene and palaeomorphology of the northeastern part of Mazowsze (Central Poland). *Studia Geol. Polon.*, 7, 1—102. Warszawa.
MOJSKI J. E. 1969. Stratigraphy of Meso-Pleistocene glacial deposits. *Kwart. Geol.*, 13 (2), 385—407. Warszawa.
— 1982. Outline of the Pleistocene stratigraphy in Poland. *Biul. Inst. Geol.*, 343, 9—29. Warszawa.
— & RZECHOWSKI J. 1981. The Pleistocene of Great Britain. *Biul. Inst. Geol.*, 327, 27—64. Warszawa.
van MONTFRANS H. M. 1971. Palaeomagnetic dating in the North Sea Basin, 1—113. *Princo*, N.V., and Rotterdam.
NIKIFOROVA K. V. KRASNOV I. I., ALEKSANDROVA A. L., VASILIEV Y. M., KONSTANTINOVA N. A. & CHEPALYGA A. L. 1980. Chronostratigraphic scheme of the Late Cenozoic of the European part of the USSR. *Intern. Geol. Congress, 26 session, Rep. of the Soviet Geologists „Quaternary geology and geomorphology, remote sensing"*, 65—68. *Nauka*; Moskva.
PAWLIKOWSKI M., RALSKA-JASIEWICZOWA M., SCHÖNBORN W., STUPNICKA E. & SZEROCZYŃSKA K. 1982. Woryty near Gietrzwałd, Olsztyn Lake during the last 12 000 years. *Acta Palaeobot.*, 22 (1), 85—116. Warszawa — Kraków.
PAZDUR M. & WALANUS A. 1979. The Konin-Maliniec Site: age assessment by radiocarbon method. *Guide-book to the Symposium „Vistulian Stratigraphy" Poland*, 45—46. Warszawa.
POLIŃSKI W. 1927. Gastropodes diluviaux de Kielce. *Posiedz. Nauk. P.I.G.*, 17, 21—22. Warszawa.
PROSZYŃSKI M. 1978. Studium geochronologii czwaartorzędu i termoluminescencji osadów czwartorzędowych. *Komitet Bad. Czwartorzędu PAN, Sprawozd. z Bad. Nauk.*, 2, 49—63. Warszawa.
RALSKA-JASIEWICZOWA M. 1966. Bottom sediments of the Mikołajki Lake (Mazurian Lake District) in the light of palaeobotanical investigations. *Acta Palaeobot.*, 7 (2), 1—118. Warszawa — Kraków.
RÓŻYCKI S. Z. 1961. Middle Poland. *Guide-book of excursion from the Baltic to the Tatraas*, 2 (1), 1—116, VIth INQUA Congress. Waraszwa.
— 1964. Les oscilations climatiques pendant le „Grand Interglaciaire". *Report of the VIth INQUA Congress*, 2, 211—225, Łódź.
— 1972. Plejstocen Polski Środkowej. 2nd ed., 1—315. *PWN*; Warszawa.
— 1978. From Mochty to a synthesis of the Polish Pleistocene. *Rocznik PTG (Ann. Soc. Géol. Pologne)*, 48 (3—4), 445—478. Kraków.
— 1980. Principles of stratigraphic subdivisions of Quaternary of Poland. *Quatern. Stud. Poland*, 2, 99—106. Warszawa — Poznań.
RUDOWSKI S. 1979. The Quaternary history of the Baltic, Poland. *Acta Univ. Ups. Symp. Univ. Ups. Annum Quingentesimum Celebrantis*, 1, 175—183. *Uppsala*.
RÜHLE E. 1970. Les nouvelle unités stratigraphiques de la glaciation de la Pologne Centrale (Riss) sur la territoire entre la moyenne Vistule et le bas Bug. *Acta Geograph. Lodz.*, 24 399—412. Łódź.
— 1973. Stratygrafia czwartorzędu Polski. Metodyka badań osadów czwartorzędowych (E. RÜHLE *Ed)*, 31—78. *Wyd. Geol.*; Warszawa.

SELLE W. 1960. Das Interglazial von Praschnitz. *Geol. Jb.*, 77, 319—327. Hannover.
SHACKLETON N. J. & OPDYKE N. D. 1973. Oxygen isotope and paleomagnetic stratigraphy of equatorial Pacific core X 28 — 238: Oxygene isotope temperatures and ice volumes on a 10[5] year and 10[6] years scale. *Quatern. Res.*, 3 (1), 39—55. Washington.
SOBOLEWSKA M. 1952. Interglacial at Barkowice Mokre near Sulejów. *Biul. P. I. G.*, 66, 245—284. Warszawa.
STANKOWSKA A. & STANKOWSKI W. The Maliniec set; the Vistulian till covering stagnant water sediments with organic sediments. *Guide-book to the Symposium „Vistulian Stratigraphy" Poland*, 42—43. Warszawa.
STARKEL L. 1968. Problems connected with the paleogeomorphological studies on the Holocene in the territory of Poland. *Folia Quatern.*, 29, 9—20. Kraków.
— 1977. Paleogeografia holocenu, 1—362. *PWN*; Warszawa.
STRASZEWSKA K. 1968. Pleistocene stratigraphy and paleogeomorphology in the Lower Bug region, Central Poland. *Studia Geol. Polon.*, 23. 1—149. Warszawa.
STUCHLIK L. 1975. Palynological characteristic of the preglacial sediments of Ponurzyca (Otwock area). *Kwart. Geol.*, 19 (3), 667—678. Warszawa.
SZAFER W. 1953. Pleistocene stratigraphy of Poland from the floristical point of view. *Rocznik PTG (Ann. Soc. Géol Pologne)*, 22 (1), 1—99. Kraków.
SZCZEPANEK K. 1982 Development of the peat-bog at Słopiec and the vegetational history of the Holy Cross Mts in the last 10 000 years. *Acta Palaeobot.*, 22 (1), 117—130. Warszawa — Kraków.
SZYNDLAR Z. 1981. Early Pleistocene reptile fauna from Kozi Grzbiet in the Holy Gross Mts. *Acta Geol. Polon.*, 31 (1—2), 81—101. Warszawa.
ŚNIESZKO Z. & TUCHOŁKA P. 1975. Badania paleomagnetyczne profilu lessowego Odonów. Przewodnik oKnf. Teren. „Less i zróżnicowanie typologiczne gleb kopalnych na Wyżynie Małopolskiej", 46—47. Łódź.
ŚRODOŃ A. 1967. Stratygrafia późnego plejstocenu Polski niżowej na podstawie paleobotanicznej. Czwartorzęd Polski (R. GALON & J. DYLIK, *Eds*), 61—71. *PWN*; Warszawa.
TOBOLSKI K. 1979. Fossil flora in the Maliniec site. *Guide-book to the Symposium „Vistulian Stratigraphy" Poland*, 43—45. Warszawa.
TUCHOŁKA P. 1977. Magnetic polarity events in Polish loess profiles. *Biul Inst. Geol.*, 305, 117—123. Warszawa.
URBAN B. 1983. Biostratigraphic correlation of the Kärlich Interglacial, Northwestern Germany. *Boreas*, 12 (2), 83—90. Oslo.
WASYLIKOWA K. 1964. Vegetation and climate of the Late-Glacial in Central Poland based on investigations made at Witów near Łęczyca. *Biul. Peryglacjalny*, 13 262—417. Łódź.
WEST R. G. 1977. Pleistocene geology and biology with especial reference to the British Isles, 1—440. *Longman*; London — New York.
WIEGANK F. 1982. Ergebnisse magnetostratigraphischer Untersuchungen im höheren Känozoikum der DDR. *Zt. Geol. Wiss.*, 10 (6), 737—744. Berlin.
WOJTANOWICZ J. 1983. Stratygrafia czwartorzędu. Kenozoik Lubelskiego Zagłębia Węglowego. *UMCS Mat. Symp.*, 73—91. Lublin.
WYSOCZAŃSKI-MINKOWICZ T. 1980. Dating of bone remmants as a fundamental criterion for determination of stratigraphy and chronology of the Pleistocene in Poland. *Guide-book of field seminar „Stratigraphy and chronology of the loesses and glacial deposits of the lower and middle Pleistocene in SE Polnd"*, 23—29. Lublin.
— 1982. Climatochronostratigraphic subdivision of the last cool period (Vistulian). *Quatern. Stud. Poland*, 3, 129—145. Warszawa — Poznań.
ZUBAKOV V., BOGATINA N. V. & PISAREVSKIY S. A. 1982. The detailed division, stratigraphic volume and geologic age of the Karangatian, Black Sea region. *Doklady Acad. Nauk SSSR*, 267 (2), 426—429. Moskwa.
— & BORZENKOWA I. I. 1983. Paleoclimates of the Upper Cenozoic, 1—214. *Gidrometeoizdat*; Leningrad.

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ZARYS CHRONOSTRATYGRAFII PLEJSTOCENU POLSKI

(Streszczenie)

Przedstawiono czas trwania i podział czwartorzędu Polski na protoplejstocen (1 870 000—950 000 lat BP), plejstocen (950 000—10 000 lat BP), oraz holocen (ostatnie 10 000 lat). W obrębie protoplejstocenu wydzielono ochłodzenie Otwocka i ocieplenie Celestynowa. W plejstocenie dzielącym się na trzy części (dolny, środkowy, górny) wyróżniono większą niż dotychczas ilość epizodów glacjalnych i interglacjalnych (*patrz* fig. 1—8). Dolny plejstocen (950 000—730 000 lat BP) reprezentowany jest przez najstarsze zlodowacenie (Narwi) i następujący po nim interglacjał (Przasnysza). W obrębie środkowego plejstocenu (730 000—128 000 lat BP), jego starsza część obejmuje trzy zlodowacenia południowopolskie (Nidy, Sanu, Mogielanki) oddzielone od siebie dwoma interglacjałami (Koziego Grzbietu, Pilczycy), część środkowa obejmuje trzy epizody interglacjalne (Ferdynandowa, Barkowic Mokrych, Zbójna) wraz z dzielącymi je zlodowaceniami (Wilgi, Liwca), a część młodsza składa się z dwóch zlodowaceń środkowopolskich (Odry, Warty) oddzielonych przedostatnim epizodem interglacjalnym (Grabówki). Górny plejstocen (128 000—10 000 lat BP) reprezentowany jest przez ostatni interglacjał (eemski) i najmłodsze zlodowacenie (Wisły). Dzięki danym paleontologicznym, paleomagnetycznym i datowaniem bezwzględnym podjęto próbę korelacji wymienionych epizodów z jednostkami podziału czwartorzędu w krajach sąsiednich (*patrz* fig. 8 i 9).
