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Main stratigraphical units of the Pleistocene in southeastern Poland and the northwestern Ukraine, and their correlation in Western and mid-eastern Europe

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Basing on key sections of glacial, lake, fluvial and loessy sediments (the latter with palaeosols), 15 main stratigraphical units of the Pleistocene were described and correlated for the area of southeastern Poland and northwestern Ukraine. Eight of these units represent glaciations (Narevian, Nidanian, Sanian 1, Sanian 2, Liviecian, Odranian, Wartanian and Vistulian), and seven are interglacials (Podlasian, Małopolanian, Ferdynandovian, Mazovian, Zbójnian, Lublinian and Eemian). Extents of Scandinavian ice-sheets in this area are presented during the described glaciations, accompanied by tentative correlation to the main stratigraphical units of the pre-Pleistocene and Pleistocene in western and mid-eastern Europe.

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INTRODUCTION

The paper presents main glacial and interglacial units of the Pleistocene and their correlation in the Małopolska, Lublin, Volhynian and Podolian Uplands, the Sandomierz Basin, the northern Polish and Ukrainian Carpathians, and their close surroundings (Fig. 1). Glacial units are indicated by glacial and glaciofluvial sediments or by subaerial loesses with preserved frost structures, occurring in key sections. Interglacial units are best represented by fluvial and lake series, comprising organic sediments with separate floristic successions, and also by intra-loessy forest palaeosols.

Sediments of glacial and interglacial units do not form a compact cover in the described area but frequently are a residuum or patches, separated by outcrops of pre-Quaternary rocks (mainly Mesozoic or Tertiary ones). Their maximum thickness, usually to several dozen metres, is mostly common in the northern surroundings of the uplands, in the pre-Pleistocene buried river valleys, occasionally of tectonic origin.

The Pleistocene cover contains frequently subtill and supratill loesses and loessy-like sediments. In spite of patchy-like occurrence, they are also significant for stratigraphical correlation of glacial and interglacial units.

This paper corresponds strictly to the previous studies of L. Lindner (1980, 1988*a–c*, 1995), W. Pożaryski *et al.* (1994, 1995), L. Dolecki (1995), J. Wojtanowicz (1984, 1995, 1996) and H. Maruszczak (1996) in the Małopolska and Lublin Uplands, named also the South-Polish ones. Results of these studies founded a basis for the Pleistocene 8 main glacial units (glaciations) i.e. Narevian, Nidanian, Sanian 1, Sanian 2 = Wilgian, Liviecian, Odranian, Wartanian and Vistulian, and 7 interglacials, namely Podlasian = Augustovian, Małopolanian, Ferdynandovian, Mazovian, Zbójnian, Lublinian = Lubavian and Eemian (L. Lindner, J. Wojtanowicz, 1996, 1997*a, b*). Main source of data for the Volhynian and Podolian Uplands comes from examination of the key loess sections (A. B. Bogutsky, T. D. Morozova, 1981; A. B. Bogucki *et al.*, 1995; J. Nawrocki *et al.*, 1996) and the authors unpublished data.

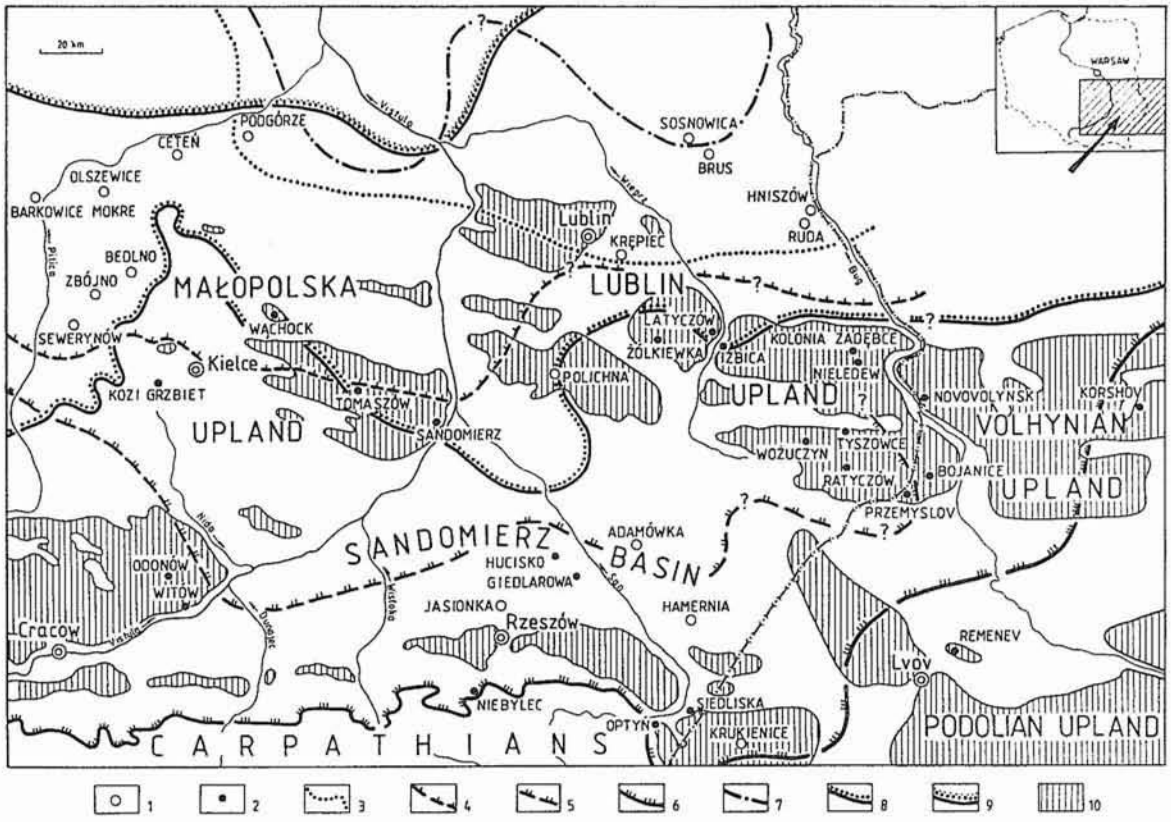

Fig. 1. Location sketch of described areas of southeastern Poland and the northwestern Ukraine, with location of key sections of the Pleistocene deposits and extents of Scandinavian ice-sheets, after L. Lindner and J. Wojtanowicz (1997*a*), supplemented
1 — section with interglacial plant remains; 2 — other key sections; ice-sheet extents during the glaciations: 3 — Narevian, 4 — Nidanian, 5 — Sanian 1, 6 — Sanian 2, 7 —Liviecian, 8 — Odranian, 9 — Wartanian; 10 — main patches of a loessy cover

Szkic lokalizacyjny opisywanych obszarów SE Polski i NW Ukrainy z położeniem reperowych profilów osadów plejstoceńskich oraz zasięgami zlodowaceń skandynawskich według L. Lindnera i J. Wojtanowicza (1997*a*), uzupełniony
1 — profile zawierające interglacjalne szczątki flory; 2 — pozostałe profile reperowe; zasięgi lądolodów w czasie zlodowaceń: 3 — narwi, 4 — nidy, 5 — sanu 1, 6 — sanu 2, 7 — liwca, 8 — odry, 9 — warty; 10 — główne płaty pokrywy lessowej

Studies of the key sections formed the foundations for a description of the Sandomierz Basin and the northern part of the Polish and Ukrainian Carpathians (among others: W. Laskowska-Wysoczańska, 1967, 1987; A. B. Bogutsky *et al.*, 1980; J. Wojtanowicz, 1985; J. Butrym *et al.*, 1987, 1988; M. Łanczont *et al.*, 1988; M. Łanczont, 1995; L. Dolecki *et al.*, 1996). Data on glacial sediments and neotectonics were also taken into account (among others: W. Laskowska-Wysoczańska, 1971, 1981; J. Buraczyński, 1986, J. Buraczyński *et al.*, 1991; M. S. Demediuk, Y. N. Demediuk, 1988, 1995), the same is true for extents and age of the Pleistocene water reservoirs (W. Laskowska-Wysoczańska, 1992).

PLEISTOCENE GLACIAL AND INTERGLACIAL UNITS

NAREVIAN GLACIATION (N)

This glaciation is represented by the oldest glacial sediments or their residuum, preserved in the northern foreland of the Małopolska and Lublin Uplands only (Fig. 1). To the north of the Małopolska Upland they are composed of the oldest till at the section Podgórze near Radom (L. Lindner, 1988*a*). Pieces of Scandinavian rocks in a fluvial series at the section Ceteń (Figs. 1 and 2) constitute presumably the equivalent of this till. They are overlain by sediments, correlated by Z. Borówko-Dłużakowa (*fide* L. Lindner, J. Wojtanowicz, 1997*a, b*) with decline of the Cromer Interglacial (Podlasian = Augustovian). Final deposition of fluvial sediments (alluvial fan?) of the Witów Series should be also referred to this glaciation (Fig. 2).

In the northern foreland of the Lublin Upland, this glaciation is indicated by two tills and the older fluvial sediments, thermoluminescence dated in the valley channel of the Giełczwa at 878 ka (M. Harasimiuk *et al.*, 1988). These fluvial sediments are underlain by the pre-Pleistocene series and are overlain by silts of the Podlasian Interglacial at the section Izbica (Fig. 2). The older till of the Narevian Glaciation is thermoluminescence dated at 822 ka at the section Horostyta (L. Dolecki, J. Wojtanowicz, 1992) whereas the younger till — at 771 ka at the section Żmiarki (L. Dolecki *et al.*, 1994) and at 784 ka at the section Serniki (J. Rzechowski, 1986).

No sediments of the Narevian Glaciation have been found in the Sandomierz Basin yet, the northern part of the Polish

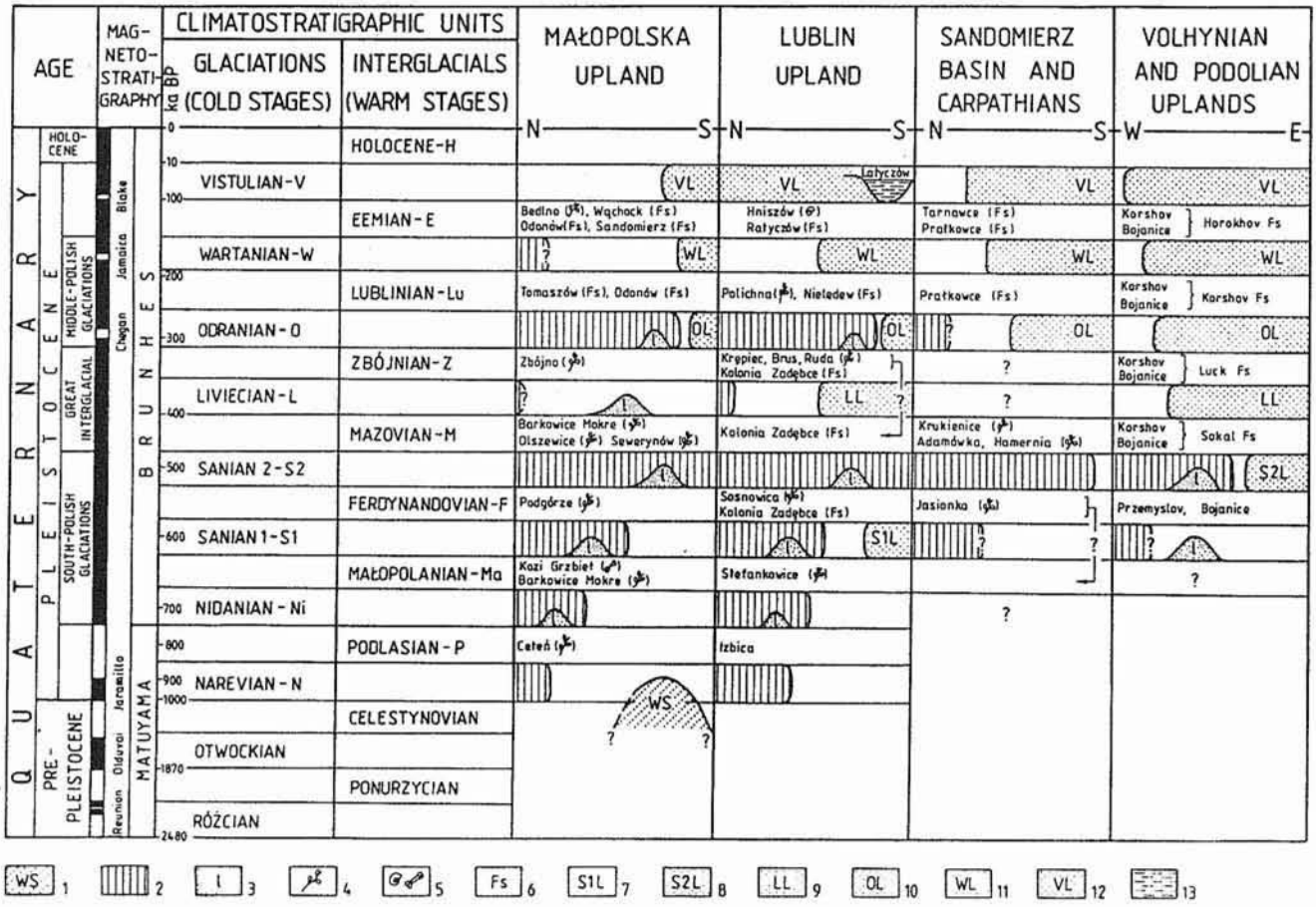

Fig. 2. Attempt of correlation of the main Pleistocene beds of glacial sediments and separating interglacial organic series as well as of loesses and separating interglacial palaeosols in the Małopolska and Lublin Uplands (after L. Lindner and J. Wojtanowicz, 1997*a*), and in the Sandomierz Basin, northern part of the Carpathians and the Volhynian and Podolian Uplands

1 — gravels and sands of the Witów Series; 2 — tills; 3 — subtill loesses; 4 — interglacial flora; 5 — interglacial fauna; 6 — interglacial palaeosols; supratill beds of subaerial loesses from the glaciations: 7 — Sanian 1, 8 — Sanian 2, 9 — Liviecian, 10 — Odranian, 11 — Wartanian, 12 —Vistulian; 13 — alluvial loesses

Próba korelacji plejstoceńskich poziomów osadów lodowcowych i oddzielających je interglacjalnych osadów organogenicznych oraz lessów i oddzielających je interglacjalnych gleb kopalnych na Wyżynie Małopolskiej i Lubelskiej (według L. Lindnera i J. Wojtanowicza, 1997*a*), w Kotlinie Sandomierskiej, północnej części Karpat oraz na Wyżynie Wołyńskiej i Podolskiej

1 — żwiry i piaski serii witowskiej; 2 — gliny zwałowe; 3 — lessy podglinowe; 4 — flora interglacjalna; 5 — fauna interglacjalna; 6 — interglacjalne gleby kopalne; nadglinowe poziomy lessów subaeralnych z okresów zlodowaceń: 7 — sanu 1, 8 — sanu 2, 9 — liwca, 10 — odry, 11 — warty, 12 — wisły; 13 — lessy aluwialne

and Ukrainian Carpathians, the Podolian and Volhynian Uplands, and their northern foreland.

PODLASIAN INTERGLACIAL (P)

Sediments of this interglacial are preserved in the northern foreland of the Małopolska Upland and in the Lublin Upland. In the first case, they are represented at the section Ceteń (Figs. 1 and 2) by a peaty gyttja, overlain by a silt (*cf.* L. Lindner, 1988*a*; L. Lindner, J. Wojtanowicz, 1997*a*). In the second case, this interglacial is indicated by a fluvial series at the section Izbica (Figs. 1 and 2), thermoluminescence dated at 767 and 731 ka (M. Harasimiuk *et al.*, 1988). No sediments of this interglacial have been found in any other part of the described area yet.

NIDANIAN GLACIATION (Ni)

Advance of ice-sheet of this glaciation in the Małopolska and Lublin Uplands was preceded by deposition of the oldest subtill loesses (Fig. 2). They were thermoluminescence dated at 638–612 ka in the eastern Lublin Upland (L. Dolecki, 1995). The younger till or its residuum (agglomerates of Scandinavian crystalline rocks) delimit a maximum extent of the ice-sheet (Fig. 1). They are present in speleothems at Kozi Grzbiet, with the conserved boundary Brunhes/Matuyama (J. Głazek *et al.*, 1977), thus determine age of this glaciation at about 700 ka (Fig. 2). Glaciofluvial sediments that underlie a till of this glaciation in the northern foreland of the Lublin Upland, were thermoluminescence dated at about 585 ka (L. Dolecki, J. Wojtanowicz, 1992). The till is presumably an equivalent of the older phase during the Serniki Stadial within

the South-Polish Glaciation when has not been subdivided previously (*cf.* J. E. Mojski, 1969). Sediments of this glaciation have not been found in any other part of the described area yet.

MAŁOPOLANIAN INTERGLACIAL (Ma)

This interglacial is represented firstly by a cave clay at the section Kozi Grzbiet in the Małopolska Upland (Figs. 1 and 2). It contains remains of fauna but also heavy minerals from destructed sediments of the Nidanian Glaciation. Rich assemblage of these faunistic remains contains numerous snails, amphibians, reptilia and mammals, indicating its Late Cromerian age (among others J. Głazek *et al.*, 1977). Similar conclusions can be drawn from dating of bones at the section by FCl/P method (700–550 ka) and from a positive polarity (Brunhes) in the bed. The oldest fluvial sediments with plant debris of the oldest interglacial (according to E. Rühle, 1952) were found at the section Barkowice Mokre (Fig. 2). Similar sediments with plant detritus occur at the section Stefankowice (Fig. 2) in the eastern Lublin Upland where they are underlain by gravels with Scandinavian material and the older pre-Pleistocene sediment, and are thermoluminescence dated at over 800 ka (L. Dolecki, 1992). They are presumably an equivalent of the fluvial sediments that represent an interphase within the Serniki Stadial (*cf.* J. E. Mojski, 1969). In the Vistula gap across the South-Polish Uplands, fluvial sediments of this interglacial are thermoluminescence dated at 697–667 ka (W. Pożaryski *et al.*, 1994, 1995). According to J. Głazek *et al.* (1976), organic sediments at the section Jasionka occur at a stratigraphical location of this interglacial (previously named the Kozi Grzbiet Interglacial), and under a bipartite till (Figs. 2 and 4) in the southern Sandomierz Basin (*cf.* W. Laskowska-Wysoczańska, 1967). This is also the very place of similar subtill sediments at the section Łowisko in the central Sandomierz Basin (A. Wójcik, oral information). No sediments of this interglacial have been found yet in any other part of the described area.

SANIAN 1 GLACIATION (S1)

A till of this glaciation is preserved in the Małopolska and Lublin Uplands (L. Lindner, J. Wojtanowicz, 1997*a*). It occurs also at the section Przemyslov as the lower of the two tills there (Figs. 1 and 3) and in the northern Sandomierz Basin, where it is thermoluminescence dated at about 595 ka (B. Kwapisz, J. Szajn, 1987).

In the eastern Lublin Upland this till is thermoluminescence dated at about 572 ka (L. Dolecki, 1995), and there are also loesses and loessy-like sediments of the same age (S1L at Fig. 2). The Sanian 1 Glaciation is presumably indicated by a lower of the two subtill loesses at the section Bojanice (Figs. 1 and 3). This loess is older than the overlying gravels and sands, thermoluminescence dated at 523 ka (Fig. 3).

At the section Sosnowica in the northern foreland of the Lublin Upland, a till of the Sanian 1 Glaciation underlies organic sediments of the Ferdynandovian Interglacial, and is thermoluminescence dated at about 574 ka (L. Dolecki *et al.*, 1994). This till probably corresponds to the younger phase of the Serniki Stadial, according to J. E. Mojski (1969). In the northern Polish Carpathians, this glaciation is indicated by extraglacial deposition of fluvial sands with gravel and gravels, preserved in the lowermost part of the section Niebylec and at the section Siedliska (Figs. 1 and 4), in which they are thermoluminescence dated at 611, 580 and 573 ka (M. Łanczont, 1995). In the central Sandomierz Basin, there was deposition of sands and silts in foreland of the ice-sheet, dated at the section Hucisko at 573 ka (Figs. 1 and 4).

FERDYNANDOVIAN INTERGLACIAL (F)

This interglacial is indicated at many sites of the described area. In the northern foreland of the Małopolska Upland, it is best represented by organic sediments at the sections Podgórze (I. Jurkiewiczowa *et al.*, 1973), Białobrzegi (Z. Janczyk-Kopikowa, 1991) and Stanisławice (Z. Janczyk-Kopikowa, M. Żarski, 1995). In the northern foreland of the Lublin Upland, there are organic sediments at the sections Ferdynandów (Z. Janczyk-Kopikowa, 1991; J. Rzechowski, 1996*a, b*) and Sosnowica, where they are thermoluminescence dated at 543–532 ka (L. Dolecki *et al.*, 1991). Fluvial sediments of the Luszawa Interstadial, according to J. E. Mojski (1969), seem to be of the same age. In the Vistula gorge between these two uplands, the Ferdynandovian Interglacial is also indicated by fluvial sediments, thermoluminescence dated at 517–489 ka (W. Pożaryski *et al.*, 1994, 1995). In the Sandomierz Basin, geological setting suggests that organic sediments at the previously cited section Jasionka (Fig. 2) correspond to this interglacial (*cf.* L. Lindner, 1988*c*; L. Lindner, L. Marks, 1994). At this time there was presumably also a deposition of the subtill silts at the section Giedlarowa, thermoluminescence dated at 539 ka (Fig. 4).

Palaeosols of this interglacial were found in the Małopolska (L. Lindner, 1988*a*) and Lublin Uplands, where they had been developed on a loessy substrate; they are thermoluminescence dated at about 517 ka at the section Stefankowice, and at about 547 ka at the section Kolonia Zadębce (L. Dolecki, 1995). This interglacial corresponds to the intertill sands at the section Przemyslov in the western Volhynian Upland (Figs. 1 and 3), and to the supratill silts at the section Novovolynsk (Fig. 3). A series of (fluvial?) sands with gravels, several metres thick, at the section Krukienice (Fig. 1) is to be referred to this interglacial. This series is mantled with till, thermoluminescence dated at 521 ka and overlain by organic sediments of the Likhvin = Mazovian Interglacial (Fig. 3). At the section Bojanice fluvial(?) sands of this interglacial, thermoluminescence dated at 523 ka, form a gravel-sandy interbedding that separates loesses of the Sanian 1 Glaciation(?) from the loesses of the Sanian 2 Glaciation (Fig. 3).

SANIAN 2 GLACIATION (S2)

During this glaciation, the Scandinavian ice-sheet was the most extensive in the whole described area, reaching the Carpathians and the Volhynian Upland (Fig. 1). In the south-

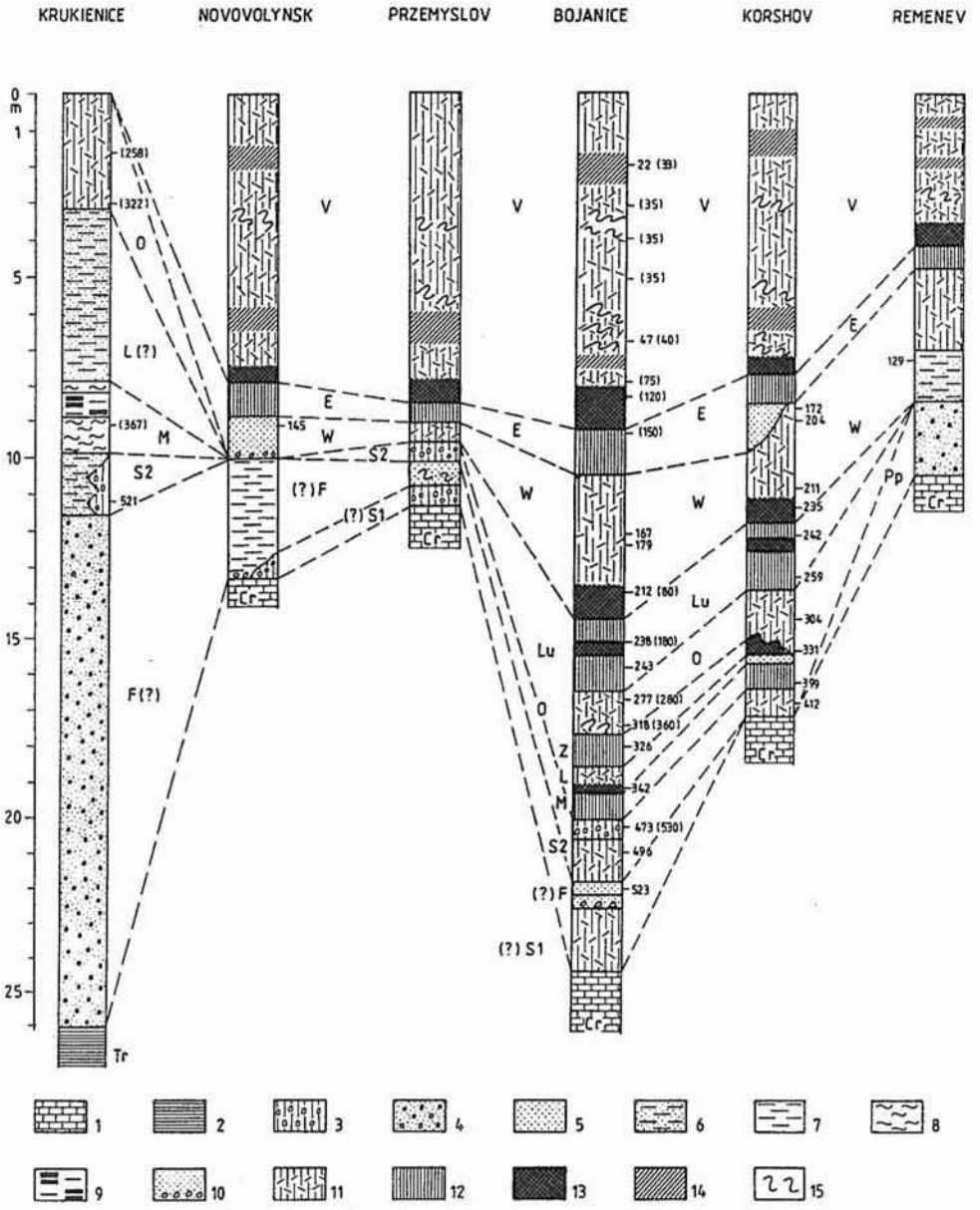

Fig. 3. Key sections of the Pleistocene deposits in the Volhynian and Podolian Uplands, and the northern foreland of the Ukrainian Carpathians: Krukienice and Novovolynsk (A. B. Bogutsky *et al.*, 1980), Przemyslov and Bojanice (A. B. Bogucki *et al.*, 1994), Korshov (A. B. Bogutsky *et al.*, 1980, supplemented) and Remenev (J. Wojtanowicz, unpublished data) in age interpretation of the authors; numbers at the sections indicate TL age in ka after J. Butrym (*fide* J. Butrym *et al.*, 1988; A. B. Bogucki *et al.*, 1995; V. N. Shelkoplyas *et al.*, 1985; J. Wojtanowicz, unpublished data), in brackets after V. N. Shelkoplyas (*fide* A. B. Bogutsky *et al.*, 1980; V. N. Shelkoplyas *et al.*, 1985; V. N. Shelkoplyas, T. F. Khristoforova, 1987)
1 — marls, 2 — clays, 3 — tills, 4 — sands with gravel, 5 — sands, 6 — sandy silts, 7 — silts, 8 — gyttjas, 9 — peats, 10 — sands and gravels with lag concentrate at the bottom, 11 — loesses and loessy-like deposits, 12 — illuvial horizons (B) of forest soils, 13 — chernozems, 14 — tundra soils, 15 — solifluction deformations, Cr — Cretaceous, Tr — Tertiary (Miocene), Pp — pre-Pleistocene, S1 — Sanian 1 Glaciation, F — Ferdynandovian Interglacial, S2 — Sanian 2 Glaciation, M — Mazovian Interglacial, L — Liviecian Glaciation, Z — Zbójnian Interglacial, O — Odranian Glaciation, Lu — Lublinian = Lubavian Interglacial, W — Wartanian Glaciation, E — Eemian Interglacial, V — Vistulian Glaciation

Profile reperowe osadów plejstoceńskich Wyżyny Wołyńskiej i Podolskiej oraz północnego przedpola Karpat Ukraińskich: Krukienice i Nowowołyńsk (A. B. Bogutsky i in., 1980), Przemysłów i Bojanice (A. B. Bogucki i in., 1994), Korszów (A. B. Bogutsky i in., 1980, uzupełniony) i Remenów (J. Wojtanowicz, materiały niepublikowane) w interpretacji wiekowej autorów; liczby przy profilach oznaczają wiek TL w tys. lat według J. Butryma (*fide* J. Butrym i in., 1988; A. B. Bogucki i in., 1995; V. N. Shelkoplyas i in., 1985; J. Wojtanowicz, dane niepublikowane), a w nawiasach według V. N. Shelkoplyasa (*fide* A. B. Bogutsky i in., 1980; V. N. Shelkoplyas i in., 1985; V. N. Shelkoplyas, T. F. Khristoforova, 1987)
1 — margle, 2 — iły, 3 — gliny zwałowe, 4 — piaski ze żwirem, 5 — piaski, 6 — mułki piaszczyste, 7 — mułki, 8 — gytie, 9 — torfy, 10 — piaski i żwiry z brukiem głazowy w spągu, 11 — lessy i utwory lessopodobne, 12 — poziomy iluwialne (B) gleb leśnych, 13 — czarnoziemy, 14 — gleby tundrowe, 15 — zaburzenia soliflukcyjne, Cr — kreda, Tr — trzeciorzęd (miocen), Pp — preplejstocen, S1 — zlodowacenie sanu 1, F — interglacjał ferdynandowski, S2 — zlodowacenie sanu 2, M — interglacjał mazowiecki, L — zlodowacenie liwca, Z — interglacjał zbójna, O — zlodowacenie odry, Lu — interglacjał lubelski = lubawski, W — zlodowacenie warty, E — interglacjał eemski, V — zlodowacenie wisły

ern foreland of the Małopolska Upland, a till of this ice-sheet is thermoluminescence dated at about 455 ka, whereas underlying silts — at about 467 and about 463 ka (L. Lindner, 1988*b*). In the western Sandomierz Basin, this till is thermoluminescence dated at about 518 and about 490 ka (J. Nitychoruk, 1991), and in the central part — at the section Giedlarowa — at about 508 ka (Fig. 4). This till is a bipartite one at the section Jasionka (Fig. 4). It does not seem, however, impossible that the lower bed represents the earlier glaciation(?). At the section Hamernia, gravel-sandy (glaciofluvial) sediments are to be referred to the Sanian 2 Glaciation. They are thermoluminescence dated at about 505 ka and overlain by lake sediments of the Mazovian Interglacial (Fig. 4).

A till of this glaciation is well preserved in the Vistula gorge across the South-Polish Uplands where it is thermoluminescence dated at 481–463 ka (W. Pożaryski *et al.*, 1994, 1995). In the Lublin Upland, the Sanian 2 Glaciation is represented by two tills, older one of which is thermoluminescence dated at about 520–500 ka, and the younger one at about 460–430 ka (J. Butrym *et al.*, 1988). In the Wieprz valley near Serniki, they probably correspond to the youngest pre-Mazovian till, correlated by J. E. Mojski (1969) to the Kock Stadial. In the eastern part of the upland, these tills are accompanied by loesses, thermoluminescence dated at 482 ka (L. Dolecki, 1995).

At the northern margin of the Carpathians, a till of this glaciation is thermoluminescence dated at the section Niebylec at 509 and 485 ka, whereas the overlying glaciofluvial sands and gravels — at 447 ka (Fig. 4). At the section Siedliska, located in the same area, this till is thermoluminescence dated at 500 and over 262 ka (Fig. 4). At the neighbouring section Optyń, the Sanian 2 Glaciation are probably represented by glaciofluvial sands with gravel and by a silt insert, thermoluminescence dated at 516–437 ka (Fig. 4). A deglaciation presumably resulted in deposition of sands and gravels with eratic material (the so-called mixed gravels) at the neighbouring Pikulice, as well as in deposition of the overlying loessy-like sands and silts, thermoluminescence dated at about 454 and 426 ka (H. Maruszczak *et al.*, 1992). In the northwestern Ukraine, a thermoluminescence age of a till of this glaciation was determined at 521 ka at the section Krukienice. At the section Bojanice these tills are thermoluminescence dated at 473 or 530 ka, whereas the underlying loesses of the same glaciation — at about 496 ka (Fig. 3). The oldest loesses at the section Korshov (S2L at Fig. 2) are their age equivalents, and are thermoluminescence dated at about 412 ka (Fig. 3).

MAZOVIAN INTERGLACIAL (M)

This interglacial is a warm unit in a stratigraphical scheme of the Pleistocene in the described area and possesses the best evidence. It is represented by numerous sections with organic sediments as well by more and more common sections with forest palaeosols.

The most representative sections of organic sediments of this interglacial in the Małopolska Upland include Sewerynów, Barkowice Mokre, Olszewice (Fig. 2) and Karsy, whereas in the Lublin Upland — the sections at Krępiec, Brus, Ruda (Fig. 2) and Serniki (L. Lindner, J. Wojtanowicz, 1997*b*). In the Sandomierz Basin (Figs. 1 and 4) they correspond to organic sediments at the section Adamówka (K. Bińka *et al.*, 1987; W. Laskowska-Wysoczańska, 1987) and Hamernia (A. Środoń, 1984; J. Butrym *et al.*, 1988). In northern foreland of the Ukrainian Carpathians (Figs. 1 and 3), this interglacial (Mazovian = Likhvin) is well represented by organic sediments at the section Krukienice (A. B. Bogutsky *et al.*, 1980; V. P. Grichuk, E. E. Gurtovaya, 1981). At the section Krępiec, sediments of this interglacial are thermoluminescence dated at less than 499 and more than 350 ka (L. Lindner, J. Wojtanowicz, 1997*b*). Thermoluminescence age of these sediments (younger than 505 ka) was determined at about 333 and 319 ka at the section Hamernia (Fig. 4), and at about 367 ka at the section Krukienice (Fig. 3).

In the described area there are also well preserved buried alluvial series of this interglacial, particularly in the Vistula gorge across the South-Polish Uplands where they are represented by the series M (W. Pożaryski *et al.*, 1994, 1995). Deposition of fluvial(?) sands and mixed gravels at Pikulice near Przemyśl can be presumably referred to the same interglacial. They are thermoluminescence dated at about 384 ka and underlain by older loessy-like sediments (*cf.* H. Maruszczak *et al.*, 1992). The mentioned palaeosols in the loessy sections of the Lublin (Kolonia Zadębce) and Volhynian (Bojanice, Korshov) Uplands have been formed during the same interglacial. In the Volhynian Upland (Fig. 2) these soils are determined as the Sokal ones (A. B. Bogutsky *et al.*, 1980; A. B. Bogucki *et al.*, 1994). At the section Bojanice, this soil has developed on a relic till, thermoluminescence dated at 473 ka (530 ka) and connected with the Sanian 2 Glaciation, and overlain by a loess, dated at 342 ka (Fig. 3). At the section Korshov this till has developed on a loess, dated at 412 ka, the upper part of which (already subjected to interglacial soil processes) is thermoluminescence dated at about 399 ka (Fig. 3).

LIVIECIAN GLACIATION (L)

A separate till that delimits ice-sheet extent during this glaciation is preserved in the northern foreland of the Małopolska and Lublin Uplands only (Fig. 1). In the vicinity of Dęblin, it is thermoluminescence dated at 393–35 (M. Żarski, 1994), and at 385 ka at the section Sosnowica (L. Dolecki *et al.*, 1991). Silts deposited at that time in the extraglacial area are dated at 388 ka at the section Zbójno (L. Lindner, J. Wojtanowicz, 1997*b*). In the northern foreland of the Ukrainian Carpathians, they probably correspond to the sandy silts that overlie organic sediments of the Likhvin = Mazovian Interglacial at the section Krukienice (Figs. 1 and 3).

Deposition of loesses occurred also in the extraglacial area (LL at Fig. 2). Two beds of loess are preserved in the Lublin Upland at the section Kolonia Zadębce (L. Dolecki, 1995). In the western Volhynian Upland there are also loesses of the same age at the section Bojanice (Figs. 1 and 3), thermoluminescence dated at 342 and 326 ka, and where they form a substrate of the younger interglacial soil (Luck Horizon).

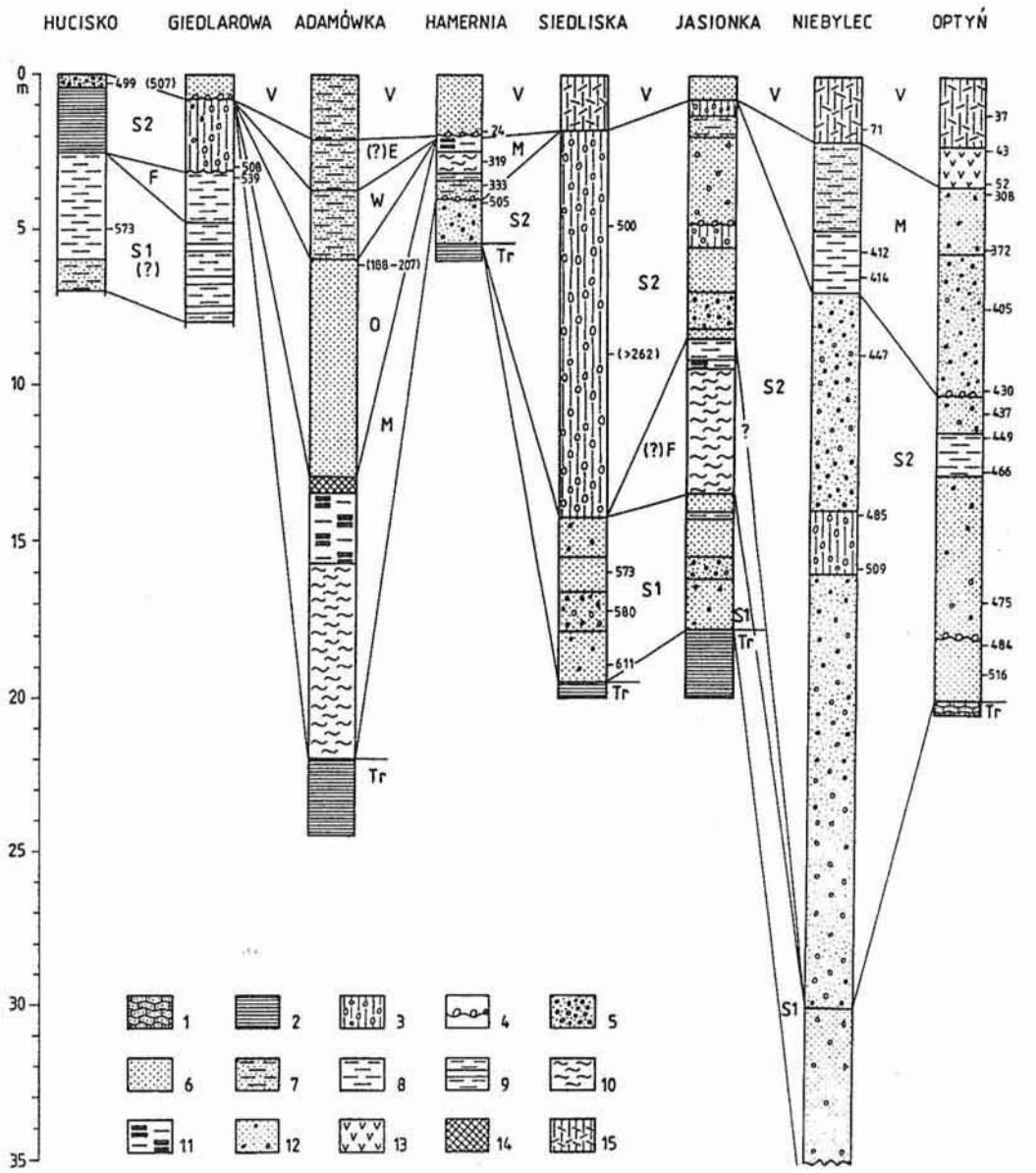

Fig. 4. Key sections of the Pleistocene sediments in the Sandomierz Basin and the northern part of the Polish Carpathians: Hucisko (J. Wojtanowicz, unpublished data), Giedlarowa (J. Wojtanowicz, 1985), Adamówka (W. Laskowska-Wysoczańska, 1987), Hamernia (A. Środoń, 1984; J. Butrym *et al.*,1988), Siedliska (M. Łanczont, 1995), Jasionka (W. Laskowska-Wysoczańska, 1967), Niebylec (J. Butrym, T. Gerlach, 1985) and Optyń (M. Łanczont *et al.*, 1988), in age interpretation of the authors; numbers at the sections indicate TL age in ka after J. Butrym (*fide* J. Butrym *et al.*, 1988; J. Butrym, T. Gerlach, 1985; M. Łanczont, 1995; M. Łanczont *et al.*, 1988; J. Wojtanowicz, 1985 and unpublished data), in brackets after M. Prószyński (*fide* W. Laskowska-Wysoczańska, 1987)

1 — shales and sandstones, 2 — clays, 3 — tills, 4 — lag concentrate, 5 — gravels and sands, 6 — sands, 7 — sands and silts, 8 — silts, 9 — silts with inserts of clay, 10 — gyttjas, 11 — peats, 12 — sands and gravels, 13 — slope deposits, 14 — palaeosols, 15 — loesses and loessy-like deposits, Tr — Tertiary (Miocene or Eocene), S1 — Sanian 1 Glaciation, F — Ferdynandovian Interglacial, S2 — Sanian 2 Glaciation, M — Mazovian Interglacial, W — Wartanian Glaciatiom, E — Eemian Interglacial, V — Vistulian Glaciation

Profile reperowe osadów plejstoceńskich Kotliny Sandomierskiej oraz północnej części polskich Karpat: Hucisko (J. Wojtanowicz, materiały niepublikowane), Giedlarowa (J. Wojtanowicz, 1985), Adamówka (W. Laskowska-Wysoczańska, 1987), Hamernia (A. Środoń, 1984; J. Butrym i in.,1988), Siedliska (M. Łanczont, 1995), Jasionka (W. Laskowska-Wysoczańska, 1967), Niebylec (J. Butrym, T. Gerlach, 1985) i Optyń (M. Łanczont i in., 1988) w interpretacji wiekowej autorów; liczby przy profilach oznaczają wiek TL w tys. lat według J. Butryma (*fide* J. Butrym i in., 1988; J. Butrym, T. Gerlach, 1985; M. Łanczont, 1995; M. Łanczont i in., 1988; J. Wojtanowicz, 1985 i dane niepublikowane), a w nawiasach według M. Prószyńskiego (*fide* W. Laskowska-Wysoczańska, 1987)

1 — łupki i piaskowce, 2 — iły, 3 — gliny zwałowe, 4 — bruk głazowy, 5 — żwiry i piaski, 6 — piaski, 7 — piaski i mułki, 8 — mułki, 9 — mułki z wkładkami iłu, 10 — gytie, 11 — torfy, 12 — piaski i żwiry, 13 — osady zboczowe, 14 — gleby kopalne, 15 — lessy i utwory lessopodobne, Tr — trzeciorzęd (miocen lub eocen), S1 — zlodowacenie sanu 1, F — interglacjał ferdynandowski, S2 — zlodowacenie sanu 2, M — interglacjał mazowiecki, W — zlodowacenie warty, E — interglacjał eemski, V — zlodowacenie wisły

Deposition of sands, separating the older interglacial soil (Sokal Horizon) from a younger interglacial soil (of the Luck Horizon), occurred at the section Korshov (Figs. 1 and 3).

ZBÓJNIAN INTERGLACIAL (Z)

In the described area (Fig. 1), this interglacial is firstly indicated by peats at the section Zbójno (L. Lindner, E. Brykczyńska, 1980). Fluvial sediments of this interglacial are thermoluminescence dated at 352 ka at the section Wąchock (L. Lindner, M. Prószyński, 1979), at 344 in the Dęblin region (M. Żarski, 1994) and at 331 ka at the section Sandomierz (W. Pożaryski *et al.*, 1994, 1995). A palaeosol of this interglacial or an interglacial soil complex are noted in loesses of the Lublin Upland at the sections Kolonia Zadębce and Nieledew (L. Dolecki, 1995; H. Maruszczak, 1996). At the loessy sections Bojanice and Korshov (Fig. 1) in the western Volhynian Upland, a palaeosol is named the Luck soil (Fig. 2). It has developed on a loess, thermoluminescence dated at 331 and 326 ka, and covered by a loess, dated by the same method at 318 ka (Fig. 3).

ODRANIAN GLACIATION (O)

Ice-sheet of this glaciation occupied a northern part of the described area (Fig. 1). It is indicated by the next, locally bipartite till, preserved under sediments of the Mazovian and Zbójnian Interglacials at northern and northwestern slopes of the Małopolska and Lublin Uplands, and in the northern foreland of the Volhynian Upland (L. Lindner *et al.*, 1991). This till is particularly well accessible in numerous exposures that cut morainic plateaux at the valley escarps of Pilica, Vistula and Bug Rivers. It is also noted in the northern part of the Sandomierz Basin (W. Laskowska-Wysoczańska, 1981; J. Buraczyński, 1986). At the section Sandomierz, this till and the underlying ice-dam clays are thermoluminescence dated at 295 and 309 ka, respectively (W. Pożaryski *et al.*, 1994, 1995).

Collected data suggest that this glaciation is indicated in the Middle Vistula drainage basin by deposition of the older lower loesses (OL at Fig. 2), preserved at many sections on this till or to the south of its extent (J. Jersak, 1973; H. Maruszczak, 1976, 1996). At the section Nieledew in the Lublin Upland, these loesses are bipartite and their thermoluminescence age is equal to about 300 and about 258 ka, respectively (L. Lindner, J. Wojtanowicz, 1997*b*). At the section Odonów in the Małopolska Upland, a bottom part of this loess is thermoluminescence dated at 264 ka and the upper part (subjected to the younger soil processes) — at 229 ka (L. Lindner, J. Wojtanowicz, 1997*b*). In the western part of the Volhynian Upland, loesses of this glaciation (OL at Fig. 2) are well preserved at the section Bojanice, as well as at the section Korshov (Figs. 1 and 3). At Bojanice, their lower part is thermoluminescence dated at 318 and 227 ka, and the upper part, subjected to younger soil processes, at 243 and 238 ka. At the section Korshov, a similar loess of this glaciation is dated at about 331 and 304 ka, as well as 259 and 242 ka, respectively.

In the northern foreland of the Ukrainian Carpathians, the loesses of this glaciation cap the section at Krukienice (Fig. 1) and are thermoluminescence dated at 322 and 258 ka (Fig. 3).

LUBLINIAN INTERGLACIAL (Lu)

In the Małopolska Upland, this interglacial is firstly indicated by a mid-loessy soil complex, preserved at the sections Tomaszów and Odonów (Fig. 1). This complex, developed on the lower older loess, is named a soil of the type Tomaszów (J. Jersak, 1973). In the Lublin Upland, it corresponds to a soil complex in loessy sections, composed of a forest soil and the overlying forest-steppe soil (H. Maruszczak, 1991). At the both mentioned uplands, this complex separates the older lower loess from the older upper one. This interglacial is indicated also by deposition of silts, sands and organic sediments as at the sections Polichna (J. Buraczyński *et al.*, 1982) and Sosnowica (L. Dolecki *et al.*, 1991). In the northern Polish Carpathians this interglacial is, according to M. Łanczont (1995), indicated by the lower palaeosol at the section Prałkowce (Fig. 2).

In the western part of the Volhynian Upland, this interglacial is expressed by a mid-loessy soil complex at the sections Bojanice and Korshov (Fig. 1). In both these sections this complex, named here the Korshov complex (Fig. 2), is composed of 2 palaeosols with superimposed chernozems (Fig. 3). Basing on the thermoluminescence data, age of this complex is equal to from about 242–238 to about 212–211 ka.

WARTANIAN GLACIATION (W)

The Scandinavian ice-sheet occupied during this glaciation a northwestern part of the described area only (Fig. 1). A till of this ice-sheet is preserved in a zone just close to the Middle Vistula valley and its thermoluminescence age is equal to 193–155 ka (M. Żarski, 1990). A remaining part of the described area occurred in an extraglacial zone of that time — in periglacial environment that favoured deposition of the older upper loesses (J. Jersak, 1973; H. Maruszczak, 1976, 1996). In most loessy sections (Odonów, Tomaszów, Nieledew, Kolonia Zadębce) of the Małopolska and Lublin Uplands, these loesses (WL at Fig. 2) separate a soil complex of the Lublinian = Lubavian Interglacial from a younger soil complex (type Nietulisko I) of the Eemian Interglacial and beginning of the younger glaciation. Thermoluminescence age of these loesses is equal to 208–147 ka.

In the western Volhynian and Podolian Uplands, this glaciation corresponds to deposition of a thick loessy cover as well as of valley sands and gravels that fill many of buried fossil incisions. Fragments of a loessy cover of this time (WL at Fig. 2) are very well preserved at the four main key sections in this area (Przemyslov, Bojanice, Korshov, Remenev), and the mentioned valley sediments are known from two sections (Novovolynsk, Korshov). At the section Przemyslov (Fig. 1), the loesses of this glaciation are underlain by a till of the Sanian 2 Glaciation and form a substrate of the younger (Eemian–Vistulian) palaeosol (Fig. 3). They are underlain by

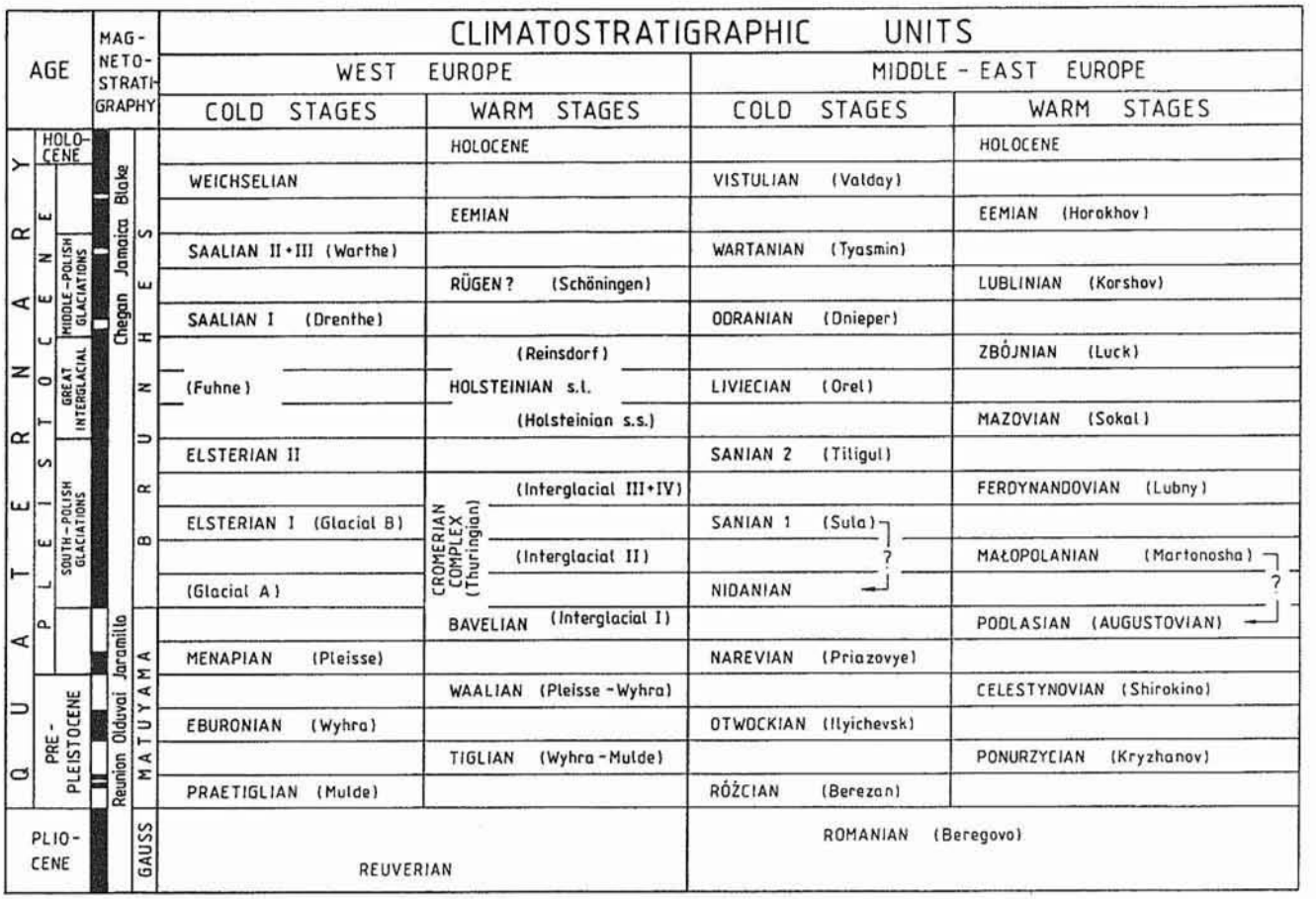

Fig. 5. Main chronostratigraphic units of the Quaternary in Western Europe (after L. Eissmann, 1994; B. Urban, 1995; F. Wiegank, 1982; W. H. Zagwijn, 1989) and mid-eastern Europe (after A. B. Bogucki *et al.*, 1994; L. Lindner, 1991*b*; L. Lindner, J. Wojtanowicz, 1997*a*; H. Maruszczak, 1996; J. Nawrocki *et al.*, 1996; M. F. Veklich, 1979), and attempt of their correlation

Główne jednostki chronostratygraficzne czwartorzędu Europy zachodniej (według L. Eissmanna, 1994; B. Urban, 1995; F. Wieganka, 1982; W. H. Zagwijna, 1989) i Europy środkowo-wschodniej (według A. B. Boguckiego i in., 1994; L. Lindnera, 1991*b*; L. Lindnera, J. Wojtanowicza, 1997*a*; H. Maruszczaka, 1996; J. Nawrockiego i in., 1996; M. F. Veklicha, 1979) oraz próba ich korelacji wiekowej

sandy silts, thermoluminescence dated at about 129 ka at the section Remenev (Fig. 1), and also form a substrate of the younger, mid-loessy soil complex (Fig. 3). These loesses mantle the older, interglacial soil complex (of the type Korshov = Tomaszów) at the sections Bojanice and Korshov (Fig. 1), and form also a substrate of a younger interglacial soil complex (Fig. 3). Thermoluminescence age of these loesses was determined at 212–150 ka.

EEMIAN INTERGLACIAL (E)

In the described area (Fig. 1), this interglacial is indicated by deposition of organic sediments (among others at Bedlno, Sławno, Karczunek), and by fluvial and weathering-soil processes (L. Lindner, J. Wojtanowicz, 1997*a, b*). The best examples for the latter are the mid-loessy soil complexes of the type Nietulisko I (J. Jersak, 1973). They do not indicate the Eemian forest soils only but also the Early Vistulian chernozems at most loessy sections (Fig. 2) of the Małopolska and Lublin Uplands (among others Odonów, Sandomierz, Tomaszów, Nieledew, Tyszowce, Wożuczyn, Hniszów, Ratyczów, Żółkiewka), and at the northern margin of the Polish Carpathians (among others Pikulice–Nehrybka, Tarnawce, Orzechowce, Prałkowce). Thermoluminescence data at the sections Odonów and Sandomierz (Fig. 1) suggest that this interglacial was younger than 149–142 ka and older than 118–98 ka (L. Lindner, J. Wojtanowicz, 1997*a, b*).

In the western Volhynian and Podolian Uplands, this interglacial is very well indicated by a lower part of the soil complex of the type Horokhov, a part of which represents an illuvial horizon (B) of a forest soil (A. B. Bogutsky, T. D. Morozova, 1981). This soil complex (Fig. 2) is preserved at the top of the older upper loesses at the sections Przemyslov, Bojanice, Korshov and Remenev (Figs. 1 and 3) and of sandy sediments at the section Korshov (Figs. 1 and 3). Thermoluminescence data from loesses that form a substrate of this soil complex at the section Bojanice and from the overlying

younger loesses, enable to determine the age of the recorded soil-forming processes during the Eemian, between 150 and 120 ka.

VISTULIAN GLACIATION (V)

During this glaciation the whole described area (Fig. 1) occurred in an extraglacial zone — in a periglacial environment that favoured loessy, slope and valley deposition, interrupted by short (interstadial) weathering-soil processes (*cf.* J. E. Mojski, 1965). Loesses of this glaciation (VL at Fig. 2), named the younger loesses (J. Jersak, 1973; H. Maruszczak, 1991), occupy a vast area (Fig. 1). Their thermoluminescence datings at many sections (among others Wąchock, Sandomierz, Nieledew, Tyszowce, Wożuczyn) suggest that loessy deposition lasted from about 120–118 ka to about 15 ka and was interrupted during 3–4 interstadial warmings. Development of slope processes and fluvial activity of that time favoured alluvial deposition in the valleys, development of supra-inundation terraces of most rivers and interfingering with deluvial deposits, named by W. Pożaryski (1953) the sands of high deposition. Periglacial conditions of this time favoured development of frost weathering and of various frost structures, preserved mainly at the loessy sections (A. Jahn, 1951), and corresponding to the main development phase of blocky fields in the Holy Cross Mts. (T. Klatka, 1962).

In the western part of the Volhynian and Podolian Uplands, this glaciation is also expressed by deposition of several loesses, well preserved at key sections of this area (Fig. 1). At most of them (Novovolynsk, Przemyslov, Bojanice, Korshov, Remenev), these loesses (VL at Fig. 2) and the separating initial tundra (interstadial?) soils have been deformed by solifluction (congelifluction) and pseudomorphs of frost wedges, thus indicating a presence of permafrost in that time. Thermoluminescence datings of these loesses at the section Bojanice suggest their deposition from about 120 ka to about 22 ka.

ATTEMPT OF CORRELATION

Presented geologic, biostratigraphic, palaeopedologic and thermoluminescence data for glacial and loessy deposits in southeastern Poland and northwestern Ukraine, enabled correlation of the main stratigraphical units of the Pleistocene in this area (Fig. 2). In this part of the paper, an attempt is undertaken to correlate them to similar units of the Quaternary of Western Europe and of a wider area in mid-eastern Europe (Fig. 5).

According to the Dutch scientists (among others W. H. Zagwijn, 1989), the earliest part of the Quaternary in Western Europe is composed of two cold stages: Praetiglian and Eburonian, represented by the Harderwijk Formation with the Fennoscandian material (*cf.* J. de Jong, G. C. Maarleveld, 1983), and two warm stages: Tiglian and Waalian (Fig. 5). In Germany (*cf.* L. Eissmann, 1994), the equivalents are the other two cold stages: Mulde and Wyhra, and two warm stages: Wyhra–Mulde and Pleisse–Wyhra (Fig. 5). In mid-eastern Europe and particularly in Poland, this part of the Quaternary is named the pre-Pleistocene or the proto-Pleistocene, and considered for a preglacial part of the Quaternary (*cf.* S. Z. Różycki, 1980). In Poland (*cf.* M. D. Baraniecka, 1991), it is also subdivided into two cold stages: Różcian and Otwockian, and two warm stages: Ponurzycian and Celestynovian (Fig. 5). In the Ukraine (*cf.* M. F. Veklich, 1979) they should correspond to two coolings: Berezan and Ilyichevsk, and two warmings: Kryzhanov and Shirokino (Fig. 5).

The Pleistocene itself, comprisin glacial after S. Z. Różycki (1980) a glacial part of the Quaternary, starts with the first advance of the Scandinavian ice-sheet in the area of mid-eastern Europe (*cf.* L. Lindner, L. Marks, 1994). This advance, in Poland (*cf.* S. Z. Różycki, 1961; L. Lindner, 1988*c*) as well as in Belarus (*cf.* L. N. Voznyachuk, 1985; Y. K. Yelovicheva, 1997), is named the Narevian Glaciation (Fig. 5). In the Ukraine, it can correspond to the cooling Priazovye (*cf.* M. F. Veklich, 1979). In western Europe, this glaciation corresponds to the cooling Menapian (*cf.* W. H. Zagwijn, 1989), with distinct supply with Fennoscandian material (Enschede Formation) in the Netherlands (*cf.* J. de Jong, G. C. Maarleveld, 1983; J. Mangerud *et al.*, 1996), and the cooling Pleisse (Fig. 5), with favourable conditions for deposition of the Mahlis Loess IV (*cf.* L. Eissmann, 1994). According to H. Maruszczak (1996), deposition of this loess should be rather connected with a younger cooling, correlated to ^{18}O stage 18.

The younger stratigraphic unit is represented by a warming, corresponding in Poland to the multi-optimal Podlasian Interglacial, a part of which has received a very good palynological evidence lately (Augustovian Interglacial) at the section Szczebra near Augustów (*cf.* Z. Janczyk-Kopikowa, 1996). In Belarus, this stratigraphical position seems to be occupied by the Minsk = Korchevo Interglacial (*cf.* L. N. Voznyachuk, 1985; Y. K. Yelovicheva, 1997), and in the Ukraine (*cf.* M. F. Veklich, 1979) — by the warming Martonosha(?). In the Netherlands, this warming should be represented by the Bavelian Interglacial, together with the younger Interglacial I within the Cromerian Complex (*cf.* W. H. Zagwijn, 1989). In Germany, this stratigraphic position is occupied by the earliest warming within the Thuringian Complex — favourable for development of the Lower Mahlis Palaeosol (*cf.* L. Eissmann, 1994).

In Poland, the next stratigraphical units of the Pleistocene (Fig. 5) are the three South-Polish Glaciations: Nidanian, Sanian 1, Sanian 2 and the separating two interglacials: Małopolanian and Ferdynandovian (*cf.* L. Lindner, 1991*a, b*; L. Lindner, L. Marks 1994; L. Lindner, J. Wojtanowicz 1996, 1997*a, b*). In the Ukraine, this part of the Pleistocene (*cf.* M. F. Veklich, 1979) is subdivided into two coolings: Sula and Tiligul, with the separating Lubny Warming (Fig. 5), and in Belarus — three glaciations with two separating interglacials (*cf.* L. N. Voznyachuk, 1985; Y. K. Yelovicheva, 1997). In the Netherlands, this part of the Pleistocene is occupied by the Glacial A and the Glacial B (Elsterian I) within the Cromerian Complex, and the following Elsterian II Glaciation (*cf.* W. H. Zagwijn, 1989). In Germany, the two older coolings are

indicated by deposition of the Mahlis Loess III and II, the cooling 3 — by deposition of the Mahlis Loess I and two tills of the Elsterian II Glaciation (Fig. 5). According to H. Maruszczak (1996), the Mahlis Loess III should be correlated to the Sula Horizon in the Ukraine, the Mahlis Loess II — to the younger Sanian 1 Glaciation and the Mahlis Loess I — to the Sanian 2 Glaciation.

The following younger stratigraphical units of the Pleistocene are represented in Poland by the interglacials: Mazovian and Zbójnian, separated by the Liviecian Glaciation (*cf.* L. Lindner, 1991*a*). In Belarus, they correspond to the interglacials: Alexandriysky and Grodnensky = Smolensky(?), with a separating pre-Dnieper Cooling (*cf.* L. N. Voznyachuk, 1985; Y. K. Yelovicheva, 1997). In the Ukraine, these interglacials should be correlated to development of the soils Sokal and Luck (*cf.* A. B. Bogutsky *et al.*, 1980), whereas deposition of the loess Orel — to a separating cooling (*cf.* M. F. Veklich, 1979). In Western Europe, the older of these interglacials is described in Germany as the Holsteinian *s.s.*, whereas the younger — as the Reinsdorf Interglacial, and a separating cooling is the Fuhne cold phase (*cf.* B. Urban, 1995). In France, Praclaux and Landos are the equivalents of these interglacials (*cf.* J. L. de Beaulieu, M. Reille, 1995).

Still younger stratigraphical units of the Pleistocene are indicated in mid-eastern as well as in Western Europe by two separate advances of the Scandinavian ice-sheet. In Poland they are represented by two Middle-Polish Glaciations: Odranian and Wartanian, and by the separating Lubavian = Lublinian Interglacial (Fig. 5). In Belarus, they correspond to the Dnieper and Sozh Glaciations, and to the separating Shklov Interglacial (*cf.* Y. K. Yelovicheva, 1997), and in the Ukraine — to the Dnieper Glaciation and the younger one, indicated by deposition of the loess Tyasmin and the separating interglacial, favourable for development of a mid-loessy Korshov soil (Fig. 5). In Western Europe, a position between the older (Saale I = Drenthe) and the younger glaciation (Saalian II + III = Warthe) is occupied among others by sediments of the Rügen Interglacial (*cf.* A. G. Cepek, 1986), and probably, also by sediments of the Schöningen Interglacial (*cf.* B. Urban, 1995).

The youngest main stratigraphical units of the Pleistocene in mid-eastern and Western Europe are the Eemian Interglacial, well represented among others by the soil Horokhov, and the following Vistulian (Weichselian, Valday) Glaciation. These units are so univocally identified that their correlation is undoubtful in the described area.

FINAL REMARKS

Presented materials prove that the Quaternary sequence in southeastern Poland and the northwestern Ukraine forms a basis to distinguish the main 15 climatostratigraphical units of the Pleistocene (the glacial Quaternary) in this area. Terminology used in Polish publications (among others L. Lindner, 1988*c*; L. Lindner, L. Marks, 1994; L. Lindner, J. Wojtanowicz, 1996, 1997*a, b*; M. D. Baraniecka, 1990; B. Słowańska, A. Makowska, 1991; W. Pożaryski *et al.*, 1994, 1995; H. Maruszczak, 1996) was applied. Eight of these units are described as separate glaciations (Narevian, Nidanian, Sanian 1, Sanian 2 = Wilgian, Liviecian, Odranian, Wartanian and Vistulian), and seven — as separate interglacials (Podlasian = Augustovian, Małopolanian, Ferdynandovian, Mazovian, Zbójnian, Lublinian, Eemian).

Analysis of many dozen of key sections and data from geological mapping and palaeogeographical analysis, also the present opinion of the authors on maximum extents of the Scandinavian ice-sheets during the Pleistocene seven glaciations are presented for the described area.

Significant role of loess stratigraphy in making a stratigraphical scheme of the glacial Quaternary more accurate is indicated, especially to determine rhythmus of the Quaternary climatic changes, and particularly a role played by loessy sections with several horizons or complexes of palaeosols.

Attempt of correlation of the main climatostratigraphical units of the Quaternary in Western and mid-eastern Europe is presented. It proves exceptional significance of the area to the south of the Baltic Sea as the part of Europe with traces of most continental glaciations and their possible correlation with the Late and Middle Pleistocene loessy-creating cycles.

Translated by Leszek Marks

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GŁÓWNE JEDNOSTKI STRATYGRAFICZNE PLEJSTOCENU SE POLSKI I NW UKRAINY ORAZ ICH KORELACJA NA OBSZARZE ZACHODNIEJ I ŚRODKOWO-WSCHODNIEJ EUROPY

Streszczenie

Na podstawie analizy 42 reperowych profilów osadów lodowcowych, jeziornych, rzecznych, jaskiniowych i lessowych, z zachowanymi w nich glebami kopalnymi (fig.1), dokonano charakterystyki i korelacji 15 głównych jednostek podziału stratygraficznego plejstocenu SE Polski i NW Ukrainy. Osiem jednostek reprezentuje odrębne zlodowacenia (narwi, nidy, sanu 1, sanu 2 = wilgi, liwca, odry, warty i wisły), siedem — odrębne interglacjały (podlaski = augustowski, małopolski, ferdynandowski, mazowiecki, zbójnowski, lubawski = lubelski i eemski). Poza ostatnim zlodowaceniem lądolody skandynawskie wkroczyły na opisywany obszar pozostawiając osady i formy rzeźby wyznaczające ich maksymalne zasięgi (fig.1).

Prezentowane opracowanie ściśle nawiązuje zarówno do wcześniejszej korelacji osadów lodowcowych i lessów oraz osadów jeziornych i gleb kopalnych na obszarze wyżyn południowopolskich (por. L. Lindner, J. Wojtanowicz, 1997*b*), jak też do prac dotyczących korelacji stratygraficznej lessów polskich i ukraińskich (por. A. B. Bogucki i in., 1995; H. Maruszczak, 1996; J. Nawrocki i in., 1996). Dzięki tym pracom i uzyskanym materiałom przedstawiono nową próbę korelacji wiekowej osadów czwartorzędowych zachowanych w profilach stratygraficznych w Kotlinie Sandomierskiej, na północnym przedpolu Karpat oraz Wyżynie Wołyńskiej i Podolskiej (fig. 3 i 4). Z uzyskanych tą drogą danych widać jak ważną rolę należy przypisać stratygrafii lessowo-glebowej przy uściślaniu schematu stratygraficznego czwartorzędu (fig. 2).

Całość zebranych materiałów pozwoliła na podjęcie próby korelacji głównych jednostek podziału stratygraficznego czwartorzędu zachodniej i środkowo-wschodniej Europy (fig. 5). Korelacja ta dowodzi wyjątkowego znaczenia SE Polski i NW Ukrainy jako obszaru, gdzie zachowały się ślady pobytu lądolodów skandynawskich w czasie 7 kolejnych zlodowaceń (od narwi do warty) oraz gdzie istnieje najlepsza możliwość korelacji tych zlodowaceń z lessami akumulowanymi zarówno w strefach brzeżnych zlodowaceń, jak też w warunkach ekstraglacjalnych.