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Stratigraphy of main Pleistocene loess horizons and paleosols in mid-eastern Europe

ABSTRACT: Outline of stratigraphy of 11 main Pleistocene (950-10 ka BP) loess horizons and separating paleosols in mid-eastern Europe is presented. Basing on geologic setting, paleomagnetic data and thermoluminescence datings, eight of these horizons (*L, J, H, F, E, D, C* and *B*; *according to* KUKLA 1978) are to be correlated with 8 main Scandinavian glaciations (Narew, Nida, San *1*, San *2*, Liwiec, Odra, Warta, and Wisła; *according to* LINDNER 1988a-d), whereas three other horizons (*K, I,* and *G*) — with climatic coolings (glaciations?) within the three older interglacials (Podlasian, Malopolanian and Ferdynandów). Paleosol complexes between main loess horizons correspond to the interglacials. A correlation of Pleistocene loess horizons and separating paleosols in mid-eastern Europe with similar sediments in western Europe and Asia is also presented.

INTRODUCTION

Stratigraphy of the main Pleistocene loess horizons in mid-eastern Europe and particularly their correlation with the interglacials being the main subdivision units of the Pleistocene (*see* LINDNER 1988d) are significant research items in the Quaternary studies. This problem has been already many a time the subject of the numerous works, basing usually on analyzed loess sections in extraglacial areas (see *i.a.* VEKLICH 1968, 1979; VEKLICH & SIRENKO 1976; VELICHKO & FAUSTOVA 1986; KUKLA 1975, 1978; PÉCSI 1979, 1986; BRUNNACKER 1986; BRUNNACKER & *al.* 1982; MINKOV & *al.* 1986).

The author presents this subject on the basis of extent of the Pleistocene loessy horizons within the area occupied by Scandinavian icesheets in Poland (Text-fig. 1). Taking into account (*cf.* BOWEN 1978; LINDNER 1984, 1988d) a subdivision of the Pleistocene into the Early (950-729 ka BP), the Middle (729-128 ka BP), and the Upper (128-10 ka BP), no loesses of the Early Pleistocene have been found yet (*cf.* LINDNER 1984, 1988c; MOJSKI 1985). Loesses of the Middle Pleistocene age (5-6 main horizons) are overlain by tills of six Scandinavian glaciations (Nida = Helme, San *1* = Elster *1*, San *2* = Elster *2*, Liwiec = Fuhne, Odra = Drenthe = Saale *1* + *2*, Warta = Warthe = Saale *3*). They occur mainly in the Małopolska Upland (LINDNER 1977, 1980, 1984, 1988c), in drainage basins of the Lower Pilica (KARASZEWSKI 1952), Lower Wieprz and

Fig. 1
Loessy cover in mid-eastern Europe against extents of main Scandinavian glaciations (*after* LINDNER 1988d)

1 — Narew Glaciation, **2** — Nida Glaciation, **3** — San *1* Glaciation, **4** — San *2* Glaciation, **5** — Liwiec Glaciation, **6** — Odra Glaciation, **7** — Warta Glaciation, **8** — Wisła Glaciation, **9** — upper younger loess

ML — Mazury Lakeland, MU — Małopolska Upland, LU — Lublin Upland, GP — Głubczyce Plateau

Lower Vistula, and also in the Mazury Lakeland (MAKOWSKA & *al.* 1976). Loesses of the Upper Pleistocene (single horizon) in the Lower Vistula drainage basin contain tills of the last glaciation (MAKOWSKA 1973, MAKOWSKA & *al.* 1976, DROZDOWSKI 1979).

Stratigraphic settings of the loess horizons are to be defined by correlation with Pleistocene Scandinavian glaciations and separating interglacials in Europe (*cf.* LINDNER 1988d), supplied with genetic features and age of intraloessic paleosols in Poland (*cf.* KONECKA-BETLEY & STRASZEWSKA 1977; JERSAK 1973, 1988; MARUSZCZAK 1985, 1987). Numerous TL datings of glacigenic and interglacial series as well as of loessy horizons are also useful (*cf.* BUTRYM & MARUSZCZAK 1984, LINDNER & PRÓSZYŃSKI 1979, BUTRYM 1985, PRÓSZYŃSKA-BORDAS, 1985, BLUSZCZ 1985).

LOESSES OF THE EARLY PLEISTOCENE (950-729 ka BP)

No loesses of the early Pleistocene age have been found in the area of Scandinavian glaciations. On the other hand they occur further to the south, namely in Austria and Hungary (*see* Text-figs 1-2).

NAREW (MENAP, HELME; ^{18}O stage *24*) GLACIATION

The older Early Pleistocene loess was deposited in Austria and Hungary during this glaciation, correlated with the ^{18}O stage *24*, when for the first time most of the Central European Lowland has been occupied by a Scandinavian icesheet (LINDNER 1988d). In Austria this period is represented by the loess horizon *L* in top of the Krems Soil complex (*cf.* FINK & KUKLA 1977, KUKLA 1978). In Hungary such loess indicates negative magnetic polarization within the upper Matuyama (PÉCSI 1979) and occurs beneath Paks-Dunakömolöd brownish-red soil (*PDK* in Text-fig. 2), dated at about 850 ka (PÉCSI 1986)

Its equivalent in Tajikistan is probably represented (*cf.* DODONOV 1986) by a loess beneath the soil complex *PK X*. In China it should be found within the Wucheng Loess (*cf.* ZHENG HONG-HAN 1985).

PODLASIAN (CROMERIAN *I* in the Netherlands; ^{18}O stages *21-23*) INTERGLACIAL

During climatic warmings of the earlier (^{18}O stage *21*) and later (^{18}O stage *23*) phases of this interglacial, organic sediments have been deposited in the European Lowland (*cf.* ZAGWIJN 1986, LINDNER 1988d). Further to the south, soils have developed on the loess of older Early Pleistocene age. They are represented by the brownish-red soil complex Paks-Dunakömolöd in Hungary (*cf.* PÉCSI 1986) and should correspond to two paleosols (*XI* and *X*) in Austria, separated with loess *K* of negative magnetic polarization within the Upper Matuyama and correlated with the cooling of the ^{18}O stage *22* (KUKLA 1978). The loess *K* has similar setting in loessy sections of Czechoslovakia (*see* Text-fig. 2) where it forms the oldest loess horizon (KUKLA 1975, 1978) but refers to the younger Early Pleistocene loess.

This loess corresponds probably to the deposition of the loessy material within the soil complex *PK X* in Tajikistan (DODONOV 1986). In China it was incorporated into the older part of the soil complex *Fs 10-14* that forms substrate of the Lishi Loess (*cf.* ZHENG HONG-HAN 1985).

LOESSES OF THE MIDDLE PLEISTOCENE (729-128 ka BP)

Loesses of the Middle Pleistocene age occur usually within the extent of the Scandinavian glaciations but also in the extraglacial area of mid-eastern Europe. In both cases they form 5-6 separate loessy horizons. During each glaciation their deposition commonly slightly preceded a maximum extent of the Scandinavian icesheet in Poland (LINDNER 1984, 1988c).

NIDA (GLACIAL *A* in the Netherlands, HELME; ^{18}O stage *20*) GLACIATION

During this glaciation, correlated with the ^{18}O stage *20*, a Scandinavian icesheet occupied most of the mid-eastern European Lowland (LINDNER 1988d). In Poland it reached northern slopes of Małopolska and Lublin uplands (*see* Text-fig. 2). It is mostly preserved on slopes of buried fluvial valleys that cut the Holy Cross Mts and is known from numerous boreholes (*cf.* CZARNOCKI 1931; ŁYCZEWSKA 1971; LINDNER 1977, 1980). The "Brecciatic" clays in the site Kozi Grzbiet with preserved Brunhes/Matuyama boundary (*cf.* GŁAZEK & *al.* 1977, LINDNER 1982) are among age equivalents of this loess. The loess connected with the Nida (or San *1*) Glaciation was also noted in the boreholes of the Ferdynandów area to the north of the Lublin Upland (*cf.* MAKOWSKA & *al.* 1976).

Outside the extent of the last glaciation, the loess of this age has been found in Austria, Czechoslovakia, Hungary and the Ukraine. In Austria and Czechoslovakia it is represented by the loessy horizon *J* with preserved Brunhes/Matuyama boundary (*cf.* KUKLA 1978). It should correspond to the loess in substrate of the paleosol PD_2 in Hungary and to the Nadazov loess *pr* in the Ukraine. Fluvial sands in substrate of the paleosol *Fs* in Bulgaria and gravels of the complex *Bb* in the Lower Rhine drainage basin of the west Germany (*cf.* BRUNNACKER & *al.* 1982) were deposited in the same time.

A complex of the Middle Pleistocene loesses in Tajikistan (*cf.* DODONOV 1986) starts with a loess over the paleosol *PG X*, and in China with the loess that forms inserts within the middle part of the soil complex *Fs 10-14* (*cf.* ZHENG HONG-HAN 1985).

MALOPOLANIAN (CROMERIAN *II* in the Netherlands; [18]O stages *17-19*) INTERGLACIAL

During climatic warmings of the earlier ([18]O stage *19*) and the later ([18]O stage *17*) part of this interglacial when organic sediments have been formed in the European Lowland (*cf.* VOZNYACHUK 1985, ZAGWIJN 1986, LINDNER 1988d), the

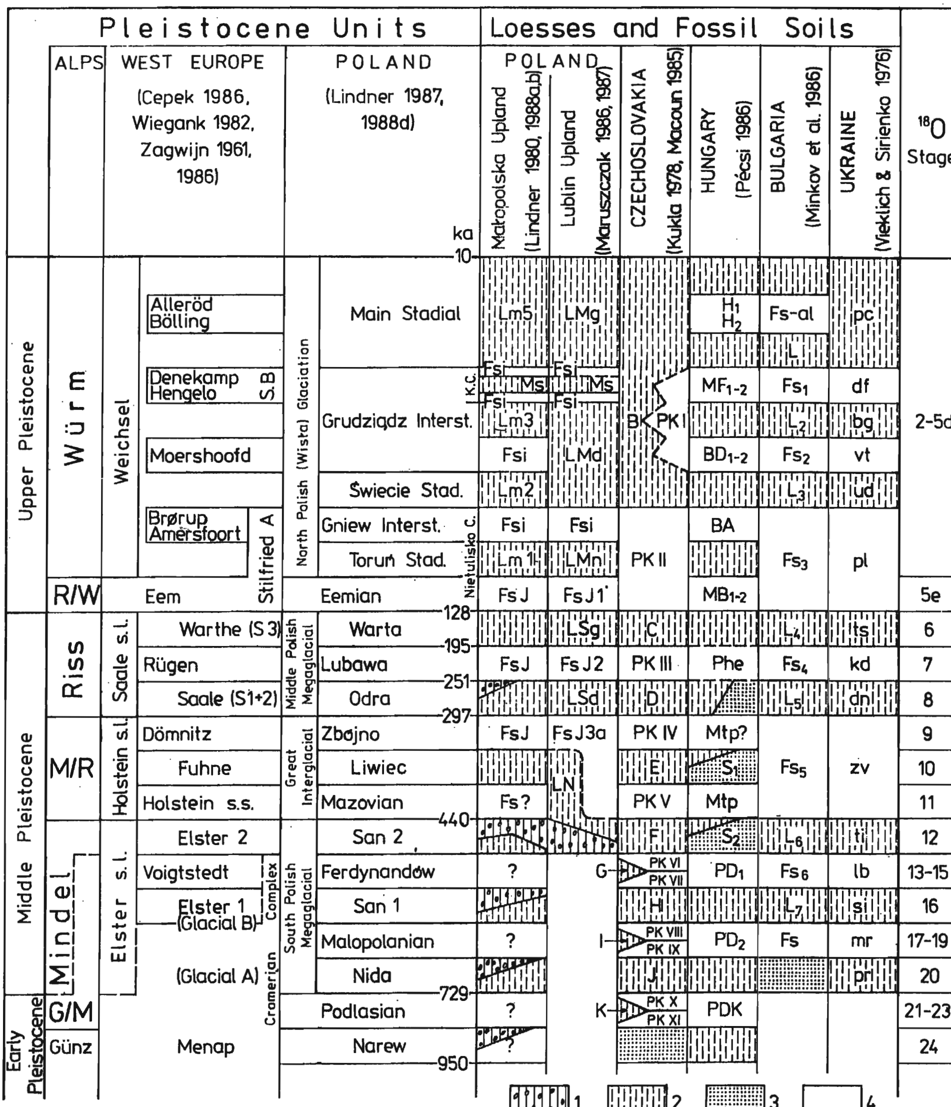

Fig. 2

Stratigraphy of loesses and paleosols of mid-eastern Europe (letter symbols as used in the text)

1 — tills, 2 — loesses, 3 — sands, 4 — paleosols

oldest Middle Pleistocene intra-loessic paleosols developed to the south of the Sudetes and the Western Carpathians. They formed soil complexes *IX* and *VIII* in loessy sections of Austria and Czechoslovakia (*cf.* FINK & KUKLA 1977, KUKLA 1978). Deposition of the loessy complex *I* that separates these soil complexes, should be connected (*cf.* KUKLA 1978) with the intrainterglacial cooling of the ^{18}O stage *18*.

In Hungary and Bulgaria this cooling has not resulted in more intensive loessy deposition but soils of the complex PD_2 and *Fs* have developed. In the Ukraine this interglacial favored development of the Martonov soil *mr*.

In loessy sections of Tajikistan this interglacial is expressed by the soil complex *IXb* (*cf.* DODONOV 1986) and in China by the younger part of the soil complex *Fs 10-14* (*cf.* ZHENG HONG-HAN 1985).

SAN *1* (ELSTER *1*, GLACIAL *B* in the Netherlands, DON; ^{18}O stage *16*) GLACIATION

During this glaciation, correlated with ^{18}O stage *16*, the Scandinavian icesheet occupied the Central European Lowland and reached northern forelands of the Sudetes and the western Carpathians, entered the Moravian Gate and occupied a considerable part of the Russian Lowland (LINDNER 1988d). In Poland it is indicated by a separate till. A loess of this time is mostly preserved in the Małopolska Upland (*see* Text-fig. 2) and similary as the older loess, it is located on slopes of buried fluvial valleys of the Holy Cross Mts and noted mainly in boreholes (*cf.* CZARNOCKI 1931, ŁYCZEWSKA 1971, LINDNER 1977). In contains macrofossils which are typical of loesses (*cf.* POLIŃSKI 1927). A loess of presumably the same age has been also noted in several boreholes in the Mazury Lakeland, northern Poland (MAKOWSKA & *al.* 1976).

Such loess in Czechoslovakia forms the horizon *H* which corresponds in Hungary to the loess under the paleosol PD_1 and in Bulgaria to the loess horizon L_7 (*see* Text-fig. 2). The Sula loess *si* was deposited in that time in the Ukraine which has been also outside the extent of the icesheet of the San *1* Glaciation (*see* Text-fig. 2) Loesses were also deposited in West Germany, extraglacial in that time, and particularly in the Middle Rhine Region where a tripartite (*C-E*) loess horizon of the Kärlich section indicates the youngest cooling within the Ville Interglacial complex (BRUNNACKER & *al.* 1982).

In Tajikistan the loess between the paleosols *IXb,* and *IXa* (*cf.* DODONOV 1986) and in China the lowest horizon of the Lishi Loess (*cf.* ZHENG HONG-HAN 1985) are to be considered for age equivalents.

FERDYNANDÓW (CROMERIAN *III* + *IV* in the Netherlands, VOIGTSTEDT, BYELOVEZHA; ^{18}O stages *13-15*) INTERGLACIAL

This interglacial is a typical example of bi-optimal development of interglacial flora in the European Lowland (*cf.* JANCZYK-KOPIKOWA & *al.* 1981, MAKHNACH & RYLOVA 1986). During its both optima (^{18}O stages *13* and *15*) forests have developed whereas vegetation was considerably poorer during the cooling of the ^{18}O stage *14*. The latter period was favorable for deposition of loess in a considerable part of western and mid-eastern Europe and has occasionally been named the Glacial *C* (*cf.* ZAGWIJN 1986).

In Czechoslovakia the mentioned bi-optimal interglacial is indicated by two soil complexes (*PK VI, PK VII*) separated by the loess horizon *G*, deposited during the intra-interglacial cooling correlated with the ^{18}O stage *14* (KUKLA 1978). In Hungary this interglacial is presumably indicated by the paleosol PD_1 and in Bulgaria by the paleosol Fs_6. In the Ukraine a climate of this time should be indicated by the Lubno soil *lb* of a humid forest, passing gradually into a subtropical steppe (VEKLICH & SIRENKO 1976).

A climate of this interglacial in the Kärlich section is indicated by two paleosols separated by the loessy horizon *F* (*cf.* BRUNNACKER & *al.* 1982). These soils have developed presumably during the warmings of the Cromerian *III* and *IV* in the Netherlands (*cf.* ZAGWIJN 1986).

In Tajikistan a climate of this interglacial was probably favorable for development of the intra-loessic paleosol *IXa* (*cf.* DODONOV 1986) whereas in China of the soil complex *Fs 7-9* in the lower part of the Lishi Loess (*cf.* ZHENG HONG-HAN 1985).

SAN *2* (ELSTER *2*, OKA; ^{18}O stage *12*) GLACIATION

During this glaciation, correlated with the ^{18}O stage *12*, the Scandinavian icesheet reached northern slopes of the Sudetes and the western Carpathians but also slightly entered the Moravian Gate (MACOUN 1985, 1987; LINDNER 1988d). Further to the east it occupied the northernmost Ukraine. In Poland its advance has been proceded by deposition of loesses in the Małopolska Upland and in the lowlands. In the former area this loess is mostly preserved on slopes of the Holy Cross Mts where is covered by till of the San *2* Glaciation and is TL dated at 580 ± 84 ka (LINDNER 1988a). Its larger patches occur under a till of this glaciation, also in the south-eastern Małopolska Upland (LINDNER 1988b). In the Mazury Lakeland a loess of this time was noted in boreholes (MAKOWSKA & *al.* 1976).

MARUSZCZAK (1985, 1986, 1987) refers the oldest supratill loess in the Lublin Upland (*LN* in Text-fig. 2) to this glaciation. Geologic setting of this loess, which in many cases overlies a weathered till of the San *2* Glaciation or its residium, as well as its TL age of about 350-300 ka BP (*cf.* MARUSZCZAK 1985, 1987) speak rather for a younger age and refer to the younger loess-creative period (*cf.* LINDNER 1987).

To the south of the Sudetes and the western Carpathians as well as in the Ukraine the loess of the San *2* Glaciation age is known from many sites. In Czechoslovakia it is represented by the loess horizon *F*, in Bulgaria by the loess horizon L_6 whereas in the Ukraine it probably corresponds to the Tiligula loess *ti* (Text-fig. 2). In Hungary this interval is represented by erosion, expressed in fluvial sands (S_2) and by an overlying loess (*see* Text-fig. 2). In the Lower Rhine drainage basin of West Germany the loess *Ga* in the section Kärlich was deposited (*cf.* BRUNNACKER & *al.* 1982).

In Tajikistan a loess horizon over the soil complex *IXa* (*cf.* DODONOV 1986) and in China the second bottom horizon of the Lishi Loess (*cf.* ZHENG HONG-HAN 1985) seem to be the loesses of this time.

MAZOVIAN (HOLSTEIN *s.s.*, LIKHVIN *s.s.*; ^{18}O stage *11*) INTERGLACIAL

This interglacial, correlated with the ^{18}O stage *11* and referred to the older part of the Great Interglacial (Holstein *sensu lato*), is indicated within the extent of the Scandinavian glaciations by numerous sites of organic sediments (*cf.* LINDNER 1988d). In the Lublin and Małopolska uplands there are also weathering sections and paleosols developed on tills of the San *2* Glaciation. According to MARUSZCZAK (1976, 1985) the paleosol *FsJ3a* (Text-fig. 2) caps the oldest loess (*LN*) whereas TL dating of under- and overlying loesses ascribes it to 330-300 ka BP. The author refers this soil to the younger, *i.e.* the Zbójno Interglacial (*cf.* LINDNER 1987, 1988a).

To the south of the Sudetes and the Western Carpathians the Mazovian Interglacial is indicated by intra-loessy paleosols. In Czechoslovakia there is the soil complex *PK V*, in Hungary — the paleosol *Mtp*. In Bulgaria this interval is to be found within the lower part of the soil complex Fs_5 and in the Ukraine — in the lower part of the Zawada soil complex *zv* (Text-fig. 2). In West Germany this interglacial should correspond to the paleosol in top of the loess *Ga*, defined in the Kärlich section as the soil of the Leutesdorfer Interglacial (*cf.* BRUNNACKER & *al.* 1982).

In Tajikistan this interglacial is probably defined by development of the soil complex *PK VIII* (*cf.* DODONOV 1986) and in China — by the soil complex *Fs 5-6* in section of the Lishi Loess (*cf.* ZHENG HONG-HAN 1985).

LIWIEC (FUHNE; ^{18}O stage *10*) GLACIATION

During the glaciation, correlated with the ^{18}O stage *10* (LINDNER 1988d), the Scandinavian icesheet occupied mid-northern Poland only (*see* Text-fig. 1). The Małopolska and Lublin uplands were entirely in extraglacial area, what made deposition of loess possible. They occur in valleys, usually as loessy silts that are TL dated at 388 ka BP (LINDNER 1988a, b). On plateaux they form the oldest supratill loess (*LN* in nomenclature of MARUSZCZAK 1985), TL dated at 367.8 ± 44 ka BP (MARUSZCZAK 1985).

In Czechoslovakia the loess of this age corresponds to the loessy horizon *E*, interpreted in the section Cérveny Kopeč as located between the paleosol complexes *V* and *IV* and referred to the Holstein Interglacial *sensu lato* (KUKLA & LOŽEK 1961). In Hungary younger fluvial sands S_1 overlain with loess and in

Bulgaria a middle part of the soil complex Fs_5 originated at that time. In the Ukraine soil processes connected with the development of the middle part of the Zawada complex *zv* continued (*see* Text-fig. 2). In the Kärlich section of the West Germany the loess horizon *Gb* has been probably deposited at this time (*cf.* BRUNNACKER & *al.* 1982).

In Tajikistan a loess between the paleosol complexes *PK VIII* and *PK VII* (*cf.* DODONOV 1986) and in China a loess between the paleosols *Fs 5-6* and *Fs 4* in the Lishi Loess (*cf.* ZHENG HONG-HAN 1985) were formed.

ZBÓJNO (DÖMNITZ, CHEKALIN; ^{18}O stage *9*) INTERGLACIAL

This interglacial, correlated with the ^{18}O stage *9* (LINDNER 1988d) is connected with deposition of organic sediments in many sites of the European Lowland (*see* ERD 1987, LINDNER & BRYKCZYŃSKA 1980). In Poland weathering horizons and a paleosol, particulary distinct in the Lublin Upland developed in tops of older tills, glaciofluvial sands and loesses. These pseudopodzolic, brown lessivé or podzolic soils (*FsJ3a*) have been formed in a forest environment. The TL age of underlying (*LN*) and overlying (*LSd*) loesses ascribes them to 330-300 ka BP (BUTRYM & MARUSZCZAK 1984, MARUSZCZAK 1985).

In loessy sections of Czechoslovakia, there was formed the Late Holstein soil complex PK *IV*, and in Hungary the horizon *Mtp?*. In Bulgaria it seems to be the equivalent of a younger part of the Zawada complex *zv*. In the Kärlich section of West Germany a paleosol of the Ariendorfer Interglacial was formed (*cf.* BRUNNACKER & *al.* 1982).

In Tajikistan this interglacial is probably defined by the soil complex *PK VII* (*cf.* DODONOV 1986), and in China — by the paleosol *Fs 4* (*cf.* ZHENG HONG-HAN 1985).

ODRA (SAALE *1+2*, DRENTHE, DNIEPER; ^{18}O stage *8*) GLACIATION

During this glaciation, correlated with the ^{18}O stage *8* (LINDNER 1988d), the Scandinavian icesheet reached northern slopes of the Sudetes, Małopolska and Lublin uplands, occupied the northern Ukraine and entered into the Moravian Gate and the Dnieper drainage basin. In the northern Małopolska Upland a till of this glaciation covers in several places the loess patches deposited just in front of the advancing icesheet (*cf.* POŻARYSKA 1948; RÓŻYCKI 1972; LINDNER 1980, 1984). In the eastern and southern Małopolska Upland and in the Lublin Upland this loess is named the older lower loess (*cf.* JERSAK 1973, 1988; *LSd* in nomenclature of MARUSZCZAK 1976, 1985, 1987). This loess comprises the Chegan event (TUCHOŁKA 1977) and its age was TL defined at 310-255 ka BP (BUTRYM & MARUSZCZAK 1984; MARUSZCZAK 1985, 1987).

In Czechoslovakia the loess horizon *D* was deposited in that time, and in Hungary — sands and loess on which the paleosol *Phe* developed afterwards. In

Bulgaria the loess horizon L_5 and in the Ukraine the Dnieper loess *dn* were then formed (*see* Text-fig. 2). In West Germany this glaciation is connected with deposition of the loess horizon *H* in the Rhine valley (*cf.* BRUNNACKER & *al.* 1982), dated in the Kärlich section at 222-232 ka BP and in the other sections at 300-235 ka BP (*cf.* ZÖLLER & *al.* 1987). In the upstream French part of the Rhine valley the loess of this glaciation was TL dated at 278-222 ka BP (BURACZYŃSKI 1982).

In Tajikistan loessy deposition of that time was expressed by the loess between the two soil complexes *PK VII* and *PK VI* (*cf.* DODONOV 1986) and in China — by the last but one horizon of the Lishi Loess, *i.e.* between the paleosols *Fs 4* and *Fs 2-3* (*cf.* ZHENG HONG-HAN 1985).

LUBAWA (RÜGEN, TREENE; ^{18}O stage *7*) INTERGLACIAL

During this interglacial, correlated with the ^{18}O stage *7* (LINDNER 1988d) when organic sediments were deposited in the European Lowland (*see i.a.* ERD 1978, KRUPIŃSKI & MARKS 1986), soils have developed on the lower older loess of the Małopolska and Lublin uplands (*cf.* JERSAK 1973; MARUSZCZAK 1976, 1985, 1987). These soils are represented by the soil complex of "Tomaszów type" (JERSAK 1973), defined as *FsJ2* in the nomenclature of MARUSZCZAK (1985). The TL datings of the underlying and overlying loesses indicated its deposition about 235-225 ka BP (BUTRYM & MARUSZCZAK 1984). In the Głubczyce Plateau of northeastern foreland of the Sudetes the soil complex of the "Tomaszów type" has developed on till of the Odra Glaciation (JERSAK 1988).

In loessy sections of Czechoslovakia the described interglacial should be connected with the soil complex *PK III* and in Hungary — with the paleosol *Phe*. In Bulgaria it corresponds to the intra-loessic paleosol Fs_4, and in the Ukraine — to the Kaydak paleosol *kd*. In the middle and lower Rhine basin this interglacial is represented by paleosols. In Alsace loess sequence, this interglacial is represented by a brown soil with chernozem in the top and TL dated at 220-176 ka BP (BURACZYŃSKI 1982). In the Kärlich section of West Germany it corresponds to the paleosol of the Kärlicher Interglacial at the top of the loessy horizon *H* (*cf.* BRUNNACKER & *al.* 1982). The overlying till was TL defined as younger than 222 ka BP and older than 152 ka BP (*cf.* ZÖLLER & *al.* 1987).

In Tajikistan loess of this interglacial is represented by the soil complex *PK VI* (*cf.* DODONOV 1986), and in China — by the youngest (*Fs 2-3*) complex of paleosols within the Lishi Loess (*cf.* ZHENG HONG-HAN 1985).

WARTA (SAALE *3*, WARTHE; ^{18}O stage *6*) GLACIATION

During this glaciation, correlated with the ^{18}O stage *6* (LINDNER 1988d), a considerable part of the Central European Lowland and the Russian Plain was occupied by the Scandinavian icesheet. In northern foreland of the Małopolska

Upland a till of this glaciation covers the slightly older loess deposited in the front of the advancing icesheet (KARASZEWSKI 1952). In the Głubczyce Plateau further to the south this loess forms more or less isolated patches (JERSAK 1988). The same is also for the Małopolska and Lublin uplands (*see* Text-Fig. 2) where this loess is named the older upper one *LSg* in nomenclature of MARUSZCZAK (1976, 1985, 1987) and was TL dated at 221-150 ka BP (BUTRYM & MARUSZCZAK 1984, MARUSZCZAK 1985).

In Czechoslovakia it corresponds to the loess horizon *C*, and in Hungary — to the loess that forms a substrate of the paleosol MB_{1-2}. In Bulgaria it should be correlated with the loess horizon L_4 and in the Ukraine with the Tishmin loess horizon *ts*. A loess connected with this glaciation is present also in the western Europe. In Alsace it is TL dated at 176-118 ka BP (BURACZYŃSKI 1982) and in the Kärlich section, where is represented by the loess horizon *Ja* (BRUNNACKER & *al.* 1982), at 152 ka BP (ZÖLLER & *al.* 1987).

In loessy sections of Tajikistan this period is represented by the loess that separates two paleosol complexes *PK VI* and *PK V* (*see* DODONOV 1986), and in China — by the uppermost horizon of the Lishi Loess (*cf.* ZHENG HONG-HAN 1985).

LOESSES OF THE UPPER PLEISTOCENE (128-10 ka BP)

EEMIAN (EEM, MURAVINO; ^{18}O stage *5e*) INTERGLACIAL

During this interglacial, commonly correlated with the ^{18}O stage *5e*, organic forest sediments have been deposited in the whole territory of Europe (*see i.a* ERD 1978, ZAGWIJN 1986, CHEBOTAREVA 1972, MAMAKOWA 1989). In the European loess section these forests are recorded by the paleosol horizon *B* in the lower part of the soil complex, named in Poland as of the "Nietulisko type" (JERSAK 1973, 1988) and correlated with Stilfried *A* of Austria (FINK & KUKLA 1977). In nomenclature of MARUSZCZAK (1976) it is defined as *FsJ1*.

In sections of Czechoslovakia the Eemian soil processes are represented by the older of the soil complex *PK II*, and in Bulgaria — by an older part of the soil complex Fs_3. In the Ukraine a lower part of the Priluga soil *pl*, and in Hungary — the paleosol MB_{1-2} developed during the Eemian Interglacial. In western Europe and particulary in the Rhine valley, the Eemian Interglacial is recorded by similar soil sections. In Alsace the Eemian soil forms a brown complex with younger chernozem (of the Amersfoort Interstadial age); according to the TL dating it is younger than 118 ka BP and older than 56 ka BP (BURACZYŃSKI 1982). In the Kärlich section this soil has developed on the loess *Ja* (BRUNNACKER & *al.* 1982) and TL datings indicate it to be younger than 152 ka BP. In other sections of Rhine loesses it is located within the time interval from about 137 ka to 110 ka BP (*cf.* ZÖLLER & *al.* 1987).

In loessy sections of Tajikistan the Eemian Interglacial is represented by the soil complex *PK V* (*cf.* DODONOV 1986) and in China — by the paleosol *Fs 1* between the Lishi Loess and Malan Loess (*cf.* ZHENG HONG-HAN 1985).

WISŁA (WEICHSEL, VISTULIAN; ^{18}O stages *2-5d*) GLACIATION

During this glaciation, commonly correlated with the ^{18}O stages *2-5d*, the Scandinavian icesheet occupied for the last time the Central European Lowland and the Russian Plain. In the Lower Vistula drainage basin its advance is indicated by several tills, separated among others by loesses (MAKOWSKA 1973, MAKOWSKA & *al.* 1976, DROZDOWSKI 1979, LINDNER 1987).

These loesses correspond to 3-5 horizons of younger loesses *LM* in the Małopolska and Lublin uplands (*see* Text-Fig. 2), in the Głubczyce Plateau and on northern slopes of the western Carpathians (MOJSKI 1965; JERSAK 1973, 1988; MARUSZCZAK 1976, 1985, 1987; LINDNER 1980, 1988a, b, 1987). In the mid-eastern Europe these loesses occupy the most extensive area (*see* Text-fig. 1). In Poland an older part of these loesses contains a chernozem of the Amersfoort + Brörup = Gniew Interstadial, and their middle part — interpleniglacial paleosols of the tundra Moershoofd + Hengelo + Denekamp = Grudziądz Interstadial. Uppermost parts of these soils form a soil complex of the "Komorniki type" (JERSAK 1973, 1988) that are correlated with Stilfried *B* in Austria (FINK & KUKLA 1977).

In the Małopolska and Lublin uplands the lowermost younger loess contains the Blake event (TUCHOŁKA 1977). The TL datings of the younger loess (1-5 horizons) in this area indicate its deposition from about 110 ka to about 15 ka BP (BUTRYM & MARUSZCZAK 1984, MARUSZCZAK 1985), interrupted during the interstadial warmings.

In Czechoslovakia this loess corresponds to the loess horizon *B* with preserved soil complex *PK I* (*see* Text-fig. 2). In Hungary it should be correlated with 4 loessy horizons and the separating three interstadial paleosols (BD_{1-2}, MF_{1-2}, H_1-H_2 in Text-fig. 2). A time of the Wisła Glaciation in Bulgaria is expressed by 4 layers of the younger loess and 3 paleosols (Fs_2, Fs_1, *Fs-al* in Text-fig. 2). In the Ukraine the loess connected with the last glaciation is expressed by three horizons, Udai (*ud*), Bug (*bg*), and Prichernomore (*pc*), separated by two paleosols, Vitachevo and Dofinov (*vt* and *df* in Text-fig 2).

Younger loesses in western European sections are composed of several horizons, separated with interstadial soils. Deposition of these loesses in Alsace has begun according to TL datings about 56 ka BP, lasted until about 15 ka and was interrupted by several episodes when interstadial soils have developed (BURACZYŃSKI 1982). In the Kärlich section the younger loess (*Jb*) is tripartite (BRUNNACKER & *al.* 1982). In the Rotenberg section a tripartity of this loess should be connected with three phases of loess deposition, TL dated at about 75 ka, 63-53 ka and 29-24 ka BP (ZÖLLER & *al.* 1987).

In section of Tajikistan the younger loess is represented by 5 horizons with 4 paleosol complexes *PK IV-I* (*see* DODONOV 1986) and in China — by deposition of the bipartite Malan Loess (*cf.* ZHEN HONG-HAN 1985).

FINAL REMARKS

Within the extent of the Scandinavian glaciations and in the extraglacial area of mid-eastern Europe there are 11 main Pleistocene loess horizons (*L-B* in nomenclature of KUKLA 1975, 1978). Eight of them (*L, J, H, F, E, D, C, B*) should be correlated with 8 Scandinavian glaciations (Narew, Nida, San *1*, San *2*, Liwiec, Odra, Warta, and Wisła) and three others (*K, I, G*) — with climatic coolings (glaciations?) within the three older interglacials (Podlasian, Malopolanin and Ferdynandów). All the three last-mentioned loessy horizons and particularly the ones in the extraglacial area, are separated by interglacial paleosol complexes.

The presented correlation of the main Pleistocene loesses and paleosols with main Scandinavian glaciations could be possible when some stadial or interstadial units have been considered for separate glaciations or interglacials (*cf.* RÓŻYCKI 1980, 1986; LINDNER 1984, 1988a-d; VOZNYACHUK 1985). When a more precise definition of climatostratigraphic units within the pre-Pleistocene (1870-950 ka BP) coolings and warmings will be possible, a number of glacial-interglacial cycles in the Quaternary of Europe can come closer to the number of loessy-soil cycles (*cf.* FINK & KUKLA 1977) in loessy section of our continent.

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STRATYGRAFIA GŁÓWNYCH PLEJSTOCEŃSKICH POZIOMÓW LESSOWYCH I GLEB KOPALNYCH W ŚRODKOWO-WSCHODNIEJ EUROPIE

(Streszczenie)

Jednym z ważniejszych problemów badawczych czwartorzędu środkowo-wschodniej Europy jest określenie wieku głównych, plejstoceńskich poziomów lessowych i przedzielających je gleb kopalnych oraz ich korelacja ze zlodowaceniami kontynentalnymi i interglacjałami uznanymi za główne jednostki podziału stratygraficznego plejstocenu (*por.* Lindner 1988a-d). W pracy wykazano, że na wymienionym obszarze (*patrz* fig. 1) zachowanych jest 11 głównych, plejstoceńskich (950 - 10 ka BP) poziomów lessowych oddzielonych glebami kopalnymi (*patrz* fig. 2). Na podstawie sytuacji geologicznej, danych paleomagnetycznych i datowań metodą TL wykazano, że 8 z tych poziomów (*L, J, H, F, E, D, C, B* w nomenklaturze Kukli 1978) należy korelować z 8 głównymi zlodowaceniami skandynawskimi (Narwi, Nidy, Sanu *1*, Sanu *2*, Liwca, Odry, Warty i Wisły w nomenklaturze Lindnera 1988a-d), zaś pozostałe 3 poziomy lessowe (*K, I, G*) z ochłodzeniami w obrębie trzech najstarszych interglacjałów (podlaskiego, małopolskiego i ferdynandowskiego). W obrębie najmłodszego poziomu wyróżniono ponadto od 3 do 5 lessów wiązanych ze stadiałami lub fazami zlodowacenia Wisły. W pracy podjęto także próbę korelacji głównych, plejstoceńskich poziomów lessowych i przedzielających je gleb kopalnych (interglacjalnych) z analogicznymi utworami zachowanymi w Zachodniej Europie i Azji oraz ze stadiami ^{18}O rejestrującymi w osadach głębokomorskich główne ochłodzenia i ocieplenia klimatyczne plejstocenu.
