ANNALES
UNIVERSITATIS MARIAE CURIE-SKLODOWSKA
LUBLIN — POLONIA
VOL. L, 5, 75–90 SECTIO B 1995

Institute of Geology, Warsaw University, Żwirki i Wigury 93, 02-089 Warszawa, Poland

Leszek LINDNER,
Anna E. SIENNICKA-CHMIELEWSKA

Loesses and their Bedrock in the Southeastern Part of the Miechów Upland (S Poland)

Lessy i ich podłoże w południowo-wschodniej części Wyżyny Miechowskiej (Polska S)

Abstract. Residues of glacial deposits of the South Polish Glaciations (Sanian 1, Sanian 2) and occurring below them the Prepleistocene gravels and sands of the Witów Series, the Miocene Krakowiec Clays and the Upper Cretaceous marls, underlie loesses in the southeastern part of the Miechów Upland. The lower and upper older loesses (Odranian, Wartanian) separated by the „Tomaszów" type paleosol (Lubawian = Lublinian) have been distinguished within them. The „Nietulisko" type paleosol (Eemian — Early Vistulian) occurs above upper older loesses, covered by middle and upper younger loesses (Vistulian) separated by an interstadial paleosol of the „Komorniki" type (Grudziądz Interstadial).

Key words: loess-paleosols sequence, loess bedrock, Quaternary stratigraphy.

INTRODUCTION

During the last decade field work under the first author's supervision on the Quaternary section of the southeastern part of the Miechów Upland (L. Cuprzyńska 1986, W. Dębek 1981, J. Janiec 1983, E. Patoleta 1983, I. Sędłak 1983, A.E. Siennicka 1992), previous investigations of J. Łyczewska (1948), R. Gradziński, R. Unrug (1959), M. Kucia-Lubelska (1966), S. Dżułyński et al. (1968), T. Osmólski (1972a), A. Walczowski (1972, 1978, 1979, 1982, 1984), M. Tyczyńska (1978) and P. Radzki et al. (1989, 1992), together with results of earlier (L. Lindner, A.E. Siennicka 1994) and new TL* datings, as well as ^{14}C datings (S.W. Alexandrowicz, J. Jersak 1991) and paleomagnetic data

* TL datings made by the Laboratory of the University of Gdańsk, subject: BW 1206/16.

(J. Nawrocki, A. Wójcik 1990) formed basis to present loess chronostratigraphy and the Quaternary bedrock in this part of the Miechów Upland. In this region — at Odonów near Kazimierza Wielka — a key loess section in Poland over a till residue there is a loess separated by two interglacial paleosols (J. Jersak 1973, 1975, J. Jersak et al. 1992). Generally, aforementioned investigations give an essential input to detailed stratigraphical correlation of main stratigraphical units of Southern and Central Poland.

QUATERNARY BEDROCK

Almost the whole area of the southeastern Miechów Upland is covered by loess, accumulation of which was strictly connected with underlying deposits and bedrock morphology. In the discussed area (Fig. 1) the bedrock of Quaternary is composed of the Upper Cretaceous marls and opokas (Upper Campanian — Upper Maestrichtian) (T. Osmólski 1972b), the overlying Upper Miocene Krakowiec Clays with intercalations of sandy mudstones and sandstones, as well as gypsum and limestones with sulphur (Z. Krysiak 1986, 1987, T. Osmólski 1972b). These deposits are strongly dislocated and form a series of shifted blocks (Fig. 2), connected with longitudinal axis of tectonic zones responsible for creation of the Słomniki Graben, the Działoszyce Depression and the Nida Graben. They are limited by the Kurdwanów–Zawichost tectonic zone from the south (northern border of the Carpathian Foredeep).

Detailed observations reveal that dislocations and fractures have the pre-Tertiary foundations (T. Osmólski 1972a), renewed to a large degree during two tectonic phases (Z. Krysiak 1986, 1987). The older (Miocene), ended at the Attic Phase, according to A. Wójcik, W. Zuchiewicz (1978) and Z. Krysiak (1986) it belongs therefore to the last stage of horizontal displacements connected with the Alpine cycle *sensu lato*. The younger stage (Pliocene — Quaternary) represents in opinion of Z. Krysiak (1986) the so-called neotectonic displacements, caused by changes in a regional stress field connected with uplifting of the Carpathians and deposition of the Carpathian gravels (the Witów Series, the Majdan Gravels) in their foreland. During the next stage, gravels and their bedrock were probably dislocated (W. Laskowska-Wysoczańska, L. Lindner 1974).

QUATERNARY DEPOSITS

Subdivision of the Quaternary deposits into the Prepleistocene (Protopleistocene, Preglacial) gravels and sands of the Witów Series, into the

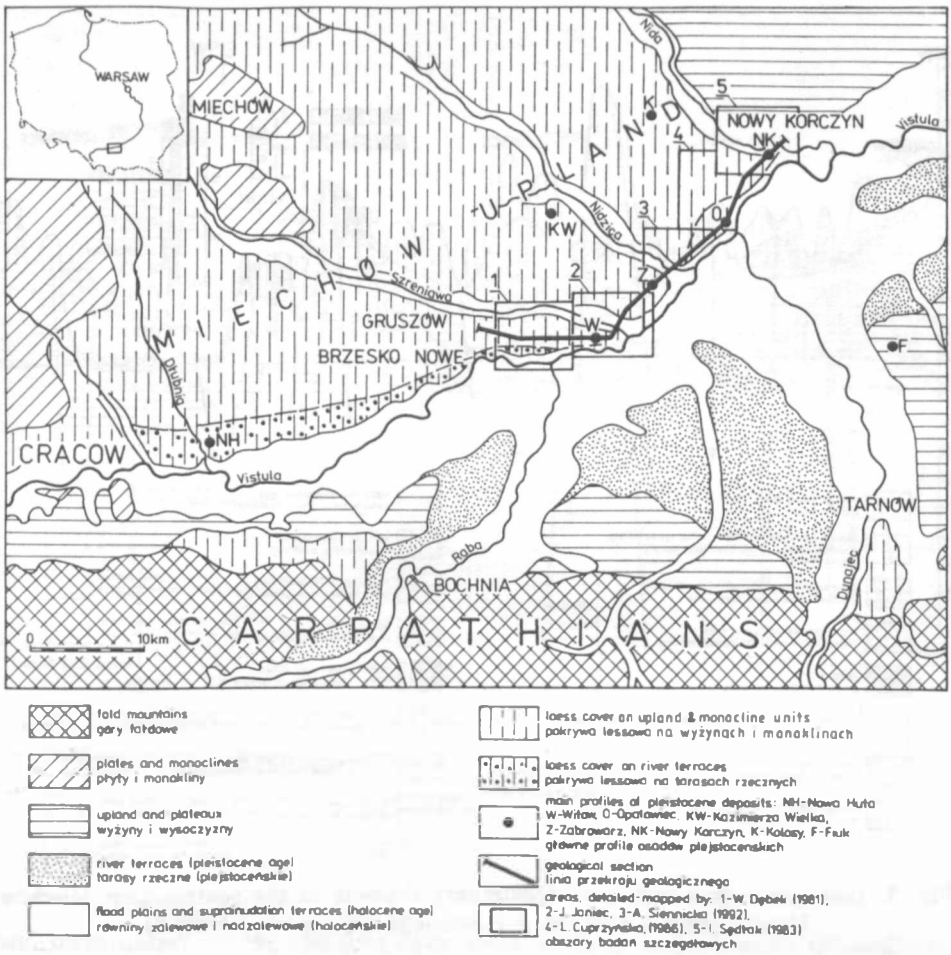


Fig. 1. Geomorphological-geological sketch of the Vistula river-basin between Kraków and Nowy Korczyn (after L.Lindner, A.E.Siennicka 1994; partly changed)

Pleistocene accumulation (mainly loesses), and finally into the Holocene deposits is clearly observed in the northern margin of the Vistula valley between Brzesko Nowe and Nowy Korczyn (Figs. 1 and 2).

PREPLEISTOCENE DEPOSITS

Accumulation of sands and the Carpathian gravels of the Witów Series can be connected with the Prepleistocene and probably with the Pliocene (Table 1). The mentioned deposits out crop in a marginal area of the Vistula River valley between Gruszów in the west and Zabrowarz in the east (Fig. 2).

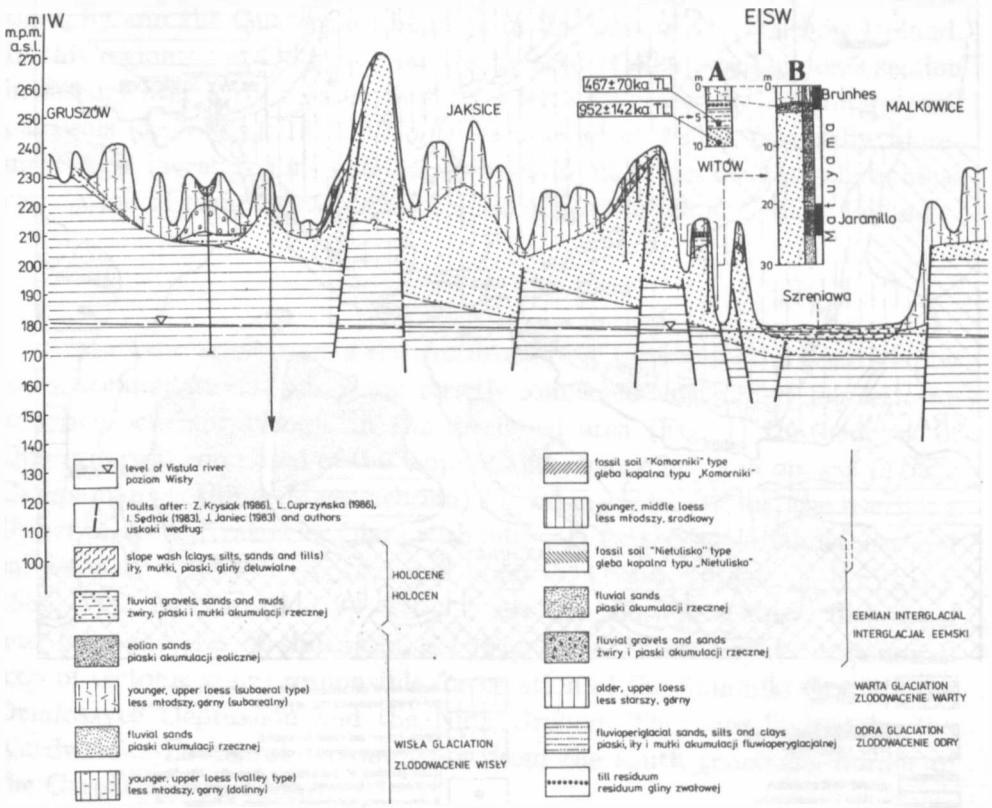
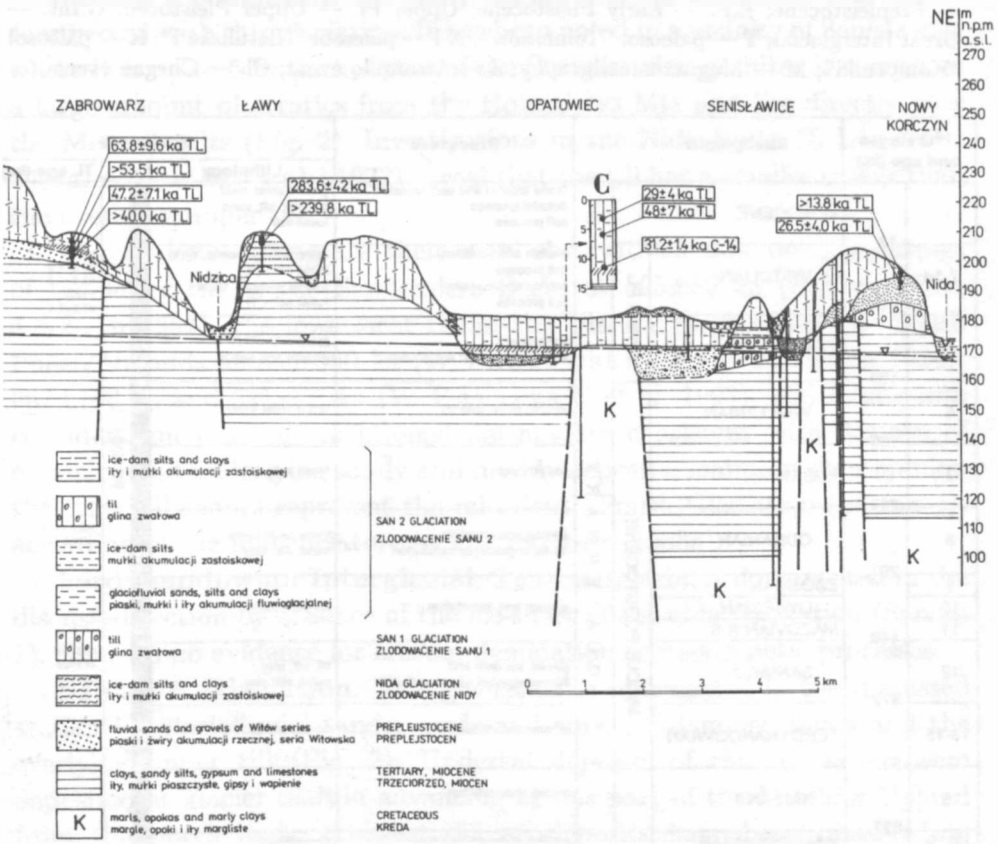


Fig. 2. Geological cross section of Quaternary deposits in the southeastern Miechów Upland (after L.Lindner, A.E.Siennicka 1994; partly changed)

Detailed mineralogical-petrographical analyses revealed that scarce fragments of a red granite (R. Gradziński, R. Unrug 1959) are not of the Scandinavian origin and represent the Carpathian exotics; together with a heavy mineral association (M. Kucia-Lubelska 1966) and sandstone boulders, they had been deposited by the ancient Raba during the earliest Quaternary (S. Dżułyński et al. 1968). The following detailed field investigations comprising among other an analysis of all outcrops of the Witów Series (W. Dębek 1981, J. Janiec 1983, J. Rutkowski 1987, I. Sędłak 1983, A.E. Siennicka 1992) and TL dating at 925±142 ka (L. Lindner 1988a), as well as identification of the paleomagnetic episode Jaramillo (Fig. 2) and the Brunhes/Matuyama paleomagnetic boundary (J. Nawrocki, A. Wójcik 1990) all determine the Prepleistocene age of the sequence. Nevertheless, a deposition began during the Late Pliocene



and terminated during the first of climatic cooling and warming (Narewian, Podlasian) of the Lower Pleistocene.

According to recent investigations, the easternmost area of the Witów Series deposits is located near Zabrowarz (A.E. Siennicka 1992) (Fig. 2). Sands with gravels up to 4 mm in diameter there, do not include any Scandinavian material; they underlie loesses with a paleosol and overlie the Krakowiec Clays. Within these sands there is quartz (80–85%), feldspars (10–15%) and micas (up to 5%). Heavy mineral content is similar to the one identified in the Witów Series by M. Kucia-Lubelska (1966).

EARLY AND MIDDLE PLEISTOCENE DEPOSITS

Early Pleistocene deposits sensu L. Lindner (1988b, 1992) have not been determined in the area until now. The Middle Pleistocene is documented mainly by ice-dammed silts and muds and two horizons of till, the up-

Table 1. Stratigraphy of Quaternary deposits in the southeastern Miechów Upland. Prepl. — Prepleistocene; E.P. — Early Pleistocene; Upper Pl. — Upper Pleistocen; G.Int. — Great Interglacial; T — paleosol "Tomaszów"; N I — paleosol "Nietulisko I"; K — paleosol "Komorniki"; M — Magnetostratigraphy; J — Jaramillo event; Ch — Chegan event

^{18}O stages and age (ka)		Stratigraphy			Processes	Sediments: Lithology	Sediments: TL age (ka)
1		HOLOCENE		QUATERNARY	fluvial erosion and accumulation deluvial process soil process	gravel, sand, mud till, clay, silt, sand fossil soil	
	13						
2-5d		VISTULIAN	UPPER PL.		aeolian accumulation soil process aeolian accumulation soil process	upper younger loess, sand fossil soil - "K" middle younger loess fossil soil - "N I"	>13.8 26.8±4.0 63.8±9.6 >63.8 47.2±7.1
	117						
5e		EEMIAN			soil process fluvial erosion and accumulation	fossil soil - "N I" gravels and sands	
	130						
6		WARTANIAN	MIDDLE PLEISTOCENE		aeolian accumulation	upper older loess	
	189						
7		LUBAWIAN			soil process	fossil soil - "T"	
	244						
8		ODRANIAN			aeolian accumulation fluvioperiglacial accumulation	lower older loess sand, silt, clay	283.8 ±42.5 >298.8
	297						
9		ZBÓJNIAN					
10		LIWIECIAN			erosion and denudation	no sediments	
11		MAZOVIAN S.S.					
	440						
12		SANIAN 2			glacial, ice dam and fluvioperiglacial accumulation	till, silt, clay sand, silt, clay	466±68 463±68 467±70
	472						
13-15		FERDYNANDOWIAN			erosion and denudation	no sediments	
	592						
16		SANIAN 1			glacial accumulation	till	
	627						
17-19		MAŁOPOLANIAN			erosion and denudation	no sediments	
20		NIDANIAN			ice-dam accumulation	clay and silt	
21-25		PODLASIAN	E.P.		fluvial erosion and accumulation	gravel and sand of Witów series	963±142 >40.0
26-28		NAREWIAN					
29		CELESTYNOWIAN	PREPL.				
30-36		OTWOCKIAN					
37-40		PONURZYCIAN					
		RÓŻCIAN					
		PLIOCENE					

Sediments: till; BRUNHES; Ch; MATUYAMA

per of which is underlain by glaciofluvial sands, muds, silts and ice-dammed muds (Fig. 2, Table 1). Residue of the above mentioned tills frequently and the so-called older lower and older upper loesses have been connnected to the Middle Pleistocene (Fig. 2, Table 1).

Nidanian Glaciation. Deposition of ice-dammed silts and muds above the Witów Series in the section Witów B (Fig. 2), described by J. Nawrocki and A. Wójcik (1990), can be connected with this glaciation. These deposits, according to the cited authors, have a mixed magnetic polarity and are placed at the Brunhes/Matuyama boundary; dated at 730 ka (Table 1).

Sanian 1 Glaciation. Probably the lower of the mentioned tills can be connnected with this glaciation. It has been noted in a vicinity of Senisławice where it is up to 5 m thick; apart of the Scandinavian granites it comprises a large amount of erratics from the Holy Cross Mts and lies directly over the Miocene silts (Fig. 2). Investigations in the Nida Basin (L. Lindner 1988a, A. Walczowski 1972) reveal that the till has a smaller extent than the overlying upper till.

The authors basing on their own observations and on TL datings of the lower till in the Sandomierz Basin at 595±89 ka (B. Kwapisz, J. Szajn 1987), the lowermost till in the Vistula gorge across the South Polish Uplands at 580–560 ka (W. Laskowska-Wysoczańska 1984), 667±100 ka and 621±93 ka (W. Pożaryski et al. 1993), and taking into consideration that the mentioned datings are consistent with datings of overlying and underlying sandy and muddy deposits, maintain their opinion that this till should represent the mid-South Polish Glaciation (Sanian 1), according to the nomenclature by L. Lindner (1988a).

Ferdynandowian Interglacial. This interglacial is documented in the discussed section by absence of the ice-sheet of the older glaciation (Sanian 1). There is no evidence for erosion-denudation or pedogenetic processes.

Sanian 2 Glaciation. This glaciation is represented in the discussed section by glaciofluvial sands, muds and silts, ice-dammed muds and the overlying upper till (Fig. 2). Undertill deposits of this glaciation were deposited at glacier margin advancing in this part of the Miechów Upland from the north and northwest. These deposits have been observed in boreholes to the east of Gruszów in a vicinity of Senisławice and Nowy Korczyn as well as in the section A at Witów (mentioned by L. Lindner, 1988a), where TL datings reveal age of 467±70 ka (Fig. 2).

Till above the mentioned deposits is up to 10 m thick, has a considerable admixture of the Scandinavian and the Holy Cross Mts. material content, and much loess silt. In the presented section area the till is incompletely preserved, and occasionally only its lag concentrate mixed with the overlying loess (Fig. 2) testifies its previous occurrence in the area. The underloess vari-grained deposits with boulders considered for a till residue by J. Jersak et al. (1992) in the Odonów section near Kazimierza Wielka, corresponds to this till and the overlying glaciofluvial and ice-dammed deposits. In the Kolosy section (Fig. 1), this till and underlying sands have been TL dated at 455±68 ka and 463±69 ka (L. Lindner 1988a). In the neighbouring area of the Tarnów Plateau in the Fiuk section (Fig. 1), this till has been TL dated at 518±77 ka and 490±73 ka whereas the underlying glaciofluvial deposits with a varve intercalation at 520±78 ka (J. Nitychoruk 1991).

Great Interglacial (Mazovian sensu lato). Fragmentary preservation of the above mentioned glaciogenic deposits on the Miechów Upland (L. Lindner 1967) and in neighbouring areas is mainly due to long-term erosion-denudation processes in this area during the Great Interglacial (L. Lindner 1988b, 1992). In the discussed section area these processes are expressed by the underloess till residue (Fig. 2), that forms the above mentioned lag concentrete. In many outcrops, in which under loess cover the upper part of San 2 till is preserved, the upper part of this till was transformed by pedogenetic processes similar to what can be observed in the Odonów section near Kazimierza Wielka (J. Jersak 1975) and in the Kolosy section (E. Patoleta 1983). Age of these processes is referred to the Great Interglacial (L. Lindner 1988a).

Odranian Glaciation. During the Odranian Glaciation the ice sheet reached the northwestern part of the Nida Basin. Its maximal extent decided about a fluvioperiglacial accumulation within the discussed area. It is documented in the Ławy section by sands, muds and silts up to 12 m thick located directly on the Tertiary silts and muds. According to the authors' previous studies they correspond to the San 2 Glaciation. New TL datings of these deposits at 283.6±42.5 ka (UG–1897) and more than 239.8 ka (UG–1898) suggest their younger age and connection with the Odranian Glaciation. Most probably, slope processes impose that covering by debris mud can correspond to the same phase (Fig. 2).

In the Odonów section near Kazimierza Wielka this stage is represented by muddy structure-loess, grey in colour, named the so-called lower older loess (J. Jersak et al. 1992) that encloses the paleomagnetic episode Chegan (P. Tucholka 1977). Examination of heavy mineral content in this loess revealed a higher heavy mineral ratio, which suggests larger content of resistant particles — zircon, rutile and tourmaline (H. Maruszczak, M. Wilgat 1978).

Lubawian = Lublinian Interglacial. In a discussed area of the Miechów Upland the Lubawian Interglacial is documented by the „Tomaszów" type paleosol in the Odonów section near Kazimierza Wielka (J. Jersak 1973), formed under a forest vegetation. TL datings of these deposits reveal the age of 168±27 ka to 120±20 ka (H. Prószyńska-Bordas et al. 1987) and point to a warming, considerably younger than the Lubawian Interglacial — probably an interstadial within the Wartanian Glaciation (L. Lindner 1988a). Investigations of a heavy mineral content in this paleosol reveal an enrichment in resistant particles, probably during erosive-pedogenetic processes (H. Maruszczak, M. Wilgat 1978).

Wartanian Glaciation. In the discussed area a thin horizon (up to

2 m thick) with the „Nietulisko I" type paleosol in its upper part, occurring west of Jaksice (Fig. 2) corresponds to the Wartanian Glaciation. In loess terminology, this loess is named the upper older loess. In the Odonów section near Kazimierza Wielka its youngest layers have been TL dated at 118±19 ka to 102±15 ka (H. Prószyńska-Bordas et al. 1987). Similarly to the older loess, this one has a large content of resistant particles (H. Maruszczak, M. Wilgat 1978).

UPPER PLEISTOCENE DEPOSITS

According to commonly accepted stratigraphical subdivision of the Quaternary (L. Lindner 1992, T. Nilsson 1983) the Upper (younger) Pleistocene consists of the Eemian Interglacial and the Vistulian Glaciation. Pleistocene layers in a northern part of the Vistula River valley are represented by erosion and accumulation of river, by pedogenetic processes and accumulation of the so-called younger loesses (Fig. 2).

Eemian Interglacial. This interglacial is represented by traces of erosive-accumulation processes mainly typical for river valleys, and by pedogenetic processes typical for loess areas (Table 1).

Traces of the first group of processes consist of fluvial deposits in the vicinity of Opatowiec and Senisławice, where they are represented by sands, gravels and silty sands. They fill up paleovalleys, formed by erosive shearing of tills of the South Polish Glaciations, upper part of the Miocene silts and in some places, also the Cretaceous deposits (Fig. 2). Pedogenesis is indicated by the lower part of the „Nietulisko I" type paleosol (J. Jersak 1973), formed on older upper loess in a vicinity of Jaksice (Fig. 2). TL dating of sediments in the Odonów section near Kazimierza Wielka reveal that this paleosol, developed as a lessive soil, is younger than 105±12 ka and 102±15 ka, and older than 100±17 ka and 55±6 ka (H. Prószyńska-Bordas et al. 1987). Similarly to the older interglacial paleosol, in this case there is also an enrichment in resistant heavy minerals (H. Maruszczak, M. Wilgat 1978).

Vistulian Glaciation. During this glaciation, the discussed area formed a main part of loess accumulation zone in Poland. Within the presented section (Fig. 1) traces of the lowermost younger loess involved almost entirely in pedogenetic processes that influenced development of the upper part of the „Nietulisko I" type paleosol, can be distinguished together with the middle younger and upper younger loesses, commonly separated by the „Komorniki" type paleosol (Fig. 2, Table 1). In the Zabrowarz section (Fig. 2) these loesses have been TL dated (Table 1) at 63.8±9.6

ka (UG–1899) and 47.2±7.1 ka (UG–1901) and the separating paleosol — at more than 53.5 ka (UG–1900).

The „Komorniki" type paleosol, especially well developed in the Opatowiec section (S.W. Alexandrowicz, J. Jersak 1991) has been the pseudogley paleosol and radiocarbon dated at 31.2±1.4 ka (Fig. 2). According to J. Jersak (1973) this type of paleosol is referred to Hengelo and Denekamp Interstadial. The „Komorniki" type paleosol represents in opinion of H. Maruszczak (1991) older warming up of the interpleniglacial (Glinde, Oerel) and is called as the weathering-soil bed (sg-Gi/LMd). The loess under this paleosol in the Opatowiec section was deposited in alluvial facies. It contains a rich malacologic sequence, of four molluscan assiociations (S.W. Alexandrowicz, J. Jersak 1991), which document gradual interstadial or interpleniglacial cooling. Similar climatic conditions, probable for the youngest part of the interpleniglacial or the beggining of Main Stadial of the last glaciation were reconstructed on basis of floristic analyses in the Nowa Huta section (Fig. 1). In this section, radiocarbon dated at 20.5±7.3/-6.7 ka to 18.4±2.5 ka, K. Mamakowa, A. Środoń (1977) claimed that climatic pessimum (upper pleniglacial) of the Vistulian Glaciation was represented in this part of Poland by deforested tundra with abundant *Betula nana* and bushy genera of *Salix*.

The overlying upper younger loess is developed in two paleorelief-dependent facies: subaqueous (valley) and subaerial (upland) ones. In the Opatowiec section the loess in valley facies was TL dated at 48±7 ka and 29±4 ka (A.E. Siennicka 1992) (Fig. 2). TL datings of the upper younger loess in upland facies reveal that in the Odonów section near Kazimierza Wielka it was deposited before 27±5 ka (H. Prószyńska-Bordas et al. 1987). New TL datings of the underloess sands and the overlying loesses in a vicinity of Nowy Korczyn (Fig. 2) at 26.5±4 ka (UG–1896) and >13.8 ka (UG–1895) respectively, impose a younger age than previously considered by authors (L. Lindner, A.E. Siennicka 1994) and seems to correspond to the youngest part of the Vistulian Glaciation. In the light of these dates the mentioned sands can represent the upper part of a fluvial series of the underloess, Vistulian terrace of the ancient Nida River.

Analysis of heavy minerals in younger loesses indicates a distinct increase of medium resistant (garnets) and non-resistant particles (amphiboles, chlorite, biotite) (H. Maruszczak, M. Wilgat 1978). They also reveal that the Pre-Quaternary rocks, the older Quaternary deposits consituted the main source of the loess detrital material. Most material was found to have been transported by westerly winds, at small distances of tens of kilometers (R. Chlebowski, L. Lindner 1992).

Aeolian deposition of sands that overlie the younger loesses (in valley facies) in surface of the loessy terrace between Opatowiec and Senisławice (Fig. 2), were connected with the youngest part of the last glaciation.

HOLOCENE DEPOSITS

In northern margin of the Vistula River valley the Holocene is represented mainly by pedogenetic processes at surface of younger loesses as well as by ravine and valley erosion, separated by intervals with predominant deluvial deposition (Table 1). In the Vistula valley and valleys of the Szreniawa, the Nidzica and the Nida that cut the mentioned marginal area, deposition of gravels, sands and muds occurred which form flood terraces (Table 1). Sediments of the Vistula flood terrace have a varying thickness, infill erosive incisions in valley bottom, formed during the youngest part of the last glaciation (Late Glacial) and mantle them with flood and channel deposits (P. Gębica, L. Starkel 1987).

Similarly to the drainage area of the Upper Nidzica (J. Jersak, Z. Śnieszko 1987), in the Szreniawa, the Nidzica, the Nida and in their tributary valleys sediments with much organic admixture were mostly deposited and in non-valley areas — the black-earths developed during the Early Holocene and the Atlantic Optimum. The post-Atlantic interval in this area is connected with increasing human activity and at the same time activation of ravine erosion as well as valley and deluvial deposition. There are numerous traces of these processes, especially in the lower Szreniawa and Nidzica valleys — silts, muds, sands and deluvial muds (Fig. 2) with detached blocks and black-earth-flows that contain fragments of pottery.

CONCLUSIONS

In the southeastern part of the Miechów Upland the loesses overlie a litologically differentiated bedrock composed of the pre-Quaternary and the pre-Pleistocene, occasionally the Middle Pleistocene rocks. The Middle Pleistocene loesses are represented by the lower older loess (Odranian) and the upper older loess (Wartanian) separated by the „Tomaszów" type paleosol (Lubawian=Lublinian). The „Nietulisko I" type paleosol (Eemian+Early Vistulian) is developed on the upper older loess. Over this paleosol two younger loesses (Vistulian) occur: the middle younger loess (Świecie Stadial) and the upper younger loess (Main Stadial), separated by the „Komorniki" type paleosol, that probably represents the Grudziądz Interstadial (L. Lindner 1992).

REFERENCES

Alexandrowicz S.W., Jersak J. 1991; Profil lessów w Opatowcu nad Wisłą (Loess section at Opatowiec on the Vistula river). H.Maruszczak (red.) Podstawowe profile lessów w Polsce. UMCS, B.91–93.

Chlebowski R., Lindner L. 1992; Źródła materiału i warunki akumulacji lessów młodszych Wyżyny Małopolskiej (Sources of sediments and sedimentary environment of younger loesses in the Małopolska Upland). Biul. Geol., Uniw. Warsz. 32,15–49.

Cuprzyńska L. 1986; Czwartorzęd okolic Chwalibogowic (Wyżyna Miechowska). Arch. Inst. Geol. Podst. WG UW.

Dębek W. 1981; Czwartorzęd okolic Śmilowic (SW część Wyżyny Miechowskiej). Arch. Inst. Geol. Podst. WG UW.

Dżułyński S., Krysowska-Iwaszkiewicz M., Oszast J., Starkel L. 1968; O staroczwartorzędowych żwirach w Kotlinie Sandomierskiej (On Lower Quaternary gravels in the Sandomierz Basin). Studia Geomorph. Carpatho-Balcan., 2, 64–75.

Gębica P., Starkel L. 1987; Evolution of the Vistula river valley at the nothern margin of Niepołomnice Forest during the last 15 000 years. (In:) Evolution of the Vistula River Valley during last 15 000 years. Geogr. Studies, Special Issue, 4, 2, 51–71.

Gradziński R., Unrug R. 1959; Geneza i wiek "serii witowskiej" (Origin and age of the "Witów series" near Cracow). Rocz. Pol. Tow. Geol., 29, 2, 181–198.

Janiec J. 1983; Czwartorzęd okolic Koszyc. Arch. Inst. Geol. Podst. WG UW.

Jersak J. 1973; Litologia i stratygrafia lessu wyżyn południowopolskich (Lithology and stratigraphy of the loess on the southern Polish Uplands). Acta Geogr. Lodz., 32, 1–118.

Jersak J. 1975; Profil lessowy w Odonowie II. Less i zróżnicowanie typologiczne gleb kopalnych na Wyżynie Małopolskiej, Przew. Konferencji Teren. Inst. Geogr. UŁ, 40–43.

Jersak J., Sendobry K., Śnieszko Z. 1992; Postwarciańska ewolucja wyżyn lessowych w Polsce (Evolution of loess covers in Poland during the post-Warta period). Prace Nauk. Uniw. Śląskiego, 1227, 7–198.

Jersak J., Śnieszko Z. 1987; Zmiany środowiska geograficznego w późnym vistulianie i holocenie na obszarach lessowych Wyżyny Miechowskiej i Opatowsko-Sandomierskiej (Changes in the geographical environment in the Late Vistulian and Holocene at loess area of the Miechowska and Opatowsko-Sandomierska Upland). Prace Nauk. Uniw. Śląskiego, 712, 7-25.

Krysiak Z. 1986; Rozwój tektoniczny południowej części Niecki Nidziańskiej w miocenie. Arch. Inst. Geol. Podst. WG UW.

Krysiak Z. 1987; Tektoniczne uwarunkowania lokalizacji i genezy złóż siarki w Czarkowicach i Posądzy (Zapadlisko Przedkarpackie) (Tectonic conditions for location and formation of sulphur deposits at Czarkowice and Podsądza, Carpathian Foredeep). Prz. Geol., 10, 503–506.

Kucia-Lubelska M. 1966; Wiek serii witowskiej w świetle badań minerałów ciężkich (The age of the Witów series based on the heavy mineral assemblages). Rocz. Pol. Tow. Geol., 36, 3, 303–312.

Kwapisz B., Szajn J. 1987; Nowe dane na temat pozycji stratygraficznej żwirów z północnego skłonu Płaskowyżu Kolbuszowskiego. (In:) Trzecio- i staroczwartorzędowe żwiry Kotliny Sandomierskiej. Mat. Sympozjum Wyd. AGH, 50–58.

Laskowska-Wysoczańska W. 1984; Z badań nad zasięgiem zlodowacenia środkowopolskiego we wschodniej części Kotliny Sandomierskiej. (In:) Zlodowacenia środkowo-

polskie na wyżynach południowopolskich i terenach przyległych. Przew. Konferencji, Uniw. Śląski, 70–72.

Laskowska-Wysoczańska W., Lindner L. 1974; The role of Carpathian overthrust in relief formation of the Sandomierz Basin (South Poland). Bull. Acad. Sc., Ser. Sc. de la Terre, 22, 2, 67–7.

Lindner L. 1967; Lessy dorzecza Uniejówki (Les loess du bassin de l'Uniejówka). Acta Geol. Pol., 17, 3, 463–493.

Lindner L. 1980; Zarys chronostratygrafii czwartorzędu regionu świętokrzyskiego (An outline of chronostratigraphy of Quaternary in the Góry Świętokrzyskie Mts. region). Kwart. Geol., 24, 3, 689–709.

Lindner L. 1988a; Jednostki glacjalne i interglacjalne w plejstocenie Wyżyny Miechowskiej i Niecki Nidziańskiej (Glacial and interglacial units in the Pleistocene of the Miechów Upland and Nida Basin). Prz. Geol., 3, 140–147.

Lindner L. 1988b; Stratigraphy and extents of Pleistocene continental glaciations in Europe. Acta Geol. Pol., 38, 1–4, 63–83.

Lindner L. (red.) 1992; Czwartorzęd: osady, metody badań, stratygrafia. Wyd. PAE, 1–683.

Lindner L., Siennicka A.E. 1994; Osady czwartorzędowe w strefie północnej krawędzi doliny Wisły na wschód od Brzeska Nowego (Wyżyna Miechowska) (Quaternary deposits in the northern zone of the Vistula River edge east of Brzesko Nowe (Miechów Upland, Southern Poland). Prz. Geol., 3, 105–112.

Łyczewska J. 1948; Sprawozdanie z badań geologicznych NW części arkusza Brzesko Nowe 1:100 000 (Report on the geological investigations in the north-western corner of Brzesko Nowe map 1:100 000, Carpathian Foreland). Biul. Państw. Inst. Geol,. 42, 3–32.

Mamakowa K., Środoń A. 1977; O pleniglacjalnej florze z Nowej Huty i osadach czwartorzędu doliny Wisły pod Krakowem (On the Pleniglacial flora from Nowa Huta and Quaternary deposits of the Vistula valley near Cracow). Rocz. Pol. Tow. Geol., 47, 4, 485–511.

Maruszczak H. 1991 (red.); Podstawowe profile lessów w Polsce (Main section of loesses in Poland). UMCS, A.13–35.

Maruszczak H., Wilgat M. 1978; Zróżnicowanie stratygraficzne i paralelizacja profili lessowych z Nieledwi i Odonowa w świetle badań minerałów ciężkich (Stratigraphic differentiation and parallelization of loess profiles from Nieledew and Odonów in the light of heavy minerals investigations). Biul. Lub. Tow. Nauk., Geografia, 20, 2, 95–101.

Nawrocki J., Wójcik A. 1990; On age of the "Witów series" in lithg of paleomagnetic studies. Studia Geomorph. Carpatho-Balcan., 30, 3–11.

Nilsson T. 1983; The Pleistocene: Geology and life in the Quaternary Ice Age. D. Reidel Publishing Company, 1–651.

Nitychoruk J. 1991; Glacial deposits in the Tarnów Plateau (S Poland) and problem of Dunajec outflow during the San 2 (=Elsterian II) Glaciation. Ann. UMCS, sec.B, 46, 187–200.

Osmólski T. 1972a; Przyczynki do znajomości czwartorzędu w widłach Wisły i Nidy (Contributions to the knowledge of Quaternary within the bifurcation area of the Vistula and Nida rivers). Prz. Geol., 3, 141–144.

Osmólski T. 1972b; Wpływ budowy geologicznej brzeżnych partii niecki działoszyckiej na rozwój procesu metasomatozy gipsów mioceńskich (The influence of the geological

structure of the marginal part of the Działoszyce Trough on the metasomatosis of gypsum). Biul. Inst. Geol., 260, 65–183.

Patoleta E. 1983; Czwartorzęd okolic Wiślicy nad Nidą. Arch. Inst. Geol. Podst. WG UW, 1983.

Połtowicz S. 1967; Młode ruchy neotektoniczne przedgórza Karpat w okolicy Krakowa i ich wpływ na ewolucję doliny Wisły i Raby (Young tectonic movements in Carpatian foreland vicinites of Cracow and their influence upon the evolution of the Vistula and Raba Rivers). Kwart. Geol., 11, 3, 699–704.

Pożaryski W., Maruszczak H., Lindner L. 1993; Stratygrafia osadów środkowo-plejstoceńskich w przełomie Wisły przez wyżyny południowopolskie w świetle analiz termoluminescencyjnych (Stratigraphy of Middle Pleistocene deposits in the Vistula River Gorge, Central Poland, in light of thermoluminescence dating). Prz. Geol., 2, 103–106.

Prószyńska-Bordas H., Stańska-Prószyńska W., Prószyński M. 1987; Termoluminescensyjne wskaźniki wieku lessów i gleb kopalnych z przekroju w Odonowie (metoda i wyniki laboratorium warszawskiego). Spraw. z Bad. Nauk. Kom. Bad. Czw. PAN, 7, 16–29.

Radzki P., Łopusiński L., Widz D. 1989; Szczegółowa mapa geologiczna Polski 1:50 000, ark. Borzęcin, Wyd. Geol., 1989.

Radzki P., Łopusiński L., Widz D. 1992; Objaśnienia do Szczegółowej mapy geologicznej Polski 1:50 000, ark. Borzęcin, Wyd. Geol.

Rutkowski J. 1987; Uwagi o żwirach witowskich. (in:) Trzecio- i staroczwartorzędowe żwiry Kotliny Sandomierskiej. Mat. Sympozjum Wyd. AGH, 62–67.

Sędłak I. 1983; Czwartorzęd okolic Nowego Korczyna nad Nidą. Arch. Inst. Geol. Podst. WG UW.

Siennicka A.E. 1992; Rzeźba i osady czwartorzędowe okolic Piotrowic na Wyżynie Miechowskiej. Arch. Inst. Geol. Podst. WG UW.

Starkel L. (red.) 1980; Przeglądowa mapa geomorfologiczna Polski, 1:500 000 (General Geomorphological Map of Poland). IGiPZ PAN.

Tuchołka P. 1977; Magnetic polarity events in Polish loess profiles. Biul. Inst. Geol., 305, 117–123.

Tyczyńska M. 1978; Delty kopalne w Kotlinie Sandomierskiej (The Fossil Deltas in the Sandomierz Basin). Folia Geogr., 11, 33–58.

Walczowski A. 1972; Zagadnienia czwartorzędowe w południowo-wschodniej części regionu świętokrzyskiego (Stratigraphy of Quaternary deposits of the SE part of the Holy Cross Mts.). Rocz. Pol. Tow. Geol., 42, 1, 125–133.

Walczowski A. 1978; Szczegółowa mapa geologiczna Polski 1:50 000, ark. Bejsce. Wyd. Geol.

Walczowski A. 1979; Objaśnienia do Szczegółowej mapy geologicznej Polski 1:50 000, ark. Bejsce. Wyd. Geol.

Walczowski A. 1982; Szczegółowa mapa geologiczna Polski 1:50 000, ark. Kazimierza Wielka. Wyd. Geol.

Walczowski A. 1984; Objaśnienia do Szczegółowej mapy geologicznej Polski 1:50 000, ark. Kazimierza Wielka. Wyd. Geol.

Wójcik A., Zuchiewicz W. 1979; Dotychczasowy stan badań nad neotektoniką Karpat Zachodnich (The present state of studies on the neotectonics of the western Carpathians). Prz. Geol., 8, 458–462.

STRESZCZENIE

Podłożem skał czwartorzędowych w południowo-wschodniej części Wyżyny Miechowskiej (ryc. 1) są utwory górnokredowe — margle i opoki, leżące na nich górnomioceńskie iły krakowieckie oraz gipsy i wapienie z siarką. Zostały one silnie zdyslokowane w czasie dwóch etapów tektonicznych: mioceńskiego zakończonego aktywnością fazy attyckiej i plioceńsko-czwartorzędowego. Z ruchami neotektonicznymi związany jest też zapewne system uskoków obejmujący piaski i żwiry karpackie serii witowskiej (ryc. 2). W osadach tej serii, odsłaniających się w wielu miejscach krawędzi Wisły między Gruszowem a Zabrowarzem, w profilu w Witowie zidentyfikowano granicę paleomagnetyczną Brunhes/Matuyama, co zdaje się ostatecznie przesądzać o preplejstoceńskim wieku tej serii.

W opisywanej części Wyżyny Miechowskiej nie znaleziono dotychczas osadów wczesnego plejstocenu (tab. 1). Osady środkowego plejstocenu udokumentowane są tu przede wszystkim przez dwie gliny zwałowe oraz lessy starsze. Dolna glina zwałowa, odznaczająca się znacznym udziałem materiału świętokrzyskiego i mniejszym zasięgiem, reprezentuje zapewne zlodowacenie sanu 1. Górna glina, zawierająca dużą domieszkę pyłu lessowego, w strefie prezentowanego przekroju zachowana jest fragmentarycznie, często w postaci bruku głazowego. Reprezentuje ona prawdopodobnie zlodowacenie sanu 2. Do osadów akumulowanych w czasie zlodowacenia odry należy zaliczyć, w świetle nowych dat uzyskanych metodą termoluminescencji rzędu 283,6±42,5 ka i więcej niż 239,8 ka, piaski, mułki i iły akumulacji fluwioperyglacjalnej w profilu w Ławach.

Lessy środkowoplejstoceńskie reprezentowane są na tym obszarze (ryc. 2) przez less starszy dolny akumulowany w czasie zlodowacenia odry. W profilu Odonów koło Kazimierzy Wielkiej w lessie tym stwierdzono epizod paleomagnetyczny Chegan, a wyżej less starszy górny akumulowany w czasie zlodowacenia warty. Interglacjał lubawski udokumentowany jest w tej części Wyżyny Miechowskiej przez glebę kopalną typu "Tomaszów" wykształconą pod zespołem roślinności leśnej. Na lessie starszym górnym rozwinięty jest profil gleby kopalnej typu "Nietulisko I", dokumentującej interglacjał eemski i początkową część zlodowacenia wisły. Osady tego interglacjału wykształcone są również w postaci piasków i żwirów wypełniających kopalne formy dolinne w rejonie Opatowca i Senisławic (ryc. 2).

W czasie ostatniego zlodowacenia skandynawskiego — zlodowacenia wisły — rejon Wyżyny Miechowskiej był jednym z obszarów akumulacji lessów młodszych w Polsce. Strzępy najniższego lessu młodszego objęte zostały prawie w całości procesami glebotwórczymi warunkującymi rozwój górnej części gleby kopalnej typu "Nietulisko I". Na wyżej leżącym lessie górnym środkowym rozwinęła się gleba kopalna typu "Komorniki", dla których to warstw w profilu Zabrowarz uzyskano daty metodą termoluminescencji odpowiednio: 47,2±7,1 ka i więcej niż 53,5 ka. Less młodszy górny wykształcony jest w dwóch facjach: subakwalnej (dolinnej) i subaeralnej (wysoczyznowej). W profilu Zabrowarz, dla lessu tego wieku, wykształconego w facji subaeralnej, otrzymano metodą termoluminescencji datę 63,8±9,6 ka. Z najmłodszą częścią wymienionego zlodowacenia wiązały się procesy eoliczne warunkujące akumulację piasków wydmowych na powierzchni górnego lessu młodszego wykształconego w facji subakwalnej.

Holocen na badanym obszarze wyrażony jest procesami rozwoju gleb kopalnych na powierzchni lessów młodszych oraz procesami erozji wąwozowej i dolinnej, przerywanej okresami akumulacji, głównie deluwialnej.