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The Conditions and Course of the Sedimentation of Older and Younger Loesses in the Wożuczyn Profile (SE Poland)

Warunki i przebieg sedymentacji lessów starszych i młodszych w profilu Wożuczyn (Polska SE)

Условия и процессы накопления лессов древних и молодых в разрезе Вожучин (ЮВ Польша)

ABSTRACT

Loess facies and horizons of pedogenesis were determined on the basis of analyses of the grain-size, heavy minerals, microelements and chemical composition. The results were discussed from the point of view of the conditions and the course of sedimentation. The alimentation sources of the loess material were found to be of local character. Material from bedrocks, mainly cretaceous marl, predominates in older loesses, whereas that from quaternary sediments in younger loesses.

The Wożuczyn profile, besides the profiles at Nieledew (J. E. Mojski 1965, H. Maruszczak 1985) and at Ratyczów (J. Buraczyński et al. 1978), can be considered as representative for older loesses of SE Poland. It is characterized by the occurrence of numerous fossil soils, horizons of cryogenic structures and lithologically differentiated layers.

The loesses at Wożuczyn reach a thickness of 16 m and, in respect of chronostratigraphy, comprise older loesses from the Saalian (Riss) and

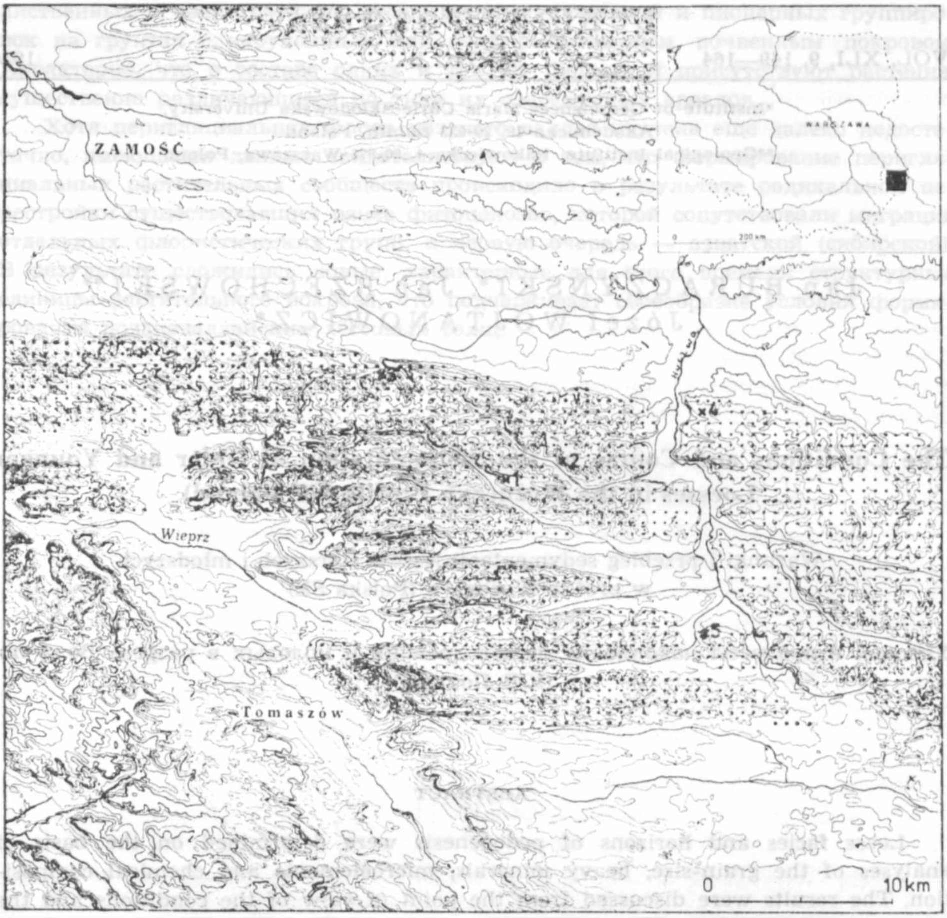


Fig. 1. Distribution of the loess cover of the western part of the Grzęda Sokalska Plateau
Loess profiles: 1 — Wożuczyn; 2 — Czartowczyk; 3 — Komarów; 4 — Tyszowce; 5 — Ratyczów

younger loesses from the Vistulian (Würm) glaciation. The stratigraphy was presented more closely elsewhere (J. B u r a c z y ń s k i et al. 1987). In this paper the conditions and course of sedimentation are analysed on the basis of a detailed analysis of the lithological properties: grain-size composition, carbonate ($CaCO_3$) and humus content (Fig. 3), heavy minerals in fraction 0.1—0.05 mm (Fig. 4) and chemical composition and microelements (Fig. 5).

The results of grain-size analyses were converted to the parameters Mz, σ_1, Sk_I and K_G in phi scale according to the formulae presented by R. L. F o l k and W. C. W a r d (1957). The analysis of heavy minerals was made by Dr. K. Radlicz from the Geological Institute in Warsaw.

The chemical analysis was carried out by D. Portka in the Department of Physical Geography, Maria Curie-Skłodowska University in Lublin. Microelements were determined spectrally in the Central Chemical Laboratory of the Geological Institute in Warsaw. Thermoluminescence

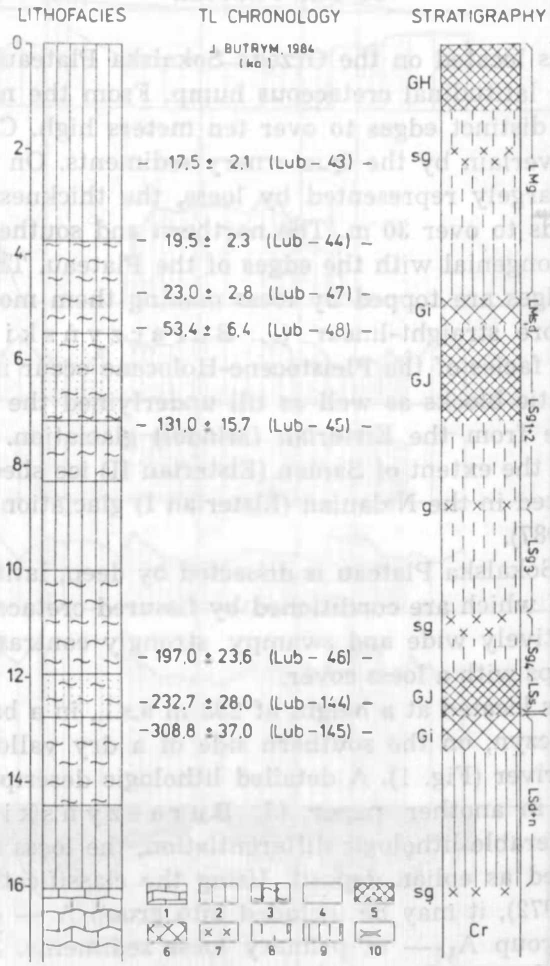


Fig. 2. Lithologic and stratigraphic scheme of the loess profile at Wożuczyn 1 — cretaceous marl; 2 — niveo-eolian loess; 3 — solifluction loess; 4 — layers distinctly transformed by pedogenesis; 5 — interglacial soils; 6 — interstadial soils; 7 — soil sediments and poorly developed interstadial soils; 8 — nonweathered, carbonate loess; 9 — weathered, carbonate-free loess; 10 — main hiatus (gap) amidst stratigraphic units of profile. Stratigraphic units of loess: L — loess, M — younger, S — older, g — upper, s — middle, d — lower, n — lowest. Soil units: G — soil with well developed genetic horizons, H — recent (Holocene) soil, J — interglacial soil, i — interstadial soil, sg — soil sediments, g — symptoms of the development of pedogenesis

analysis (TL) was performed by Dr. J. Butrym in the Department of Physical Geography, Maria Curie-Skłodowska University in Lublin.

GELOGIC-GEOMORPHOLOGICAL CONDITIONS AND DESCRIPTION OF THE PROFILE

The profile is located on the Grzęda Sokalska Plateau in its western part, which is a latitudinal cretaceous hump. From the north and south it is limited by distinct edges to over ten meters high. Cretaceous marl and chalk are overlain by the Quaternary sediments. On interfluves the Quaternary is largely represented by loess, the thickness of which increases eastwards to over 30 m. The northern and southern limit of the loess extent is congenial with the edges of the Plateau. The old, Neogen-Eopleistocen edges are topped by loess making them more distinct and their course more straight-linear (J. Buraczyński et al. 1983). Various alluvial facies of the Pleistocene-Holocene occur in river valleys. Gravel and erratic blocks as well as till underlyined the loess on interfluves; they are from the Elsterian (Mindel) glaciation. The discussed area was within the extent of Sanian (Elsterian II) ice sheet and it might also been glaciated in the Nidanian (Elsterian I) glaciation (M. Harasimiuk et al. 1987).

The Grzęda Sokalska Plateau is dissected by deep, latitudinal valleys, the directions of which are conditioned by fissured cretaceous rocks. The valleys are relatively wide and swampy, strongly contrasting with high intervalley humps with a loess cover.

The profile is located at a height of 233 m a.s.l., in a brickyard in the village of Wożuczyn, on the southern side of a dry valley in the basin of the Huczwa river (Fig. 1). A detailed lithologic description was given by the authors in another paper (J. Buraczyński et al. 1985). Despite a considerable lithologic differentiation, the loess at Wożuczyn is totally considered as eolian deposit. Using the classification of H. Maruszczak (1972), it may be included into group A — of proper loess sediments, subgroup A_1 — of primary loess sediments. H. Maruszczak has distinguished several genetic types (facies), which were formed in different sedimentation environments (subaerial and subaqueous) and in different geomorphological conditions (interfluve, slope and valley= =terrace loesses). In our loesses we distinguish niveo-eolian facies and solifluction facies of subaerial environment. Simplifying the division by using other classifications (J. Jersak 1976), the niveo-eolian facies can be distinguished as subaerial. It should be stressed that loess of solifluction facies is considered as that of eolian accumulation, with simultaneous syngenetic or post-sedimentation solifluction processes. The loess of soli-

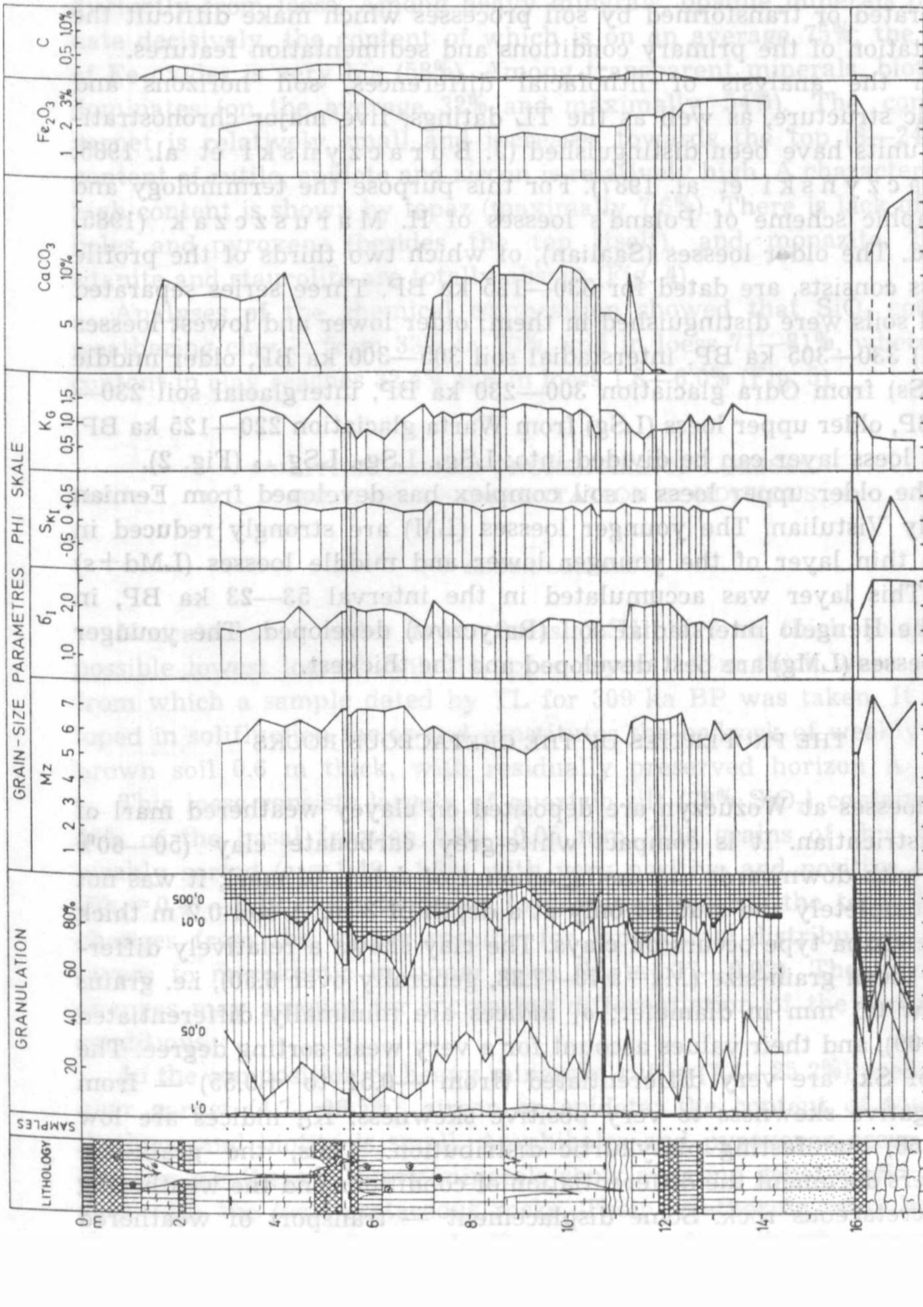


Fig. 3. Grain-size composition and parameters in phi scale, $CaCO_3$, Fe_2O_3, and humus contents in loess at Wożuczyn; Mz — mean diameter, σ_1 — graphic standart deviation, Sk_I — graphic skewness, K_G — graphic kurtosis, $CaCO_3$ — carbonate content, Fe_2O_3 — content of free iron in HCl, C — humus content

fluction facies shows distinct trace of frequently disturbed layering and streaking, specific for the periglacial conditions.

The texture of a considerable part of loess in the Wożuczyn profile is obliterated or transformed by soil processes which make difficult the interpretation of the primary conditions and sedimentation features.

From the analysis of lithofacial differences, soil horizons and cryogenic structure, as well as the TL datings, five major chronostratigraphic units have been distinguished (J. Buraczyński et al. 1985, J. Buraczyński et al. 1987). For this purpose the terminology and stratigraphic scheme of Poland's loesses of H. Maruszczak (1985) was used. The older loesses (Saalian), of which two thirds of the profile thickness consists, are dated for 330—125 ka BP. Three series separated by fossil soils were distinguished in them: older lower and lowest loesses (LSd+n) 330—305 ka BP, interstadial soil 305—300 ka BP, older middle loess (LSs) from Odra glaciation 300—230 ka BP, interglacial soil 230—220 ka BP, older upper loess (LSg) from Warta glaciation 220—125 ka BP. The last loess layer can be divided into: LSg_4, LSg_3, LSg_{1+2} (Fig. 2).

On the older upper loess a soil complex has developed from Eemian and early Vistulian. The younger loesses (LM) are strongly reduced in which a thin layer of the younger lower and middle loesses (LMd+s) occurs. This layer was accumulated in the interval 53—23 ka BP, in which the Hengelo interstadial soil (Ratyczów) developed. The younger upper loesses (LMg) are best developed and the thickest.

THE PROPERTIES OF THE CRETACEOUS ROCKS

The loesses at Wożuczyn are deposited on clayey weathered marl of the Maastrichtian. It is compact white-grey carbonate clay (50—60% $CaCO_3$), with downwards increasing amount of debris of marl; it was not drilled completely and studied only at a depth of 3 m. A soil 0.2 m thick of the rendzina type occurs on clays. The clay shows a relatively differentiated mean grain-size (Mz=5.78—7.38, generally over 6.50), i.e. grains are below 0.1 mm in diameter; σ_1 indices are minimally differentiated (2.00—2.09), and their values account for a very weak sorting degree. The values of Sk_I are very differentiated (from —0.51 to +0.55) — from very negative skewness to very positive skewness. K_G indices are low (0.49—0.68) manifesting platykurtic distribution. Thus, the grain-size parameters document the differentiation of conditions and the weathering rate of cretaceous rock. Some displacement — transport of weathered clayey rock on the slope cannot be excluded. A rendzina-like soil, as regards grain-size parameters, shows a big similarity to the overyling loess (Fig. 3). It seems that the similarity of the grain-size indices of the soil developed on weathered marl and loess results both from pedogenesis and soil enrichment by eolian silt.

In respect of mineralogical composition weathering clays differ distinctly from loess. Among heavy minerals, opaque minerals predominate decisively, the content of which is on an average 75%; the amount of Fe oxides is very big (58%). Among transparent minerals, biotite predominates (on the average 32% and maximally 54%). The content of garnet is relatively small and increases towards the top (8—24%). The content of rutile, epidote and zircon is relatively high. A characteristically high content is shown by topaz (maximally 7.6%). There is lack of amphiboles and pyroxene (besides the top itself), and monazite, brookite, titanite and staurolite are totally absent (Fig. 4).

Analyses of the chemical composition showed that SiO_2 content in weathering clay is from 33% to 70%, and in loess 71—81%, whereas CaO content in clay reaches 32.4% and in loess 1.8—6.0% (Fig. 5).

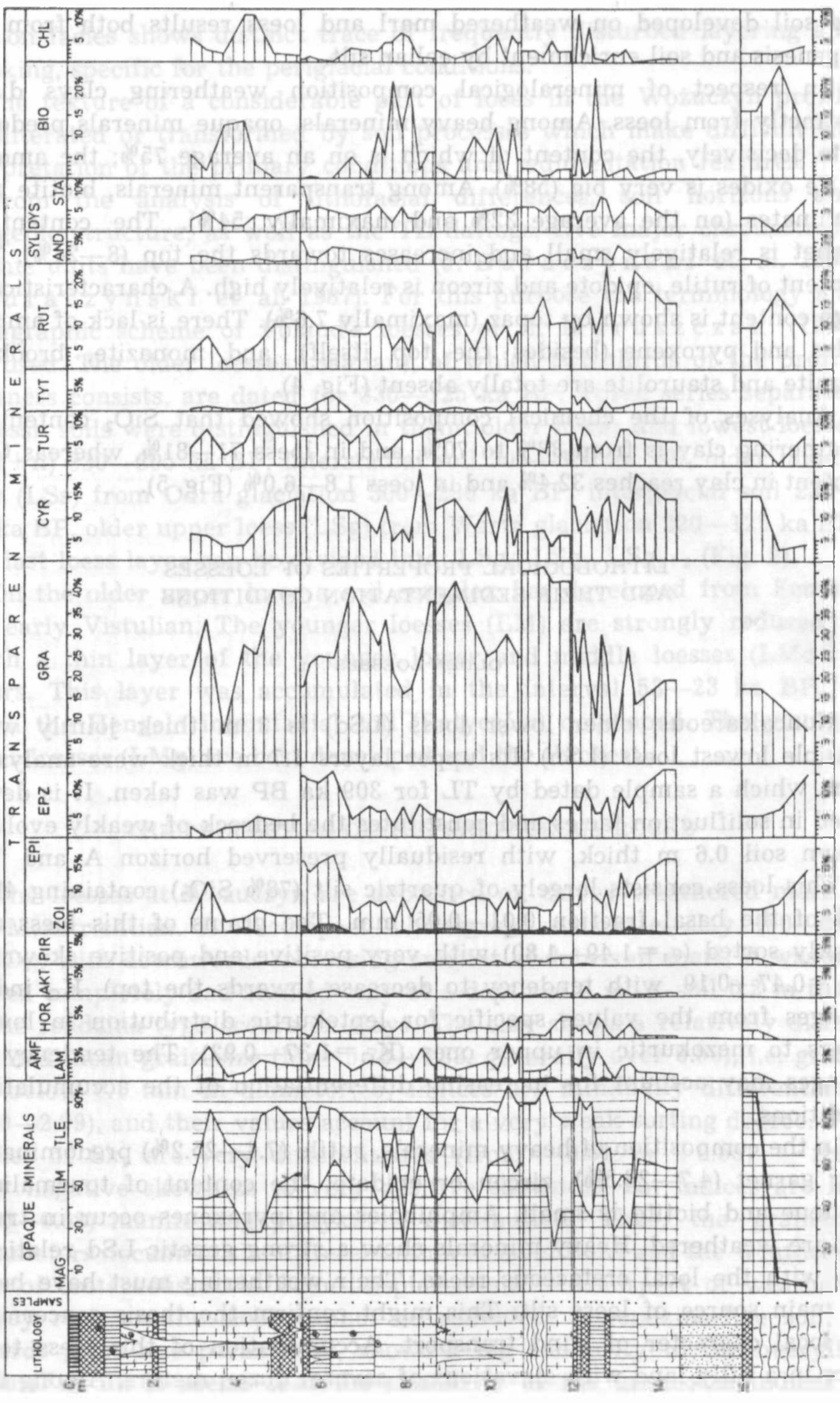
LITHOLOGICAL PROPERTIES OF LOESSES AND THEIR SEDIMENTATION CONDITIONS

OLDER LOESSES

Noncalcareous, older lower loess (LSd) is 3 m thick jointly with possible lowest loess (LSn). Its upper layers 1.7 m thick were analysed, from which a sample dated by TL for 309 ka BP was taken. It is developed in solifluction facies and constitutes the bedrock of weakly evolved brown soil 0.6 m thick, with residually preserved horizon A and (B).

This loess consists largely of quartzic silt (78% SiO_2) containing 41—66% of the basal fraction 0.01—0.05 mm. The grains of this loess are weakly sorted (σ_1 = 1.49—1.80) with very positive and positive skewness (Sk_I = 0.47—0.19, with tendency to decrease towards the top). K_G index changes from the values specific for leptokurtic distribution in lower layers to mezokurtic in upper ones (K_G = 1.37—0.92). The tendency of changes may account for increasing differentiation of the accumulation conditions.

In the composition of heavy minerals, rutile (7.4—25.2%) predominates over garnet (4.7—26.5%), zircon or epidote; the content of tourmaline, disthene and biotite is small. Amphiboles and pyroxenes occur in trace and are weathered. Heavy minerals show a strong genetic LSd relationship with the local cretaceous rocks. Their weathering must have been the main source of loess silt. This might confirm the thesis concerning the local character of wind transport. Accumulation of this loess took place in a hilly land with elevations of several dozen meters. Among the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superficial sediments weathered cretaceous rocks predominated. Quaternary sediments occurred only in residual patches on interfluves. Fluvial sands occurred in the valleys of the Huczwa river and its tributaries. Larger covers of Quaternary sediments occurred in depressions neighbouring from the north and south with the Grzęda Sokalska Plateau.

Older middle loess (LSs), noncalcareous, 1.5 m thick, was totally involved in soil processes. A sample from the middle layer was dated by TL for 233 ka BP. This loess represents only the youngest part of LSs. Fine silt (Mz=5.51—6.51) predominates in it with a distinct increase of clay fraction in the top. The index σ_I (1.55—2.01) are evidence of weak sorting. The weakest sorting is shown by the top layers — most strongly weathered. Sk_I indices (1.19—0.30) point to positive skewness, and the K_G (0.81—1.14) to mezokurtic distribution at the bottom, and platykurtic at the top. Flattening of the granulometric curves in the upper parts of the layer is also an evident result of pedogeneseis.

The association of heavy minerals is complex and very differentiated; medium resistant garnet predominates (10.7—32.6%) over resistant minerals (zircon, rutile, tourmaline) and little resistant epidote. The minerals are strongly weathered. An increased content of chlorite and biotite and maximal content of amphiboles can also be seen in the profile. Soil processes must have strongly changed the association of heavy minerals, which undoubtedly makes the reconstruction of the accumulation conditions difficult. However, it can be found that the influence of alimentation from the Quaternary covers becomes distinct, the evidence of which is a considerable content of garnet, amphiboles, pyroxene and epidote — distinctly higher than in the bedrock. Moreover, the influence of local rocks is also distinct, the evidence of which are biotite, zircon, rutile, tourmaline. In the content of microelements a great similarity between LSd and LSs can be seen.

It can be generally stated that in the period of LSs accumulation, cretaceous rocks were exposed on the surface in the environs of Wożuczyn, and they formed characteristic "windows" in discontinuous loess cover. A source of increased content of scandinavian material in loess

Fig. 4. Heavy minerals composition in fraction 0.05—0.1 mm in loess at Wożuczyn Opaque minerals: MAG — magnetite, ILM — ilmenite, TLE — oxides Fe and Mn. Transparent minerals: AMF — amphibole, LAM — lamprobolite, HOR — hornblende, AKT — actinolite, PIR — pyroxene, EPI — epidote, ZOI — zoisite, GRA — garnet, CYR — zircon, TUR — tourmaline, TYT — titanit, RUT — rutile, SYL — silimanite, AND — andalusite, DYS — disthene, STA — staurolite, BIO — biotite, CHL — chlorite

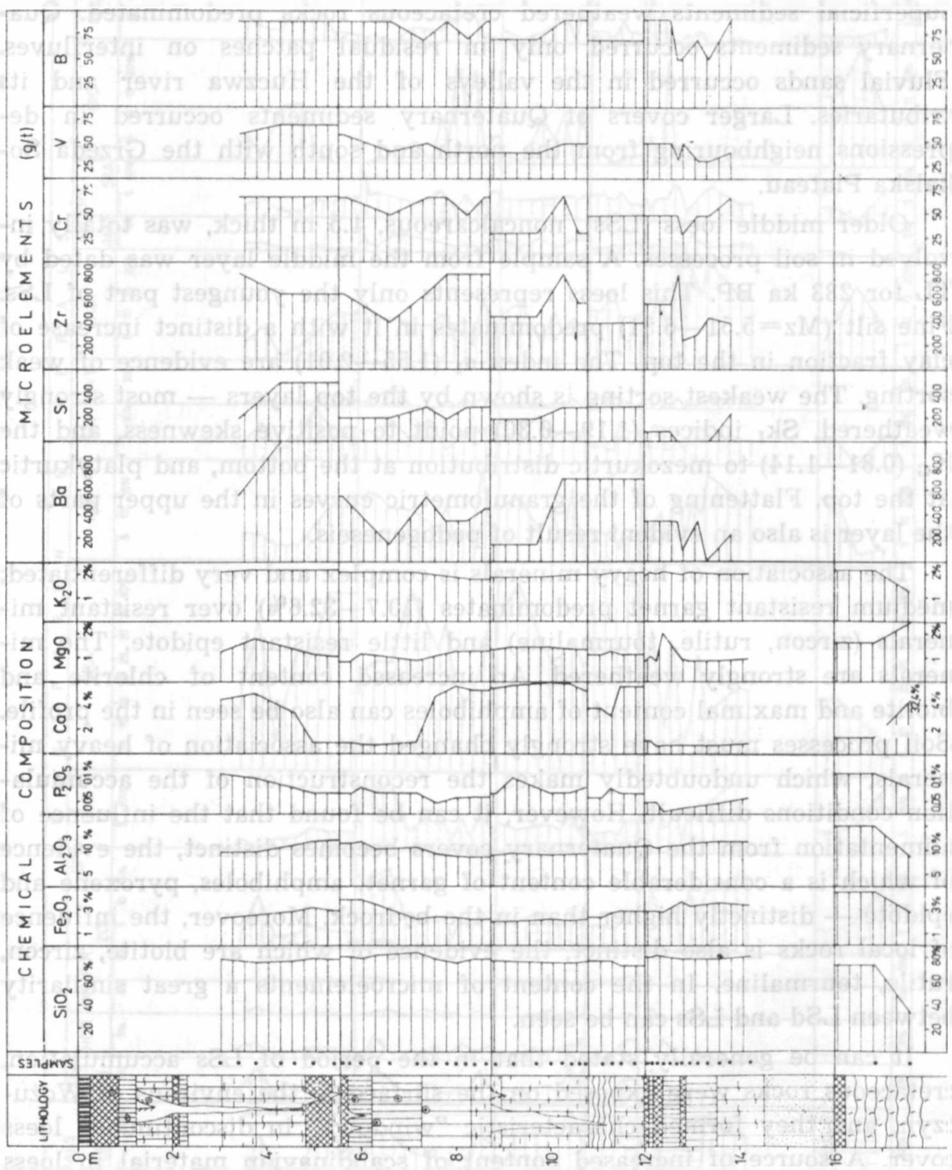

Fig. 5. Chemical composition and microelements of loess at Wożuczyn

silt could have been various sediments from Odra ice sheet, the maximal extent of which was about 50 km north of the Wożuczyn profile (M. H a r a s i m i u k et al. 1987).

Older upper loess (LSg) is of the greatest thickness (6.1 m), calcareous, except for the upper part involved in pedogenesis in the Eemian

Interglacial. A sample from the bottom layer was dated by TL for 197 ka BP, and from the top layer for 131 ka BP. This loess is distinctly divided into three parts separated by horizons showing pedogenesis.

In the lower part, i.e. LSg_4, it is gleyed loess of solifluction facies, distinctly streaky. It is overlain by developed pseudogley tundra soil with humus streaks. This loess is distinguished by high Mz indices (6.34—6.57), a distinctly increased content of clay fraction and by a very weak sorting (σ_1=1.96—2.04). In the soil developed on it grains are distinctly larger (Mz=5.42—5.81) and better sorted (σ_1=1.59—1.69). In solifluction loess, K_G indices (0.62—0.84) point to platykurtic, and in tundra soil (K_G= =1.04—1.46) to meso- and leptokurtic distribution. Index Sk_I (0.20—0.36) is little differentiated, fringing upon positive and very positive skewness. The grain-size parameters in the upper part of loess should be attributed to real changes of the sedimentation conditions before the soil developed. This is connected with the climatic change, increasing drought and continentalism mark, and with the change of loess facies — from solifluction to niveo-eolian. Then, this is folowed by warming up and humidity of the climate and formation of a weakly developed soil, which affected the inconsiderable change of the features of loess.

Among heavy minerals in LSg_4, garnet (42.1—46.2%, maximum for the whole profile) decisively predominates over rutile (9.8—17.1%), zircon, epidote and tourmaline. Such minerals as amphiboles, pyroxenes and epidotes are found weathered to greater extent in solifluction loess than in the soil. This confirms the opinion about a bigger role of changed sedimentation conditions than of the effect of pedognesis in this concrete case. The analysis of heavy minerals also allows the stating that the participation of the alimentation material of the local bedrock was still considerable here.

The LSg_3 layers are much thicker, probably without bigger stratigraphic breaks. They end in a distinct horizon of cryogenic structures with ice wedge casts and very weakly marked gley soil. The loess is developed in two facies: solifluction at the bottom and niveo-eolian at the top. The differences in the material of both facies are big, and those in grain-size parameters almost inconspicuous. The mean grain-size (Mz= =4.95—5.92) with a very distinct predominance of the basal fraction (45—61%), and only in the floor itself a distinct increase of clay fraction is observed. Sorting is weak (σ_1=1.43—1.73). Sk_I indices (0.11—0.38) are in the interval of positive skewness, and K_G indices (0.75—1.34) testify the passing from platykurtic to leptokurtic distributions, which may point to "upwards" stabilization of the dynamic sedimentation conditions.

Differences between both LSg_3 facies are more distinct in the composition of heavy minerals. In solifluction loess garnet (24—30%) predominates over biotite (0—27%). Other minerals reach small values and occur alternately. However, garnet (24—42%) predominates always distinctly in niveo-eolian facies; zircon and rutile generally come second.

The most upper part of older upper loesses, i.e. LSg_{I+2}, consists of niveo-eolian loess at the bottom, of overlying solifluction loess. Niveo--eolian loess is of the same facies as that of LSg_3. It is characterized by the lowest Mz values (5.17—5.37) in the profie, i.e. by relatively coarsest grains, as well as by one of the smallest σ_1 indices (1.46—1.47), which testifies a better sorting than that in the horizons discussed. Sk_I indices (0.17—0.26) are in the positive skewness, whereas K_G values (1.26—1.29) in the leptokurtic interval. In the overlying solifluction facies, a small reduction of the Mz values (5.25—6.16) and deterioration of σ_1 indices (1.55—2.08) are observed. An increase of Sk_I value (0.21—0.38) and a decrease of K_G index (1.01—1.33) indicate more differentiated dynamic sedimentation conditions.

An increased content of fraction below 0.002 mm can be observed in the most upper layers of LSg within the range of interglacial Eemian soil. Mz index increases here to 6.47—6.87, which corresponds to the grain-size a little below 0.01 mm; sorting index (σ_1 = 1.77—1.96) is worse than in solifluction loess. A distinct flattening of the grain-size curves occurred, which is reported by lower values of Sk_I (0.14—0.33) and K_G (0.58—1.03). This gives evidence of the fact that pedogenesis occurred very clearly.

The mineralogical composition also points to change in facies and pedogenic transformation within LSg_{I+2}. In niveo-eolian facies garnet (24.2—38.4%) predominates over zircon and rutile or biotite, tourmaline and rutile. Increased content of the minerals of metamorphic rocks points to increased content of the material of glacial origin. In solifluction facies biotite (22.0—46.3%) decisively predominates over garnet and chlorite in the lower part. In the upper part garnet (27.2—33.6%) precedes biotite, zircon and rutile. Amphiboles and epidotes are almost totally weathered. In the soil except the top, garnet (22.9—41.6%) distinctly predominates over epidote (15% — maximum content in profile) and over zircone and rutile. We also find here maximum content of staurolite, andaluzite, apatite, hipersten and titanite. The mineralogical composition of LSg_{I+2} shows the predominance of alimentation from the glacial material.

YOUNGER LOESSES

Younger lower and middle loess (LMd+s) is reduced to 0.7 m, gleyed and deformed in respect to solifluction, totally affected by interstadial pedogenesis. It is decalficied; only in the top secondary carbonates are found. Soil processes are testified by a considerable humus content (0.34—0.41%). From the floor part a sample dated by the TL method for 53 ka BP was taken. A small thickness of the layer do not give grounds for reconstruction of the sedimentation conditions. It can only be noted that all heavy minerals points to the predominance of alimentation from sediments of glacial origin.

Younger upper loess (LMg) is calcareous, its thickness reaches 5 m and shows a big lithologic-stratigraphic differentiation, which is characteristic for the last main cold phase of Vistulian (J. Buraczyński et al. 1987). The older layers from the interval 23—17 ka BP were only analysed. Solifluction and niveo-eolian fractions were subsequently separated; the age boundary between them falls to 19 ka BP.

The solifluction facies is distinctly streaky with signs of gleyization and cryogenesis. It is characterized by a relatively fine grain ($Mz = 6.00$—6.32) and weak sorting ($\sigma_1 = 1.58$—1.97), distinctly increasing upwards. Sk_I index (0.20—0.27) is little differentiated, and K_G are very differentiated (0.80—1.28) increasing upwards and pointing to the transition from platykurtic to leptokurtic distribution. Thus, the accumulation conditions must have been more homogeneous upwards. This was connected with periglacial climate, initially humid, was more and more dry and frosty, the consequence of which solifluction was weak and pedogenic processes were abating. Among the heavy minerals garnet (6.1—27.4%) slightly predominate over biotite and chlorite. Amphiboles, epidotes and pyroxenes are weathered, particularly strongly in the top.

Niveo-eolian facies in the lower part was analysed, of yellow loess, still distinctly streaky, with content of Fe_2O_3 (2.0—2.3%) and of humus (0.17—0.22%) distinctly decreasing upwards. Silt is distinctly coarser, its size increases gradually ($Mz = 5.30$—5.43), which may account for increased velocity of the wind. It is distinctly better sorted ($\sigma_1 = 1.47$—1.51). Little variable indices Sk_I (0.20—0.37) and K_G (1.09—1.19) point to a homogeneous environment. The grain-size parameters given here can be considered as typical for subaerial loess of the main accumulation phase in the Vistulian period. Similar indices were also found for the Ratyczów profile (J. Buraczyński et al. 1978). Among the heavy minerals, garnet (18.6—33.7%) predominate over biotite and epidote. There is a larger amount of amphiboles and rutile than in the solifluction facies; amphiboles and epidotes are less weathered.

The source of the material for both facies of LMg were largely glacial sediments.

CONCLUSIONS

1. An analysis of heavy minerals allowed the character of the source of loess material to be determined in the particular stratigraphic horizons. For LSd, LSs, LSg_4 and LSg_3, the main silt source were calcareous weatherings of Cretaceous rock, whereas Quaternary deposits for the LSg_{1+2} and LM.

2. Local alimentation sources were of decisive significance, which were in the vicinity or at distance of several dozen kilometers. This results both from the analysis of the mineralogical composition and grain-size distribution. The content of the basal fraction (0.01—0.05 mm) usually exceeds 50%.

3. Two basic loess facies — solifluction and niveo-eolian — specific for the subaerial environment have been distinguished. These facies show a distinct difference in the mean values of grain-size indices: $Mz = 5.84 : 5.42$, $\sigma_1 = 1.72 : 1.54$, $Sk_I = 0.28 : 0.25$, $K_G = 1.08 : 1.25$. Solifluction facies has finer and more weakly sorted grains, higher Sk_I index and distinctly lower K_G index, which points to more differentiated dynamic sedimentation conditions. Solifluction facies contains more opaque minerals, more Fe oxides and little resistant minerals: biotite and chlorite. This indicates some difference of the sedimentation conditions and proceses.

4. Relatively significant changes in the properties of loesses occurred under the influence of pedogenesis. The soil from the Eemian Interglacial, developed on LSg_{1+2} and the soil from the Lublin Interglacial, developed on LSs are distinguished in this respect. Changes in grain-size are best characterized by the indices Mz (6.58 : 5.53) and σ_1 (1.97 : 1.64) for soil horizon and loesses on which they developed. Silt in soil horizon is finer and worse sorted. Because of differentiated parent material (different facies and stratigraphic horizon of loess), type and character of pedogenic processes, the direction of changes of the Sk_I and K_G indices is various. The same concerns heavy minerals, where changes caused by pedogenic processes are less significant.

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STRESZCZENIE

Profil lessowy cegielni we wsi Wożuczyn położony jest na wysokości 233 m n.p.m., na zboczu suchej dolinki w dorzeczu Huczwy, w zachodniej części Grzędy Sokalskiej. Występują tutaj lessy starsze ze zlodowacenia Saalian (Riss) i lessy młodsze ze zlodowacenia Vistulian (Würm) o ogólnej miąższości 16 m. Na podstawie datowań termoluminescencyjnych (J. Buraczyński et al. 1987) i w nawiązaniu do schematu stratygraficznego lessów polskich H. Maruszczaka (1985) dokonano szczegółowego podziału na jednostki litologiczno-stratygraficzne. Dla wybranych próbek lessów analizowano uziarnienie, zawartość węglanów i próchnicy, skład minerałów ciężkich we frakcji 0,1—0,05 mm oraz skład chemiczny i zawartość mikroelementów. Na podstawie wyników tych analiz określono charakterystyczne cechy materiału lessowego z poszczególnych poziomów stratygraficznych.

Dla lessów starszych najniższych, dolnych oraz środkowych główne źródło pyłu stanowiły węglanowe zwietrzeliny skał górnokredowych. Dla lessów starszych górnych i lessów młodszych głównym źródłem były utwory czwartorzędowe. Decydujące znaczenie miały lokalne źródła alimentacji, znajdujące się w sąsiedztwie lub w odległości do kilkudziesięciu kilometrów. Wynika to zarówno z analizy składu mineralnego, jak i uziarnienia; udział podstawowej frakcji pylastej (0,05—0,01 mm) przekracza zwykle 50%.

W profilu wyróżniono dwie facje lessu subaeralnego: soliflukcyjną i niveo-eoliczną. Facje te różnią się średnimi wielkościami wskaźników uziarnienia Mz 5,84 : 5,42, σ_1 1,72 : 1,54, Sk_I 0,29 : 0,25, K_G 1,08 : 1,25. Less soliflukcyjny ma drobniejsze i słabiej wysortowane ziarno, wyższy wskaźnik Sk_I i wyraźnie niższy wskaźnik K_G, co wskazuje na bardziej zróżnicowane warunki dynamiczne sedymentacji. Zawiera on więcej minerałów nieprzezroczystych, więcej tlenków Fe oraz minerałów mało odpornych: biotytu i chlorytu. Less facji niveo-eolicznej ma grubsze

i lepiej wysortowane ziarno oraz charakteryzuje się wyższą zawartością minerałów odpornych (cyrkon, rutyl), a także wyższą średnią zawartością granatu.

Dość istotne zmiany właściwości lessów następowały pod wpływem pedogenezy. Dotyczy to głównie dwóch gleb, z interglacjału eemskiego oraz lubelskiego. Poziomy glebowe, w porównaniu z macierzystym lessem, mają drobniejsze i gorzej wysortowane ziarno. W składzie mineralnym różnice są mniej czytelne i różnokierunkowe, co może być uwarunkowane znacznym zróżnicowaniem cech substratu glebowego.

РЕЗЮМЕ

Разрез лессов при кирпичном заводе в деревне Вожучин расположен на высоте 233 м н.у.м., в области склона сухой долины в бассейне реки Гучвы, в западной части Сокальской гряды. Открываются здесь лессы древние из рисского (Saalian) оледенения и лессы молодые из вюрмского (Vistulian) оледенения общей мощностью 16 м. На основании термолюминесцентных датировок (J. Buraczyński et al. 1987) и ссылаясь на схему стратиграфического деления лессов в Польше по Х. Марущаку (H. Maruszczak 1985), детально выделено литолого-стратиграфические горизонты (единицы). Для образцов избранных из этих горизонтов определялись: гранулометрический состав, содержание карбонатов и гумуса, состав тяжелых минералов во фракции зерна 0,1—0,05 мм, химический состав и содержание микроэлементов. На основании результатов этих исследований определено характерные свойства лессового материала из отдельных стратиграфических горизонтов.

Для лессов древних самих нижних, нижних и средних главный источник лессовой пыли составляли карбонатные элювии верхнемеловых местных пород. Для лессов древних верхних и лессов молодых главный источник пыли составляли четвертичные образования. Преобладали местные источники питания, из ближайшего соседства или расположенные на расстояниях до нескольких десятков километров. Это вытекает из анализы тяжелых минералов, а тоже гранулометрических признаков; содержание основной для лессов фракции пыли 0,05—0,01 мм обыкновенно выше 50%.

В разрезе выделено две фации субаэрального лесса: солифлюкционную и нивально-эоловую. Эти фации отличаются средними величинами гранулометрических показателей как следует: Mz 5,84:5,42 ф, σ_I 1,72:1,54, Sk_I 0,29:0,25, K_G 1,08:1,25. Лесс солифлюкционный имеет мелчайшие и хуже отсортированные зерна, более высокий показатель Sk_I и резко меньший показатель K_G, что свидетельствует о более дифференцированных динамических условиях накопления. Содержит он большое количество непрозрачных тяжелых минералов, более окисей железа и более неустойчивых минералов: биотитов и хлоритов. Лесс нивально-эоловый имеет крупнейшие и лучше отсортированные зерна, содержит более устойчивых минералов (циркон, рутил) и в среднем повышенные количества гранатов.

Обнаружено существенные изменения свойств лесса под влиянием почвообразования. Это касается главным образом почвенных горизонтов из межледникового времени: последнего (Eemian) и предпоследнего (Lublinian=Odintsovian). Эти почвенные горизонты, в сравнении с материнскими лессовыми слоями, отличаются мелчайшими и хуже отсортированными зернами. Различия состава тяжелых минералов менее резкие и разнонаправленные, что вероятно обусловлено значительными различиями состава отдельных слоев лессовой основы.