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Stratigraphic and Paleogeographic Interpretation of Analysis Results of Magnetic Susceptibility of Loesses at Bojanice (NW Ukraine)*

Stratygraficzna i paleogeograficzna interpretacja wyników analiz podatności magnetycznej lessów w Bojanicach (Ukraina NW)

Abstract. A large exposure at Bojanice near Sokal represents one of the most complete sequences of loesses in the Volhynia Upland, NW Ukraine. Four interglacial intraloess soils and several significant soil horizons of a lower stratigraphic rank have been distinguished here. Studies of magnetic susceptibility (profile 24 m thick, from which samples were taken every 0.1 m) confirm that at Bojanice a good record of events in the three last glacial cycles of loess accumulation is available. They are also a basis for elucidation of some doubts concerning the soil representing the last but one interglacial.

Key words: loesses and paleosols, magnetostratigraphy, middle and upper Pleistocene, SE Poland, NW Ukraine.

Bojanice is located 9 km west from Sokal, in the southwest subregion of the Volhynia Upland, distinguished as Sokal Plateau-ridge. This

* Over the last years, the exposure at Bojanice was studied in cooperation with the Committees of Quaternary Studies of the Polish and Ukrainian Academy of Sciences (the subject: "Stratigraphic correlation of loesses and glacial deposits in SE Poland and NW Ukraine"). Studies in SE Poland territory could be carried out largely due to funds allocated by the Committee of Scientific Researches in Warsaw for the research project No 6.0577.91.01 (the subject: "Stratigraphy and paleogeographical conditions of the accumulation of loesses in Central Europe"; the head of the project — Prof. dr Henryk Maruszczak).

Plateau-ridge and the whole Volhynia Upland are covered with thick deposits of proper loess, in which a long time ago paleosols were found to occur. On the basis of paleosols criterion Lk. Sawicki (1932) carried out the first stratigraphic studies of loesses in Volhynia. After the war such studies were continued largely in the western part of the Volhynia Upland, which is now Poland's territory (A. Jahn 1956, J.E. Mojski 1965, H. Maruszczak 1974, J. Buraczyński and J. Wojtanowicz 1975). In the Ukrainian part of this region, stratigraphic studies of loesses were carried out by A. Bogucki (1972) in the seventies.

LITHOLOGIC-STRATIGRAPHIC STUDIES OF LOESSES AT BOJANICE

Loesses are exposed here in a big exposure from which raw material is exploited for a brick-kiln in Sokal. In the eastern part of this exposure the post-exploitation scarps reach a depth of 25 m. On them loess layers, in the sequence representative for the Volhynia Upland, are exposed with four soils of various ages of interglacial rank.

The exposure is about 230 m a.s.l., 1.5 km SW from the Bojanice village, on the east side of "Dębinki" forest. It is located in the zone of the western slope of the Bug river gorge through the Sokal Plateau-ridge. This zone is dissected by the valleys of the Bród and Okopowa Dolina streams flowing into the Bug river 189–188 m a.s.l. The interfluve of Sokal Plateau-ridge rises up to 260–270 m a.s.l. in the surroundings. The relative relief is 50–60 m within a radius of 2 km from the exposure.

The description of the exposure is largely based on the documentation made by A. Bogucki in 1992. It was supplemented by the observations of H. Maruszczak recorded in 1993 when taking samples for paleomagnetic analyses. With regard to the lowest part of the exposure the results of studies carried out in 1994, connected with presentation of the profile during a Polish–Ukrainian field seminar, were also taken into consideration. The top of the exposure was determined for 230 m a.s.l., the depths and thickness of the layers are given in metres. The main stratigraphic units of loesses and the interglacial soils separating them have been determined according to A. Bogucki's scheme (1987, 1992). They were correlated with the corresponding units distinguished in the stratigraphy scheme of loesses in Poland (H. Maruszczak 1991). A graphical version of this correlation is presented in Fig. 2.

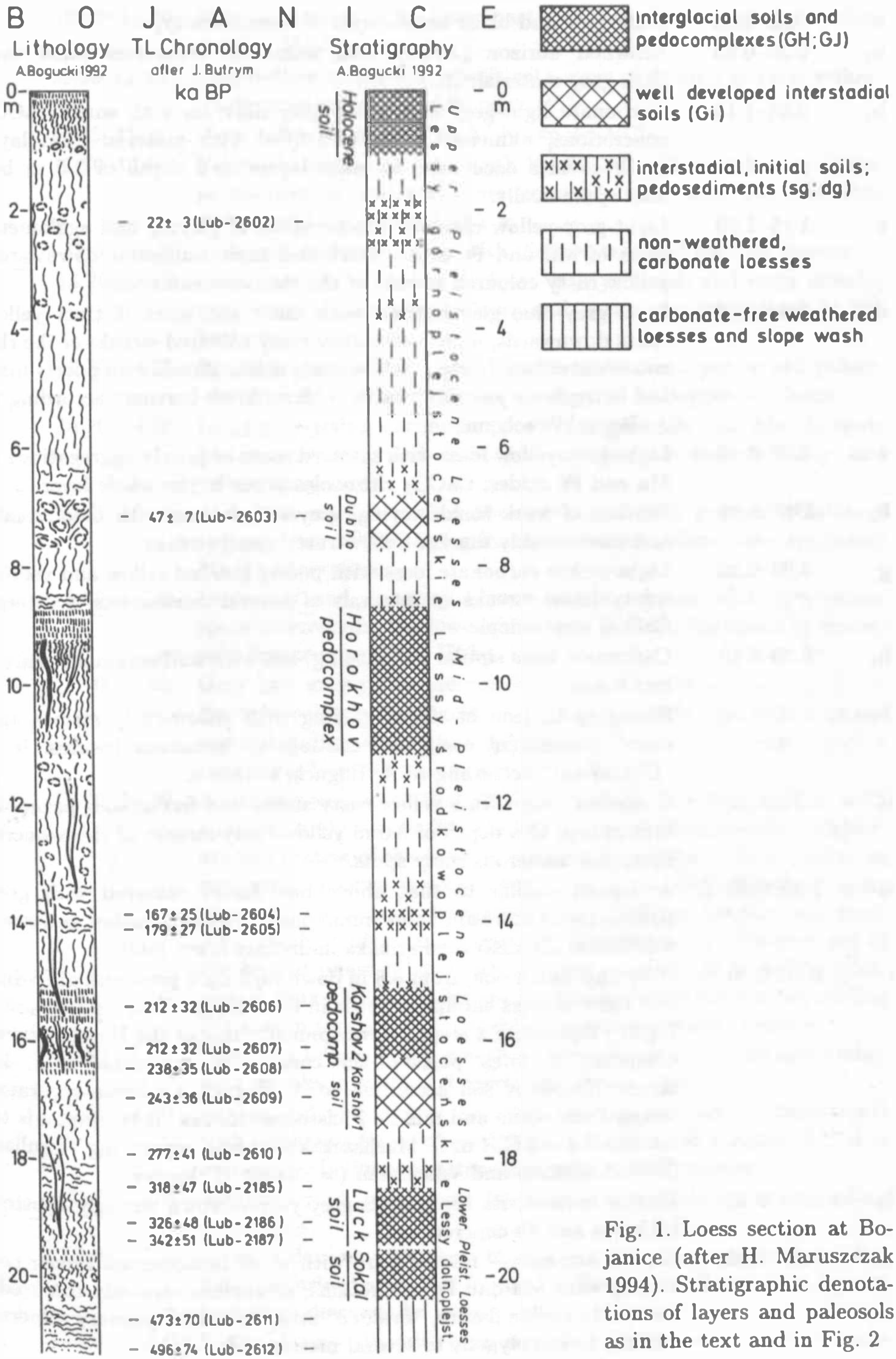


Fig. 1. Loess section at Bojanice (after H. Maruszczak 1994). Stratigraphic denotations of layers and paleosols as in the text and in Fig. 2

a	0.00–0.30	Dark-grey and black arable layer of chernozem type.
b_1	0.30–0.65	Browned horizon (A/B?) with numerous crotovines filled with dark-grey material; HCl–.
b_2	0.65–1.15	Carbonate light-grey and yellow-grey illuvium with small $CaCO_3$ concretions; numerous crotovines filled with material from layer a. Crotovines occur also in lower layers to a depth of 3.5 m but only sporadically.
c	1.15–1.80	Light-grey-yellow carbonate loess; spots of gleying and agglomerations of Mn and Fe oxides more and more numerous downwards; yellow-rusty coloured streaks of the rhizoconcentration.
d	1.80–2.70	Light-grey-blue gley horizon with more and more distinct yellow spots downwards; numerous yellow-rusty coloured streaks of the rhizoconcentration. In top a yellow-rusty colour streak with poorly marked ferruginous pseudofibres. It is "Krasilovsk horizon" according to A. Bogucki's scheme.
e	2.70–3.40	Light-grey-yellow loess with scatterd spots of poorly aggregations of Mn and Fe oxides; $CaCO_3$ rhizocoles occur in the whole layer.
f	3.40–3.90	Horizon of weak zonal gleying; grey-yellow loess with blue streaks and more weakly marked yellow-rusty small streaks.
g	3.90–6.20	Light-yellow carbonate loess with poorly marked yellow and yellow--rusty layers-streaks in intervals of several centimetres; scattered $CaCO_3$ concretions.
h_1	6.20–6.80	Carbonate loess similar to that in g, but with soliflunctionally disturbed layers.
h_2	6.80–7.70	Blue-grey horizon of strong gleying with yellow-rusty stripes and streaks; abundant carbonate coatings in numerous fissures. It is "Dubno soil" according to A. Bogucki's scheme.
i_1	7.70–8.40	Grey-dun loess with a yellow-rusty streak and ferruginous pseudofibres in top; to a depth of 8.0 m yellow-rusty streaks of rhizoconcretions and numerous rusty spots.
i_2	8.40–8.70	A deposit similar to that above but darker coloured with grey streaks-layers more and more numerous downwards; yellow and rusty soliflunctionally disturbed streaks; indistinct lower limit.
j	8.70–9.20	Grey humus horizon, from 8.8 m downward dark grey with grey-dun and rusty streaks similar to those in i_2; indistinct and uneven limit. Layer j represents a steppe development phase of the Horokhov soil complex. The forest phase of this complex is represented by k_1–k_4 layers. Horokhov soil according to A. Bogucki's scheme separates young-Pleistocene and middle-Pleistocene loesses. It corresponds to interglacial soil GJ1 in H. Maruszczak's scheme, separating Vistulian (= Weichselian) and Wartanian (= Saalian II) loesses.
k_1	9.20–9.40	Illuvial horizon; its top part is grey-yellow-brown strongly spotted with Mn and Fe concretions.
k_2	9.40–10.20	Illuvial horizon — middle part with most homogenous brown colouring with Mn and Fe concretions; crotovines variously coloured. Distinctly visible fissure, "braided" structures with primary mineral infilling form polygons to several metres wide.
k_3	10.20–10.40	Deposit as in k_2 but coloured lighter with grey-yellow spots.

k_4	10.40–11.20	Illuvial horizon; in its lower part with light-brown and grey-yellow streaks; Mn/Fe spots.
l_1	11.20–11.45	Grey-yellow-bluish silt deposit with signs of spotted gleying; yellow--rusty streaks in its middle part; HCl–.
l_2	11.45–11.70	Grey-yellowish deposit with blue spots; HCl–.
ł	11.70–12.50	Yellowish carbonate loess with light-blue, yellow and rusty spots; pseudomycelia and carbonate coatings in fissures; not numerous crotovines to a depth of 12.1 m.
m	12.50–13.20	Yellowish carbonate loess with distinct traces of spotted gleying.
n	13.20–13.70	Grey-blue gleyed carbonate loess with yellowish and rusty streaks; numerous Mn/Fe conctretions, and carbonate concretions in the bottom.
o	13.70–14.20	Bluish horizon of zonal gleying with streaks and yellow and yellow--rusty spots. "Tarnopol soil" according to A. Bogucki's scheme.
p_1	14.20–14.90	Light-grey-yellow carbonate loess with greenish tint; Mn/Fe spots and concretions, and from 14.5 m down numerous rusty and yellow-rusty spots.
p_2	14.90–15.10	A deposit similar to that above but with thin grey interbeddings coming from the soil lying lower; numerous yellow-rusty spots and Mn/Fe concretions.
r_1	15.10–15.70	Dark-grey and dun-grey humus horizon, darker with grey-yellow spots downwards; the lower limit very uneven, disrupted by numerous fissure structures; HCl–.
r_2	15.70–16.00	Grey and grey-yellow deposit with numerous Mn/Fe spots; HCl–. Numerous fissure structures — reaching also layer r_3 — with primary mineral infilling coming from layer r_1; these structures form polygons measuring from several decimetres to 2 m.
r_3	16.00–16.30	A deposit similar to that above but coloured a little lighter with a bigger number of Mn/Fe concretions; numerous crotovines. Carbonate-free matrix of the deposit, but pseudomycelia — more and more numerous downward occur. According to A. Bogucki r_1–r_3 layers represent the second development phase of the Korshov soil complex; the first phase is represented by layers s_1–s_2. Korshov soil of the second phase of this pedocomplex corresponds to soil of interglacial rank GJ2 according to H. Maruszczak's scheme, separating Wartanian (= Saalian II) and Odranian (= Saalian I) loesses.
s_1	16.30–16.55	Dun-grey humus horizon with numerous pseudomycelia and carbonate streaks in vertical fissures; Mn/Fe concretions.
s_2	16.55–17.50	Greish and grey-yellow browned horizon (carbonate illuviation?) with numerous forms of secondary carbonates; to a depth of 17.0 m numerous Mn/Fe concretions and yellow-rusty streaks.
t	17.50–17.70	Yellowish and yellow-grey loess with various forms of secondary carbonates.
u	17.70–18.00	Loessial deposit with signs of spotty gleying and secondary carbonates occuring in various forms; Mn/Fe concretions more and more numerous downwards.
w_1	18.0–18.2/18.5	Silty-loamy deposit with irregular streaks and grey-dun and blue-yellow lenses with scattered Mn/Fe concretions; soliflunctionally

		translocated material containing lenses of material from upper horizons of soil occuring lower.
w_2	18.20–18.50	A and Ae horizons of forest soil preserved in situ here and there, disturbed involutionally.
w_3	18.50–19.50	Illuvial horizon of forest soil, in top brown, downwards lighter and lighter yellow-brown-rusty; Mn/Fe concretions and spots. Layers w_1–w_3 represent Luck soil according to A. Bogucki's scheme, separating middle and lower Pleistocene loesses. According to H. Maruszczak's scheme it corresponds to interglacial soil GJ3a (= Zbojnian = Dömnitz Warm Stage = Schöningen?), separating Odranian and Liwiecian (= pre-Saalian) loesses.
x_1	19.50–19.70	Humus and eluvial horizon (A and Ae) of forest soil greyish and in bottom white-greyish; Mn/Fe concretions and spots. Scattered gravels of Scandinavian rocks occur in places.
x_2	19.70–20.40	Brown and brown-olive illuvial horizon, yellow-brown downwards; signs of spotted gleying and more and more numerous Mn/Fe concretions downwards. Gravels and boulders of Scandinavian rocks occur, forming pavement in places. Layers x_1–x_2 in A. Bogucki's scheme represent Sokal soil. According to H. Maruszczak's scheme it corresponds to interglacial soil GJ3b (= Mazovian = Holsteinian) separating Liwiecian and Sanian (= Elsterian) loesses.
y_1	20.40–21.60	Olive-brown loamy, stratified loess-like deposit with gleying spots; relatively numerous Mn/Fe spots. In some interbeddings a distinct admixture of sand and, sporadically, gravels of Scandinavian rocks.
y_2	21.60–21.90	A deposit similar to that above but with a considerable admixture of gravels and fragments of local upper Cretaceous rocks.
y_3	21.90–22.00	Yellow brown sandy-loamy deposit with brown-rusty streaks.
y_4	22.00–22.40	Sands and sands with flint gravels; brown loamy-sandy interbeddings.
z	22.40–24.10	Silts and loamy subhorizontally stratified silts, olive-dun in top and light-grey-olive in bottom.

The comparison of the stratigraphic units presented in the description of the profile with those distinguished in Poland was made on the basis of an analysis of paleosols and the results of datings by the TL method. A detailed motivation of this comparison was given by H. Maruszczak (1994). Doubts may be caused by the suggestion that the second development phase of the Korshov soil complex corresponds to soil of interglacial rank. In the Bojanice profile signs of meadow-sod pedogenesis predominate. Comparative analysis of coeval intraloess soils from Poland's territory indicates that at Bojanice this process developed after the degradation phase of brown forest soil (grey-brown podzolic soil?). In Poland such forest soils have been preserved almost intergrally in some profiles (e.g. Łopatki, Orzechowce). However, in other they have been degraded (decapitated) to a similar extent

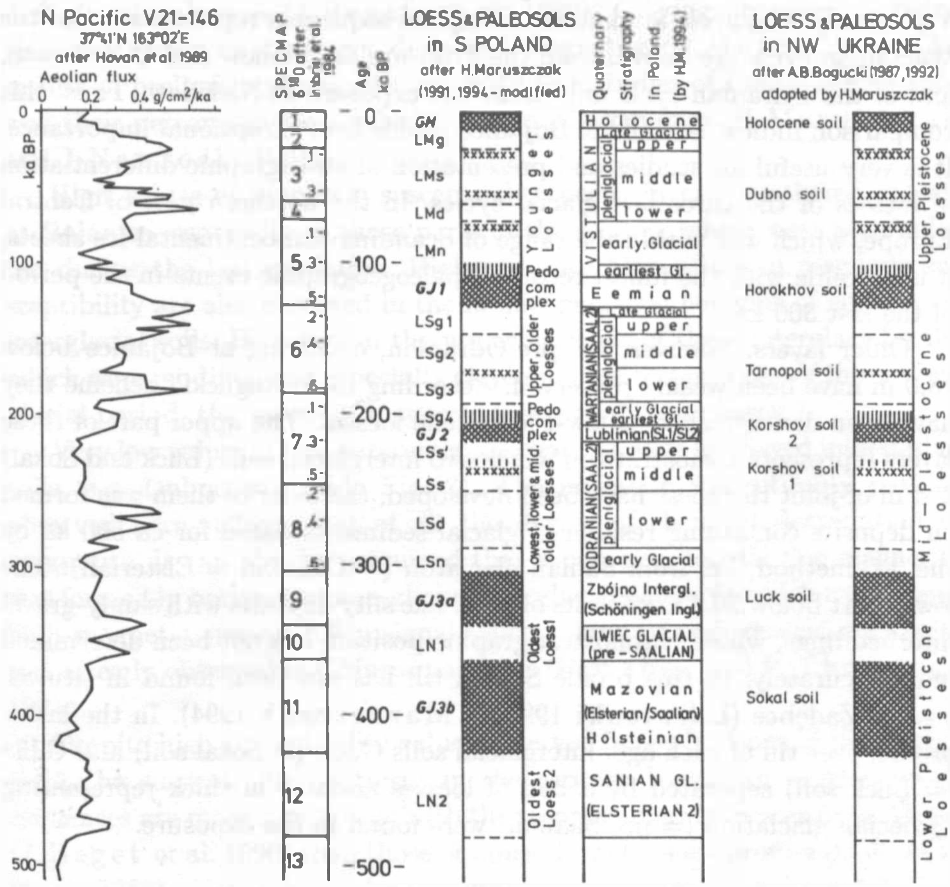


Fig. 2. Global cycles of eolian accumulation during the last 500 ka and chronostratigraphy of loesses in S Poland and NW Ukraine; a — changes in concentration of dust of continental origin in marine deposits of the northern Pacific (after S.A. Hovan et al. 1989); b — oxygen-isotope stages of marine deposits (after J. Imbrie et al. 1984); c_1 — chronostratigraphy of loesses and paleosols in S Poland (after H. Maruszczak 1991, 1994 — adequately modified); c_2 — Quaternary stratigraphy in Poland (by H. Maruszczak 1994); d — chronostratigraphy of loesses and paleosols in NW Ukraine (after A. Bogucki 1987, 1992 — adapted by H. Maruszczak)

or a little less than at Bojanice before the phase when humus sod horizon was overlaid (H. Maruszczak 1987, 1991, 1995).

From the above comments it can be concluded that at Bojanice almost complete profiles of loesses of the last glacial cycles, distinctly separated by soils of interglacial rank, have been preserved. In the territory of Poland no profiles are known with such well-preserved records of events of the last 300 ka. Of course numerous profiles representing records of events in the last, i.e. Vistulian glacial cycle are known. Complete sequences representative of the Wartanian cycle are known from the exposure at Odonów and Orzechowce, and of the Odranian cycle only from one exposure at Nieledew. Thus, this comparison indicates that the Bojanice profile is of exceptional importance. It is very useful for studies and presentation of stratigraphic differentiation of loesses of the three last glacial cycles. In the northern part of Central Europe, which was within the range of Scandinavian continental ice sheets, it is a profile with the fullest record of paleogeographic events in the period of the last 300 ka.

Older layers, however, i.e. pre-Odranian, occurring at Bojanice below 18.0 m have been weakly preserved. According to A. Bogucki's scheme they have been distingiushed as low-Pleistocene loesses. The upper part of these layers represents a substrate on which two interglacial soils (Luck and Sokal) 2–4 m of joint thickness have been developed; the older of them was formed on deposits containing residua of glacial sediments dated for ca 500 ka by the TL method, i.e. from Sanian glaciaton (= Okanian = Elsterian). The lower part below 20.4 m consists of loess-like silty deposits with sandy-gravel interbeddings, whose chronostratigraphic position has not been determined more accurately. In this profile Sanian till has not been found in situ as, e.g., at Zadębce (L. Dolecki 1995, H. Maruszczak 1994). In the latter profile, over till of such age, interglacial soils GJ3b (= Sokal soil) and GJ3a (= Luck soil) separated by a bed of loesses about 4 m thick representing Liwiecian glaciation (= pre-Saalian) were found in the exposure.

METHOD AND RESULTS OF MAGNETIC SUSCEPTIBILITY ANALYSIS

The Bojanice section was sampled at 10 cm intervals only for magnetic susceptibility analysis. The low-field susceptibility was determined using a KLY-2 susceptibility brigde. The magnetic susceptibility graphs obtained for the investigated section are presented in Fig. 3.

The concentration of magnetic minerals in the sedimant may be reflected by low-field magnetic susceptibility values. In some sedimentary rocks the distribution of magnetic suscepibility carriers depended on the climatic conditions in which they were deposited. Thus magnetic susceptibility may serve as a paleoclimatic indicator. Such a situation is observed in marine and lacustrine sediments (R. Thompson and F. Oldfield 1986, N. Thouveny et al. 1994), and particularly in loess-paleosol sequences.

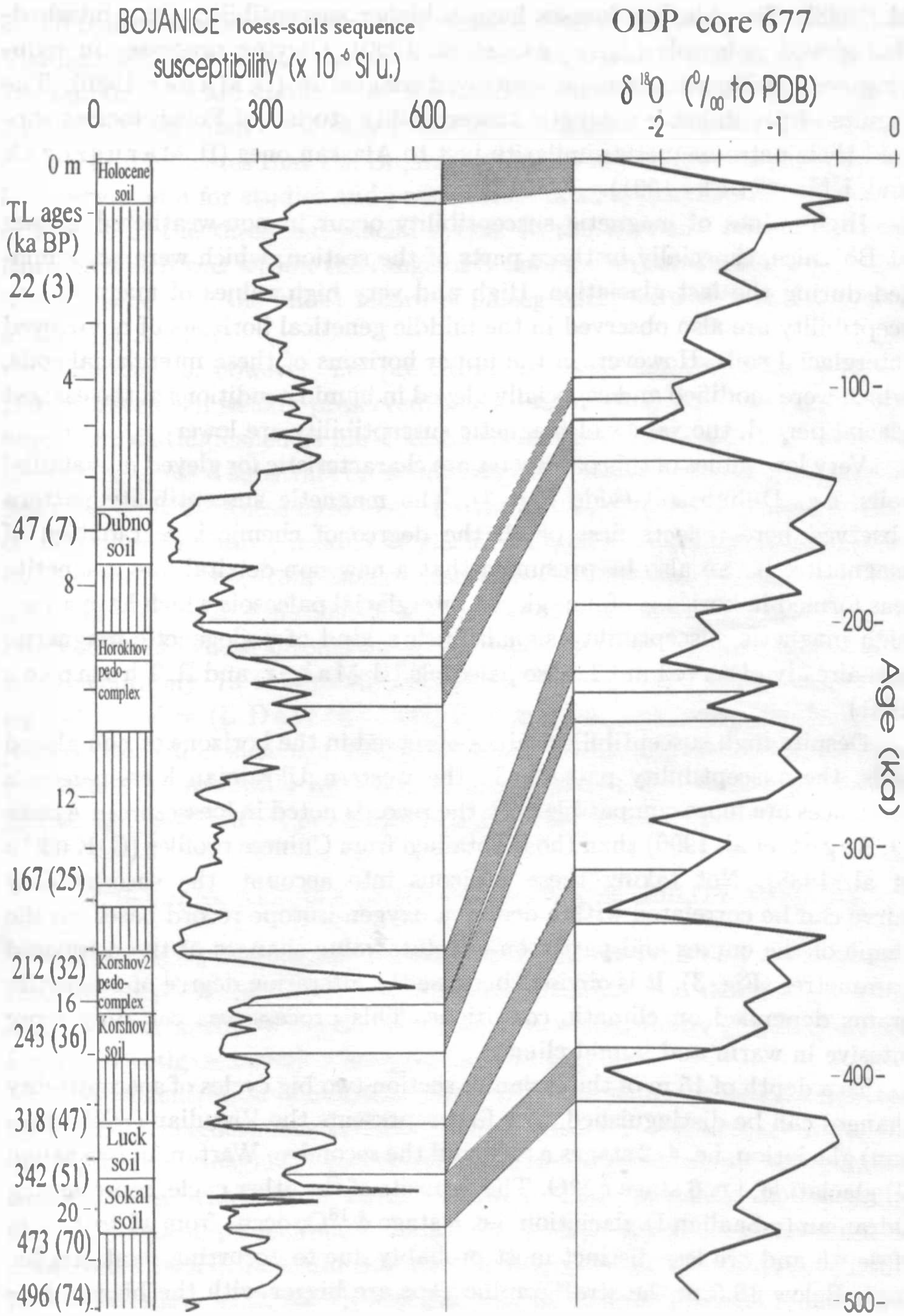
In Chinese loess-paleosol profiles soils have a distinctly higher susceptibility than loess (F. Heller and Liu Tungsheg 1986, G. Kukla et al. 1988). The Alaskan loesses have a higher susceptibility than interbedded gleyed paleosols (J. Beget et al. 1990). Gleying processes in reducing weathering environment destroyed magnetite (B. Maher 1986). The results of preliminary magnetic susceptibility studies of Polish loesses showed their petromagnetic similarity just to Alaskan ones (H. Maruszczak and J. Nawrocki 1991).

High values of magnetic susceptibility occur in non-weathered loesses at Bojanice, especially in those parts of the section, which were accumulated during the last glaciation. High and very high values of magnetic susceptibility are also observed in the middle genetical horizons of non-gleyed interglacial soils. However, in the upper horizons of these interglacial soils, which were modified and especially gleyed in humid conditions of the earliest glacial period, the values of magnetic susceptibility are lower.

Very low values of this parameter are characteristic for gleyed interstadial soils, e.g. Dubno soil (vide Fig. 3). The magnetic susceptibility pattern observed here reflects first of all the degree of chemical degradation of magnetite. It can also be presumed that a new non-detrital fine magnetite was formed in horizons of non-gleyed interglacial paleosols which have a very high magnetic susceptibility signal. Such a kind of pedogenetic magnetite was already observed in Chinese paleosols (B. Maher and R. Thompson 1991).

Despite high susceptibility values observed in the horizons of non-gleyed soils, the susceptibility patterns in the western Ukrainian loess-paleosols sequences are more compatible with the records noted in loesses from Alaska (J. Beget et al. 1990) than those obtained from Chinese profiles (G. Kukla et al. 1988). Not taking these horizons into account, the susceptibility curve can be correlated with a deep-sea oxygen-isotope record based on the shape of the curves and partly on absolute value changes of the compared parametres (Fig. 3). It is obvious because the alteration degree of magnetite grains depended on climatic conditions. This process was certainly more intesive in warm and humid climate.

To a depth of 15 m of the Bojanice section two big cycles of susceptibility changes can be distinguished. The first represents the Vistulian (=Weichselian) glaciation, i.e. 4–2 stages $\delta\ ^{18}O$, and the second — Wartanian (=Saalian II) glaciation, i.e. 6 stage $\delta\ ^{18}O$. The deposits of the other cycle, representing Odranian (=Saalian I) glaciation, i.e. 8 stage $\delta\ ^{18}O$, occur from 15 to 18.5 m of depth and are less distinct most probably due to occurring stratigraphic gaps. Below 18.5 m the stratigraphic gaps are bigger with the biggest hiatus at ca 19.5 m corresponding to Liwiecian (=pre-Saalian) glaciation, i.e. 10 stage $\delta\ ^{18}O$. However, below 20.5 m no loess occurs, but only redeposi-


BOJANICE loess-soils sequence
susceptibility (x 10⁻⁶ SI u.)
0
300
600
ODP core 677
δ18O (‰ to PDB)
-2
-1
0
0 m
TL ages (ka BP)
22 (3)
4
47 (7)
8
12
167 (25)
212 (32)
16
243 (36)
318 (47)
342 (51)
20
473 (70)
496 (74)
Holocene soil
Dubno soil
Horokhov pedo-complex
Korshov2 pedo-complex
Korshov1 soil
Luck soil
Sokal soil
-100-
-200-
-300-
-400-
-500-
Age (ka)

ted degraded till (Sanian=Okanian=Elsterian) and other older deposits are found.

Volhynian loess-paleosol sequences were accumulated after Brunhes/ Matuyama polarity transition. Thus, this very important paleomagnetic horizon can not be used for chronostratigraphic linking of the investigated sections. On the other hand, the geological age of underlying Elsterian till residuum, pedostratigraphic features and additional TL dating results can serve as control points of correlation between magnetic susceptibility and oxygen-isotope curves.

CONCLUSIONS

1. The analysis results of magnetic susceptibility are convergent with the geological interpretation of the loess profile at Bojanice. They have confirmed the fact that layers from three glacial cycles of loess accumulation have been well presented here. The first and second cycle, representing the last and last but one glaciation, are characterized by a distinct tendency of magnetic susceptibility to change. The susceptibility curve in both cycles is similar to that in Chinese loesses. More significant differences are observed in layers which at Bojanice underwent epigenetic gleying. These differences allow us to suggest that from paleomagnetic point of view Volhynian loesses show a kind of intermediate features between Chinese and Alaskan ones.

2. Loesses representing the second and third glacial cycles are characterized by a considerable thickness and can serve for comparative studies of Chinese loesses having been investigated paleomagnetically in detail. It seems that it would be difficult to find for such studies better profiles in Central and West Europe. As regards periglacial loesses from the last glacial cycle the profile at Bojanice is certainly more suitable than that at Achenheim. The results of magnetic susceptibility analyses of loesses at Achenheim published recently (D.D. Rousseau et al. 1994) show that layers representing the oxygen-isotope stage 4 are absent there, whereas this stage is represented at Bojanice.

Fig. 3. The continental susceptibility records from Bojanice as a function of the profile depth, compared with oceanic isotope records from ODP core 677 (N.J. Shackleton et al. 1990 — simplified) plotted against an absolute timescale by J. Nawrocki 1995. Intervals with reversed correlation (horizons of some soils) were marked by dark belts. TL age after J. Butrym as in Fig. 1

3. The analysis results of magnetic susceptibility confirm the opinion that among Mesopleistocene loesses there occur layers corresponding to the oxygen-isotope stage 7. They possess paleomagnetic features similar to those of the layers representing the stage 5 (the last interglacial). Thus, the interval separating Saalian I and Saalian II glaciation possessed paleogeographical features due to which it can be attributed an interglacial rank. Therefore, it is reasonable to consider the Korshov 2 pedocomplex as representing the last but one interglacial.

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STRESZCZENIE

Wielka odkrywka w Bojanicach koło Sokala, przedstawiająca jedną z najpełniejszych sekwencji lessów na Wyżynie Wołyńskiej, badana jest od 1972 r. W ostatnich latach wyróżniono tutaj cztery śródlessowe gleby interglacjalne oraz kilka istotnych poziomów glebowych niższej rangi stratygraficznej. Spośród gleb interglacjalnych najwięcej wątpliwości natury paleopedologicznej nastręczała przedostatnia. W celu skontrolowania wyników wcześniejszych badań chronostratygraficznych wykonano analizy podatności magnetycznej próbek, pobranych w interwale 0,1 m, z profilu o miąższości ogólnej 24,1 m.

W pracy prezentowany jest pierwszy obszerniejszy opis litostratygraficzny profilu, zestawiony na podstawie badań A. Boguckiego z lat 1992-1994, uzupełniony spostrzeżeniami H. Maruszczaka zanotowanymi podczas pobierania próbek do analiz paleomagnetycznych. Diagram litostratygraficzny profilu, według schematu opracowanego przez A. Boguckiego (1987, 1992) dla Ukrainy NW, przedstawia ryc. 1. Dla lessów w Bojanicach były wykonane (przez dr J. Butryma w laboratorium lubelskim) datowania metodą TL. Ułatwiło to wzajemne skorelowanie schematów stratygrafii lessów ukraińskich i polskich ze stadiami izotopowo-tlenowymi osadów głębokomorskich (ryc. 2). Wyniki analiz podatności magnetycznej ilustruje ryc. 3. Przedstawiono na niej także próbę skorelowania krzywej podatności magnetycznej z krzywą $\delta\ ^{18}O$ osadów głębokomorskich.

Wyniki analiz podatności magnetycznej potwierdzają interpretację, według której w Bojanicach mamy dobry zapis trzech ostatnich, glacjalnych cykli akumulacji lessu, rozdzielonych glebami interglacjalnymi. Przedostatni interglacjał reprezentuje gleba typu czarnoziemnego, którą A. Bogucki (1987) wyróżnił jako II fazę rozwoju korszowskiego pedokompleksu. Pierwszą fazę pedokompleksu miała reprezentować niżej występująca gleba, trudniejsza dla genetycznej interpretacji. Wyniki analiz paleomagnetycznych wskazują, że glebie korszowskiej I fazy raczej nie można przypisywać rangi interglacjalnej.

Analizy wykazały, że gleby interglacjalne w Bojanicach wyróżniają się podwyższoną podatnością magnetyczną w poziomach iluwialnych. Natomiast górne poziomy tych gleb, tzn. poziomy eluwialne oraz nałożone na nie poziomy humusowo-darniowe z oznakami oglejenia, wykazują tendencję do obniżania podatności magnetycznej. Lessy wschodniej części Europy Środkowej wykazują więc cechy pośrednie między chińskimi (najwyższa podatność magnetyczna w glebach interglacjalnych) i alaskańskimi (najniższa podatność w glebach interglacjalnych).