Geological Quarterly, Vol. 40, No. 2, 1996, p. 231–244

Jerzy NAWROCKI, Anna E. SIENNICKA-CHMIELEWSKA

Loess magnetism in the Odonów section (S Poland)

The paper presents results of palaeomagnetic investigations in the loess section at Odonów II. The previously noted (P. Tuchołka, 1977) relative inclination decrease just above the oldest palaeosol of the Warta Interstadial is reinterpreted as the Jamaica event. Palaeomagnetic events within other Polish sections with loesses and loess-like sediments have also been partly reinterpreted and compiled. The results of palaeomagnetic susceptibility investigations reveal that the value of this parameter is strictly connected with climatic conditions during the sedimentation of examined deposits; at the same time direct influence was caused by climatically controlled pedogenetic processes. High values of magnetic susceptibility have been observed in the Nietulisko I type palaeosol complex, what is connected with the formation of a new generation of magnetite during intensive pedogenesis. Low values of magnetic susceptibility are typical mainly for gleyed interstadial palaeosols, in which disintegration of grains of the main susceptibility carrier — magnetite — took place. The correlation of susceptibility changes plot from Odonów with the oxygen plot is not as easy as in the case of Chinese loesses (see G. Kukla *et al.*, 1988). This fact is caused by diametrically different factors determining values of magnetic susceptibility in interglacial and interstadial palaeosols.

INTRODUCTION

The Odonów outcrop is situated within a lobe of the Kraków–Miechów loesses (Fig. 1). Two workings are situated south of Kazimierza Wielka: Odonów I — where Tertiary Krakowiec Clays are intensely exploited for the needs of a local brickwork, and Odonów II — presently abandoned.

The Odonów II section, one of a few in Poland, reveals two complexes of interstadial palaeosols — the Tomaszów type from the Lublin (= Lubawa) Interglacial and the Nietulisko I type developing from the end of the Warta Glaciation, through the Eemian Interglacial, to the beginning of the Wisła Glaciation. It is a type locality for loesses from the South-Polish Uplands and is the basis of studies on regional stratigraphy of the Pleistocene of the Miechów Upland (see L. Lindner, 1988; L. Lindner, A. E. Siennicka-Chmielewska, 1995). For over two decades this section has been the point of interest for

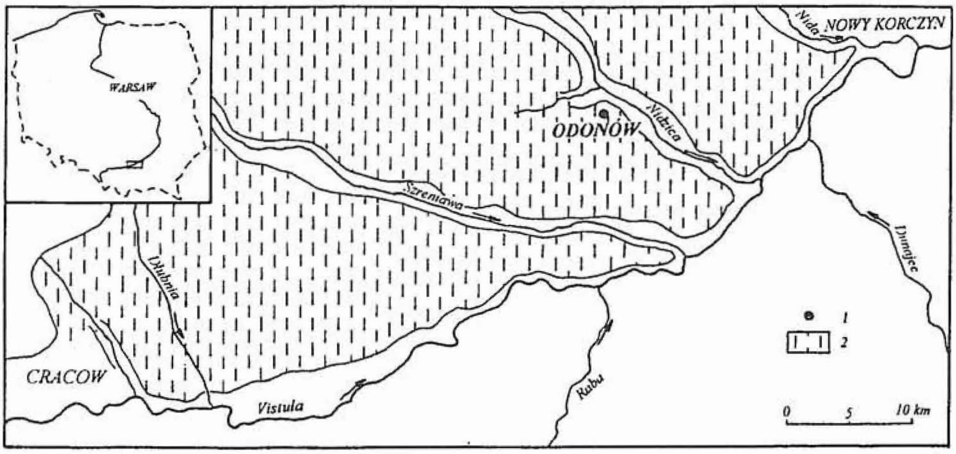


Fig. 1. Location sketch of the Odonów section
1 — location of the studied section; 2 — loess cover
Szkic lokalizacyjny odsłonięcia Odonów
1 — lokalizacja badanego profilu; 2 — pokrywa lessowa

investigators. Research work on the lithology and stratigraphy of loesses and palaeosols was conducted by J. Jersak (1973, 1975, 1988). The following problems have also been investigated: palaeomagnetism (Z. Śnieszko, P. Tuchołka, 1975; P. Tuchołka, 1976, 1977), heavy mineral content (H. Maruszczak, M. Wilgat, 1978), clay mineral content (L. Stoch *et al.*, 1982), malacofauna diversity (M. Jastrzębska-Mamełka, 1975; S. W. Alexandrowicz, 1986) as well as geological-engineering characteristics (Z. Frankowski, 1991). The Quaternary deposits have also been TL-dated in three laboratories (Gliwice, Lublin and Warsaw) (M. F. Pazdur, 1987; A. Bluszcz, 1987; J. Butrym, 1987; H. Prószyńska-Bordas *et al.*, 1987).

The last dozen of years have brought considerable progress in the field of investigations of magnetic properties in Quaternary deposits. The age of Quaternary palaeomagnetic events has been determined as well as investigations on the dependence of values of some petromagnetic parameters on palaeoclimatic conditions are under way. It seems that magnetic susceptibility can be used as an indicator of palaeoclimatic changes in marine and lacustrine deposits (R. Thompson, F. Oldfield, 1986; N. Thouveny *et al.*, 1994), as well as in loess sequences (F. Heller, T. S. Liu, 1986; G. Kukla *et al.*, 1988). Preliminary results of magnetic susceptibility investigations in the Polish loesses reveal that the value of this parameter is a derivative of climatic conditions, which occurred during their deposition (J. Nawrocki, 1992). The purpose of palaeomagnetic re-examination of the Odonów section was to investigate magnetic susceptibility and sources of its changes in particular, as well as to determine parts with anomalously low inclination values.

GEOLOGY

The Odonów II outcrop is placed on the right slope of a depression passing into the Małoszówka river valley, cutting a denudation spur of the loess cover parallel to its axis. The upper part of the outcrop lies about 218 m a.s.l. According to J. Jersak (1975) a San 2 Glaciation (after L. Lindner, 1988) till debris is preserved on Tertiary Krakowiec Clays. The debris is covered with up to 15 m of deposits, among which J. Jersak determined: lower older loess, accumulated during the Odra Glaciation, a Tomaszów type palaeosol from the Lublin Interglacial in its upper part, upper older loess accumulated during the Warta Glaciation with an interstadial Nieledew type palaeosol, a Nietulisko I type palaeosol complex, the development of which took place from end of the Warta Glaciation, through the Eemian Interglacial, to the beginning of the Wisła Glaciation, and younger loess accumulated during the Wisła Glaciation separated by a Komorniki type interstadial palaeosol. A detailed profile of the Odonów II outcrop is as follows (after J. Jersak *et al.*, 1992; K. Dwucet, Z. Śnieszko, 1995) counting upwards (numbers of layers as on Fig. 2 and 3):

1 — Krakowiec Clays, Tertiary — Miocene;

2 — washed-out till, striped, San 2 Glaciation;

3 — grey loess with rusty spots, with high clay content, gleyed (Lsd), Odra Glaciation;

4–10 — Tomaszów type palaeosol complex — two silty soils placed one on another (4–8) and chernozem (10), Lubawa Interglacial: 4 — brown loess, with high clay content, illuvial horizon (Btg); 5 — grey loess with low humus admixture, poorly developed palaeosol horizons A1/A3; 6 — loess with high clay content, brown with grey spots and small ferruginous concretions, illuvial horizon with upper gley (Bt); 7 — grey loess with small ferruginous concretions, leach horizon with upper gley (A3g); 8 — grey loess with small ferruginous concretions, accumulation horizon (A1); 9 — light brown loess with molehill infilled with black sediment from overlying soil (LsgI), Warta Glaciation; 10 — black loess, with fine rusty spots, gleyed, chernozem with secondary gley (Ad);

11 — striped and laminated loess, in lower part with admixture of underlying chernozem, in upper part grey loess, eolian-slope sediment, Warta Glaciation;

12 — yellow loess with rusty and grey spots, poorly gleyed (LsgIIa), Warta Glaciation;

13 — grey loess with rusty spots and high admixture of secondary carbonates in form of concretions, strongly gleyed, Nieledew type pseudogley palaeosol;

14 — yellow loess poorly gleyed (LsgIIb), Warta Glaciation;

15 — "marble" grey loess with fine rusty spots, eolian sediment accumulated in aquatic conditions (LsgIIb), Warta Glaciation;

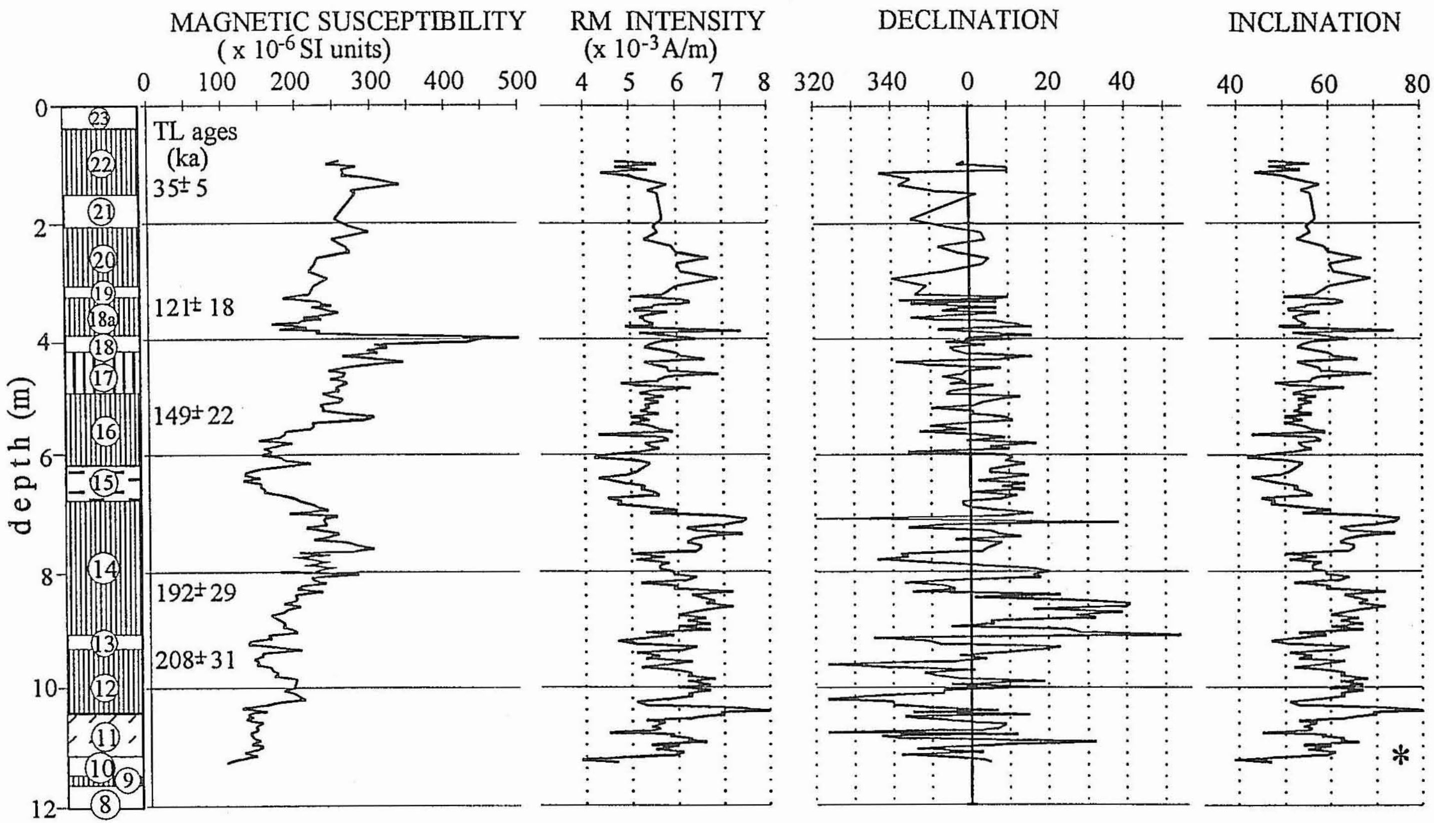
16 — sandy silt with indistinct lamination (LsgIIb), Warta Glaciation;

17–18 — Nietulisko type palaeosol complex: 17 — orange-brown loess, illuvial clay horizon (B1t); 18 — faded loess, silty with fine ferruginous concretions and pea-structured charcoal, leaching horizon (A3); 18a — yellow loess, gleyed in lower part;

19 — dark grey loess, with frequent molehill, chernozem (Ad), Wisła Glaciation;

20 — loess ochre coloured in upper part, in lower part brown with grey gley spots (LmIIa), Wisła Glaciation;

21 — grey loess with rusty stripes and spots, strongly gleyed, pseudogley soil — Komorniki type palaeosol complex, Wisła Glaciation;



$N = 202$; D = 1°; $I = 58°$; $\alpha = 1.2$; $K = 64$; $\phi = 79°$; $\lambda = 20°$; $dp = 1.8$; $dm = 1.4$

22 — light yellow loess, in lower part slightly gleyed, Wisła Glaciation;
23 — grey loess — recentarable horizon.

METHODS

A total of 202 samples was taken for palaeomagnetic investigations from horizons 10 to 22. Within the first three metres of the upper part of the section, samples were taken every 10 cm. The remaining part of the section was sampled more densely, every 5 cm. Gradual demagnetization of 10 randomly chosen samples in an alternating field revealed that characteristic directions obtained in the method of line fitting are closest to directions obtained after demagnetization in 30 mT. This field was also applied to demagnetize the main part of the samples.

Measurements of the strength components of magnetic remanence were carried out on a rotation magnetometer *JR-5*. Magnetic susceptibility was measured on a *KLY-2* bridge, whereas magnetic carriers were investigated with the thermomagnetic method.

MAGNETIC CARRIERS

The thermomagnetic method, which was used to determine the unblocking temperature spectrum of magnetic carriers, shows that magnetite and probably maghemite are magnetic carriers in the non-weathered loesses (Fig. 4). The maximum blocking temperatures characteristic for this sediment slightly exceed 500°C but a significant decrease of saturation remanence intensity is observed here at temperature range between 200 and 400°C. For the gleyed horizons, the main magnetic carriers appear to be different. The maximum blocking temperatures exceed distinctly 600°C and a considerable decrease in saturation remanence intensity is observed below 200°C. These observations along with the relatively low values

Fig. 2. Magnetic susceptibility, intensity of remanence (after demagnetization in 30 mT), characteristic declination and inclination plots prepared for the Odonów loess section

Numbers of lithological horizons in the synthetic lithological column are explained in the text; some palaeomagnetic parameters obtained from the Odonów section are presented below the graphs (*N* — number of samples, *D* — mean declination, *I* — mean inclination, α, *K* — Fisher's statistic parameters, ϕ — latitude of palaeopole, λ — longitude of palaeopole, *dp* — error of the distance between site and palaeopole, *dm* — palaeodeclination error; the place where P. Tuchołka (1977) found a palaeomagnetic event is marked by an asterisk; TL ages presented after J. Butrym (1987)

Wykresy zmian podatności magnetycznej, pozostałości magnetycznej (po rozmagnesowaniu w 30 mT) oraz deklinacji i inklinacji charakterystycznej w obrębie profilu lessowego Odonów

Numery poziomów litologicznych naniesione na syntetyczny profil objaśniono w tekście; niektóre parametry paleomagnetyczne otrzymane z profilu Odonów przedstawiono poniżej wykresów (*N* — liczba próbek, *D* — średnia deklinacja, *I* — średnia inklinacja, α, *K* — parametry statystyki Fishera, ϕ — szerokość geograficzna paleobieguna, λ — długość geograficzna paleobieguna, *dp* — błąd odległości między miejscem badań a paleobiegunem, *dm* — błąd paleodeklinacji; miejsce, gdzie P. Tuchołka (1977) zidentyfikował zdarzenia paleomagnetyczne, zaznaczono gwiazdką; daty TL przedstawiono według J. Butryma (1987)

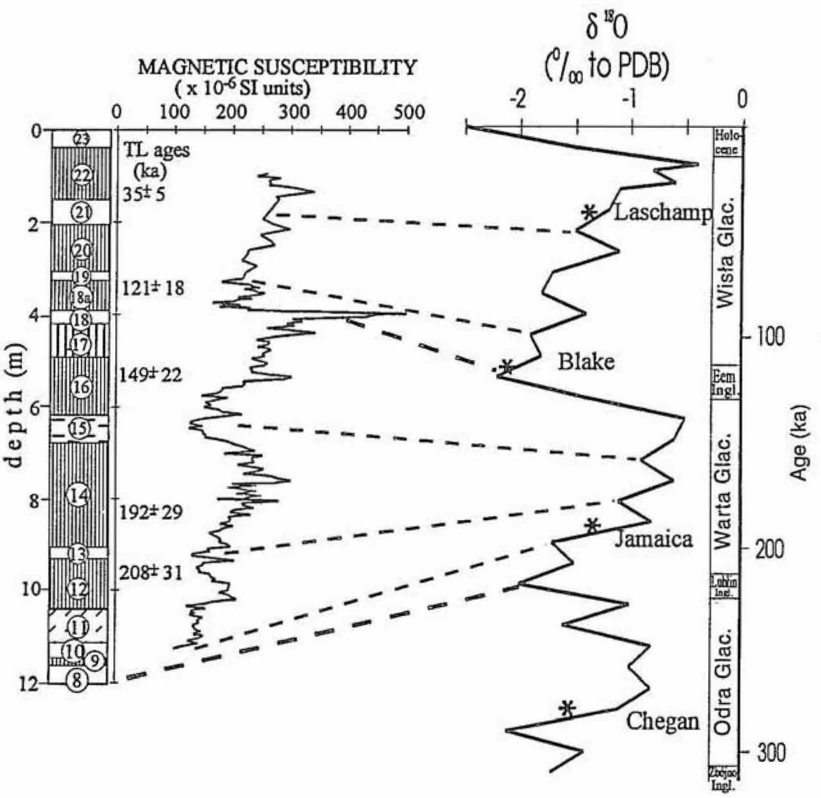


Fig. 3. The continental susceptibility record from Odonów as a function of profile depth compared with the oceanic isotope record from ODP core 677 (N. J. Shackleton *et al.*, 1990, simplified) plotted against an absolute timescale

Positions of palaeomagnetic events which occurred during the last 300 ka are marked by asterisks; TL ages are presented after J. Butrym (1987); lithological horizons are numbered as in the text

Korelacja zapisu podatności magnetycznej w utworach z Odonowa z oceanicznym zapisem izotopowym uzyskanym w rdzeniu 677 (N. J. Shackleton i in., 1990, uproszczone) i przedstawionym na tle skali czasowej

Miejsca zdarzeń paleomagnetycznych, występujących w ciągu ostatnich 300 tys. lat, zaznaczono gwiazdkami; daty TL naniesiono według J. Butryma (1987); poziomy litologiczne ponumerowano jak w tekście

of saturation remanence indicate that hematite and may be ferric hydroxides are the main magnetic carriers in the gleyed sediments. All magnetic carriers described above probably occur in the sample taken from the illuvial horizon. However, relatively high values of saturation remanence could indicate that magnetite and probably maghemite are predominant in the illuvial horizon. Magnetite, hematite and probably maghemite occurs also as carriers of saturation remanence in the sample taken from interglacial soil which revealed high values of magnetic susceptibility. High value of saturation remanence (Fig. 4) could show that hematite is not predominant there.

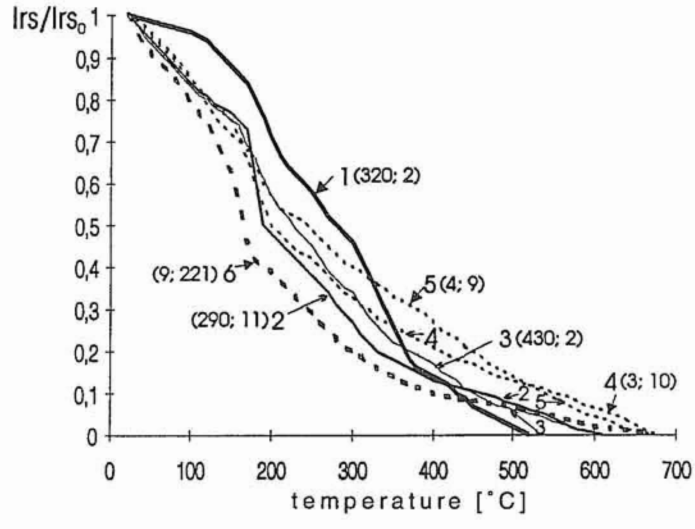


Fig. 4. Thermal demagnetization of saturation remanent magnetization (*Irs*) (thermomagnetic analysis) of samples prepared for different lithological horizons from the Odonów loess-palaeosol sequence

1 — non-weathered loess, 2 — illuvial horizon of Eemian palaeosol, 3 — high susceptible horizon of Eemian palaeosol, 4 — gleyed interstadial palaeosol (Nieledew), 5 — gleyed chernozem, 6 — gley horizon with carbonate concretions; Irs_0 — the initial value of saturation remanent magnetization; values of Irs_0 intensities (expressed in arbitrary units) and ratios of Irs_0 obtained after first heating (the second thermomagnetic curves are not presented here) to Irs_0 before heating are presented in brackets

Rozmagnesowanie termiczne pozostałości magnetycznej nasycenia (*Irs*) (analizy termomagnetyczne) próbek pobranych z różnych horyzontów litologicznych profilu lessowego w Odonowie

1 — less niezwietrzały, 2 — poziom illuwialny gleby eemskiej, 3 — poziom gleby eemskiej wskazujący wysoką podatność magnetyczną, 4 — oglejona gleba interstadialna typu Nieledwi, 5 — oglejony czarnoziem, 6 — poziom glejowy z konkrecjami węglanowymi; Irs_0 — wartość początkowa namagnesowania nasycenia; wartości parametru Irs_0 (wyrażone w jednostkach arbitralnych) oraz stosunek namagnesowania nasycenia, otrzymanego po pierwszym wygrzewaniu (krzywych drugiego grzania nie przedstawiono), do namagnesowania nasycenia przed wygrzewaniem przedstawiono w nawiasach

RESULTS OF DEMAGNETIZATION

Natural magnetic remanence (NRM) of a loess sample has one component in general. Starting from the demagnetization horizon of 10 mT the position of remanence vector does not change (Fig. 5). NRM strength decrease is gradual. In a 100 mT field about 30% of its primary value still remains. The NRM of an Eemian soil sample is in 70% composed of a low-stabile (viscous?) component, which is removed in 20 mT. Above the demagnetizing horizon of 20 mT the soil sample is demagnetized similarly to loess samples (Fig. 5).

Figure 2 presents plots of characteristic inclinations and declinations, obtained after demagnetization in 30 mT. Only in one sample the characteristic inclinations drops down below 40. The sample comes from just above the chernozem (horizon 10). In this part of the section relatively low inclination values were also obtained by P. Tuchołka (1977), according to whom this is a record of the Chegan magnetic event. Declination and

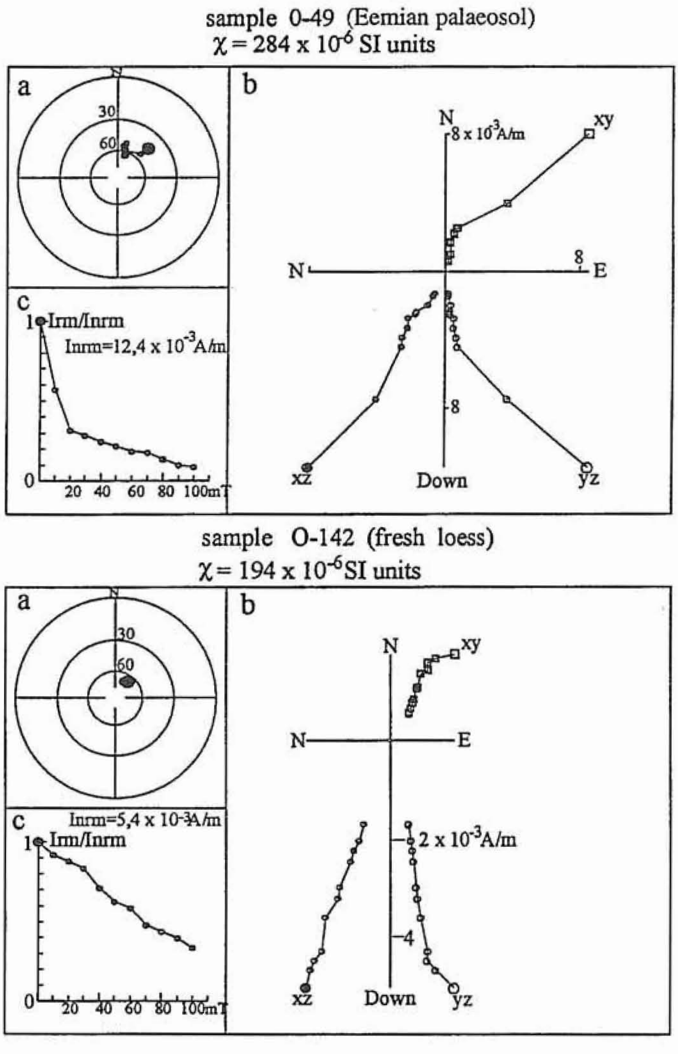


Fig. 5. Results of demagnetization (a — lower hemisphere polar projection of demagnetizing path, b — orthogonal plot, c — intensity decay curve) of two samples taken from the Odonów section

Bigger symbol on the stereonet — natural remanent magnetization (NRM) direction; *Irm* — intensity of remanent magnetization after demagnetization; *Inrm* — intensity of NRM; bigger symbols on the orthogonal plot — NRM components; *x, y, z* — projection planes

Wyniki rozmagnesowania (a — projekcja stereograficzna na dolną półsferę ścieżki rozmagnesowania, b — diagram ortogonalny, c — krzywa spadku natężenia) dwóch próbek pobranych z profilu Odonów

Większy symbol na siatce stereograficznej — kierunek naturalnej pozostałości magnetycznej (NRM); *Irm* — natężenie pozostałości magnetycznej po rozmagnesowaniu; *Inrm* — natężenie NRM; większym symbolem na diagramie ortogonalnym oznaczono składowe NRM; *x, y, z* — płaszczyzny projekcji inclination plots, apart from a few short- or medium-term time changes of the geomagnetic field, reveal also long-term changes, reaching up to 100 000 years. Such a cycle can be observed particularly in the upper part of the section, where, within 1 to 7 m of depth, inclination values at first gradually increase, reaching the highest values near the Eemian palaeosol, and then falls down again to values occurring in the upper part of the section (Fig. 2).

MAGNETIC SUSCEPTIBILITY AND PALAEOCLIMATE

Highest values of magnetic susceptibility (up to 500 x 10^{-6} SI units) are connected with the Nietulisko I palaeosol complex (Fig. 2). Low values of this parameter occur within gleyed interstadial soils as well as in parts with high content of sand fraction i.e. within 5.3 –6.2 m of depth. The decrease of magnetic susceptibility in parts with interstadial soil can be connected with magnetite disintegration (see B. Maher, 1986). In these points hematite is the main magnetic carrier.

High magnetic susceptibility is typical for non-gleyed interglacial soils (see A. Bogucki *et al.*, 1995). It can be connected with higher concentration of magnetite, a part of which was most probably generated in result of pedogenetic processes (see B. Maher, R. Thompson, 1991). This magnetite is a carrier of a very high NRM component, demagnetizing however in 20 mT (Fig. 5).

The relationship between magnetic susceptibility changes occurring in the Odonów section with pedogenetic processes points unequivocally to climate as the main factor modelling susceptibility plots. Figure 3 shows the correlation of magnetic susceptibility record with an oxygen curve, obtained in deep marine environments, plotted against an absolute timescale. The correlation basis is the curve shape and collected stratigraphic data. Simple correlation is complicated with a coincidence of two contrasting processes determining the value of magnetic susceptibility i.e. the process of magnetite degradation in loesses and interstadial soils and the process of accumulation of new magnetite in interglacial soil.

DISCUSSION AND CONCLUSIONS

The results of thermomagnetic analyses and demagnetization in an alternating field show that the primary carriers of magnetization in Odonów loesses are magnetite and hematite. Presence of maghemite cannot be also excluded. The low-stabile form of magnetite, present in Eemian palaeosol, is the source of a secondary (viscous) magnetization.

Table 1 shows a specification of geomagnetic events, which are recorded in sediments representing the last 500 000 years, as well as their age according to three different teams of scientists. Blake and Biwa III events took place unquestionably in interglacial periods, although some authors postulate that a part of Blake event slightly postdate the Eemian Interglacial (see e.g. J. Reinders, U. Hambach, 1995). Nevertheless, the recording of these events is rather not possible in Polish loesses. The Blake event took place during the

Table 1

Ages of the geomagnetic events in the last 500 ka

Event	Age [ka BP] after U. Bleil, G. Gard (1989)	Age [ka BP] after D. E. Champion *et al.* (1988)	Age [ka BP] after J. P. Valet, L. Meynadier (1993)
Laschamp	44	42	40
Blake	135	114	118
Jamaica (Biwa I	180	182	195
Chegan (Biwa II)	337	289	280
Biwa III	–	389	412
Empereur	479	443	419

formation of Eemian palaeosol, which in Polish loess sections is typically deprived of upper horizons (J. Jersak, 1973). The Biwa II event occurred during the Mazovian Interglacial. Palaeosol deposits from this period were palaeomagnetically tested only within loess-like sediments of Załubińcze (J. Nawrocki, A. Wójcik, 1995).

Table 2 presents palaeomagnetic events hitherto recorded within Polish loesses and loess-like sediments. There is no record of the Laschamp event. This event took place during the third oxygen stadial correlated with the Glinde and Orel warmenings dated at 48–51 and 54–58 ka (K. E. Behre, J. Van der Plicht, 1992). Warmening of climate probably caused breaks in loess accumulation, connected with the development of the Komorniki palaeosol complex, breaks precluding recording of the Laschamp event. Low inclination values, noted in the Odonów section directly above horizon 10, can be connected with the Jamaica event. This event has also been recorded in Orzechowce and Załubińcze sections, where zero values of inclination were noted in the same stratigraphic position (Tab. 2). The climatos-

Table 2

Geomagnetic events in the Polish loesses and loess-like sediments

Event	Locality	I_{min}	D	References
Jamaica (Biwa I)	Odonów	32	300	P. Tuchołka (1977)
	Orzechowce	0	20	P. Tuchołka (1977)
	Załubińcze	0	345	J. Nawrocki, A. Wójcik (1995)
Chegan (Biwa II)	Nieledew	–42	318	P. Tuchołka (1976)
	Załubińcze	–67	312	J. Nawrocki, A. Wójcik (1995)
Empereur	Załubińcze	–65	198	J. Nawrocki, A. Wójcik (1995)

I_{min}, D — minimum value of inclination and corresponding declination tratigraphic position of sediments from Odonów, Orzechowce and Załubińcze sections holding anomalously low (but not negative) inclinations, perfectly corresponds with the age of the Jamaica event. These sediments originated just above the oldest Warta Interstadial palaeosol.

Magnetic susceptibility within Odonów loesses is highest mainly in parts devoid of pedogenetic processes. The exception is the Eemian Interglacial palaeosol. High susceptibility values noted here can be connected with the origin of a new magnetic mineral during pedogenetic processes, possibly magnetite. The increase of magnetic susceptibility values in Eemian palaeosol is not caused by relative concentration with the already existing magnetite, as carriers of a large part of NRM in Eemian palaeosol and in loess differ in alternate field demagnetization values (Fig. 5). These conclusions and results of previous investigations (A. Bogucki *et al.*, 1995) point to the fact that magnetic susceptibility can be a good indicator of determining interglacial soils form interstadial soils.

Acknowledgments. We would like to thank Professor Leszek Lindner for helpful discussions and critical remarks.

Translated by Anna Żylińska

Zakład Geofizyki
Państwowego Instytutu Geologicznego
Warszawa, ul. Rakowiecka 4
Instytut Geologii Podstawowej
Uniwersytetu Warszawskiego
Warszawa, al. Żwirki i Wigury 93
Received: 30.04.1996

REFERENCES

ALEXANDROWICZ S. W. (1986) — Molluscan assemblages from a loess profile at Odonów (Małopolska Upland). Biul. Peryglac., **31**, p. 7–15.

BEHRE K. E., VAN DER PLICHT J. (1992) — Towards an absolute chronology for the last glacial period in Europe: radiocarbon datas from Oerel, Northern Germany. Veget. Hist. Archeobot., **1**, p. 111–117.

BLEIL U., GARD G. (1989) — Chronology and correlation of Quaternary magnetostratigraphy and nannofossil biostratigraphy in Norwegian-Greenland Sea sediments. Geol. Rundsch., **78**, p. 1173–1187, no. 3.

BLUSZCZ A. (1987) — Sprawozdanie z datowania termoluminescencyjnego próbek lessu z Odonowa. Spraw. z Bad. Nauk. Kom. Bad. Czwart. PAN, **7**, p. 8–9.

BOGUCKI A., MARUSZCZAK H., NAWROCKI J. (1995) — Stratigraphic and paleogeographic interpretation of analysis results of magnetic susceptibility of loesses at Bojanice (NW Ukraine). Ann. UMCS, Sec. B, **50**, p. 51–64, no. 3.

BUTRYM J. (1987) — Wiek lessów z profilu w Odonowie k. Kazimierzy Wielkiej. Spraw. z Bad. Nauk. Kom. Bad. Czwart. PAN, **7**, p. 10–15.

CHAMPION D. E., LANPHERE M. A., KUNTZ M. A. (1988) — Evidence for a new geomagnetic reversals from lava flows in Idaho: Discussion of short polarity intervals in the Brunes and late Matuyama polarity chrons. J. Geophys. Res., **93**, p. 667–680.

DWUCET K., ŚNIESZKO Z. (1995) — Odonów: odsłonięcie lessów. In: Przewodnik wycieczek. III Zjazd geomorfologów polskich nt. „Procesy geomorfologiczne — zapis w rzeźbie i osadach", p. 36–45. UŚl. Sosnowiec.

FRANKOWSKI Z. (1991) — Właściwości geologiczno-inżynierskie lessów: profil Odonów. In: Podstawowe profile lessów w Polsce (ed. H. Maruszczak), **B 77**. UMCS. Lublin.

HELLER F., LIU T. S. (1986) — Paleoclimatic and sedimentary history from magnetic susceptibility of loess in China. Geophys. Res. Lett., **13**, p. 1169–1172.

JASTRZĘBSKA-MAMEŁKA M. (1975) — Malakofauna utworów lessowych w Odonowie. Przew. Konf. Teren. nt. „ Zróżnicowanie typologiczne gleb kopalnych na Wyżynie Małopolskiej", p. 43–46. UŁ. Łódź.

JERSAK J. (1973) — Lithology and stratigraphy of the loess on the Southern Polish Uplands (in Polish with English summary). Acta. Geogr. Lodziensia, **32**.

JERSAK J. (1975) — Profil lessów w Odonowie II. Przew. Konf. Teren. nt. „Less i zróżnicowanie typologiczne gleb kopalnych na Wyżynie Małopolskiej", p. 40–43. UŁ. Łódź.

JERSAK J. (1988) — Stratigraphic position of the older loesses in the uplands of southern Poland (in Polish with English summary). Pr. Nauk. UŚl. Ser. Geologia, p. 22–46, no. 914.

JERSAK J., SENDOBRY K., ŚNIESZKO Z. (1992) — Evolution of loess covers in Poland during the post-Warta period (in Polish with English summary). Pr. Nauk. UŚl., no. 1227.

KUKLA G., HELLER F., LIU X. M., XU T. C., LIU T. S., AN Z. S. (1988) — Pleistocene climates in China dated by magnetic susceptibility. Geology, **16**, p. 811–814.

LINDNER L. (1988) — Glacial and interglacial units in the Pleistocene of the Miechów Upland and Nida Basin (in Polish with English summary). Prz. Geol., **36**, p. 140–147, no. 3.

LINDNER L., SIENNICKA-CHMIELEWSKA A. E. (1995) — Loesses and their bedrock in the southeastern part of the Miechów Upland (S Poland). Ann. UMCS, sec. B, **50**, p. 75–90, no. 5.

MAHER B. (1986) — Characterization of soils by mineral magnetic measurements. Phys. Earth Planet. Intern., **42**, p. 76–92.

MAHER B., THOMPSON R. (1991) — Mineral magnetic record of the Chinese loess and paleosols. Geology, **19**, p. 3–6.

MARUSZCZAK H., WILGAT M. (1978) — Zróżnicowanie stratygraficzne i paralelizacja profilów lessowych z Nieledwi i Odonowa w świetle badań minerałów ciężkich. Fol. Soc. Sc. Lubl., **20**, p. 89–95, no. 2.

NAWROCKI J. (1992) — Magnetic susceptibility of Polish loesses and loess-like sediments. Geol. Zb. Geol. Carpathica, **43**, p. 179–180.

NAWROCKI J., WÓJCIK A. (1995) — Lithology and stratigraphy of Pleistocene loess-like deposits in the Załubińcze section (Nowy Sącz Basin — Outer Carpathians). Geol. Quart., **39**, p. 121–144, no. 1.

PAZDUR M. F. (1987) — Opracowanie metodą chronologii C-14 wybranych profili torfowych oraz opracowanie chronologii metodą TL profilu lessowego w Odonowie. Spraw. z Bad. Nauk. Kom. Bad. Czwart. PAN, **7**, p. 5–7.

PRÓSZYŃSKA-BORDAS H., STAŃSKA-PRÓSZYŃSKA W., PRÓSZYŃSKI M. (1987) — Termoluminescencyjne wskaźniki wieku lessów i gleb kopalnych z przekroju w Odonowie (metoda i wyniki laboratorium warszawskiego). Spraw. z Bad. Nauk. Kom. Bad. Czwart. PAN, **7**, p. 16–29.

REINDERS J., HAMBACH U. (1995) — A geomagnetic event recorded in loess deposits of the Tonchesberg (Germany): identification of the Blake polarity episode. Geophys. Jour. Intern., **122**, p. 407–418.

SHACKLETON N. J., BERGER A., PELTIER W. R. (1990) — An alternative astronomical calibration of the lower Pleistocene timescale based on ODP site 677. Trans. R. Soc. Edinburg, Earth Sc., **81**, p. 251–261.

STOCH L., MARUSZCZAK H., HELIOS-RYBICKA E. (1982) — Clay minerals of loesses of SE Poland. Miner. Pol., **13**, p. 43–59, no. 1.

ŚNIESZKO Z., TUCHOŁKA P. (1975) — Badania paleomagnetyczne profilu lessowego „Odonów". Przew. Konf. Teren. nt. „Less i zróżnicowanie typologiczne gleb kopalnych na Wyżynie Małopolskiej", p. 46–47. UŁ. Łódź.

THOMPSON R., OLDFIELD F. (1986) — Environmental magnetism. Ed. Allen and Unwin. London.

THOUVENY N., BEAULIEU J. L., BONIFAY E. *et al.* (1994) — Climate variations in Europe over the past 140 kyr deduced from rock magnetism. Nature, **371**, p. 503–506.

TUCHOŁKA P. (1976) — Secular variations of the magnetic field in paleomagnetic investigation of loess. Publ. Inst. Geophys. Pol. Acad. Sc., **101**, p. 83–89.

TUCHOŁKA P. (1977) — Magnetic polarity events in Polish loess profiles. Biul. Inst. Geol., **305**, p. 117–123.

VALET J. P., MEYNADIER L. (1993) — Geomagnetic field intensity and reversals during the past four million years. Nature, **336**, p. 234–238.

Jerzy NAWROCKI, Anna E. SIENNICKA-CHMIELEWSKA

MAGNETYZM PROFILU LESSOWEGO W ODONOWIE

Streszczenie

W artykule przedstawiono wyniki badań paleomagnetycznych profilu odsłonięcia lessowego z Odonowa II. Obserwowane wcześniej w tym profilu (P. Tuchołka, 1977) relatywne obniżenie inklinacji tuż nad najstarszą warciańską glebą interstadialną określono jako Jamaica event. Częściowo zreinterpretowano i zestawiono również zdarzenia paleomagnetyczne zanotowane w innych polskich profilach z utworami lessowymi i lessopodobnymi.

Wyniki badań podatności magnetycznej wskazały, że wartość tego parametru jest w ścisłym związku z warunkami klimatycznymi jakie panowały w momencie sedymentacji badanych skał, przy czym bezpośredni wpływ miały tu uwarunkowane klimatycznie procesy pedogenetyczne. Wysokie wartości podatności zaobserwowano w kompleksie glebowym typu Nietulisko I, co należy wiązać z powstawaniem nowej generacji magnetytu w trakcie intensywnej pedogenezy. Niskie wartości podatności są charakterystyczne przede wszystkim dla interstadialnych gleb oglejonych, w których zachodził rozkład ziarn głównego nośnika podatności — magnetytu. Korelacja krzywej zmian podatności z Odonowa z krzywą tlenową nie jest tak prosta jak np. w przypadku lessów chińskich (por. G. Kukla i in., 1988). Fakt ten wynika z diametralnie różnych czynników kształtujących wartości podatności magnetycznej w glebie interglacjalnej i glebach interstadialnych.