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The Importance of Paleomagnetic Investigations for the Stratigraphic Analysis of Loesses on the Example of the Section at Łopatki (SE Poland)

Znaczenie badań paleomagnetycznych dla stratygraficznej analizy lessów na przykładzie profilu w Łopatkach (Polska SE)

Роль палеомагнитных исследований для стратиграфического расчленения лёссов на примере разреза в местности Лопатки (ЮВ Польша)

ABSTRACT

For paleomagnetic investigations the loesses at Łopatki were sampled in a continuous system. A new method for interpretation of analyses of the secondary magnetization constituents was used. It allows us to distinguish inversions of the geomagnetic field which occurred during breaks in sedimentations or breaks caused by erosion. The results have shown the existance of at least 13 breaks in the recorded events in the examined loess section. Inversions of the geomagnetic field occurred during 7 breaks. So far, lithostratigraphic and paleopedologic studies have allowed us to distinguish only some of these breaks. Traces of the occurrence of 7 inversions of the geomagnetic field allow us to determine the age of the examined loesses, irrespective of the datings made by other methods. The results of the datings of the loesses at Łopatki (presented during the International Symposium on Loess in 1985) made by the TL method used in the Warsaw laboratory (H. Prószyńska-Bordas) are totally divergent, while those from the Lublin laboratory (J. Butrym) agree with paleomagnetic data. We can assume that the new method proposed here for detailed paleomagnetic analysis will allow us to correlate different profiles of Pleistocene loesses.

The section of Quaternary deposits at Łopatki has been investigated since the end of the forties (A. J a h n 1956). From the beginning particular attention was paid to the interglacial-rank forest soil, which in that section was formed on weathered glacial deposits of the Middle Polish glaciation=Saalian. Among the loesses overlying that soil three less developed gleyed soils of interstadial rank, and some generations of cryogenic structures of different ages were found. On the basis of these facts the forest soil was connected with the latter, i.e. the Eemian interglacial, and the overlying loesses with the last glacial cycle, i.e. with Würm→Vistulian. It seemed that the sequence of interstadial soils and ice-wedge casts well corresponded with the successive development stages of the last glacial cycle.

Therefore, in 1983 that section was chosen for more detailed chronostratigraphic and paleomagnetic studies. The chronostratigraphic investigations were carried out in two laboratories, which used different modifications of the thermoluminescence (TL) method for dating. From the results of TL analyses done by Dr. J. Butrym (Department of Physical Geography, Maria Curie-Skłodowska University in Lublin) the age of horizon A_1 of the interglacial soil was estimated at about 220 ka BP, while from those obtained by Dr. H. Prószyńska-Bordas from Warsaw at about 50 ka BP (J. Butrym 1985, H. Maruszczak 1985a, H. Prószyńska-Bordas 1985). Both datings seemed to contradict the correctness of the correlation of the forest soil with the Eemian, the age of which has been lately estimated rather unanimously at about 130/125—110/100 ka BP. Such a great divergence of the results called in question the correctness of both TL methods used for dating in Lublin and in Warsaw. The loess section at Łopatki was presented during the International Symposium of the INQUA Commission on Loess in 1985. Many of the participants concluded to neglect the results of TL analyses, and support the primary stratigraphic interpretation of that section.

In such a situation a particular importance can be ascribed to the results of the paleomagnetic investigations. They show that in the section at Łopatki only fragments of different parts of the glacial cycles of silt deposits sedimentation have been preserved. The number and role of various breaks (hiatuses) in the recorded events are more distinctly exposed in the light of the paleomagnetic investigations than in the light of the datings done by the TL method.

RESULTS OF THE INVESTIGATIONS OF THE ESSENTIAL STRATIGRAPHIC AND PALEOGEOGRAPHIC FEATURES

The loess section at Łopatki was investigated and described for the first time by A. Jahn (1956, p. 45—49). In the subsequent years it was examined by graduate completing his master these under the direction of H. Maruszczak in the Department of Physical Geography UMCS in Lublin (A. Mazurkiewicz 1973). J. Jersak (1973, p. 38 and 105, phot. 11) also published some fragmentary information about this section. At an international conference H. Maruszczak presented the results of his own investigations carried out in the years 1971—1980. Owing to the TL datings done by J. Butrym in 1984, it was possible to present the new stratigraphic interpretation of the section during the Symposium of the INQUA Commission on Loess in 1985 (H. Maruszczak 1985a, b). It suggested that the forest soil occurring in the section should not be correlated with the Eemian interglacial (as previously), but with a warm period of the inter-Saalian (interglacial? Lublinian=Treenian= =Odintsovian). The results of the datings also indicated that in this section at least two long-lasting breaks had occurred. Until now, the

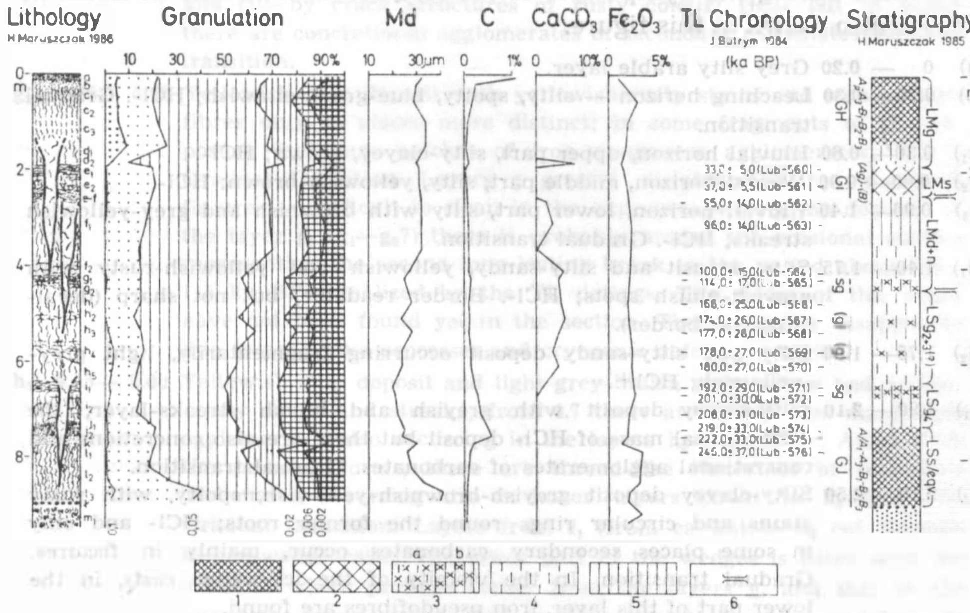

Fig. 1. Loess section at Łopatki
Granulation — grain size; Md — median grain size; C — humus content; $CaCO_3$ — carbonate content; Fe_2O_3 — iron oxides content. Letter symbols of stratigraphic units of loess: L — loess, M — younger, S — older, g — upper, s — middle, d — lower, n — the lowest. Letter symbols of soil units: G — soils showing well--developed genetic horizons, H — contemporary (Holocene), J — fossil interglacial, i — fossil interstadial, sg — soil sediments, (g) — traces of development of pedogenesis. Graphic signatures: 1 — Holocen and interglacial soils; 2 — interstadial soils; 3 — soil sediments and weekly developed interstadial soils; 4 — unweathered, calcareous loesses, 5 — weathered, decalcified loesses; 6 — greater hiatuses in the section

traces of those breaks have not been recorded. Attempts were made to discover them during the investigations in the new parts of the exposure, which was extended during digging out material for the brick-yard in 1985/86.

The description of the section has been based on the results obtained from the investigations of the brick-yard exposures at Łopatki 30 km WNW of Lublin, carried out in 1971, 1980, 1983/84 and 1985/86. The exposures investigated are situated on a slope gently inclined to S-SSW; their top reaches a height of about 206 m a.s.l. The excavation walls from 0 to 8.5 m are directed to NNW-SSE. At their foot there are sounding pits from 8.5 to 9.4 m, and a boring from 9.4 to 10.3 m made with an earth auger. The sequence of the layers included in this description and the results of analyses of the samples collected from them are presented in Fig. 1. The stratigraphic interpretation of the layers in the version presented during the Symposium of the INQUA Commission on Loess in 1985 is also shown in this figure.

a) 0 — 0.20 Grey silty arable layer.

b) 0.20— 0.30 Leaching horizon — silty, spotty, blue-grey-yellowish; HCl-. Gradual transition.

c_1) 0.30— 0.60 Illuvial horizon, upper part, silty-clayey, brown; HCl-.

c_2) 0.60— 0.90 Illuvial horizon, middle part, silty, yellowish-brown; HCl-.

c_3) 0.90— 1.40 Illuvial horizon, lower part, silty with brownish and grey-yellowish streaks; HCl-. Gradual transition.

d_1) 1.40— 1.75 Silty deposit and silty-sandy, yellowish and yellowish-rusty with greyish-bluish spots; HCl-. Border readable, but not sharp (decalcification border).

d_2) 1.75— 1.90 Silty and silty-sandy deposit occurring fragmentarily, light grey--yellowish; HCl+.

e_1) 1.90— 2.10 Silty-clayey deposit with greyish and bluish streaks-layer; the fundamental mass of HCl- deposit but there are also concretions and concretional agglomerates of carbonates. Gradual transition.

e_2) 2.10— 2.50 Silty-clayey deposit greyish-brownish-yellowish, spotty, with rusty stains and circular rings round the former roots; HCl- and only in some places secondary carbonates occur, mainly in fissures. Gradual transition. In the vicinity of the ice-wedge casts, in the lower part of this layer, iron pseudofibres are found.

e_2—f_1) In a part of the excavation uncovered in 1985/86 a distinct erosional surface was found, on which distinct fine laminated, lighter coloured, silty and silty-sandy deposits are accumulated; the thickness of these deposits is various and reaches 0.3 m. These must be products of washing which proceeded on the slope. In other parts of the excavation without a cover of washing products, the erosional surface is not visible. Its finding is almost impossible because the underlying and overlying deposits are similar. The reason why it should be specially stressed is that the discused erosional surface represents — according to the TL datings — a long-lasting break in the interval about 90—40 ka BP.

f_1) 2.50— 3.90 Silty-clayey deposit and silty, yellowish and yellowish-brownish, layered-streaky, marbled-spotted with stains and streaks yellowish--rusty and bluish patches and also microagglomerates of iron-manganese concretions, downwards lighter and greyish-yellowish with a bigger number of iron-manganese agglomerates; HCl- but from 2.8 thread-like carbonate pseudomycelia (or rhizocoles) occur; in a part of the exposure HCl+ weakly beneath 3.5 m. Gradual transition. Layers from d to f_1 cut by great ice-wedge casts; the lower, fissure parts of the wedges reach down to the layers g.

f_2) 3.90— 4.20 Silty deposit bluish-grey-yellowish with a considerable number of tiny iron-manganese concretions, in places with distinct iron pseudo-fibres in the lower part; HCl+ weakly and medium within the microdepressions of the fossil surface, and HCl- within relief convexity. Gradual transition — in places as if indented with the underlying deposit.

g_1) 4.20— 4.35 Bluish silty deposits, downwards with many various yellow-rusty stains, in some fragments solifluctionally or involutionally displaced and cut by crack structures of rusty colour; HCl- but in places there are concretional agglomerates of secondary carbonates. Gradual transition.

g_2) 4.35— 4.45 Yellowish silty deposit with yellowish-rusty stains and iron pseudo-fibres only in places more distinct; in some fragments of the exposure there are patches of iron-manganese agglomerates; HCl+. Gradual transition. Layers g greatly disintegrated by numerous fissures — difficult to clean in the exposure. Among the deposits of the layer g_2 (g_1—g_2?) there is probably hidden the erosional surface representing the second long-lasting break in the period about 160—115 ka BP signalized by the TL datings. The traces of this break have not been found yet in the section. They probably disappeared due to pedogenic processes and cryogenic deformations.

h_1) 4.45— 5.00 Yellowish silty deposit and light grey-bluish with yellow and yellow--rusty stains and streaks; from 4.7 there are spotty iron-manganese agglomerates also occurring in the layers h_2—h_5; HCl+. Apart from the primary forms, there are thread-like rhizocoles of secondary carbonates, occurring also in lower layers down to h_5 inclusive. Gradual transition. Layers from f_1 (from ca 3.5) to h_2 cut through by ice-wedge casts. The lower part of the wedges is filled with the material which perhaps comes from the layers g, and that of the upper one from layer f_1, and probably mainly from layers which do not occur in the section at present and correspond to those of the period 90—40 ka BP. The material which fills the wedges is cut from the top by the erosional surface described in layer e_2—f_1.

h_2) 5.00— 5.15 Silty deposit light grey-bluish-dunnish; weakly contoured gley horizon; HCl+. Gradual transition.

h_3) 5.15— 5.60 Silty deposit, similar to h_1, in places with irregular silty-sandy inserts; HCl+. Gradual transition.

h_4) 5.60— 5.85/6.10 Silty deposit, light grey-blue-dunnish, spotty; a indistinctly contoured horizon of weak gleyization, in places distinguishing itself by a great number of stains of iron-manganese concentrations.

Gradual transition. The thickness of this horizon is increased in places — mainly over ice-wedge casts occurring below.

h_5) 5.85— 6.40 Silty deposit and silty-clayey, yellowish-dunnish with bluish spots, from 6.20 more numerous; HCl+. Gradual transition.

i_1) 6.40— 6.60/6.70 Silty-clayey deposit, greyish-bluish with yellowish and yellowish-rusty spots; this horizon of gleyization splits in places and its thickness increases; HCl+ weakly. Gradual transition.

i_2) 6.60— 7.30 Silty-clayey deposit, light grey-bluish with spots and yellowish and yellow-rusty streaks. At a depth 7.05—7.10 a layered-streaky lighter coloured deposit occurs, which may account for intensive development of erosion (degradation) on the slope. From 7.05—7.10 iron pseudofibres occur, very distinct at the top especially in the near vicinity of the ice-wedge casts, lower — less distinct and irregular. Fundamental mass of HCl- deposit; at a depth 7.00—7.05 horizons of carbonate concretions over iron pseudofibres and at the floor of the layer. Indistinct borderline — in places of gradual transition. Layers from i_1 to k are cut by ice-wedge casts, reaching down to layers l. The filling of the wedges in the lower and middle parts from layers i—j, at the top — from layer h_5.

j_1) 7.30— 7.45 Humus horizon upper part, silty, grey and bluish-grey, more homogeneous; fundamental mass HCl- but there are concentrations of secondary carbonates. Gradual transition.

j_2) 7.45— 7.60 Humus horizon lower part, silty, grey and grey-dunnish spotty, in places with a large amount of charcoal detritus; HCl-. Gradual transition.

k) 7.60— 7.75 Leaching horizon, silty, bluish-greyish with light-brownish spots downwards, a lot of iron-manganese concretions; in places numerous "krotovines" filled with the material from the overlying and underlying soil horizons; HCl-. Transition typically gradual.

l_1) 7.75— 8.00 Illuvial horizon — upper part, silty-clayey, rusty-brown, in the upper part patchy and spotty with iron-manganese concretions; "krotovines" also occur in this horizon as well as in the underlying ones; HCl-.

l_2) 8.00— 8.60 Illuvial horizon — middle part, silty-clayey and silty, brownish with weakly marked blue-yellowish streaks, at the top still patchy, but more homogenous downwards; HCl-. In places distinctly marked pseudomorphs of small ice-lense structures of the segregational ground ice. In layers l there are also visible irregular, fissured "tongue-like" structures, which form weakly marked, little polygons in the horizontal plane. The width of these "tongues" to 0.1 m, depth to 0.8—1.0 m, and the infilling with the material from layers j—k, pointing to the features of vertical pseudolamination, which allows us to interpret them as frost fissures with primary mineral infilling. Such fissures can be formed in the conditions of seasonally strongly frozen ground.

l_3) 8.60— 8.95 Illuvial horizon — lower part, clayey-sandy, light-brown with the irregular blue-grey-dunnish streaks, and with a few small iron-manganese concretions; HCl-. In the illuvial horizon (l_1—l_3) single pebbles of the Scandinavian rocks occur.

ł) 8.95— 9.00 Horizon of a considerable accumulation of pebbles and stones of the

Scandinavian rocks, a larger part of them — weathered (erosional pavement layer).

m_1) 9.00— 9.85 Loamy boulder material (morainic?) more and more sandy downwards.

m_2) 9.85—10.30 Watered loamy sandy till.

The stratigraphic position of fossil soils occurring in this section was determined according to the datings made by J. Butrym (Fig. 1). The first soil from the top Gi/LMs (e_1—e_2 layers) is characterized by the features of gley or rather subarctic brown gleyed soil. It represents the younger of two interstadials of the Vistulian interpleniglacial, which has been distinguished as Denekamp in west Europe (H. Maruszczak 1985b). The next fossil soil is, strictly speaking, only a soil sediment (sg) with features of a distinctly gleyed horizon (layers g_1—g_2), which might have been formed in the earliest Vistulian. It may correspond to the interstadial Amersfoort, because the substrate on which this horizon was developed has been dated at 114 ka BP. The successive one, an older soil sediment or gleyization horizon (layer i_1) represents a not closer determined episode of interstadial rank (?) from the early Wartanian (=Saalian II). The last one which is a well-developed forest soil GJ/LSs (j—k—l layers) represents inter-Saalian, which many authors attribute the interglacial rank (according to the terminology used by some Polish authors it is Lublinian=Treenian=Odintsovian).

RESULTS OF PALEOMAGNETIC STUDIES

Paleomagnetic studies of loesses in SE Poland have shown that the present methods used in magnetostratigraphy do not come up to expectations. This results from the occurrence of numerous stratigraphic gaps in loess sections, in which inversions of the magnetic field may have occurred, which are reference marks for stratigraphic correlation. Therefore, M. Tkacz (1987) used another method for interpretation of the paleomagnetic analysis results. He assumed that each preserved layer series of a sediment during breaks (hiatuses) had its separate topographic surface. If during such breaks inversions of the magnetic field occurred, subsurface geochemical processes were fixing the recording of the secondary field constituents specific for a given inversion, overlapping the directions of normal magnetization of the layers accumulated earlier. It was also assumed that inversion vectors included in NRM had different directions and their magnitudes decreased from the top downwards in each layer series. This allows to identify the particular series subjected to postsedimentation impact of definite inversion. Using this method it is also possible to analyse the sediments with inversive magnetization

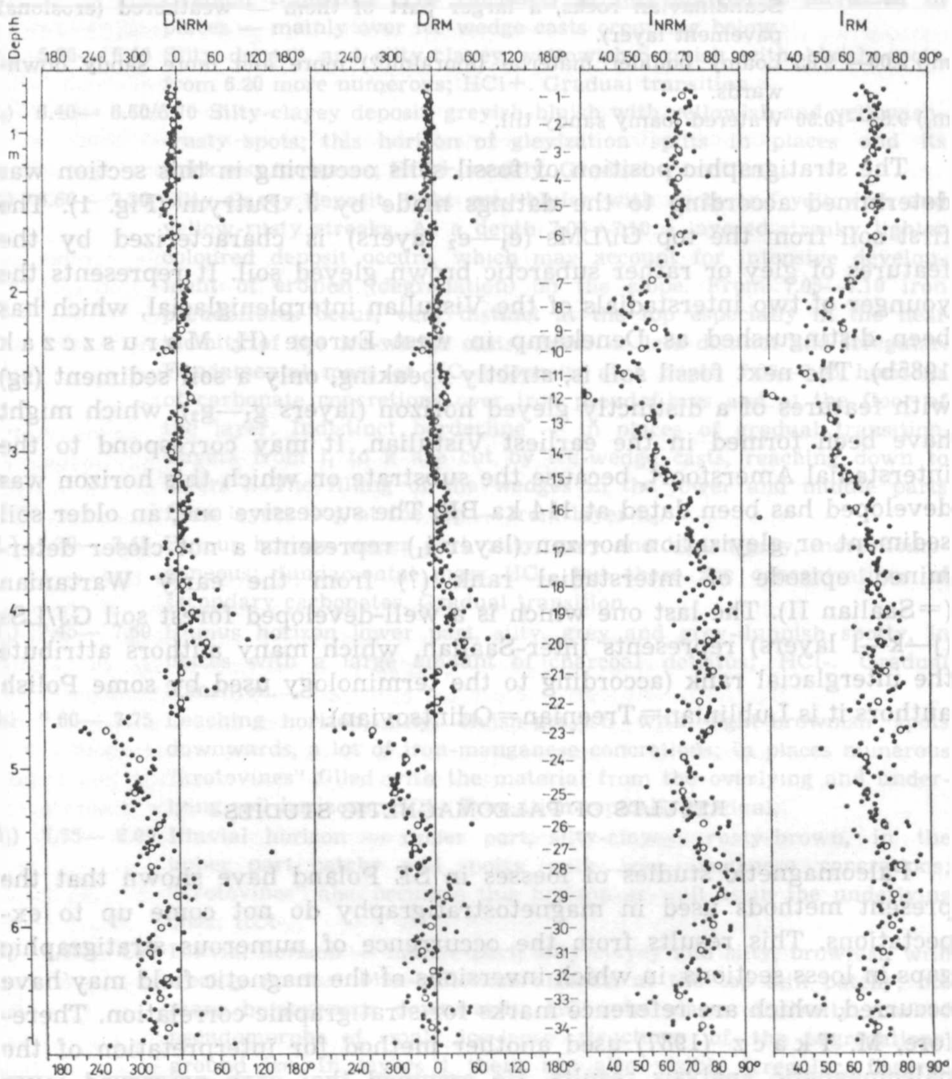

Fig. 2. Diagram of the changes of declination and inclination of samples from the loess section at Łopatki (before and after magnetic cleaning)

Circlets mark mean positions for 34 sample groups distinguished according to the principle defined in the text; numbers of the sample groups (1—34) are given in the middle part of the diagram

the directions of which were not synchronous with the inversion of the magnetic field, but were formed as a result of subsequent geochemical processes. Little stable, secondary magnetization constituents NRM were found earlier; methods for examination of their directions were also determined (among others K. A. Hoffman and R. Day 1978, J. L. Kirschvink 1980).

The loesses at Łopatki were continuously sampled. Starting from the depth of 0.7 m (middle horizon of Holocene soil) down to the depth of 6.75 m (i.e. 0.05 m over horizon A_1 of interglacial soil), 353 samples were taken. The results of paleomagnetic analysis of these samples are shown

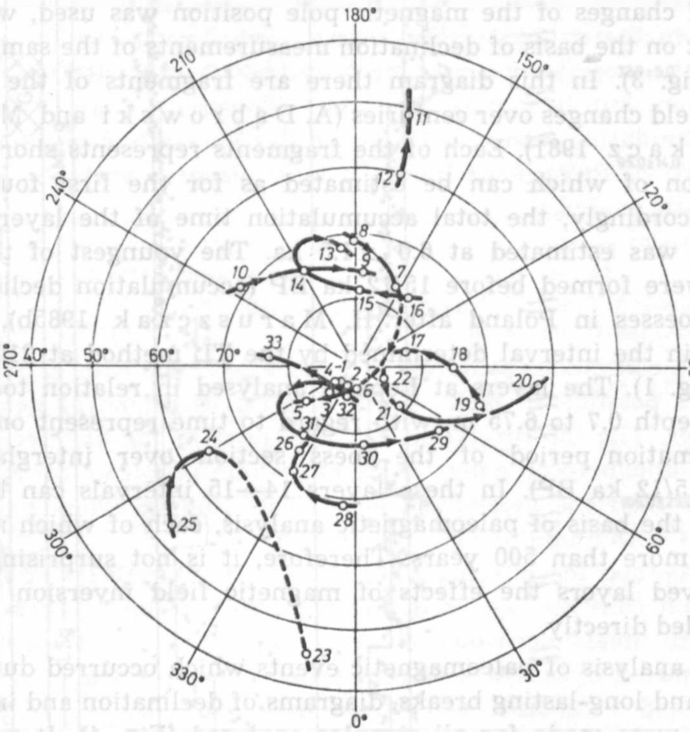

Fig. 3. Mean positions of the magnetic paleopole for 34 sample groups distinguished in the loess section at Łopatki (plotted on the equal-area Lambert projection)

in Fig. 2. It should be stressed that these samples were taken in 1983 at a site more than 10 m from the exposures studied by H. Maruszczak in previous years. This shows the difference in the depth of the interglacial soil found, which is 0.5 m in relation to the lithologic sequence presented in Fig. 1.

To facilitate the interpretation of the analysis results, the whole collection of samples was divided into 34 groups. In their division discontinuity of declination and inclination recording was taken into consideration, as well as the results of studies of the secondary constituents.

Among the distinguished sample groups, the first four comprising the youngest layers studied deserve a special attention. They are characterized by almost identical declination and inclination values and thus can be considered to represent the layers accumulated without significant breaks in a period lasting several hundred years. If accumulation had lasted longer the declination and inclination values would have changed more significantly. The average rate of loess deposition in that period was about 3—4 mm/year.

For determination of the accumulation time of the other layers a diagram of changes of the magnetic pole position was used, which was worked out on the basis of declination measurements of the samples from Łopatki (Fig. 3). In this diagram there are fragments of the curve of magnetic field changes over centuries (A. Dąbrowski and M. Tkacz 1976, M. Tkacz 1981). Each of the fragments represents short periods, the duration of which can be estimated as for the first four sample groups. Accordingly, the total accumulation time of the layers studied at Łopatki was estimated at 6.0 ±1.5 ka. The youngest of the layers analysed were formed before 15/12 ka BP (accumulation decline of the youngest loesses in Poland after H. Maruszczak 1985b), whereas the oldest in the interval determined by the TL method at 219—208 ka BP (see Fig. 1). The layers at Łopatki analysed in relation to that, i.e. from the depth 0.7 to 6.75 m, with regard to time represent only 3—4‰ of the formation period of the loess section over interglacial soil (219/208—15/12 ka BP). In these layers 14—15 intervals can be distinguished on the basis of paleomagnetic analysis, each of which may have lasted not more than 500 years. Therefore, it is not surprising that in the preserved layers the effects of magnetic field inversion have not been recorded directly.

For the analysis of paleomagnetic events which occurred during very numerous and long-lasting breaks, diagrams of declination and inclination increments were made for all samples analysed (Fig. 4). It was found that it is difficult to interpret the changes of declination increments because they are obscured by effects connected with secondary "excursions" of the geomagnetic field. Therefore, attention was largely drawn to the record of inclination increments. The highest part of the section has a positive mark (positive reflex) of these increments, whereas the remaining part a negative mark. In the part of the sequence with negative reflexes there occurs one characteristic positive episode and several changes of the mean values of inclination increments. Changes from positive to negative reflexes as well as changes of mean values within reflexes of one type were connected with inversions of the magnetic field. In the studied Łopatki section 7 magnetic field inversions were distinguished in this way, one of which (the fifth from above) was multiphase, at least four-phase.

The finding at Łopatki of an indirect record of so numerous inversions

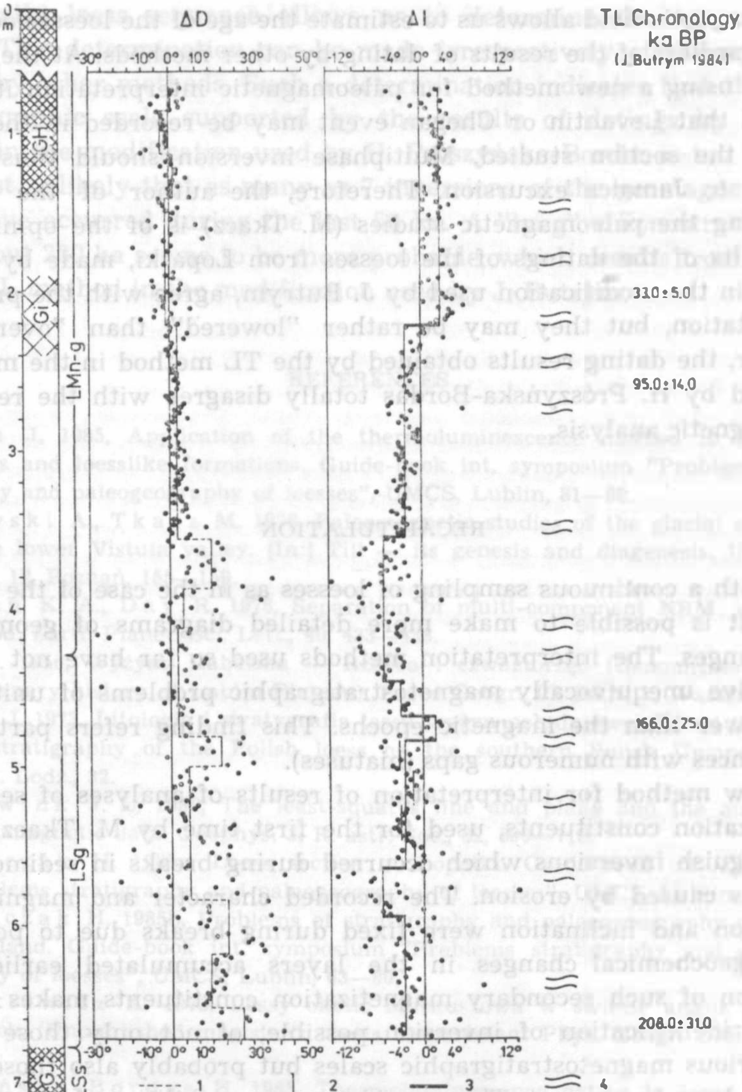

Fig. 4. Diagram of the changes of declination and inclination increments (ΔD and ΔI) determined for the samples from the loess section at Łopatki. On the left a simplified stratigraphic scheme of the section, with letter symbols as in Fig. 1
1 — zones of considerable changes of declination increments (ΔD); 2 — mean magnitudes of ΔD and ΔI between the successive zones of changes; 3 — zones of considerable changes of inclination increments (ΔI) identified with inversions of the geomagnetic field during breaks in sedimentation or erosive discontinuities in the section; 4 — hiatuses in the section

of the magnetic field allows us to estimate the age of the loesses occurring in it regardless of the results of dating by other methods. At the present stage of using a new method for paleomagnetic interpretation it can be assumed that Levantin or Chegan event may be recorded in the lowest part of the section studied. Multiphase inversion should thus be paralleled to Jamaica excursion. Therefore, the author of the chapter concerning the paleomagnetic studies (M. Tkacz) is of the opinion that the results of the datings of the loesses from Łopatki, made by the TL method in the modification used by J. Butrym, agree with the presented interpretation, but they may be rather "lowered" than "overstated". However, the dating results obtained by the TL method in the modification used by H. Prószyńska-Bordas totally disagree with the results of paleomagnetic analysis.

RECAPITULATION

1. With a continuous sampling of loesses as in the case of the Łopatki section it is possible to make more detailed diagrams of geomagnetic field changes. The interpretation methods used so far have not allowed us to solve unequivocally magnetostratigraphic problems of units of an order lower than the magnetic epochs. This finding refers particularly to sequences with numerous gaps (hiatuses).

A new method for interpretation of results of analyses of secondary magnetization constituents, used for the first time by M. Tkacz, allows to distinguish inversions which occurred during breaks in sedimentation or breaks caused by erosion. The recorded character and magnitude of declination and inclination were fixed during breaks due to postdepositional geochemical changes in the layers accumulated earlier. The distinction of such secondary magnetization constituents makes a more accurate identification of inversion possible, of not only those known from various magnetostratigraphic scales but probably also those which have not been known yet. This provides new possibilities of stratigraphic correlation of any section of Pleistocene deposits.

2. The results of detailed paleomagnetic studies by using the new method have shown that in the Łopatki loess section very numerous breaks occur in the record of events. The present lithostratigraphic and paleopedologic studies have permitted to determine only some of these breaks. Also the datings by the TL method have pointed to the occurrence of only two certain long-lasting breaks. Paleomagnetic analyses have shown the existance of at least 13 breaks; during 7 of them inversions of the magnetic field occurred.

3. The finding of traces of 7 inversions of the geomagnetic field in

the Łopatki loess sequence allows us to determine the age of these loesses. This determination can be made irrespectively of the results of datings by other methods. Such a determination indicates that the chronostratigraphic scale supported by the results of datings by the TL method in the modification used by H. Prószyńska-Bordas is too "short". It is most unlikely that as many as 7 inversions of the geomagnetic field could have occurred during the last 50 ka. A "long" chronostratigraphic scale about 220 ka seems to be more probable, which results from datings by the TL method in the modification used by J. Butrym.

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STRESZCZENIE

Profil lessów w Łopatkach (30 km na WNW od Lublina) od dawna wzbudzał zainteresowanie ze względu na występowanie śladów kilku generacji struktur kriogenicznych oraz dobrze wykształconej, kopalnej gleby leśnej. Glebę tę wiązano dawniej z ostatnim interglacjałem. Wyniki datowań termoluminescencyjnych (TL), wykonanych przez J. Butryma w laboratorium w Lublinie, nie potwierdziły takiej interpretacji. Na podstawie tych datowań H. Maruszczak (1985a) skorelował glebę leśną z przedostatnim interglacjałem. Taka interpretacja była krytycznie oceniona podczas międzynarodowego sympozjum lessowego w 1985 r. m. in. z tego powodu, że H. Prószyńska-Bordas (1985) przedstawiła wyniki datowań TL w laboratorium w Warszawie zasadniczo różne. Jeśli bowiem według datowań J. Butryma wiek poziomu humusowego gleby interglacjalnej miałby wynosić około 220 ka BP, to według H. Prószyńskiej-Bordas zaledwie 50 ka BP.

W takiej sytuacji szczególne znaczenie można przypisywać wynikom badań paleomagnetycznych, które wykonał M. Tkacz. W 1983 r. pobrał on z profilu w Łopatkach 353 próbki, w układzie ciągłym, z głębokości 0,7—6,75 m. Próbki te zbadał szczegółowo, stosując przy tym nową, własną metodę analizy wtórnych składowych namagnesowania (M. Tkacz 1987). Pozwala ona wyodrębnić inwersje pola geomagnetycznego, które występowały podczas przerw w sedymentacji czy też przerw spowodowanych przez erozję. Uzyskane wyniki wykazały, że w badanym profilu lessów występuje co najmniej 13 przerw w zapisie zdarzeń. W ciągu 7 przerw występowały inwersje pola magnetycznego. Najstarsza z tych przerw może być przy tym paralelizowana z Levantin lub Chegan event. Dotychczasowe badania litostratygraficzne i paleopedologiczne pozwalały wyodrębniać tylko małą część tych przerw. Przy pomocy tych metod niekiedy wręcz niemożliwe jest identyfikowanie przerw ukrytych wśród mało zróżnicowanych warstw lessowych.

Oznaki występowania 7 inwersji pola magnetycznego dają podstawę do oceny wieku lessów badanych w Łopatkach, niezależnej od datowań innymi metodami. Ocena taka wskazuje, że skala chronostratygraficzna sugerowana dla lessów z Łopatek przy pomocy datowań metodą TL w wersji stosowanej przez H. Prószyńską-Bordas jest zbyt "krótka". Jest bowiem zupełnie nieprawdopodobne, aby w ciągu 50 ka mogło wystąpić 7 inwersji pola geomagnetycznego. O wiele bardziej prawdopodobna wydaje się „długa" skala chronostratygraficzna (około 220 ka), wynikająca z datowań metodą TL w wersji stosowanej przez J. Butryma.

Przedstawiony przykład profilu z Łopatek wskazuje, że analiza wtórnych składowych namagnesowania umożliwia dokładniejszą identyfikację inwersji, i to nie tylko już znanych z różnych skal magnetostratygraficznych. Można się spodziewać, że pozwoli ona wyodrębnić inwersje dotychczas mało zdefiniowane. Daje to nowe możliwości korelacji stratygraficznej dowolnych profili lessowych osadów plejstoceńskich.

РЕЗЮМЕ

Разрез лёссов в местности Лопатки (30 км ЗСЗ г. Люблина) уже давно обращал внимание, в связи с обнаружением нескольких ярусов псевдоморфоз криогенных явлений и хорошо развитой погребенной лесной почвы. Эта почва раньше коррелировалась с последним межледниковием. Результаты определения возраста термолюминесцентным (ТЛ) методом применяемым Ю. Бутримом в ла-

боратории Отделения физической географии Университета им. Марии Склодовской-Кюри в Люблине, не подтверждали такой корреляции. На основании этих ТЛ определений X. Марущак (1985 а) сопоставил лесную почву с предпоследним межледниковием. Это было критически обсуждено во время международного лёссового симпозиума в 1985 г., между прочим потому, что одновременно X. Прушиньская-Бордас (1985) предложила резко отличающиеся результаты ТЛ датировок, полученные другим методом в варшавской лаборатории. Если по анализам Ю. Бутрима возраст гумусового горизонта межледниковой почвы определялся около 220 тыс. лет, то по анализам X. Прушиньской-Бордас только 50 тыс. лет.

В такой обстановке специальное внимание нужно обратить на результаты палеомагнитных исследований проведенных М. Ткачом. В 1983 г. взял он из разреза Лопатки 353 образца в непрерывной последовательности, из глубины 0,7—6,75 м. Эти образцы исследовал детально, применяя новый, собственный метод изучения вторичных составляющих намагниченности (М. Ткач 1987). Этот метод разрешает выделять инверсии геомагнитного поля, которые наступали во время перерывов в накоплении лёсса, или связанных с эрозионными срезами. Из полученных данных вытекает, что в исследованном лёссовом разрезе находится не менее 13 перерывов в летописи природных явлений. Во время 7 перерывов наступали инверсии геомагнитного поля. Самый древний из этих последних перерывов можно сопоставлять с Левантин или Чеган эвент. На основании проведенных до сих пор литостратиграфических и палеопедологических исследований возможно было выделение только небольшой части этих перерывов. При помощи этих последних методов невозможно обнаружение перерывов скрытых среди похожих и однородных слоев лёссовых образований.

Косвенны признаки проявления 7 инверсий геомагнитного поля можно принять за основу оценки возраста лёссов из разреза Лопатки, независимой от результатов датировок другими методами. Из такой оценки следует, что хроностратиграфическая шкала подсказыванная датировками ТЛ методом применяемым X. Прушиньской-Бордас кажется необыкновенно „короткой". Вполне невероятно, чтобы на протяжении 50 тыс. лет наступило 7 инверсий геомагнитного поля. Более вероятной кажется „длинная" хроностратиграфическая шкала (около 220 тыс. лет), вытекающая из датировок ТЛ методом применяемым Ю. Бутримом.

Предложенный пример разреза Лопатки свидетельствует, что на основании изучения вторичных составляющих намагниченности можно более детально отождествлять инверсии, в том числе не только известные из существующих магнитостратиграфических схем. Можно ожидать, что этим методом возможно будет выделить инверсии до сих пор плохо установленные. Таким образом получаются новые возможности стратиграфических корреляций любых разрезов плейстоценовых лёссов и лёссовых образований.