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RESULTS OF TL DATING OF THE LOESS PROFILE AT ODONÓW (SOUTHERN POLAND) IN THE GLIWICE TL LABORATORY

Summary: This paper presents the results of studies of sediments, which have been sampled from the exposure at Odonów near Kazimierza Wielka (southern Poland). The studies carried out by the author are the part of the research project sponsored by the Committee of Quaternary Research of the Polish Academy of Science, in which two other TL laboratories took part (from Warsaw and Lublin). The results of succesive steps of dating procedure are presented in detail, as well as 17 final results of dating obtained for 13 samples of loesses and fossil soils. These results are compared to those obtained in two other laboratories. The results obtained in Warsaw and Gliwice are in general agreement except two samples of fossil soils. This difference is considered as not accidental, and preliminary explanation is suggested. The results obtained in Lublin are systematically older than those obtained in Warsaw and Gliwice, but because of lack of clear and detail description of the laboratory technique, they are not discussed.

1. INTRODUCTION.

In the joint project of the Committee of Quaternary Research of the Polish Academy of Sciences three TL dating laboratories of in Gliwice, Lublin and Warsaw attempted to date 14 samples from the loess profile at Odonów n. Kazimierza Wielka, southern Poland. The profile is more than 15m thick and contains two well developed polygenetic fossil soils. The sequence of loessy deposits in Odonów was investigated by several authors who expressed different oppinions about the stratigraphy and chronology of the fossil soils (Jersak, 1975, 1976; Maruszczak, 1976, 1980a, b; Mojski, 1985). Samples were collected in 1984 by the group consisting of Prof. H. Maruszczak (Maria Curie Skłodowska University, Lublin), Prof. J. Jersak (Silesian University, Sosnowiec), Dr J. Butrym (TL Laboratory, Lublin), the author and other persons. Sampling places were indicated by H. Maruszczak and J. Jersak. Fourteen samples were taken from the exposure down to the depth of 12m. While sampling the author measured in several

places the gamma dose-rate by means of the portable scintillation counter. Samples were taken from loessic layers as well as from fossil soils and then divided into three portions, one for each laboratory (samples for the Warsaw TL Lab were send sometime later). The sketch of the profile with sampling points is provided in Fig.1.

Three participating laboratories dated the collected samples and reported the results in the issue of the research reports of the Quaternary Research Committee (Butrym, 1987; Prószyńska-Bordas et al., 1987; Bluszcz, 1987).

This paper presents the short summary of dating carried out in the TL laboratory in Gliwice. The techniques of sample preparation and TL measurements were described in details in previous papers (Bluszcz and Pazdur, 1985; Bluszcz, 1985) so only the most important information is given below.

2. SAMPLE PREPARATION

In the TL laboratory in Gliwice the coarse grain method (mineral inclusion method) was employed in dating the samples. The samples were divided into two parts: one for determination of radioactive elements and other for extracting suitable mineral grain fraction.

Firstly, the bulk sample was wet sieved through the 56μm sieve to remove fine grain fraction. The remaining was then subsequently treated with 2%HCl and 4% NaOH solutions for 48h at an ambient temperature. After washing and vacuum drying at the temperature lower than 40°C the material was sieved into two size fractions: 88-100μm and 100-150μm. Both size fractions were then treated with 1N HF for 150 minutes at an ambient temperature, either separately or combined together when their amounts were insufficient for making ED determination. After final washing and drying the dose of absorbed radiation accumulated in extracted grains was determined by means of TL measurements.

In the time when the preparation and measurements were being performed it was assumed (after Fleming, 1979) that etching with 1N HF was enough for removing all mineral fractions but quartz. However, it occurred later that such a weak solution of hydrofluoric acid hardly affected even the outer surface of feldspar grains. This fact required some recalculations introduced in the effective dose-rate assessment.

3. EFFECTIVE DOSE RATE ASSESSMENT

The assessment of the dose-rate absorbed by mineral grains based on measurements of ^{238}U, ^{232}Th and ^{40}K contents in each sample. These measurements were made by means of the tripple-channel gamma scintillation

spectrometer. Secular equilibrium in U and Th chains was assumed and alpha, beta and gamma radiation dose-rates calculated using the conversion tables of Aitken (1983).

Effective dose-rates were formerly calculated taking into account alpha and beta rays attenuation in grains (Fleming, 1979; Mejdahl, 1979) and the influence of etching with HF acid upon alpha and beta effective doses.

Table 1

Additional information on the dated samples.

Lab. no.	depth [m]	water [%]	lithological description*	grain size [μm]
GdTL-100	1.60-1.70	-	pseudo-gleyed soil, clayey decalcified loess	88-150
GdTL-99	3.20-3.30	16	slightly clayey carbonate loess	88-150
GdTL-98	3.40-3.50	-	chernozem soil	100-150
GdTL-102	3.40-3.50	-	chernozem soil	88-100
GdTL-97	3.70-3.80	-	illuvial horizon, clayey orange-brown material	100-150
GdTL-103	3.70-3.80	-	illuvial horizon, clayey orange-brown material	88-100
GdTL-96	4.80-4.90	-	stratified dusty deposit, decalcified	100-150
GdTL-95	6.00-6.20	-	stratified dusty deposit, carbonateous	100-150
not dated	6.20-6.30	-	stratified dusty deposit, carbonateous	
GdTL-101	8.00-8.10	15	carbonate light-yellow loess	88-150
GdTL-94	9.85-9.95	-	poorly-gleyed carbonate loess	100-150
GdTL-104	9.85-9.95	-	poorly-gleyed carbonate loess	88-100
GdTL-93	10.80-10.90	13	gleyed carbonate loess on dark grey humus	88-150
GdTL-92	11.10-11.20	26	secondarily gleyed chernozem, upper part	100-150
GdTL-105	11.10-11.20	26	secondarily gleyed chernozem, upper part	88-100
GdTL-91	11.55-11.65	-	secondarily gleyed chernozem, lower part	88-100
GdTL-90	12.10-12.20	-	humus horizon, dusty dark grey material	88-100
GdTL-89	12.80-12.90	21	illuvial gleyed horizon clayey material	100-150

* - lithological description as given by Jersak (1974)

After the fact had been revealed that that etching did not take place the dose-rate values were reassessed. It was observed that the glow curves produced during the measurements of thermoluminescence of extracted grains were characteristic for feldspars. Due to that it was assumed that the TL emission is almost completely dominated by feldspar grains containing ca. 7% of potassium on average (no measurements were possible at this stage to confirm the figure).

The water contained in the sample required correction of the effective dose absorbed by grains. This was done using the average value 20±5% for all samples. In fact the water content, as measured in the laboratory, increased with the depth of the sample in the profile (see the Table 1). This was also confirmed by measurements done by Borowczyk and Frankowski (1979) who reported the water content varying from 10% at the top to nearly 25% below 8m depth in piston holes in the area of exposure. The main reason for using rather average value 25±5% instead of measured one was to make the results directly comparable with those obtained in other laboratories where the water content was not determined.

The contribution to the total dose-rate resulting from absorption of the cosmic rays was calculated according to the formula of Yokoyama et al. (1982) assuming the mean density of sediments equal to $2g/cm^3$. It was also assumed that the alpha radiation efficiency factor equalled to k=0.14 in extracted grains. The values of U, Th and K concentrations in samples and the corresponding effective dose-rates are given in the Table 2.

4. EQUIVALENT DOSE (ED) EVALUATION

All samples were dated by the regeneration method. The natural TL (NTL) of grains were reduced by the exposure to the mercury UV lamp corresponding approximately to one day of natural sunlight. Grains with reduced NTL were then irradiated with ^{60}Co source. NTL was matched to TL regenerated after irradiations yielding the value of ED. The Table 3 gives information on values of gamma doses, percentage of NTL remaining after artificial bleaching at 330°C, results of plateau test and ED values.

Examples of typical glow curves recorded during TL measurements and typical results of plateau tests for two samples GdTL-99 and GdTL-91 are shown in Fig. 2 - 4.

5. FINAL RESULTS AND DISCUSSION

Final results of dating are shown in the Table 2 and in the Fig. 1 which provides the section of the Odonów exposure. In the Fig.1 there are also presented the dates obtained in the Warsaw TL laboratory (Prószyńska-Bordas et al., 1987) and in the Lublin TL laboratory (Butrym, 1987).

Table 2

Results of measurements.

lab. no.	U, TH & K [ppm]	effective dose rates [Gy/ka] alpha	beta	gamma	cosm.	annual dose [Gy/ka]	ED [Gy]	TL age [ka BP]
GdTL-100	U 2.80±0.15 Th 11.3±0.4 K 1.71±0.02	0.31	1.70	1.04	0.17	3.23±0.32	105±20	33±8
GdTL-99	U 2.48±0.15 Th 10.3±0.4 K 1.75±0.02	0.28	1.66	0.97 1.20±0.20*	0.14	3.05±0.31	185±20	61±9
GdTL-98	U 2.51±0.09	0.27	1.42	0.90	0.14	2.77±0.28	270±35	98±17
GdTL-102	Th 10.1±0.4 K 1.38±0.02	0.36	1.42	0.90 1.10±0.20*	0.14	2.82±0.28	280±20	99±13
GdTL-97	U 2.78±0.10	0.29	1.58	0.98	0.14	2.99±0.30	340±50	114±21
GdTL-103	Th 10.9±0.2 K 1.51±0.02	0.39	1.54	0.98	0.14	3.05±0.30	305±30	100±15
GdTL-96	U 2.36±0.06 Th 9.9±0.4 K 1.58±0.03	0.25	1.55	0.91 1.10±0.20*	0.13	2.84±0.28	300^{+100}_{-30}	106^{+34}_{-15}
GdTL-95	U 2.42±0.12 Th 8.5±0.2 K 1.33±0.01	0.24	1.40	0.82	0.12	2.57±0.26	320±45	125±22
not dated	U 2.42±0.09 Th 9.5±0.2 K 1.63±0.01			0.91±0.04 1.10±0.20*				
GdTL-101	U 2.95±0.09 Th 11.3±0.2 K 1.83±0.02	0.32	1.78	1.07	0.11	3.28±0.33	300±30	92±13
GdTL-93	U 2.54±0.15 Th 9.9±0.3 K 1.58±0.01	0.28	1.57	0.93 1.10±0.20*	0.09	2.87±0.29	345±35	120±18
GdTL-92	U 2.54±0.09	0.30	1.58	1.01	0.09	2.98±0.30	400±80	134±31
GdTL-105	Th 12.2±0.4 K 1.50±0.02	0.40	1.54	1.01 1.00±20*	0.09	3.04±0.31	400±100	132±36
GdTL-91	U 2.74±0.11 Th 11.4±0.4 K 1.62±0.03	0.40	1.61	1.02 1.10±0.20*	.09	3.12±0.31	475±50	152±23
GdTL-90	U 2.72±0.12 Th 12.9±0.4 K 1.55±0.03	0.32	1.63	1.07 1.10±0.20*	0.09	3.11±0.31	500±100	161±36
GdTL-89	U 2.72±0.18 Th 11.3±0.2 K 1.66±0.02	0.29	1.67	1.02	0.09	3.07±0.31	490±60	160±26

The table gives: the results of measurements of ^{238}U, ^{232}Th and ^{40}K concentrations with statistical 1σ errors; calculated values of dose-rate (annual dose is given with overall 1σ error); in situ measured gamma dose-rates (denoted with asterisk); values of equivalent dose and TL Age with overall 1σ errors.

Table 3

Results of bleaching and plateau tests

Lab. no.	grain size [μm]	rTL [%]	laboratory gamma doses [Gy]			plateau test [°C]
GdTL-100	88-150	18	50	100	200	300-400 (vg)
GdTL-99	88-150	10	100	200	300	300-400 (vg)
GdTL-98	100-150	10	50	100	200	320-380 (s)
GdTL-97	100-150	10	100	200	300	300-400 (s)
GdTL-102	88-100	9	150	200	300	300-400 (vg)
GdTL-103	88-100	9	200	300	400	300-400 (g)
GdTL-96	100-150	8	150	200	300	300-400 (g)
GdTL-95	100-150	8	200	300	400	300-400 (g)
not dated						
GdTL-101	88-150	9	200	300	400	300-400 (vg)
GdTL-94	100-150	9	200	300	400	300-400 (g)
GdTL-104	88-100	7	300	400	500	300-400 (s)
GdTL-93	88-150	10	200	300	400	300-400 (g)
GdTL-92	100-150	6	200	300	400	350-400 (s)
GdTL-105	88-100	9	400	500	600	300-400 (vg)
GdTL-91	88-100	9	300	400	500	320-400 (vg)
GdTL-90	88-100	6	300	400	500	300-400 (s)
GdTL-89	100-150	10	400	500	600	300-400 (g)

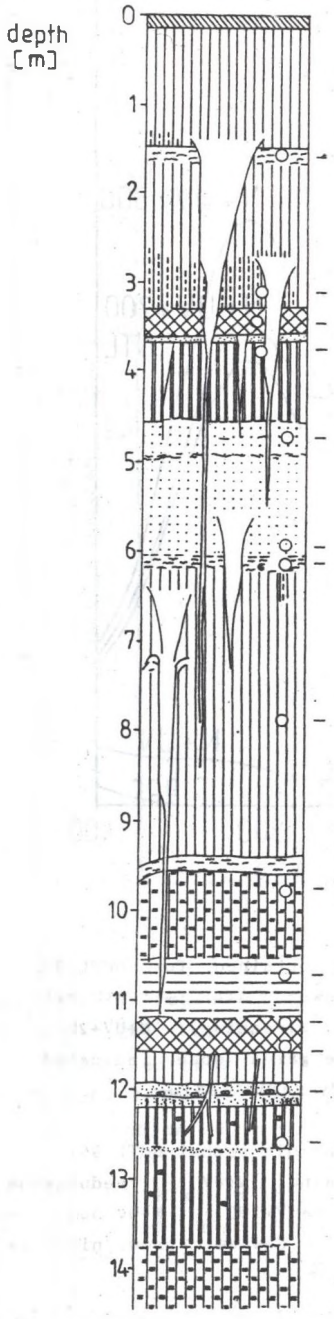
rTL - is the reduced thermoluminescence after bleaching as the percentage of NTL at 330°C.

plateau test - gives the temperature range in which plateau was found and its qualitative evaluation: s - satisfactory, g - good, vg - very good.

In general sets of dates from Warsaw and Gliwice follow the similar pattern, although the formers were obtained for much finer grains (10-30μm). There are two differences (Prószyńska-Bordas and Bluszcz, 1987), however, which are probably not accidental. They occur in the fossil soil (chernozem) levels. Coarse grains give almost identical ages for the fossil soil and the underlying loess. On the other hand, fine grains give younger ages for the fossil soil and very close to the age of the overlying loess. This can be regarded as indication that during the period of the biological activity of the soil exist some mechanisms which differentiate between grain fractions.

I can think about two explanations:

(i) - There is a continual supply of finer fractions (which are bleached during transportation) while coarse grains are much less mobile due two plants covering the soil surface.



TLage [ka B.P.]			
Warsaw	Gliwice		Lublin
27±5	33±8		35±5
51±6	61±9		98±14
55±8	98±17	99±13	121±18
105±12	114±2.	100±	140±21
106±12	106^{+34}_{-15}		149±22
118±19	125±22		177±26
118±19	—		189±28
96±10	92±13		192±29
122±19	135±37	150±31	208±31
120±20	120±18		217±32
125±14	134±31	132±36	223±33
127±14	152±23		229±34
155±25	161±36		254±38
168±27	160±26		264±39

Fig. 1. The schematic section of the Odonów loess profile (Jersak, 1976). Sampling places are indicated by circles.

Rys. 1. Uproszczony profil lessowy w Odonowie (wg: Jersak, 1976). Położenia datowanych próbek zaznaczono kółkami.

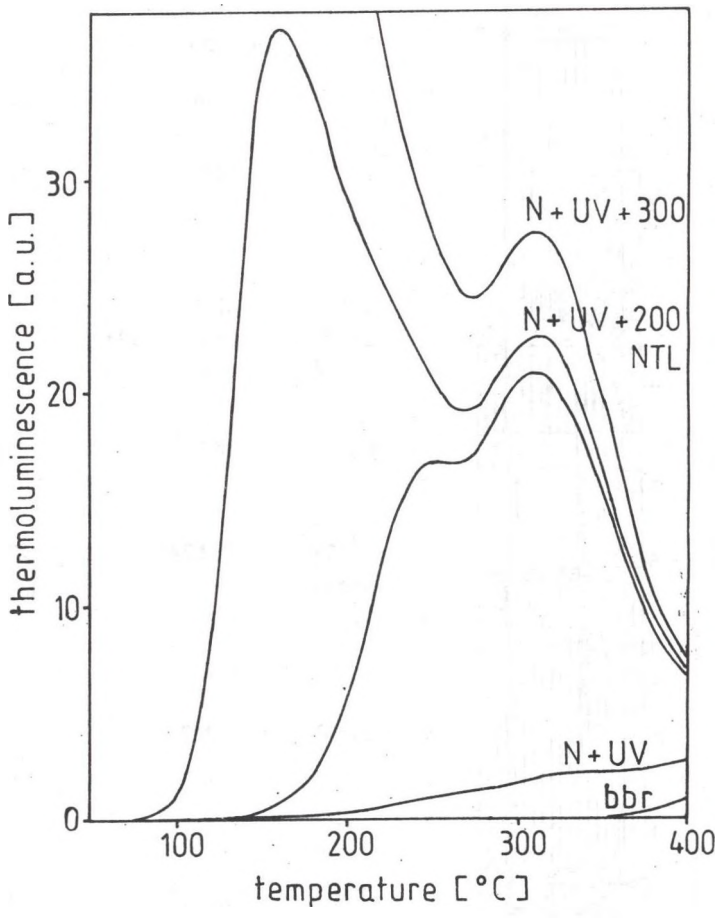


Fig. 2. The reproduction of the TL glow curves obtained for GdTL-99 sample. The curves are described as follows: NTL - natural thermoluminescence; N+UV - reduced NTL (after bleaching); N+UV+200, N+UV+300 - regenerated thermoluminescence by the gamma dose indicated in Gy; bbr - background (black body radiation).

Rys. 2. Przykładowe krzywe świecenia TL otrzymane dla próbki GdTL-99. Opis krzywych: NTL - termoluminescencja naturalna; N+UV - zredukowana wybielaniem termoluminescencja naturalna; N+UV+200, N+UV+300 - termoluminescencja zregenerowana podanymi (w Gy) dawkami promieniowania gamma; bbr - tło termiczne.

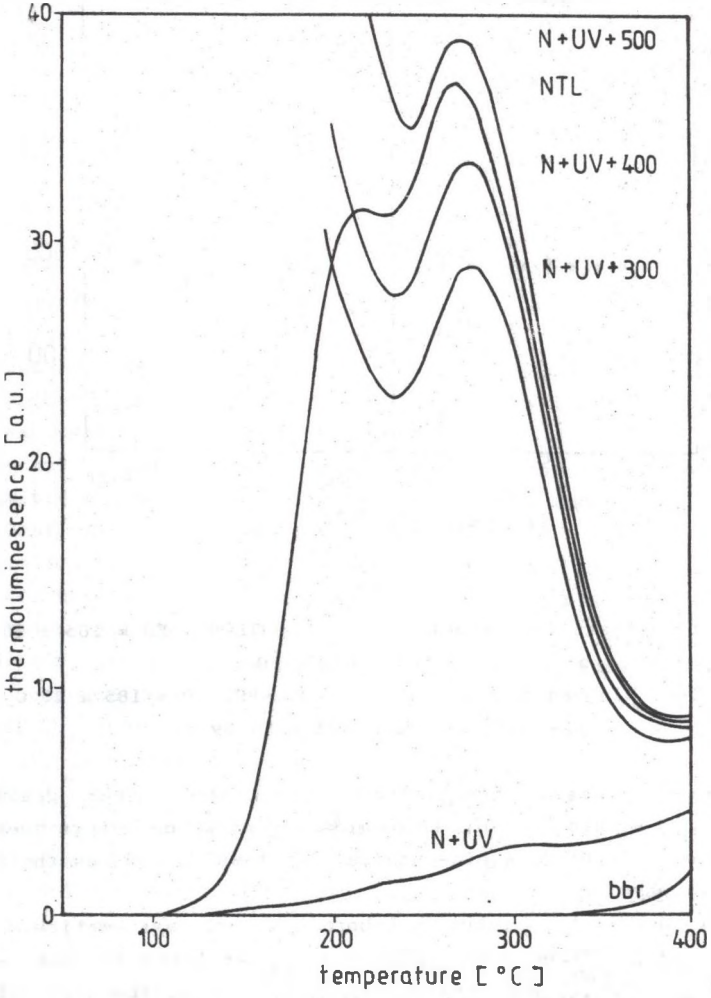


Fig. 3. The reproduction of the TL glow curves obtained for GdTL-91 sample. The curves are described as follows: NTL - natural thermoluminescence; N+UV - reduced NTL (after bleaching); N+UV+300, N+UV+400, N+UV+500- regenerated thermoluminescence by the gamma dose indicated in Gy; bbr - background (black body radiation).

Rys. 2. Przykładowe krzywe świecenia TL otrzymane dla próbki GdTL-91. Opis krzywych: NTL - termoluminescencja naturalna; N+UV - zredukowana wybielaniem termoluminescencja naturalna; N+UV+300, N+UV+400, NTL+UV+500 - termoluminescencja zregenerowana podanymi (w Gy) dawkami promieniowania gamma; bbr - tło termiczne.

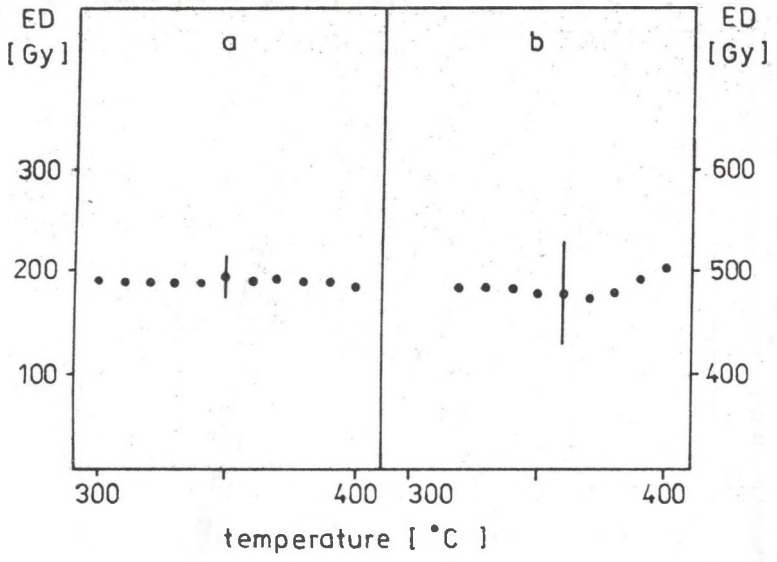


Fig. 4. Plateau tests for samples: a - GdTL-99, ED = 185 ± 20 Gy; b - GdTL-91, ED = 475 ± 50 Gy.

Rys. 4. Test plateau dla próbek: a - GdTL-99, ED = 185 ± 20 Gy; b - GdTL-91, ED = 475 ± 50 Gy

(ii) - There is no supply of new mineral material but finer grains are "bleached" due to either some bio-mechanical agent which brings them up to the surface and sunlight or a bio-chemical agent which reduces their TL in a chemical (bio-physico-chemical) way.

Dates obtained in the Lublin TL Laboratory are systematicaly older than those obtained in Warsaw and Gliwice. This is probably due to the specific techiques imployed in this laboratory, significantly different from those used in the majority of other laboratories and never clearly and detaily described in the published form, unfortunately. The more detailed discussion of the comparison of results obtained in three participating laboratories is prepared for publication elswhere.

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Recenzent: Prof. dr S. W. Alexandrowicz

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WYNIKI DATOWANIA TL PROFILU LESSOWEGO W ODONOWIE W LABORATORIUM TL W GLIWICACH

Streszczenie

Artykuł przedstawia rezultaty badań próbek osadów pobranych ze stanowiska w Odonowie koło Kazimierzy Wielkiej. Badania wykonane przez autora stanowią część projektu badawczego sponsorowanego przez Komitet Badań Czwartorzędu PAN i obejmującego trzy laboratoria datowania metodą termoluminescencyjną: w Warszawie, Lublinie i Gliwicach. W artykule są przedstawione szczegółowo wyniki poszczególnych etapów badań i 17 dat TL otrzymanych dla 13 próbek lessów i gleb kopalnych. Otrzymane przez autora wyniki są porównane z datami z pozostałych laboratoriów. Wyniki otrzymane w Warszawie i w Gliwicach są generalnie zgodne, za wyjątkiem dwóch przypadków gleb kopalnych. Podana jest propozycja wyjaśnienia tej różnicy, uważanej za nieprzypadkową. Wyniki laboratorium lubelskiego znacznie odbiegają od pozostałych i ze względu na brak bliższych danych o sposobie wykonywania pomiarów, nie są komentowane.

РЕЗУЛЬТАТЫ ДАТИРОВАНИЯ TL ЛЕССОВЫХ ОТЛОЖЕНИЙ В ОДОНОВЕ ЮЖНАЯ ПОЛЬША В ЛАБОРАТОРИИ TL В ГЛИВИЦАХ

Резюме

Работа представляет результаты исследований образцов из лессовых отложений в Одонове возле Казимежи Велькой (южная Польша). Исследования выполненные автором работы являются частью проекта научных исследований Комитета Исследований Четвертичного Периода при участи еще двух

термолюминесцентных лабораторий из Варшавы и Люблина. В работе представлены результаты исследований, приводятся 17 TL датировок для 13 образцов лессовых осадков и погребенных почв. Результаты полученные в Варшаве и Гливицах хорошо совпадают между собой, за исключением 2 датировок погребенных почв. Автор приводит в работе объяснение этой разницы, полагая, что она не случайна. Результаты датирования люблинской лаборатории значительно отличаются от остальных, но эта розница не обсуждается в работе в связи с тем, что методика датирования указанного лаборатория не достаточно освещена в публикациях.