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AGE CORRELATION OF LOESS WITH OTHER PLEISTOCENE DEPOSITS ON THE BASIS OF TL AND OSL DATING

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Abstract: The author collected 26 samples from six loess profiles located in Poland and Ukraine and 16 samples from three galcigenic profiles in Lithuania. TL and OSL dates were obtained for the samples. The TL dates were calculated in the Gdańsk University laboratory and the OSL dates were obtained by the Institute of Physics Laboratory at the Silesian Technical University. The dating results were referred to the OSL = f(TL) chart. In respect of luminescent dating results, the Upper Vistulian loess shows a high similarity of TL and OSL dates. It means that loess formation took place in conditions conductive to ensure that solar radiation the grains were exposed to reduce the energy accumulated in them. The TL dates of Middle and Upper Vistulian loess are slightly older than the OSL dates. The largest discrepancies were found in soil sample dates. The analysis of glacigenic profile dates is not unambiguous. The fact that the TL dates are older than the OSL dates may mean that during deposition the conditions were not sufficiently conductive to reduce the energy stored earlier in the grains examined with the TL method. This time could have been sufficient to reduce the energy examined with the OSL method.

Keywords: TL, OSL, loess, sand eolian, lacustrine sand, silty sand, Carpathian Foothills, Sudeten Foreland, Dniester River Basin, Podolia, Vilnius

1. INTRODUCTION

Loesses are the most highly valued research material as far as luminescent dating is concerned. Sand deposits, including beach sand and fluvial sand, receive lower marks in the luminescent dating suitability rankings (Bluszcz, 2000). The above mentioned deposit types are used by the vast majority of international laboratories in their laboratory work which is often limited to materials deposited before 200,000 BP years. The already mentioned deposit type, as well as its deposition time, has been used to compare the dating results of TL and OSL methods.

Twenty six samples were collected from 6 loess profiles. As far as Polish sites are concerned, the samples were collected in the Carpathian Foothills: in Dybawka (DA) and Tarnawce (TA); in the Sudeten Foreland: in Dankowice (DN) and Biały Kościół (BK). Some loess profile samples were also taken in Ukraine, at sites located in Halič (H) in the Dniester River Basin and in Velykyj Hlybočok (VH) in Podolia. As regards glacigenic profiles in Lithuania, 16 samples were taken in Vilkiškes (V), Tartokai (T) and Rokai (R).

Each sample was dated with the TL method in the University of Gdańsk Laboratory by the author of the present study. A. Bluszcz from the Institute of Physics at The Silesian University of Technology in Gliwice dated the same samples with the OSL method. The dating was commissioned by the author of the present work as a part of his own research project (BW: 1230-5-0125-3 and 1230-5-0044-4).

2. GEOLOGICAL SETTING

The samples were taken from geologically well-analysed sites (**Fig. 1**), where much laboratory research was carried out, resulting in lithologic and stratigraphic studies. The dating samples were taken by the authors of the stratigraphic study concerning a particular research site. At sites in Ukraine the samples were collected by A. Boguckyj and M. Łanczont, in the Carpathian Foot-

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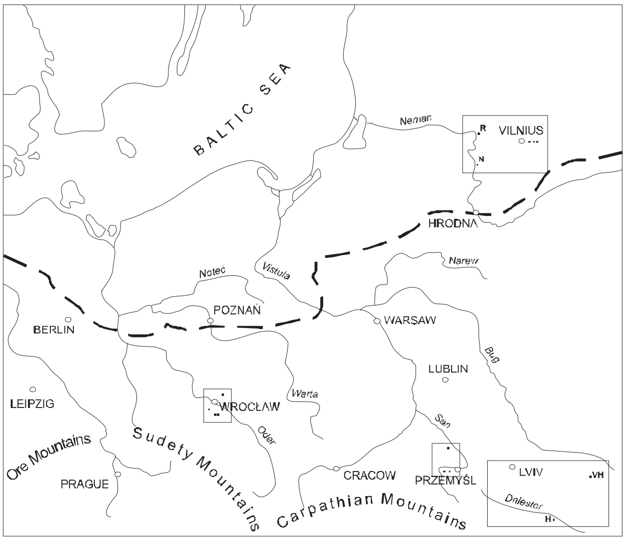

Fig.1. *Location of geological profiles in the Sudeten Foreland, Carpathian Foothills, Dniester River Basin, Podolia, in the vicinity of Vilnius.*

hills by M. Łanczont, in the Sudeten Foreland by Z. Jary and D. Ciszek, and finally in Lithuania by A. Gaigalas (Fedorowicz, 2005 and 2006a).

Loess formations typical of the Carpathian Foothills near Przemyśl and the Sudeten Foreland near Wrocław do not form a continuous cover; they appear in sheets. The thickness of loess layers in the Foothills does not exceed 20 metres, whereas in the Foreland 10 metres, and sometimes not even 2 metres. The loess layers are of different age. There are Vistulian loesses near Wrocław (Vistulian = Weichselian), and near Przemyśl, apart from the loesses of the last glaciation (Vistulian), there are also older loesses (Warthanian loesses). The loesses near Przemyśl are marked by a low content of carbonates and a higher content of iron oxides and humus. They were transported at small distances and the initial accumulation of loesses was accompanied by greater climate humidity (Łanczont, 1995; Łanczont and Fedorowicz, 2004). Loess formations in SW Poland emerged on fossil soil of the last interglacial period. The research has shown that their source was local bed-rock waste. The loesses in the Sudeten Foreland are classified as humid loess (Ciszek *et al.*, 2001a and 2001b).

The Ukrainian loesses are a part of the western periphery of a huge loess area, recognized as the East-European loess province, one of the greatest in the world. In Ukraine there are a few loess areas with broad and thick covers. These are the areas in the western part of Ukraine (the Volhynian-Podolian Upland and eastern Subcarpathia**)**, as well as the Dniester River Valley basin and the Black Sea coast loesses in the middle and southern parts of the country. The Halyč profile is one of the basic sites in the Dniester River Basin. In this area, the loess-soil series include units which maintain the continuity in the profiles from at least the Brunhes-Matuyama magnetostratigraphic boundary. The loesses in Podolia represent younger Pleistocene periods. Stratigraphic studies of Halyč and Velykyj Hlybočok profiles were prepared by Boguckyj and Łanczont (Buguckyj *et al.*, 2000; 2002 and 2003; Łanczont and Boguckyj, 2002).

The profiles of glacigenic deposits come from southern Lithuania. Near Vilnius, not far from each other, there are natural outcrops in the valley slopes of the Rivers Neris, Jesia and Nemunas. The outcrops are about 20 metres high and consist of Aeolian sand, stratified lacustrine deposits and fluvial sand. The profiles include also glacial deposits (boulder clay) which were not covered by the analysis due to the methodological limitations adopted. The majority of the chosen profiles are stratotypical profiles covered by the international research scheme.

3. DATING METHODS

The TL dating was completed in the TL laboratory at the University of Gdańsk**.** The dose rate was measured with the MAZAR 95 scintillation spectrometer. Dry deposit was put into plastic Marinelli containers with a volume of 1.5 dm^3 and placed in the protective chamber of the spectrometer. 20 measurements were conducted and each of them lasted 2000 s.

The sum of pulses in channels determined the concentration of the three nuclides: ^{226}Ra, ^{232}Th and ^{40}K. The values received are converted into dose rates for alpha, beta and gamma radiation. Corrections were made to account for earlier measurements of deposit humidity (Aitken and Xie, 1985). A cosmic radiation dose (d_c) was added to the estimated alpha, beta and gamma radiation doses. The uncertainty of the dose rate estimation is about 3%. For the estimation of the equivalent dose from the total mass of the sample a fraction of grains with a size of 80–100 μm was separated. The grains, isolated with the sieve method, were subject to initial extraction to remove the external layer from the quartz grains and to clean their surface. The grains are then treated with 10% HCl acid and 40% HF acid within 24 hours. The samples were rinsed with distilled water and dried in room temperature. The the absorbed rate ED was measured with the multi aliquot regeneration method (Fedorowicz, 2006a). For each aliquot of extracted grains from 10 to 20 diagrams of the glow curve were prepared, as well as a plateau check test. Its results shed light on the accuracy of the initial TL value estimation and give some hints whether the laboratory time of sample bleaching was optimal (Bluszcz, 2000). The sensitivity of grains is also checked by way of complementary measurements according to the technique used in additive method. The uncertainty of ED determination is about 10%. Glow curves are done with the use of a reader-analyser type RA'94. The samples are heated up to 400°C with the heating speed of 8°C per second.

The OSL dating was done in Gliwice. The dose rate was determined with the gamma radiation semiconductor spectrometry method (Poręba and Fedorowicz, 2005). A high-purity coaxial germanium detector (HPGe) CANBERA P was used. The samples were measured using Marinelli measuring geometries of 600 cm^3. The equivalent dose was determined after the initial extraction, similar to that carried out in Gdańsk, with the SAR regeneration method and the use of a luminescence reader type 1150 made by Daybreak (Bluszcz, 2000).

Table 1. *TL and OSL Dates of the following loess profile samples: Halyč (H). Tarnawce (TA). Dybawka (DA). Velykyj Hlybočok (VH). Biały Kościół (BK). Dankowice (DN). Range of OSL dates without Lab. No – private information from Z. Jary.*

Sample	Depth (m)	TL date (ka BP) (Lab. No)	OSL date (ka BP) (Lab. No)	Range of OSL results (ka BP)	Number of OSL meas-urements	Average OSL result (ka BP)	Loess and soil levels and MOIS
H.IC.1	1.54	17.4±2.6 **(UG-5630)**	10.62±0.39 13.32±0.46 **(Gd TL-717)**	10.2 – 33.5	16	15.92	Upper younger loess (**2**)
H.IC.2	2.00	19.0±2.9 **(UG-5631)**	15.49±0.59 20.51±0.70 **(Gd TL-721)**	14.1 – 23.3	13	18.61	Upper younger loess (**2**)
H.IC.3	2.52	20.0±3.2 **(UG-5633)**	18.1±1.3 **(Gd TL- 721)**	4.7 – 22.9	8	16.43	Upper younger loess (**2**)
H.IIA1	5.40	108.3±12.3 **(UG-5608)**	54.6±1.6 50.1±2.2 **(Gd TL-742)**	20.7 – 77.7	16	52.10	Eem interglacial soil (**5e**)
H.IIA4	8.60	152.1±20.8 **(UG-5611)**	62.7±3.7 104.1±4.9 **(Gd TL-722)**	17.5 – 186.0	12	96.81	Wartanian loess (**6**)
H.IIA8	12.70	171.6±21.9 **(UG-5615)**	38.2±1.5 72.4±2.6 **(Gd TL-743)**	7.3 – 97.0	20	57.94	Lublin interglacjal soil (**7**)
H.IIA10	15.00	164.9±24.7 **(UG-5617)**	49.4±2.0 **(Gd TL -720)**	33.5 – 115.0	9	68.32	Odranian loess (**8**)
TA-1	1.60	12.6±1.4 **(UG-5666)**	9.27±0.30 **(Gd TL-728)**	6.69 – 13.8	13	9.70	Upper younger loess (**2**)
TA-2	2.80	16.6±1.5 **(UG-5667)**	12.82±0.46 15.95±0.58 **(Gd TL -728)**	2.91 – 18.85	15	13.89	Upper younger loess (**2**)
TA-4	3.70	30.8±3.2 **(UG-5669)**	29.9±1.3 **(Gd TL-729)**	8.1 – 36.7	11	29.55	Middle younger loess (**3**)
DA-2	2.25	10.9±1.4 **(UG-5688)**	8.14±0.54 **(Gd TL -719)**	6.1 – 12.4	10	8.57	Recent soil (**1**)
DA-5	4.40	10.4±1.4 **(UG-5691)**	6.10±0.42 **(Gd TL -744)**	0.59 – 10.6	11	5.14	Upper younger loess (**2**)
DA-6	5.15	14.6±1.6 **(UG-5692)**	10.08±0.38 14.97±0.60 **(Gd TL -723)**	2.89 – 26.9	18	11.92	Upper younger loess (**2**)
DA-9	7.95	15.8±2.0 **(UG-5695)**	11.53±0.37 12.97±0.40 **(Gd TL-724)**	8.86 – 14.31	17	11.85	Upper younger loess (**2**)
VH-11	1.60	38.0±4.9 **(UG-5645)**	9.05±0.27 19.21±0.68 **(Gd TL -755)**	8.9 – 60.3	17	27.26	Middle younger loess (**2**)
VH-13	2.10	81.0±10.2 **(UG-5647)**	52.25±2.0 13.26±0.39 **(Gd TL -754)**	13.2 – 95.3	17	57.66	Lower younger loess (**5b**)
BK-6	4.75	17.2±2.5 (**UG-5875**)	24.8±0.9	10.4 – 46.9			Interstadial soil (**3**)
BK-8	5.65	42.0±5.5 (**UG-5877)**	26.7±0.9	16.9 – 50.2			Lower younger loess (**4**)
DN-1	1.30	20.0±2.2 (**UG-5883)**	19.1±0.7	17.7 – 46.2			Upper younger loess (**2**)
DN-2	2.05	14.3±1.5 (**UG-5884)**	11.3±0.4	10.3 – 19.1			Upper younger loess (**2**)
DN-3	2.80	23.8±2.8 (**UG-5885)**	22.6±0.9	17.9 – 36.8			Upper younger loess (**2**)
DN-4	3.50	21.0±2.8 **(UG-5886)**	21.6±0.4	16.4 – 42.1			Upper younger loess (**2**)
DN-5	4.10	14.5±1.9 **(UG-5887)**	10.8±0.7	10.1 – 19.6			Upper younger loess (**2**)
DN- 6	4.65	23.7±2.8 **(UG-5888)**	21.1±0.7	10.3 – 39.2			Upper younger loess (**2**)
DN-7	5.30	21.8±2.4 **(UG-5889)**	20.7±0.8	12.1 – 34.4			Upper younger loess (**2**)

Table 1. *Continuation.*

Sample	Depth (m)	TL date (ka BP) (Lab. No)	OSL date (ka BP) (Lab. No)	Range of OSL results (ka BP)	Number of OSL measurements	Average OSL result (ka BP)	Loess and soil levels and MOIS
DN-8	6.70	27.2±3.3 **(UG-5891)**	23.8±0.8	16.1 – 43.6			Interstadial soil (**3**)
DN-9	7.45	63.5±7.6 **(UG-5892)**	64.8±2.1	36.2 – 97.3			Interstadial soil (**5a -5b**)
DN-10	8.00	80.9±9.7 **(UG-5893)**	73.1±2.5	46.1 – 94.9			Eem interglacial soil (**5e**)

Table 2. *TL and OSL Dates of the profile samples: Vilkiškes (V), Tartokai (T), Rokai (R). Lithology after: Gaigalas and Fedorowicz, 2002; Gaigalas et al., 2005.*

Sample	Depth (m)	TL date (ka BP) (Lab. No)	OSL date (ka BP) (Lab. No)	Range of OSL results (ka BP)	Number of OSL measurements	Average OSL result (ka BP)	Lithology
V-3	4.40	14.3±2.1	12.71±0.53	2.0-19.0	18	12.3	Sand eolian
V-9	14.50	37.2±5.6	129.0±34.0	110.0-301.8	7	200.0	Lacustrine sand, laminited
V-11	17.80	54.8±8.2	150.7±5.8	91-220	21	157.0	Silty sand with interlayers of silt
V-16	25.70	184.9±28.0	211.0±16	98-346.4	13	214.6	Sand laminated
V-19	33.00	280.6±42.0	127.9±6.5	110-240	21	170.4	Sand
T-6	27.20	188.8±27.0	49.3±5.6 191.0±11	44.2-199.0	6	114.5	Sand fine-grained
T-13	19.50	109.7±15.6	133.6±7.2 203.0±12.0	123.0-300.0	9	175.4	Sand fine-grained laminated
T-15	15.50	47.8±7.5	73.5±3.1 85.7±3.8 108.0±5.2	54.4-115.4	15	90.1	Sand fine-graned laminated
T-19	4.00	18.9±3.1	125.9±5.9	53.5- 158	13	103.9	Sand fine-grained, laminated
R-4	24.00	50.4±7.5	17.9±0.75 24.3±1.1	14.9-31.7	23	21.2	Silt and gravel
R-7	22.50	38.0±5.0	13.9±0.68 17.84±0.76	12.1-34.5	20	19.7	Silt and gravel
R-10	21.00	34.8±5.0	16.72±0.76 25.0±1.3	7.9-37.2	22	20.1	Silt and gravel
R-12	34.00	67.2±9.0	26.0±1.2 30.7±1.3	18.7-53.7	24	32.9	Sand, gravel and pebble
R-14	32.00	64.8±9.0	24.25±0.94 32.2±1.3	13.1-63.4	23	33.6	Silt and gravel
R-18	23.50	36.0±5.4	24.1±1.0 29.4±1.2 17.6±0.91	8.9-55.9	25	23.2	Silty sand and gravel
R-20	22.00	31.7±4.8	13.94±0.61 16.95±0.73	12.0-43.3	20	19.8	Silty sand and gravel

It should be noted that the uncertainty of the equivalent dose determination with the single aliquot method is several times smaller that with the multi aliquot method. The difference is due to the fact that in the multiple aliquot method the grains are subject to different doses of radiation and then the luminescence is measured. The aliquots differ in their mass, mineral composition and individual grain qualities. This causes an unavoidable and considerable diversity of results. In the single aliquot method an automated reader with a built-in source of radiation is used. The programmed reader does the irradiation and measurement for a single aliquot independently. In this way the precision of measurement increases (Bluszcz, 2000).

ANALYTICAL METHODS

Simultaneous TL and OSL dating covered 42 samples in total. The comparison of dating results of loess profiles samples is presented in **Table 1.** The samples contained mostly the loess whose deposition took place in the last glacial cycle. There were 8 samples of Upper Plenivistulian loess, associated with MOIS 2, 2 samples of Middle Vistulian loess (MOIS 3), 1 sample of early Vistulian loess (OIS 5b), 1 sample of Warthanian (= Warthe) (MOIS 6) and Oder loess (= Drenthe) (MOIS 8), as well as 1 sample of interglacial fossil soil (Holocene soil; MOIS 1), Eemian soil (MOIS 5e) and Lublin soil (= Rügen Interglacial) (MOIS 7). Each sample was assigned one TL date and one or two OSL dates. Two or even more OSL dates of one sample prove the age heterogeneity of the grains included (**Table 1**). The OSL age distribution usually concentrated around two modes. Having regard to the OSL date distribution for single aliquots, a study of them was prepared (Fedorowicz, 2006a). Moreover, **Table 1** accounts for the number of the aliquots examined and the range of single OSL dates for each of the samples. The values are shown around which the greatest number of dates concentrates. They were placed in the first row of the results for each sample. A chart of logarithmic interrelations OSL = f(TL) (**Fig. 1**) was prepared, with the first (the youngest) OSL date taken into account.

Table 1 contains no information about the number of OSL dates done for the samples from the BK and DN profiles, their distribution and their average value. The owner of this data is Z. Jary and it has not been published yet. The data in **Table 1** concerns the youngest mode. The analysis of the results presented in **Table 1** and in **Fig. 2** shows that:

1) A vast majority of results are below the line of equal ages. This proves that the majority of TL dates are older than OSL dates.
2) The majority of results, especially those defining the time of Upper Vistulian loess formation, are almost parallel to the line of equal ages.
3) The age heterogeneity of the examined grains has been noticed thanks to OSL dates (**Table 1**) in 10 out of 16 samples covered by the analysis.
4) A vast majority of TL dates fall within the range of single OSL results.
5) The greatest discrepancies between TL and OSL dates appear in the case of samples collected from soil.

Luminescent TL and OSL dates of the same samples from glacigenic profiles are presented in **Table 2** and **Fig. 3**. The chart in **Fig. 3** takes into account the youngest OSL dates. The analysis of the data shown in the chart proves that:

1) OSL dates of 6 samples are older than TL dates.
2) OSL dates of 10 samples are younger than TL dates.
3) The age heterogeneity of the examined grains has been noticed thanks to OSL dating (**Table 3**) in 10 samples. Twice (the samples T-15 and R-18) the analysis proves that three modes exist.
4) TL dates fall within the range of single OSL results only in half of the samples from the Lithuanian profiles.

4. RESULTS AND DISCUSSION

The results of luminescent dating of Upper Vistulian loess reveal great similarity of TL and OSL dates. For this loess TL dates are very similar or slightly older than OSL dates. This means that during the loess formation the conditions were favourable and the solar radiation reaching the grains was able to reduce the energy accumulated in them. The luminescent dates of Upper Vistulian loess, both TL and OSL, are consistent with stratigraphic diagnosis (Fedorowicz, 2006a). The majority of older dates, for the Middle and Lower Vistulian loess, are consistent with the stratigraphic diagnosis. Their low number, though, makes it impossible to draw any conclusions about the results obtained.

The analysis of glacigenic profile dates is not as unambiguous as in the case of loess profile samples. The fact that TL dates are usually older than OSL dates may prove that in the time of the deposition of the above-mentioned deposits the conditions were not favourable enough to reduce the energy, accumulated earlier in grains, measured with the TL method. The time may have been sufficient for reducing the energy measured with the OSL method (Bluszcz, 2000). The discrepancies between TL and OSL luminescent dates, as well as the differences between dates and stratigraphic data have led to further laboratory work with the samples of lacustrine sand from Vilkiškes and Tartokai profiles in the Gdańsk laboratory. The results have been already published (Fedorowicz, 2006a and 2006b). They are not reported in the present study because the samples for the methodological studies mentioned were collected in some other places. The methodological studies concern only TL dates.

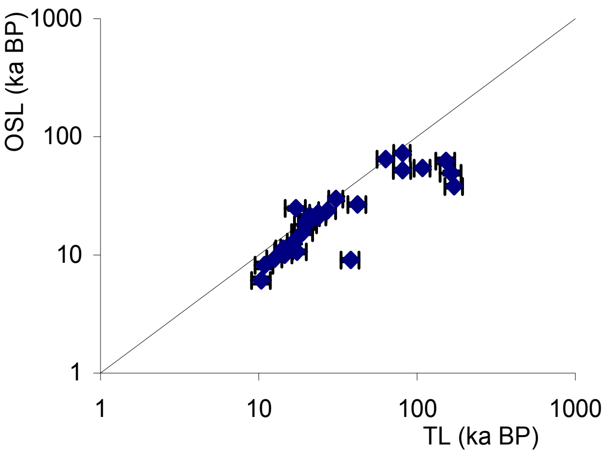

Fig. 2. *OSL =f(TL) dating results for the same profiles: Halyč (H), Tarnawce (TA), Dybawka (DA), Velykyj Hlybočok (VH).*

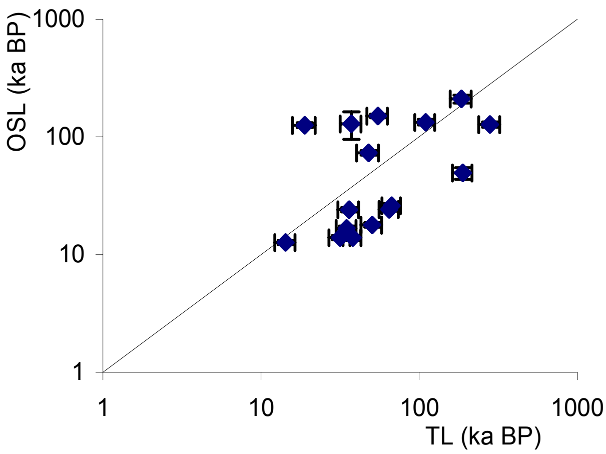

Fig. 3. *OSL = f(TL) dating results for the glacigenic profile samples; Vilkiškes (V), Tartokai (T), Rokai (R).*

5. CONCLUSION

There is no radiometric method yet whose dates would be absolutely consistent with naturalists' hypothesis. Researchers who deal with dating are looking for new methods, new measuring techniques and research equipment because they want dates to determine more precisely when a given geological event took place. Time scale calibration is used in radiometric dating (especially in the radiocarbon dating method), many aim at interlaboratory comparisons – all this to state that a given method determines the absolute age. It is similar with luminescent methods. The present study shows the comparative results of the older luminescent method (TL) together with the newer one (OSL).The data reveals the similarities and discrepancies between these dates. Both physicists (Fedorowicz, 2006a and 2006b) and naturalists are trying to find the reasons for the differences between luminescent dates and stratigraphic studies.

REFERENCES

Aitken MJ and Xie J, 1985. Moisture correction for annual gamma dose. *Ancient TL* 8: 6–9.

Bluszcz A, 2000. Datowanie luminescencyjne osadów czwartorzędowych – teoria, ograniczenia, problemy interpretacyjne (Luminescence dating of Quaternary sediments – theory, limitations, interpretation problems). *Geochronometria* 17: 1-104 (in Polish).

Boguckyj A, Łanczont M and Racinowski R, 2000. Conditions and course of sedimentation of the middle and upper pleistocene loesses in the Halič profile (NW Ukraine). *Studia Quaternaria* 17: 3–17.

Boguckyj A., Łanczont M., Madeyska T., 2002. Loesses, loess landscapes and Paleolithic of the Ukraine. Ukrains'ko-pol'ska naukova konferencija *Rol' prirodno-zapovidnykh terytoij Zahidnoho Podillja ta Juri Ojcos'koj u zbereženni biologičnoho ta landšaftnoho riznomanittja*. Zapovidnyk „Miodobory", Grymailov: 35.

Boguckyj A, Cyrek K, Łanczont M, Madeyska T and Sytnyk O, 2003. Middle Palaeolithic stratigraphy in Podolla and East Carpathian Foreland, Ukraine. The Joint Workshop Meeting Loess and Paleoenvironments, INQUA Commission, INQUA Carbon Commission, May 26 – June 1, Moscow, Russia, *Abstract and Field Excursion Guidebook*: 13.

Ciszek D, Jary Z, Kida J and Karamański P, 2001a. Profil lessowy w Białym Kościele (wzgórza Niemczańsko- Strzelinskie) (Loess profile in Biały Kościół (Niemczańsko-Strzelińskie Hills)). In: Jary Z, Kida J, eds, Osady plejstoceńskie przedpola Sudetów (Pleistocene deposits in the foreland of the Sudeten). *Materials from the conference „Korelacja stratygraficzna lessów i utworów lodowcowych Polski i Ukrainy"* (Stratigraphic correlation of loess and glacial formations in Poland and Ukraine), Wrocław - Jarmołtówek, 23 - 28.09.2001: 54 -56 (in Polish).

Ciszek D, Jary Z, Kida J and Karamański P, 2001b. Profil lessowy w Dankowicach (wzgórza Niemczańsko- Strzelińskie) (Loess profile in Dankowice (Niemczańsko-Strzelińskie Hills)). In: Jary Z, Kida J, eds, Osady plejstoceńskie przedpola Sudetów (Pleistocene deposits in the foreland of the Sudeten). *Materials from the conference „Korelacja stratygraficzna lessów i utworów lodowcowych Polski i Ukrainy"* (Stratigraphic correlation of loess and glacial formations in Poland and Ukraine), Wrocław - Jarmołtówek, 23 - 28.09.2001:50 -53 (in Polish).

Fedorowicz S, 2005. Korelacja dat TL i OSL próbek z czterech profili lessowych Polski SE i SW (Correlation of TL and OSL dates four loess profile samples from SE and SW Poland). *Przegląd Geologiczny* 53(11): 1047 – 1050 (in Polish).

Fedorowicz S, 2006a. *Metodyczne aspekty luminescencyjnego oznaczania wieku osadów neoplejstoceńskich Europy Środkowej* (Methodological aspects of luminescence dating of Central Europe's neopleistocene deposits). Wydawnictwo Uniwersytetu Gdańskiego: 156pp (in Polish).

Fedorowicz S, 2006b. TL age of Upper Pleistocene stratified deposits measured with the additive, regeneration and RΓ methods. *Geological Quaterly* 50(2): 211-114.

Gaigalas A and Fedorowicz S, 2002. Thermoluminescence dates Mid- and Late Pleistocene in exposure Eastern Lithuania. *Geologija* 38: 31 -40.

Gaigalas A, Fedorowicz S and Melesyte M, 2005. TL dates of aquatic sandy sediments of Middle- Upper Pleistocene in Lithuania. *Geologija* 51: 39 -50.

Łanczont M, 1995. Paleogeograficzne warunki rozwoju vistuliańskich utworów lessowych w okolicy Przemyśla (Paleogeographic conditions for the development of Vistulian loess formations in the region of Przemyśl). In: Wojtanowicz J, ed., *Materials from the conference "Przemiany geomorfologii i paleogeografii czwartorzędu"* (Quaternary Geomorphology and Paleogeography Changes), UMCS, Lublin, 10-11 04.1999: 40 -43 (in Polish).

Łanczont M and Boguckyj A, 2002. Badane profile lessowe i stanowiska paleolityczne Naddniestrza Halickiego. In: Madeyska T, ed., Lessy i paleolit Naddniestrza halickiego (Loess and Palaeolithic of the Dniester River Basin, Halyč region (Ukrwione). *Studia Geologia Polonica* 119: 33 -165 (in Polish).

Łanczont M and Fedorowicz S, 2004. The age of loess deposits at Dybawka, Tarnawce and Zarzecze (SE Poland) based on luminescence dating *Geologija* 47: 8-14.

Poręba GJ and Fedorowicz S, 2005. Gamma spectrometry for OSL and TL dating of loess deposits at Dybawka and Tarnawce (SE Poland) *Geochronometria* 24: 27 -32.