

DATING OF A DUNE IN KĘPA KUJAWSKA

HUBERT L. OCZKOWSKI¹, KRZYSZTOF R. PRZEGIĘTKA¹,
KRZYSZTOF R. LANKAUF² and JACEK B. SZMAŃDA²

¹ Thermoluminescence and Dating Laboratory, Institute of Physics,
Nicholas Copernicus University, ul. Grudziądzka 5, PL-87-100 Toruń, Poland
(e-mail: hubertus@phys.uni.torun.pl.)

² Institute of Geography, Nicholas Copernicus University, ul. Fredry 6/8, PL-87-100 Toruń, Poland
(e-mail: szmanda@geo.uni.torun.pl)

Abstract. A dune in Kępa Kujawska is located on the edge of the Toruń Basin. Preliminary studies on the natural thermoluminescence (TL) revealed relative chronology of the dune. The TL profile exposed three stages of the dune formation, which are correlated with three eolian members of dune deposits indicated by sedimentological investigations. The experiments on optical bleaching show that light (sunlight as well as laboratory light) only partially resets natural TL in that material. The high level of residual TL was taken into account in absolute dating of the dune. The TL ages obtained for quartz sand from the upper member are confirmed by radiocarbon dating of soil and burn horizon in proximal part of the dune. Archaeological remains found in the dune give another evidence for truthfulness of TL dating results. The TL age of the middle member is consistent with conclusions from pollen analysis in the dune and its environments. The formation of this dune was started in the Late Glacial, probably in the Younger Dryas. In this period eolian deposition was stimulated by variable climate conditions. The upper member of the dune is connected with Neolithic and Iron Age Cultures when anthropogenic activity initiated eolian processes again. During the Atlantic and the Subatlantic periods the dune was rebuilt.



1. INTRODUCTION

Dune deposits seldom become the subject of the thermoluminescence dating (TL), though there have been quite a few works on this subject in recent years (Jaśkowski, 1996; Barcicki and Jaśkowski, 1992).

Due to the fact they are exposed to sunlight during transportation, and thus, they can be theoretically bleached out of the absorbed radioactive energy, it would seem they constitute a good material for thermoluminescence dating. Therefore, the attempt to date dune deposits at the site located in the vicinity of the Kępa Kujawska has been taken up in the frames of the scientific research activity conducted by the Interdisciplinary Team for Absolute Dating Methods of the Nicholas Copernicus University in Toruń. The initial results of the sedimentological analyses and relative dating of the TL profile were published previously (Lankauf *et al.*, 1996). This article contains the results of further works at the above mentioned site.

The investigation site is located in the south-west part of a huge dune formation called the *Góra Toruń-*

ska, on the edge of the Toruń Basin and the Kujawska Plateau, approximately 20 km to the south-west of Toruń (**Fig.1**).

Detailed sedimentological investigation enabled to differentiate three members of eolian deposits. This differentiation was also partially confirmed by the investigations of absolute age through the thermoluminescence method (Lankauf *et al.*, 1996).

Textural and mineralogical analyses, as well as TL sensitivity indicate that deposits constituting the dune are very homogenous. The structure, however, varies in particular members of the dune. There is also some difference in mineral composition (particularly in thicker fractions) and hardly noticeable variation in grain size and profiling between both the lowest eolian deposit member and the members located above as well as the deposits of the proximal and distal part of the dune. Structural features of the two parts of the dune correspond to the proximal and distal members differentiated by Nowaczyk (1994), Izmailow and Nalepka (1994) and Borówka (1980) and others.

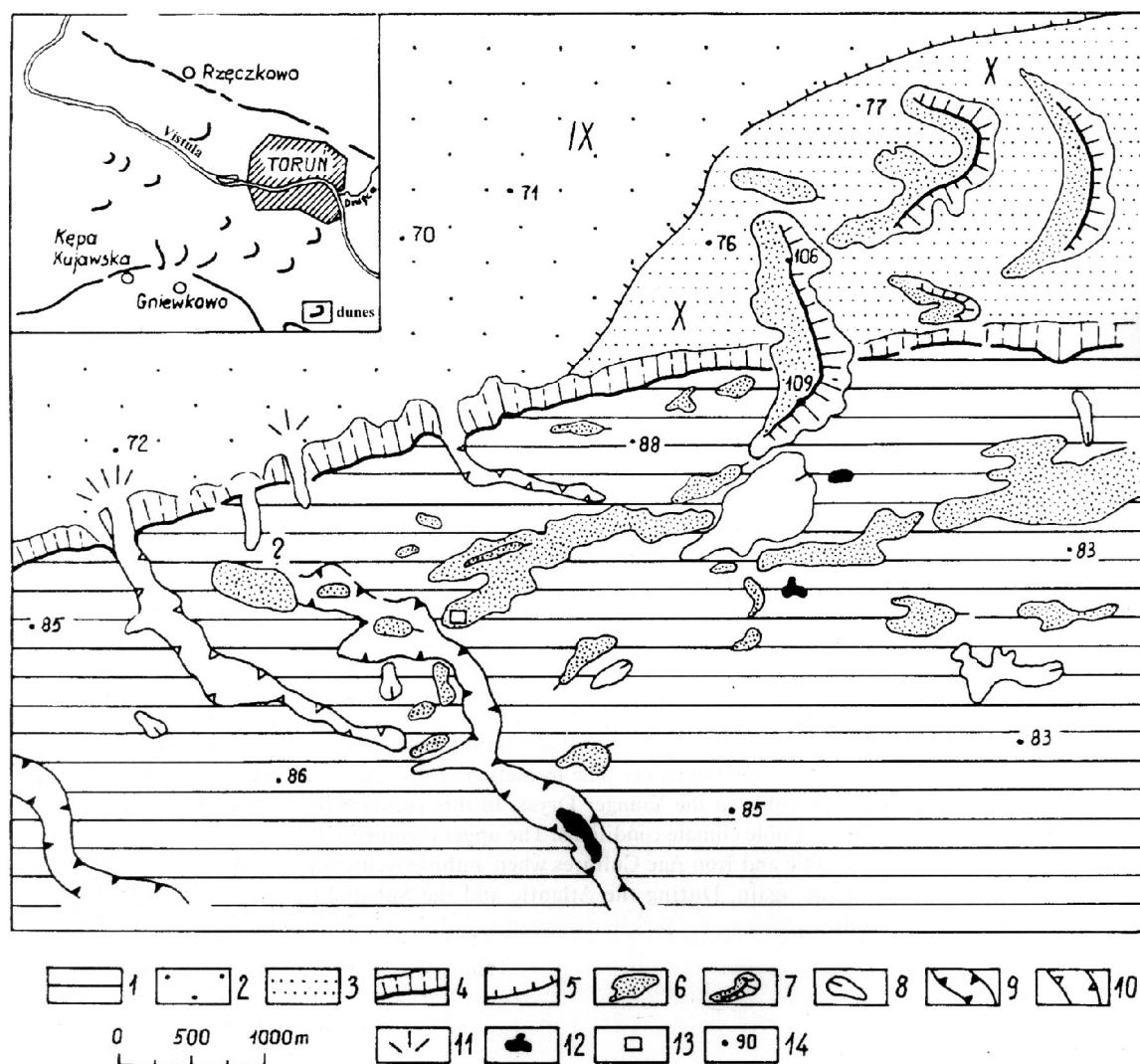


Fig. 1. Geomorphological outline of Kępa Kujawska environs.

1 – moraine plateau, 2 – IX Vistula terrace, 3 – X Vistula terrace, 4 – edges of moraine plateau, 5 – edges of terrace, 6 – sand hills and fields, 7 – regular formed dune, 8 – deflation holes and of other genesis, 9 – subglacial channels, 10 – valleys, 11 – alluvial fans, 12 – lakes, 13 – investigated site Kępa Kujawska, 14 – altitude points.

2. TL DATING

TL investigations were carried out in two profiles. In the first profile (I) a material that had not been previously separated was analysed. High purity of the material was to guarantee the measurement of natural TL.

This resulted in obtaining a profile of glowing curves intensity, which defined a relative (logical) deposition time. (Lankauf *et al.*, 1996). The separation of the samples from the second profile (II) (from the depth of 1.1, 2.7 and 3.9 m) was conducted in the Toruń Laboratory. The fraction of 102-120 μm was revealed in the sieves from the studied samples. In all cases the samples were etched in 10% HCl solution in order to dissolve carbonates and iron compounds, and in 30% H_2O_2

as to remove organic material. The reaction was carried out until effervescence had stopped. With respect to the previously stated material homogeneity (mono-mineral, Lankauf *et al.*, 1996) – the studied samples contain almost entirely quartz – mineral separation was not conducted. In the case of the sample from the depth of 7 m (149-297 μm fraction) from the first profile, the analysis was carried out in co-operation with the University Dating Laboratory in Helsinki. Apart from etching in the 10% HCl solution and 30% H_2O_2 , minerals were also differentiated through applying heavy liquids of 2.53; 2.63 and 2.70 g/cm^3 density which were obtained from the $3\text{Na}_2\text{WO}_4 \cdot 9\text{WO}_3 \cdot \text{H}_2\text{O}$ solution. In order to remove exterior quartz layer accessible from α radiation, the samples were etched in 40% HF solution.

The samples taken from Kępa Kujawska were the subject of a careful investigation of the kinetics of the bleaching process of natural TL signal. Bleaching was performed in sunlight and in a specially designed chamber with a sunlight simulator. During TL bleaching in that chamber, the grains of the material are slowly moved, which reproduces conditions connected to the process of eolian transportation. Systematic study of the bleaching phenomenon indicated that residual TL constituted a significant part of so-called "light-sum of natural TL" (approximately 50%). The presence of such a big value of residual TL was taken into account while applying regeneration method in a thoroughly bleached material from Kępa Kujawska. The SYSTEM-DA-12 with ^{90}Sr beta source incorporated was used in this procedure. The annual dose rates were determined on the basis of high-resolution gamma spectrum measured with Canberra MCA-100 analyser. Detailed analysis of measuring and computational procedures of defining the date has been shown in the publication by Oczkowski and Przegiętka (1998). Contrary to the initial studies which were presented at the previous Conference (Lankauf *et al.*, 1996), the investigation results presented now are solely based upon the TL measurements conducted on the RISO TL/OSL SYSTEM-DA-12 apparatus.

3. RESULTS OF MEASUREMENTS AND DEVELOPMENT OF THE DUNE

The conducted investigations suggest the following scheme of chronological development of the dune in Kępa Kujawska. The bottom of the dune is composed of six-metre thick member of fine sands (Mz 2.9-3.02 phi, i.e. 0.45-0.12 mm). They are well or moderately sorted ($\sigma_1 = 0.43-0.58$), wedge cross-bedded, tabulated. The directions of bed dip are changeable, directed S-SW, S, and S-SE (this may indicate they have previously been formed by winds blowing from the north and north-west sector). The mineral composition of fractions smaller than 0.25 mm is dominated by quartz (93-97%). However, substantial attention was focused on the mineral composition in the fractions above 0.5 mm, where there is much bigger portion of grains, different from quartz or feldspars (amounting at 26.5% maximum) than in upper members. However, the portion of these fractions with respect to total mass of the deposit is minimal (up to 1%). Coated grains and above partly-coated dominate in the bottom of the member.

Approximately 75% of coated and partly-coated grains have mat surfaces. These deposits were transported by wind from the area of the IX terrace in the Toruń Basin. This terrace constituted a big deflation area.

The discussed member of eolian deposits was accumulated in the Younger Dryas and at the beginning of the Preboreal. This cold period is commonly regarded as one of the main periods of dune formations (Nowaczyk, 1996). This conclusion is supported by the obtained results: 10600 ± 2400 BP (TOR-2) from the depth of 7 m in the second profile (II) and 9020 ± 2400 (TOR-1) from the depth of 8 m in the first profile (I). The measurements of glowing curves (Lankauf *et al.*, 1996) in the first profile (I) indicate that the samples taken from that member (from 6.8 and 5.5 m) were deposited at the comparable times. The layer of not laminated fine sands, which is located 20 cm above, was dated to 5300 ± 1070 BP (TOR-6), the sample from the depth of 4.5 m from the first profile). This explicitly indicates the age differentiation. It emerged at the end of the Atlantic Period, presumably as a result of human activity. Several traces of Funnel Baker Culture were documented (Prinke and Szmyt, 1990).

Subsequent 3-meter thick eolian member is represented by the deposits of the proximal and distal part of the dune (Fig. 2). In the proximal part, it is composed of fine sands that are slightly thicker than in the lower member (Mz 2.7-2.8 phi; 0.2-0.12 mm) and remain alternately sorted: well and moderately well. They are of negative values of curve skewness. In the mineral composition of smaller fractions (from 0.25 mm) quartz dominance is considerably bigger (98%) than in the beds from the bottom of the dune; the portion of feldspars amounts at 1.5% to 4%. In vestigial amounts of thicker fractions (from 0.5 mm) whose total content exceeds 1% in the sample 6 only, the amount of quartz grain varies between 85% and 91%, whereas the amount of feldspars between 5% and 12%. The portion of other grains than quartz and feldspars, however, remains very small, definitely smaller than in the beds from the bottom of the dune. It may indicate that it is a material of redeposition origin mainly with tabular diagonal plane bedding. The beds dip 5° towards W and W-SW. The morphology of the dune and its structural features indicate that the proximal slope of the dune has remained. It has been piled up by the winds blowing from the west sector. The distal part of the dune, whose deposits stay in the second profile (II) located several meters to the ESE of the first profile (I),

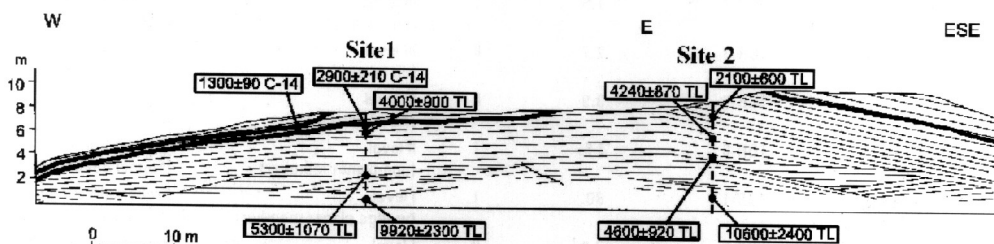


Fig. 2. Diagram of the geological structures of the dune in Kępa Kujawska.

combines eolian sands which contain a bigger addition of silt (Mz 2.9-3.0 phi). These are moderately well sorted deposits of symmetric and positively skewed grain distribution. The bedding here is diagonal and planar, laminae dip more than 20° towards E. This member was deposited during the Atlantic and the Subboreal Periods. For the second profile (II) the following TL ages were obtained 4600±920 BP (TOR-5) at the depth of 3.9 m, and for the first profile (I) 4200±900 BP (TOR-3) at the depth of 2.7 m. Archaeological investigations carried out in the vicinity of Kępa Kujawska (Prinke and Szmyt, 1990; Czerniak and Szmyt, 1990) give evidence of increased anthropogenic activity (numerous archaeological sights to the west and south of the Kępa Kujawska). Traces of the Funnel Baker Culture and Globular Amphora Culture suggest that it was human activity that caused eolian processes.

Lake Jezuickie located several kilometres to the west of the site in Kępa Kujawska proved to contain lake deposits of a strongly sand profile (the Atlantic and the Subboreal Periods) (B. Noryśkiewicz – private information), which caused a hole in the silt diagram. Human activity is also confirmed by the findings of flint splits interpreted as Neolithic by W. Chudziak (private inform). After the phase of relatively intensive eolian accumulation, transformation and rebuilding of dunes, the stable period began. Soil layer was formed at that time. Its remaining part occurs at the depth of 1.5–1.2 m in the upper part of the dune. This fossil soil level was dated by the ¹⁴C method at the Radiocarbon Laboratory of the Silesian University of Technology. It was dated to 2900±210 BP. Reactivation of eolian processes occurred after the fire. The soil on the dune was partly destroyed. A new one-meter sand member was accumulated. In the proximal slope it is of a diagonal plane tabular bedding with the angle of 5° towards WSW. The deposits in the distal slope are slightly of a finer graining with the dip angle of more than 20° towards E. These deposits were dated by the TL method

resulting in the age of 2100±600 BP (TOR-4, sample from the depth of 1.1 m in the second profile). This member was accumulated between the Subboreal and the Subatlantic Periods. The eolian sedimentation was implicated by the anthropogenic activity of the Łużycka Culture (Prinke, Szmyt, 1990) and the Iron Age.

In March 1997, while conducting field investigations, another higher level of soil-burn horizon was distinguished in the form of little charcoals. It was dated by the ¹⁴C method to 1300±60 BP. Presumably, the fire of the forest was connected to the human activity in this region in the early Middle Ages. The results of the dates are presented in the **Table 1** and **Fig. 2**.

4. DISCUSSION

Currently the investigations to date soil-burn levels by the TL method are being conducted. Apart from the sun's optical activity during eolian transportation, the dating of these levels requires to consider the residual TL, connected to the thermal factor. The differences between dune deposits bleached solely by the optical factor and those bleached additionally by the thermal factor, both in size and quality of the TL signal, were shown in the shape of the glowing curve (Lankauf *et al.*, 1996). In order to determine the correct date defining the time of the fire and not of the sand deposition, it is essential to consider the residual TL connected to the impact of high temperature upon the signal bleaching. Exceptionally big TL residual value linked to the transportation and eolian deposition in the dune in the Kępa Kujawska (Oczkowski and Przegiętka, 1998) cannot constitute the groundwork for computing the dates of soil and soil-burn levels. The members of the Team are working to define the impact of the thermal factor in the bleaching process of the signal upon the residual TL amount, and correlate TL dating with the already existing ¹⁴C dates from soil-burn levels in the dune in Kępa Kujawska.

Table 1. Results of TL dating of the aeolian deposits and soil-burns levels of the dune in Kępa Kujawska.

No.	Age [BP]	Lab. No.	Depth [m]	Stand	Eolian level (others)	Chronostratigraphy (Cultural period)
1.	1300±60 ¹⁴ C	Gd-7975	approx. 0.7	-	IV level (proximal part)	Subatlantic (early Middle Ages)
2.	2100±600 TL	TOR-4	1.1	II	IV level (distal part)	Subatlantic (Hallstatt)
3.	2900±210 ¹⁴ C	Gd-9804	Approx. 1.1	I	IV level (proximal part)	Subboreal/Subatlantic (Łużycka Culture)
4.	4000±900 TL	TOR-7	1.5	I	III level (proximal part)	Subboreal Period (Globular Amphora Culture)
5.	4240±870 TL	TOR-3	2.7	II	III level (distal part)	Subboreal (Globular Amphora Culture)
6.	4600±920 TL	TOR-5	3.9	II	III level (distal part)	Subatlantic/Subboreal (Globular Amphora Culture)
7.	5300±1070 TL	TOR-6	4.5	I	II level (non-planar member)	Atlantic Period (Funnel Baker Culture)
8.	9920±2300 TL	TOR-1	80.	I	I level (wedge planar member)	Preboreal/Younger
9.	10600±2400 TL	TOR-2	7.0	II	I level (wedge planar member)	Younger Dryas

ACKNOWLEDGEMENTS

The above presented investigations were financed within the frames of the grants from the Nicholas Copernicus University 424-G and from the Committee for Scientific Research 2 PO3B 130 13. The authors wish to thank dr Högne Junger from the University Dating Laboratory in Helsinki for his continuous scientific support. K. R. Przegiętka and J. B. Szymańda are particularly grateful for financing scientific internship at the Laboratory in Helsinki.

REFERENCES

- Barcicki M. and Jaśkowski B., 1992: Budowa i wiek wydym w Okońsku, Kieleckie. *Studia Geograficzne* 5:
- Borówka K. R., 1980: Współczesne procesy transportu i sedimentacji piasków eolicznych oraz ich uwarunkowania i skutki na obszarze wydym nadmorskich (Present-day transport and sedimentation processes of eolian sands – controlling them factors and resulting phenomena on a coastal dune area). *PTPN, Prace Kom. Geogr.-Geolog.* Vol. XX: 1-126.
- Czerniak L. and Szmyt M., 1990: Z badań nad periodyzacją rozwoju kultury amfor kulistych. In: Cofta-Broniewska A., ed., *Kultura amfor kulistych w rejonie Kujaw. Seria Archeologia* 36, UAM, Poznań: 53-78.
- Izmańłow B. and Nalepka D., 1994: Wiek i efektywność najmłodszej fazy rozwoju wydmy w Przerzetym Borze na Wysoczyźnie Tarnowskiej (Age and effectiveness of the youngest development phase of the dune in Przerzety Bór of the Tarnów Plateau). In: *Vistuliańsko-Holocońskie Zjawiska i Formy Eoliczne. Stowarzyszenie Geomorfologów Polskich*, ed., Poznań: 33-45.
- Jaśkowski B., 1996: Geneza i wiek wydym Gór Świętokrzyskich w świetle datowań ^{14}C i TL (The Genesis and age of the Holly Cross Mountains dunes in the light of ^{14}C and TL dating results). *Zeszyty Naukowe Politechniki Śląskiej, Z. 80, Seria Matematyka-Fizyka, Geochronometria* 14: 31-46.
- Lankauf K. R., Szymańda J. B., Chruścińska A., Oczkowski H. L. and Przegiętka K. R., 1996: Badania sedimentologiczne i wstępne datowanie metodą termoluminescencji osadów eolicznych z Kępy Kujawskiej (Sedimentological reaserch and preliminary dating of eolian deposits of Kępa Kujawska by the means of thermoluminescence method). *Zeszyty Naukowe Politechniki Śląskiej, Seria Matematyka-Fizyka, Z. 80., Geochronometria* 14: 131-145.
- Nowaczyk B., 1986: Wiek wydym, ich cechy granulometryczne i strukturalne a schemat cyrkulacji atmosferycznej w Polsce w późnym vistulianie i holocenie (The age of dunes, their textural and structural properties against atmospheric circulation pattern of Poland during the Late Vistulian and Holocene). *Seria Geografia* 28, UAM.
- Nowaczyk B., 1994: Holocońskie przeobrażenia wydym w okolicy Osieczki koło Konina (Holocene transformations of dunes of the Osieczka region near Konin). In: *Vistuliańsko-Holocońskie Zjawiska i Formy Eoliczne. Stowarzyszenie Geomorfologów Polskich*, ed., Poznań: 47-55.
- Oczkowski H. L. and Przegiętka K. R., 1998: TL dating of young aeolian deposits from Kępa Kujawska. *Radiation Measurements* 29 (3-4): 435-439.
- Prinke D. and Szmyt M., 1990: Pozycja kultury amfor kulistych w procesie zasiedlania Kotliny Toruńsko-Bydgoskiej. In: Cofta-Broniewska A., ed., *Kultura amfor kulistych w rejonie Kujaw. Seria Archeologia* 36, UAM: 115-148.