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The age of the dunes of the Vistula Spit in the vicinity of Stegna

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TL dating of 90 samples of brown, yellow and white dunes confirms the previous dates by Tomczak (1990) who advocates four development stages of the spit. However, these stages to some extent vary by age. The age of the two earlier stages is similar to the age presented in previous publications, while the two younger stages are, in our opinion, somewhat older.

Key words: the Vistula Spit, dune ridges, thermoluminescence (TL) dating

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INTRODUCTION

Aeolian loess and dune sands are the most appropriate deposits for luminescence dating. They received a very good grade as far as their usefulness for dating is concerned. The most useful samples are the ones collected from excavation sites (Bluszcz, 2000; Fedorowicz, 2006). The Thermoluminescence Laboratory at Gdansk University, the first laboratory in Poland, dated dune sands from the southern Baltic coast. Comparable work was carried out in Brandendurgia (Baray, Zoller, 1994; Hilgers et al., 2000). TL and OSL dating of dune sands was also performed by Tatumi et al. (2002, 2003).

The Vistula Spit is an area well known to natural scientists. The history of research in this area is almost one-hundred-year long. Only more than ten radiocarbon dates were taken from sediments underlying the dunes of the spit (Tomczak et al., 1989, 1998). So far, not a single luminescent date has been taken. Thus, it is the first study to introduce new data extending the current state of knowledge about this area.

GEOLOGICAL SETTING

The Vistula Spit is one of the forms of relief typical of the southern Baltic seashore. The total length of the spit exceeds 115 km (Fig. 1). It stretches from Sopot to the Kaliningrad District border. Its width varies from several tens of meters in the area of Sopot to over 3 km in the area of Stegna and Sztutowo.

The views found in the literature on the sources of the spit formation material are discrepant. Rosa (1963) summarized the discussions and presented an overview of the opinions presented during the past hundred years. According to Rosa (1963), the Vistula Spit did not yet exist at the end of the littoral period. However, other views point out to the Atlantic age of the spit related to the final stage of the marine transgression (Rosa, Wypych, 1980; Tomczak, 1995). This is suggested by the age of peat deposits 14–15 m deep, underlying the Vistula Spit in Piaski and Krynica Morska. The age of the deposits is 7560 ± 90 BP (Gd-5141) and 7590 ± 70 BP (Gd-5154), respectively. On the other hand, in the area of the Vistula Lagoon, about 15 m deep, Early Atlantic mud was discovered, which proved that the water basin had been shallow during this period (Zachowicz, 1985). The transgression peak is believed to have occurred 6330 years BP (Gd-1408) (Tomczak, 1989). According to Rosa, Wypych (1980), the oldest dune ridges (brown dunes) are former embankments of this period, transformed by aeolian processes. An intensive process of the Vistula Spit formation is said to have taken place 4000–5000 BP, as other spits of the southern Baltic Sea are of a similar age. Equally old are the peats that fill in the oldest dune depressions (Musielak, 1980; Tomczak, 1990).

Rosa (1963) cites the views of German scientists who claimed that the spit developed as a result of accumulation processes derived from two sides – one from the direction of Sopot and the other from Sambia. It was not until the

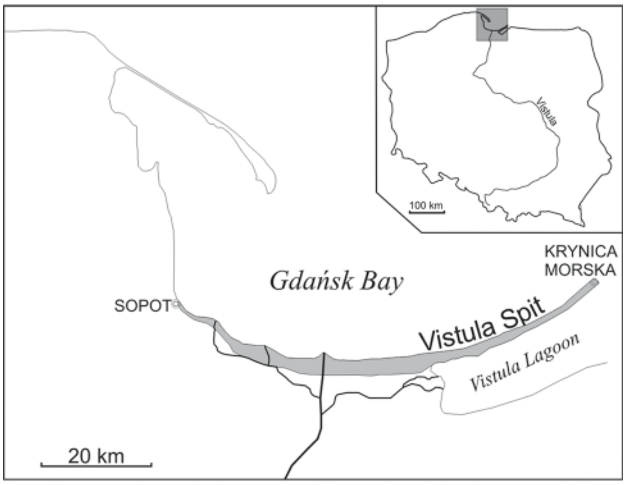


Fig. 1. Location of the study area
1 pav. Tirto ploto padėtis

Middle Ages that the final closure of the spit took place. This thesis was proved by existence of the youngest white dunes distributed in the central part of the spit. According to Rosa, the spit developed simultaneously in its entire length more or less in the same place where it is located now. This view is shared by Mojski et al. (1995), Tomczak (1995), Uścinowicz (2003). At the same time, Tomczak (1995) claims that the spit did not relocate in the course of its development. Sz. Uścinowicz (2003) classifies the Vistula Spit as a spit form heavily supplied with sandy material, similarly to the Świny, Łebska and Sarbska spits. At the beginning, the spit was narrower and smaller; due to this fact, during storms its structure was frequently disrupted. This fact is evidenced by the sands accumulated in outwash fans, which interfinger with muddy formations of the Vistula Lagoon (Zachowicz, Uścinowicz, 1997). Klautsch (1917) (*cf.* Rosa, 1963) was the first researcher to distinguish particular stages of the Vistula Spit development. Inspired by Keilhack's research carried out in 1912 in Brama Świni, he distinguished brown, yellow, and white dunes (Rosa, 1963). The problem of the spit's phased development was discussed in detail by Tomczak (1990). She distinguished four stages of the spit development. According to Tomczak, the spit began to develop at the end of the lithorine transgression peak, i. e. about 6330 BP. The receding sea unveiled the embankments which were transformed into brown dunes as a result of the aeolian process (Rosa, Wypych, 1980). This stage lasted for about 1.200 years from about 5000 BP. Typical of this stage, in addition to brown dunes, are inland peatlands which date to 3920–3160 BP. The second stage lasted from 1200 until 1060 BP. It was the time when the highest dunes were formed, exceeding 40 m above the sea level. These are the so-called yellow dunes. Conducive to their formation was the dry and cool climate and the lowest level of water in the Gdańsk Bay. The third stage lasted between 1060 and 910 BP. It is the shortest stage of all development stages. To its distinctive features belong the fossil alluvial layers with a 65-centimeter thick series containing salt-water fauna found 2.5 m below the sea level. It developed due to seawater transgression into the area of the Vistula delta as well as numerous discontinuities in the spit structure. The discontinuities were caused by the rising sea level and, as a consequence, the increased water level in the Vistula Lagoon. The fourth stage has continued since 910 BP. At this stage, the youngest white dunes were formed. Also, slight fluctuations of the coastline occurred, while the discontinuities were filled in. It has been noted that the process of undercutting the youngest dune ridges was increasingly more frequent.

SAMPLING AND TL DATING OF DUNES OF THE VISTULA SPIT

For the purpose of TL dating, 90 samples along three cross-sections (here named W, K, S – see Fig. 2) were taken from white, yellow, and brown dunes in the fall of 2007. In order to obtain comparable results, all samples were collected at the same level below ground, i. e. 120 cm, 150 cm and 180 cm (Fig. 3). During the survey, it has appeared that some dunes are not fully typologically developed and they are of a transient nature – yellow and brown, or white and yellow. As a consequence, within the three cross-sections, nine samples were taken from white dunes, nine samples from white dunes and yellow dunes, 36 samples from yellow dunes, nine samples from yellow and brown dunes and 27 samples from brown dunes. All samples were sieved and subject to granulometric analysis (Kapka, 2008; Wrzaszcz, 2008). An 80-100 μm fraction obtained through sieving was subjected to TL dating. Samples were prepared and dated by S. Fedorowicz at the TL Laboratory of Gdańsk University. The preparatory process and measurement method are described in (Fedorowicz, 2006). The results of dating are presented in Tables 1, 2 and 3.

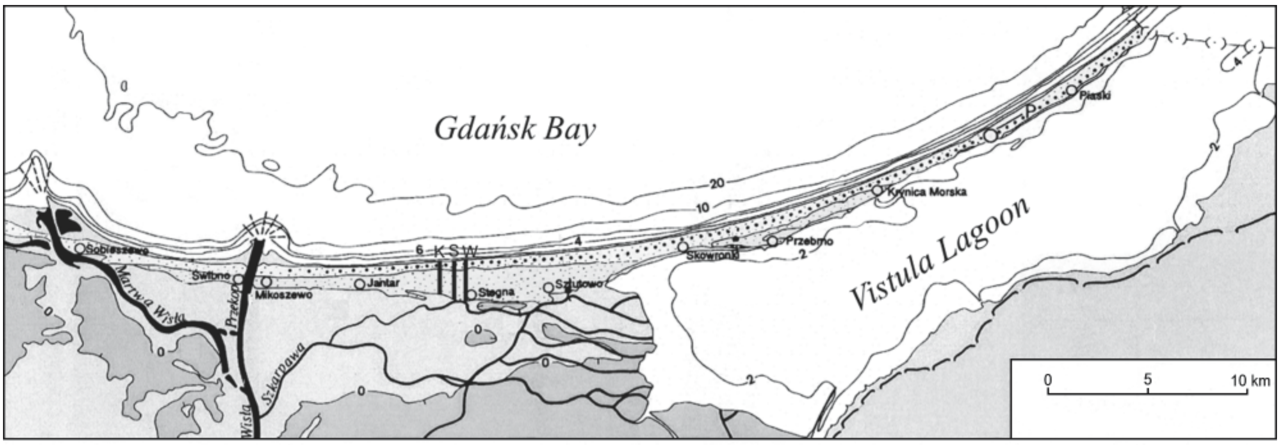
RESULTS

The age of 90 samples collected from the K, S, W cross-sections was grouped and assigned to certain types of dunes (Table 4). Timeframes which specify the deposition time of yellow, yellow and brown, and brown dunes are clearly divergent, unlike the ones related to white, and white and yellow dunes. It may be assumed that the two latter types of dunes developed simultaneously.

Ninety radiometrical dates are quite enough for a statistical and methodological analysis, as well as for interpretation which, in turn, enables to reassess and verify the earlier views concerning particular development stages of the Vistula Spit. Statistical data presented in Table 4 suggest four stages of the dune development. The first stage ended between 6.06–6.99 ka BP, the second between 4.68–5.48 ka BP, the third between 1.76–2.02 ka BP, and the fourth one ended between 0.47–0.61 ka BP.

Table 1. **Luminescence dates of samples from Stegna profile W**
1 lentelė. **Stegnos W profilio pavyzdžių liuminescencinės datos**

Samples	Dune ridges	Depth, cm	Dose rate Dr [Gy / ka]	Equivalent dose ED [Gy]	TL age [ka BP]	No. Lab. [UG]
Stegna W1-1	White	120	2.44 ± 0.1	1.22 ± 0.12	0.5 ± 0.1	5973
Stegna W1-2	White	150	2.40 ± 0.1	0.96 ± 0.09	0.4 ± 0.1	5974
Stegna W1-3	White	180	2.37 ± 0.1	0.95 ± 0.09	0.4 ± 0.1	5975
Stegna W2-1	White / yellow	120	2.45 ± 0.1	1.47 ± 0.15	0.6 ± 0.1	5976
Stegna W2-2	White / yellow	150	2.50 ± 0.1	1.50 ± 0.16	0.6 ± 0.1	5977
Stegna W2-3	White / yellow	180	2.42 ± 0.1	1.45 ± 0.15	0.6 ± 0.1	5978
Stegna W3-1	Yellow	120	2.68 ± 0.1	4.02 ± 0.40	1.5 ± 0.2	5979
Stegna W3-2	Yellow	150	2.63 ± 0.1	3.95 ± 0.4	1.5 ± 0.2	5980
Stegna W3-3	Yellow	180	2.71 ± 0.1	4.61 ± 0.5	1.7 ± 0.2	5980
Stegna W4-1	Yellow	120	2.67 ± 0.1	4.27 ± 0.5	1.6 ± 0.2	5981
Stegna W4-2	Yellow	150	2.60 ± 0.1	6.0 ± 0.6	2.2 ± 0.3	5982
Stegna W4-3	Yellow	180	2.67 ± 0.1	5.07 ± 0.5	1.9 ± 0.3	5983
Stegna W5-1	Yellow	120	2.63 ± 0.1	4.47 ± 0.5	1.7 ± 0.4	5984
Stegna W5-2	Yellow	150	2.70 ± 0.1	4.59 ± 0.5	1.7 ± 0.4	5985
Stegna W5-3	Yellow	180	2.63 ± 0.1	5.00 ± 0.5	1.9 ± 0.3	5986
Stegna W6-1	Yellow	120	2.68 ± 0.1	2.9 ± 0.3	1.08 ± 0.2	5987
Stegna W6-2	Yellow	150	2.61 ± 0.1	3.5 ± 0.3	1.33 ± 0.2	5988
Stegna W6-3	Yellow	180	2.73 ± 0.1	3.7 ± 0.3	1.37 ± 0.2	5989
Stegna W7-1	Yellow / brown	120	2.79 ± 0.1	15.1 ± 1.4	5.42 ± 0.55	5990
Stegna W7-2	Yellow / brown	150	2.69 ± 0.1	15.1 ± 1.5	5.63 ± 0.60	5991
Stegna W7-3	Yellow / brown	180	2.67 ± 0.1	14.0 ± 1.4	5.25 ± 0.68	5992
Stegna W8-1	Brown	120	2.99 ± 0.1	19.0 ± 2.0	6.36 ± 0.66	5993
Stegna W8-2	Brown	150	2.89 ± 0.1	18.5 ± 1.9	6.40 ± 0.62	5994
Stegna W8-3	Brown	180	2.85 ± 0.1	19.2 ± 1.9	6.72 ± 0.68	5995
Stegna W9-1	Brown	120	3.02 ± 0.1	19.6 ± 1.9	6.48 ± 0.70	5996
Stegna W9-2	Brown	150	2.94 ± 0.1	18.9 ± 1.9	6.44 ± 0.65	5997
Stegna W9-3	Brown	180	2.90 ± 0.1	20.0 ± 2.0	6.83 ± 0.70	5998
Stegna W10-1	Brown	120	2.96 ± 0.1	19.3 ± 1.8	6.52 ± 0.65	5999
Stegna W10-2	Brown	150	2.89 ± 0.1	19.7 ± 2.0	6.83 ± 0.71	6000
Stegna W10-3	Brown	180	2.95 ± 0.1	20.5 ± 2.1	6.96 ± 0.73	6001



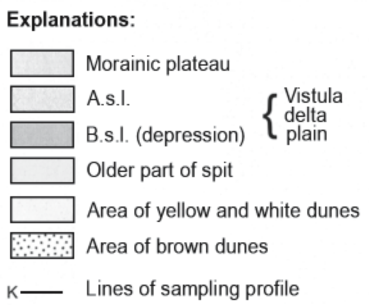


Fig. 2. Location of cross-sections K, S, W in Stegna area in Vistula Spit
2 pav. K, S, W skersinių pjūvių padėtis Vyslos nerijos Stegnos apylinkėse

Table 2. **Luminescence dates of samples from Stegna profile S**
2 lentelė. **Stegnos S profilio pavyzdžių liuminescencinės datos**

Samples	Dune ridges	Depth, cm	Dose rate Dr [Gy / ka]	Equivalent dose ED [Gy]	TL age [ka BP]	No. Lab. [UG]
Stegna S1-1	White	120	2.39 ± 0.1	1.20 ± 0.13	0.5 ± 0.1	6032
Stegna S1-2	White	150	2.48 ± 0.1	1.24 ± 0.12	0.5 ± 0.1	6033
Stegna S1-3	White	180	2.38 ± 0.1	1.43 ± 0.14	0.6 ± 0.1	6034
Stegna S2-1	White / yellow	120	2.48 ± 0.1	1.49 ± 0.15	0.6 ± 0.1	6035
Stegna S2-2	White / yellow	150	2.42 ± 0.1	1.49 ± 0.15	0.6 ± 0.1	6036
Stegna S2-3	White / yellow	180	2.47 ± 0.1	1.48 ± 0.15	0.6 ± 0.1	6037
Stegna S3-1	Yellow	120	2.66 ± 0.1	4.10 ± 0.43	1.54 ± 0.2	6038
Stegna S3-2	Yellow	150	2.67 ± 0.1	4.16 ± 0.13	1.60 ± 0.2	6039
Stegna S3-3	Yellow	180	2.62 ± 0.1	4.00 ± 0.4	1.53 ± 0.5	6040
Stegna S4-1	Yellow	120	2.60 ± 0.1	5.51 ± 0.5	2.12 ± 0.2	6041
Stegna S4-2	Yellow	150	2.69 ± 0.1	8.9 ± 0.9	3.31 ± 0.3	6042
Stegna S4-3	Yellow	180	2.72 ± 0.1	10.1 ± 1.2	3.71 ± 0.4	6043
Stegna S5-1	Yellow	120	2.62 ± 0.1	4.95 ± 0.5	1.89 ± 0.2	6044
Stegna S5-2	Yellow	150	2.60 ± 0.1	5.02 ± 0.5	1.93 ± 0.2	6045
Stegna S5-3	Yellow	180	2.69 ± 0.1	1.61 ± 0.3	0.6 ± 0.1	6046
Stegna S6-1	Yellow	120	2.70 ± 0.1	4.46 ± 0.5	1.65 ± 0.2	6047
Stegna S6-2	Yellow	150	2.62 ± 0.1	4.45 ± 0.5	1.70 ± 0.2	6048
Stegna S6-3	Yellow	180	2.64 ± 0.1	5.83 ± 0.6	2.21 ± 0.3	6049
Stegna S7-1	Yellow / brown	120	2.73 ± 0.1	11.6 ± 1.2	4.25 ± 0.44	6050
Stegna S7-2	Yellow / brown	150	2.70 ± 0.1	11.8 ± 1.2	4.37 ± 0.46	6051
Stegna S7-3	Yellow / brown	180	2.64 ± 0.1	13.5 ± 1.4	5.10 ± 0.51	6052
Stegna S8-1	Brown	120	2.93 ± 0.1	20.0 ± 2.0	6.83 ± 0.70	6053
Stegna S8-2	Brown	150	2.89 ± 0.1	19.3 ± 2.0	6.68 ± 0.70	6054
Stegna S8-3	Brown	180	2.96 ± 0.1	20.4 ± 2.1	6.88 ± 0.70	6055
Stegna S9-1	Brown	120	2.83 ± 0.1	20.6 ± 2.1	7.26 ± 0.71	6056
Stegna S9-2	Brown	150	2.89 ± 0.1	21.3 ± 2.2	7.37 ± 0.74	6057
Stegna S9-3	Brown	180	2.89 ± 0.1	21.5 ± 2.2	7.44 ± 0.75	6058
Stegna S10-1	Brown	120	2.89 ± 0.1	20.2 ± 2.1	6.98 ± 0.70	6059
Stegna S10-2	Brown	150	2.96 ± 0.1	20.7 ± 2.1	7.00 ± 0.73	6060
Stegna S10-3	Brown	180	2.99 ± 0.1	21.8 ± 2.2	7.28 ± 0.74	6061

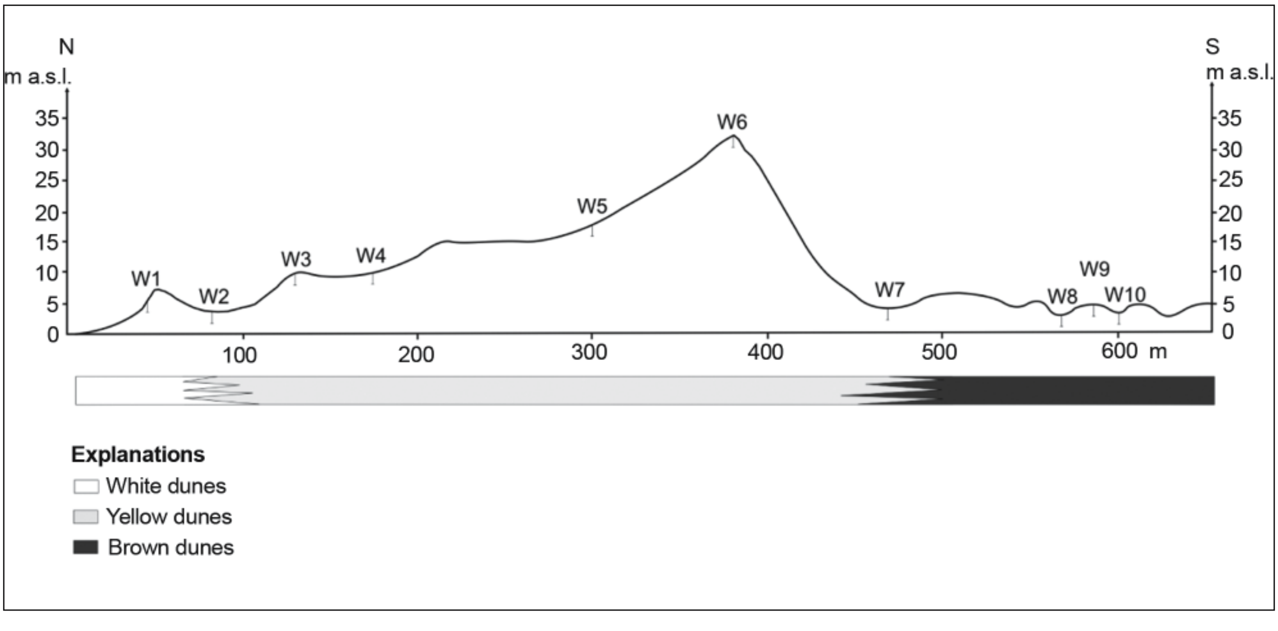


Fig. 3. Topography of cross-section W through different generations of dunes. Sampling sites are indicated
3 pav. W geologinio pjūvio per Vyslos nerijos skirtingos genezės kopas topografija. Nurodytos pavyzdžių paėmimo vietos

Table 3. **Luminescence dates of samples from Stegna profile K**
3 lentelė. **Stegnos K profilio pavyzdžių liuminescencinės datos**

Samples	Dune ridges	Depth,cm	Dose rate Dr [Gy / ka]	Equivalent dose ED [Gy]	TL age [ka BP]	No. Lab. [UG]
Stegna K1-1	White	120	2.37 ± 0.1	1.45 ± 0.15	0.6 ± 0.1	6002
Stegna K1-2	White	150	2.47 ± 0.1	1.24 ± 0.13	0.5 ± 0.1	6003
Stegna K1-3	White	180	2.28 ± 0.1	1.37 ± 0.14	0.6 ± 0.1	6004
Stegna K2-1	White / yellow	120	2.44 ± 0.1	0.98 ± 0.10	0.4 ± 0.1	6005
Stegna K2-2	White / yellow	150	2.47 ± 0.1	1.48 ± 0.15	0.6 ± 0.1	6006
Stegna K2-3	White / yellow	180	2.49 ± 0.1	1.49 ± 0.15	0.6 ± 0.1	6007
Stegna K3-1	Yellow	120	2.63 ± 0.1	5.08 ± 0.51	1.93 ± 0.21	6008
Stegna K3-2	Yellow	150	2.59 ± 0.1	4.27 ± 0.43	1.65 ± 0.17	6009
Stegna K3-3	Yellow	180	2.62 ± 0.1	4.24 ± 0.42	1.62 ± 0.16	6010
Stegna K4-1	Yellow	120	2.60 ± 0.1	5.62 ± 0.57	2.16 ± 0.22	6011
Stegna K4-2	Yellow	150	2.68 ± 0.1	6.30 ± 0.63	2.35 ± 0.22	6012
Stegna K4-3	Yellow	180	2.64 ± 0.1	5.78 ± 0.58	2.19 ± 0.22	6013
Stegna K5-1	Yellow	120	2.63 ± 0.1	4.84 ± 0.50	1.84 ± 0.18	6014
Stegna K5-2	Yellow	150	2.66 ± 0.1	4.79 ± 0.48	1.80 ± 0.18	6015
Stegna K5-3	Yellow	180	2.61 ± 0.1	4.72 ± 0.48	1.81 ± 0.19	6016
Stegna K6-1	Yellow	120	2.66 ± 0.1	7.61 ± -0.70	2.86 ± 0.28	6017
Stegna K6-2	Yellow	150	2.70 ± 0.1	7.02 ± -0.70	2.60 ± 0.27	6018
Stegna K6-3	Yellow	180	2.63 ± 0.1	5.79 ± 0.60	2.20 ± 0.21	6019
Stegna K7-1	Yellow / Brown	120	2.68 ± 0.1	13.7 ± 1.40	5.12 ± 0.52	6020
Stegna K7-2	Yellow / Brown	150	2.72 ± 0.1	14.5 ± 1.52	5.32 ± 0.55	6021
Stegna K7-3	Yellow / Brown	180	2.66 ± 0.1	14.1 ± 1.40	5.30 ± 0.58	6022
Stegna K8-1	Brown	120	2.89 ± 0.1	17.2 ± 1.70	5.96 ± 0.60	6023
Stegna K8-2	Brown	150	2.93 ± 0.1	18.0 ± 1.80	6.14 ± 0.62	6024
Stegna K8-3	Brown	180	2.97 ± 0.1	18.4 ± 1.82	6.20 ± 0.65	6025
Stegna K9-1	Brown	120	2.96 ± 0.1	17.6 ± 1.76	5.94 ± 0.60	6026
Stegna K9-2	Brown	150	2.88 ± 0.1	16.9 ± 1.70	5.88 ± 0.62	6027
Stegna K9-3	Brown	180	2.83 ± 0.1	17.7 ± 1.78	6.24 ± 0.64	6028
Stegna K10-1	Brown	120	2.92 ± 0.1	19.0 ± 1.90	6.52 ± 0.66	6029
Stegna K10-2	Brown	150	2.86 ± 0.1	10.1 ± 1.62	3.54 ± 0.46	6030
Stegna K10-3	Brown	180	2.83 ± 0.1	18.9 ± 1.91	6.68 ± 0.70	6031

Table 4. **The average value of dates obtained for a given type of dunes**
4 lentelė. **Vidutinis kai kurių kopų tipų amžius**

Type of dunes	Timeframe (ka BP)	Average date (ka BP)	No. of samples
White	0.4–0.6	0.51 ± 0.04	9
White–yellow	0.4–0.6	0.57 ± 0.04	9
Yellow	0.6–3.71	1.89 ± 0.15	36
Yellow–brown	4.25–5.63	5.08 ± 0.4	9
Brown	3.54–7.44	6.53 ± 0.46	27

The histogram (Fig. 4) of all 90 ages is constructed for 300-year time intervals. The age distribution clearly points out to two timeframes, the first one ranging from 7.5 ka BP to 5.0 ka BP, and the second from 2.4 ka BP to 0.3 ka BP. The two distinguished timeframes, in particular the younger one, have particular peaks. The older one is characterized by a regular distribution of ages within 300-year timeframes with peaks at 6.9 ka BP to 6.3 ka BP and from 5.4 ka BP to 5.1 ka BP. The obtained dates were measured in samples of brown and yellow and brown dunes. The two subsequent peaks in the histogram occur at 2.4 ka BP to 1.5 ka BP and from 0.9 to 0.3 ka BP. The former peak comprises samples collected from yellow dunes, while the latter one characterizes white dunes and white and yellow dunes.

DISCUSSION

TL dates contribute to the verification of the current views concerning the time of dune development. Radiocarbon ages of samples collected from deposits of the Vistula Spit constitute the first point of reference, although they are scarce, and not a single one was collected in the area of Stegna. They mark the beginning of the development of particular dune types. Radiocarbon ages of silt, clay and peat deposits from Dziady, Piaski, Krynica, Przebrno, Komary and Przejazdowo are included in the timeframe ranging from 8120 ± 140 BP (Gd-4145) to 6330 ± 60 BP (Gd-1408) (Tomczak, 1989). Radiocarbon ages 3920 BP and 3160 BP of inter-dune peatlands of Wisłoujście (Tomczak, 1990) separate the period of brown dune formation from yellow dunes formation.

Another point of reference is data by (Tomczak, 1990), in which she distinguishes four stages of dune development

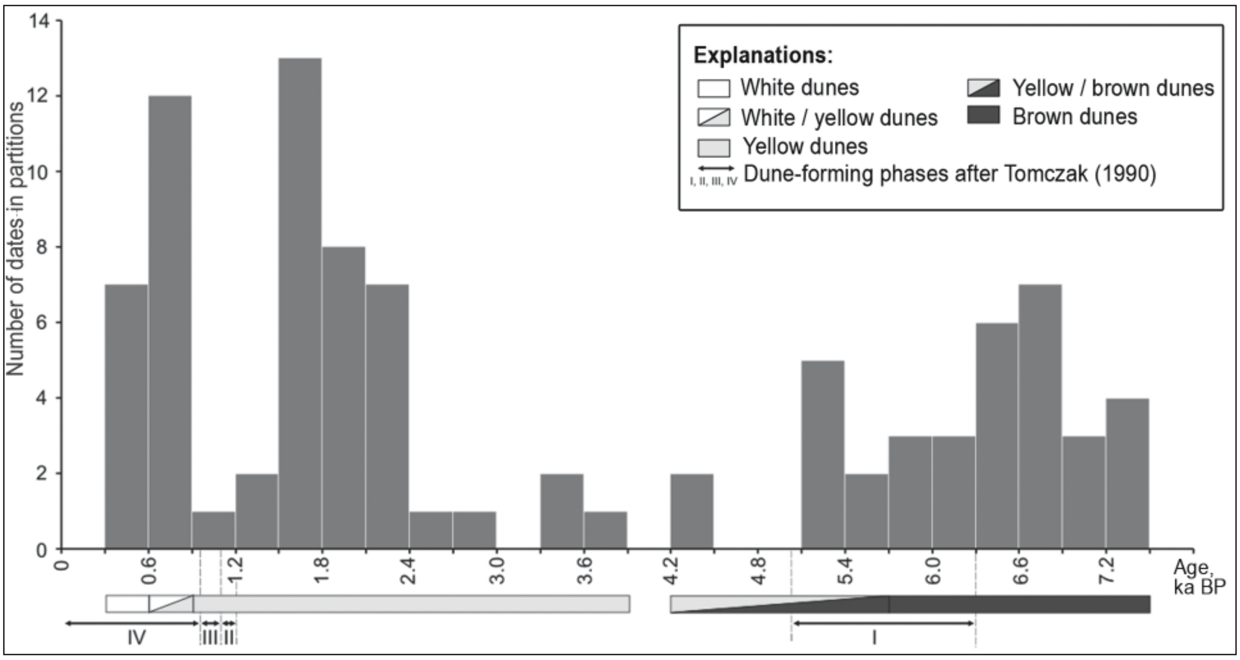


Fig. 4. Histogram showing the distribution of TL ages (300 year time frame) from dune sediments of cross-sections K, S, W compared with dune development stages by Tomczak (1990)
4 pav. Kopų nuosėdų TL amžiaus histogramos (300 metų inervalu). Amžius matuotas pavyzdžiuose, paimtuose iš K, S, W profilių. Rezultatai palyginti su išskirtomis stadijomis (pagal Tomczak, 1990)

based on radiocarbon dates, palynological studies and geological peculiarities. The number of stages, based on TL dating, is consistent with the stage number identified by Tomczak (1990). The first stage lasted from 6330 BP to about 5100 BP. The end of brown dune formation is marked by TL ages 6.53 ± 0.46 ka BP. According to Tomczak (1990), the first stage of dune formation in the Vistula Spit lasted about 1200 years. At this stage, the second younger range of yellow and brown dunes developed in the area of Stegna. The range was completely formed by 5.08 ± 0.4 ka BP. These TL dates are in concert with the well estimated first, the longest, stage of dune development. The second stage, which lasted about 200 years, ended 1200 years ago and resulted in yellow dunes (Tomczak, 1990). Luminescence dates do not, however, confirm these data (Tables 1–4). They are younger than radiocarbon ages derived from dune peatlands in Wisłoujście, and older than the ages provided by Tomczak (1990). The ages ranging from 2.4 to 1.5 ka BP in the histogram as well as the low uncertainty of ages estimated for this range (Table 4), which is below 10%, lead to some conclusions. This observation is not a matter of coincidence. In total, 36 samples of yellow dunes were subject to dating. With an exception of three samples whose ages (Tables 1–3) differ from the whole collection (0.6, 3.3 and 3.7 ka BP), the samples show a high accuracy of absorbed dose measurements. Such samples must have been equally reset during the deposition of sediment grains in each sample, also those collected 1.8 m, 1.5 m or 1.2 m below sea level. It seems to evidence the very fast sedimentation during the last stage of yellow dune development. A very low level of the residual thermoluminescence, reaching about 3% of the absorbed dose value, may follow from the fact that the period of solar exposition of examined yellow dune grains was very long. The above arguments may show that the development of yellow dunes in Stegna cross-sections might was completed later than suggested by Tomczak (1990). On the other hand, their formation might have been longer. The next stage of dune formation took place between 1060 and 910 BP, and the final stage continued since 900 BP (Tomczak, 1990). Such a distinction cannot be made by TL dating. In the second range, there are all dates of the samples collected from yellow and white dunes and white dunes. The age of these samples clusters between 600 to 400 years, with uncertainties up to 20–25%.

Analysis of the TL age of particular dune types, both in cross-sections and in boreholes, is a source of valuable information. Brown dune samples were collected from three dune cross-sections. In each W, S and K cross-section, three boreholes were drilled (in total, 9 boreholes were drilled and 27 samples collected). The fact that the age grows with sampling depth is typical of this type of dunes.

The yellow and the brown dunes have similar features (Tables 1–3). Yellow dune samples, collected from 12 boreholes, are in some cases characterized by the inversion of ages. The ages of samples from drilled white and yellow dunes are stable despite the depth, whereas samples of white dunes show an inverse trend. This may suggest that the material for younger dunes is derived from an older material.

CONCLUSIONS

TL dates presented in our work contribute to the collection of radiometrical data from the area of the Vistula Spit. They not only allowed for the verification of earlier data and views concerning the time of the Spit formation, but also motivated the researchers to continue studies in this area. Further works, sample collection for the purpose of luminescent dating in another section of the spit may allow for specifying the data and views related to its origin.

Future studies should undergo some modifications. Firstly, the aim should be to bore until the floor of each dune is reached and organic material for radiocarbon dating is collected. Secondly, the material should be preferably collected from excavation sites. The dates would constitute a set of numerical values limited in the cross-section from the floor with the C-14 date, the luminescence date which marks the beginning and end of the development process. Extreme luminescence dates would be particularly interesting, if the dune range developed during a long time.

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VYSLOS NERIJOS KOPŲ AMŽIUS STEGNOS APYLINKĖSE

Santrauka

Straipsnyje analizuojami Vyslos nerijos kopų terigeninės medžiagos kilmė ir sedimentacijos amžius. Šiuo klausimu detaliai aptarti literatūriniai duomenys.

Autoriai nustatė 90 pavyzdžių, paimtų iš įvairaus tipo kopų, sedimentacijos amžių ir patvirtinto anksčiau postuluotą (Tomczak, 1990) keturių formavimosi stadijų modelį.

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ВОЗРАСТ ДЮН ВИСЛИНСКОЙ КОСЫ В ОКРЕСТНОСТЯХ СТЕГНЫ

Резюме

В статье рассмотрены вопросы, связанные с источниками материала, формирующего пересыпь (косу), а также оценены возраст пересыпи и её развитие. Представлены мнения, которые за почти столетнюю историю исследований появились в литературе.

Проведенно датирование TL 90 образцов бурых, жёлтых и белых дюн, которое подтвердило результаты, ранее полученные Томчак (1990), показывающие существование четырёх фазисов развития пересыпи. Однако эти фазисы частично различаются по возрасту.