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Chronostratigraphy of the vistulian deposits in the southern part of the Lower Vistula region (north Poland) in the light of TL dating

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Abstract: Lithostratigraphy and chronostratigraphy of the Vistulian deposits in the southern part of the Lower Vistula region are presented. In detail, sedimentological investigations and thermoluminescence (TL) dating of thick glaciogenic and fluvial deposits exposing at Rzęczkowo and Łążyn sections in the southwest of the Chełmno Lakeland are described.

In profile of the Vistulian deposits have been distinguished two glaciogenic formation: Łążyn (La) and Starogród (Sa) which are represented mainly by tills and glaciolacustrine lithofacies. Fluvial deposits of Rzęczkowo formation (Rz) separate these formations.

Four samples (R-2, L-1, L-2, L-3) taken from fluvial sand and silts of Rzęczkowo formation and two samples taken from glaciolacustrine silts (R-1) and stratified diamicton (L-4) of Starogród formation were investigated by thermoluminescence method. Obtained TL dates especially for the samples R-2 – 49 ± 6 ka and L-3 – 50 ± 8 ka indicate that chronostratigraphic position of distinguished formations can be younger than it was previously expected. So far Rzęczkowo formation has been related to the Gniew Interstadial (the Early Glacial). It is suggested that Rzęczkowo formation can be related with the younger Grudziądz Interstadial (the Inter-pleniglacial).

Key words: northern Poland, Vistulian Glaciation, thermoluminescence dating.

Introduction

The southwestern scar of the Chełmno Lakeland exposes a thick glaciogenic and fluvial deposits. These are of great significance to stratigraphy and palaeogeography of the Vistulian Glaciation in the southern part of the Lower Vistula region. Detailed lithostratigraphic investigations and thermoluminescence dating of these deposits have been conducted at the two sites located to the northwest of Toruń: Rzęczkowo and Łążyn (Fig. 1). Some results of these studies have already been published (Wysota *et al.* 1996, 1997). The paper presents the latest effects of the authors' examinations at Rzęczkowo and Łążyn sections.

Recently the researches have been carried out at several new sites to the north of Rzęczkowo and Łążyn – Unisław, Kiełp, Starogród and Chełmno (Fig. 1). These are to do the correlation of the stratigraphic units of the Vistulian Glaciation in the southern part of the Lower Vistula region.

The field of researches took sedimentological and termoluminescence methods. The sedimentological investigations included (1) lithofacial analysis of the sedimentary units, (2) the analysis of palaeocurrents, (3) till fabric analysis, (4) the textural analyses, including grainsize composition through sieving and laser method, carbonate contents through the use of the Scheibler analysing method and quarz grain abrasion, and (5) pethrograhic composition of gravels (fraction 5–10 mm) from tills. Five samples of sediments from Łążyn and Rzęczkowo sites were dated by TL method (description in further chapter).

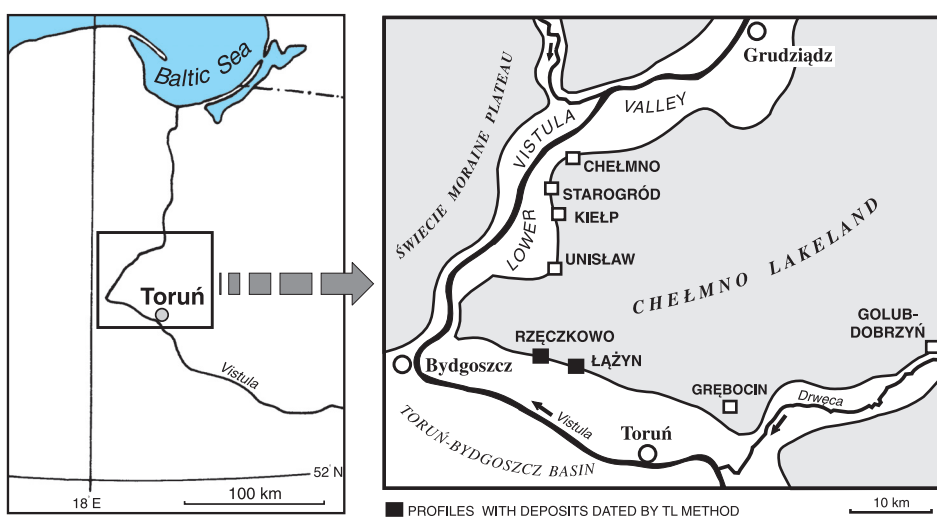


Fig. 1. Location of the study area.

Lithostratigraphic units and their palaeoenvironmental interpretation

The Vistulian deposits are here of 30–40 m thickness. In their profile (Fig. 2) have been distinguished two glaciogenic formations – Łążyn (La) and Starogród (Sa) separated by non-glaciogenic formation – Rzęczkowo (Rz), so far referred to as Rzęczkowo series (Wysota *et al.* 1996). Sediments of environments of glacial (tills) and proglacial (glaciofluvial and glaciolacustrine lithofacies) deposition represent glaciogenic formations. Non-glaciogenic formation – Rzęczkowo is composed of sediments of fluvial depositional environment (Wysota *et al*. 1996). This formation exists in the position of Gniew formation defined by Makowska (1979, 1986). Below the Vistulian sequence fluvial sands of the formation of the Lower Vistula region occur. It represents the Eemian Interglacial (Makowska 1979, 1986).

Łążyn formation (La) of 5–7 m thickness comprises glaciolacustrine clays and silts. In certain places a thin non-continuous layer of clay-rich diamicton (to 1.5 m thick) separates them. This diamicton doesn't occur at Rzęczkowo and Łążyn profiles. It is known only from few boreholes for example, in the Bągart profile described by Makowska (1980), and its extent and origin have not been well defined yet.

Rzęczkowo formation (Rz) is 15–23 m thick. It is composed of homogeneous very well sorted fine and medium sands, somewhere with interbeddings of sandy silts and silts. Indicator lithofacies are planar cross-bedded sands (Sp), parallel laminated sands (Sh) and ripple cross-laminated sands (Sr). Occasionally lithofacies of trough cross-bedded sands (St), ripple cross-laminated silty sands (FSr), climbing-ripple cross-laminated silty sands (FSrc), parallel laminated silts with sedimentary deformation structures (Fh and Fd) occur. The lithofacial association's show that sediments of Rzęczkowo formation were deposited in the environment of sand-bed braided river (Wysota *et al.* 1996). This river was characterised by well-developed channel subenvirnonment with the most typical downstream-accreation macroforms and weekly developed floodplain subenvironment. The predominant palaeotransport direction of fluvial deposits was western direction with deviation to the S and N.

Within Starogród formation (Sa) three members have been distinguished: Sa-1, Sa-2 and Sa-3. The lowest member Sa-1 comprises three units: Sa-1a, Sa-1b and Sa-1c. The unit Sa-1a is composed of massive light-brownish sandy diamicton (DSm) of 1.5 m thickness. Imbricated lenses and drag minor folds of incorporated sand of underlying Rzęczkowo formation were ascertained in diamicton. It is characterised by distinct till fabric (NE direction) (Figs. 3 and 4). This diamicton is interpreted as a lodgement till.

Above it there is stratified diamicton of 0.5–0.7 m thickness (unit Sa-1b). It consists of thin layers of sandy and clay-rich diamicton (DSs, DFs) of different

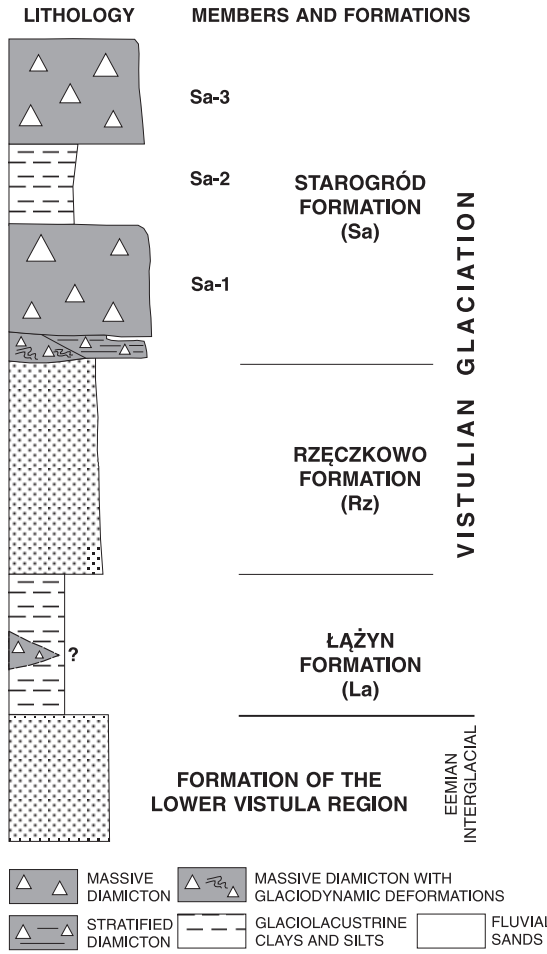


Fig. 2. Lithostratigraphy of the Vistulian Glaciation in the southern part of the Lower Vistula region.

colour (brownish, blackish, pinky and greyish). Occasionally, there are thin sands and clay laminae between them. In some clay laminae structures of sedimentary breccia were observed. The top of the diamicton is covered with a thin layer (20 cm) of massive brown clay. This diamicton was deposited in subglacial environment. Its stratified structure can be explained by gradual accumulation of basal debris and overlapping successive thin till layers. Deposition of till layers was interrupted by episodes of subglacial meltwater deposition, which resulted in sandy and clay laminae. These laminae indicate temporal ice-bed separation to ice motion (Piotrowski & Krause 1997). It was connected with local lifting of ice-sheet from the bed by meltwater.

Stratified diamicton is covered with massive, light-brownish sandy diamicton (DSm), which is 1.5–5 m thick (unit Sa-1c). It forms the continuous horizon

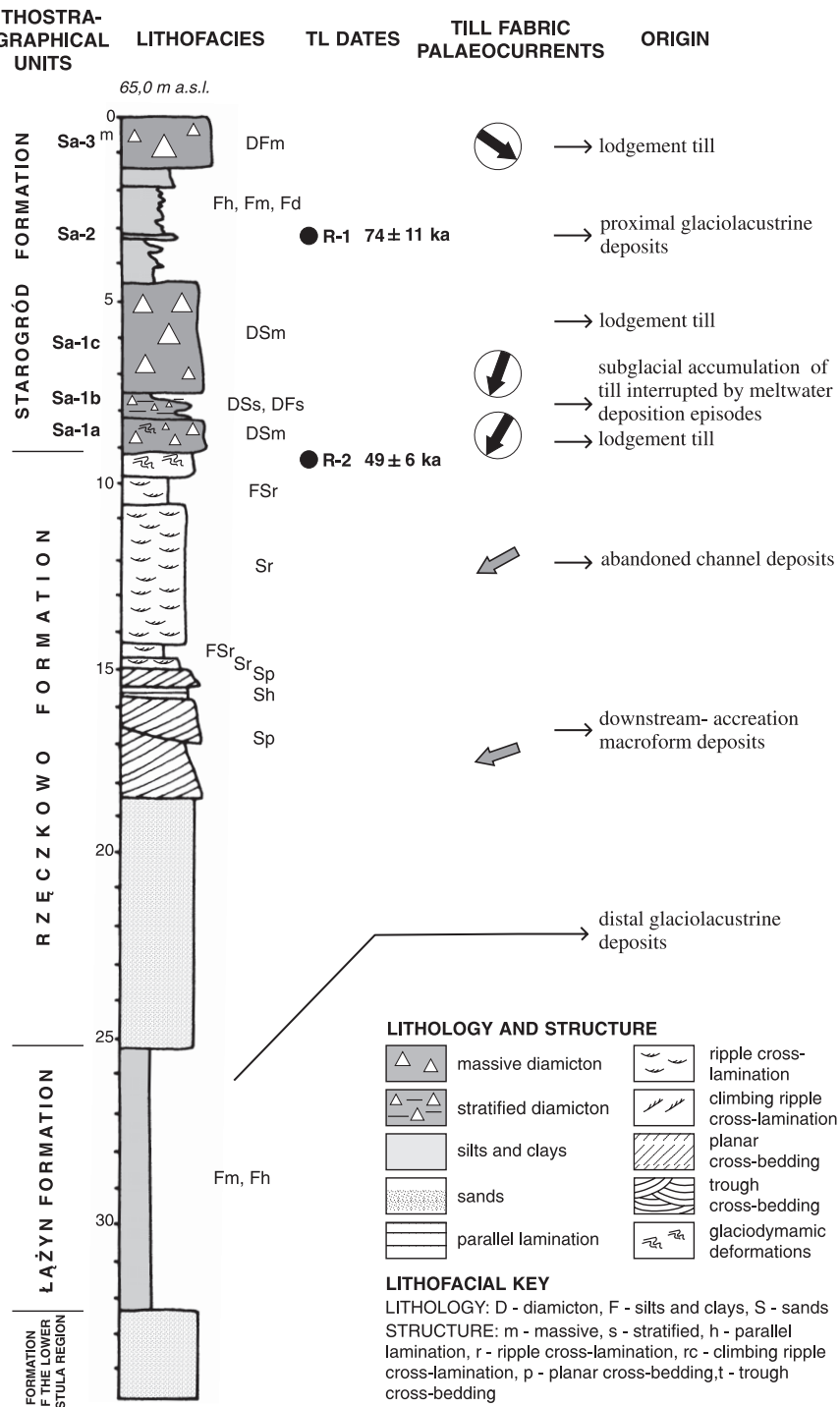


Fig. 3. Lithostratigraphy and sedimentology of the Vistulian deposits at Rzęczkowo section.

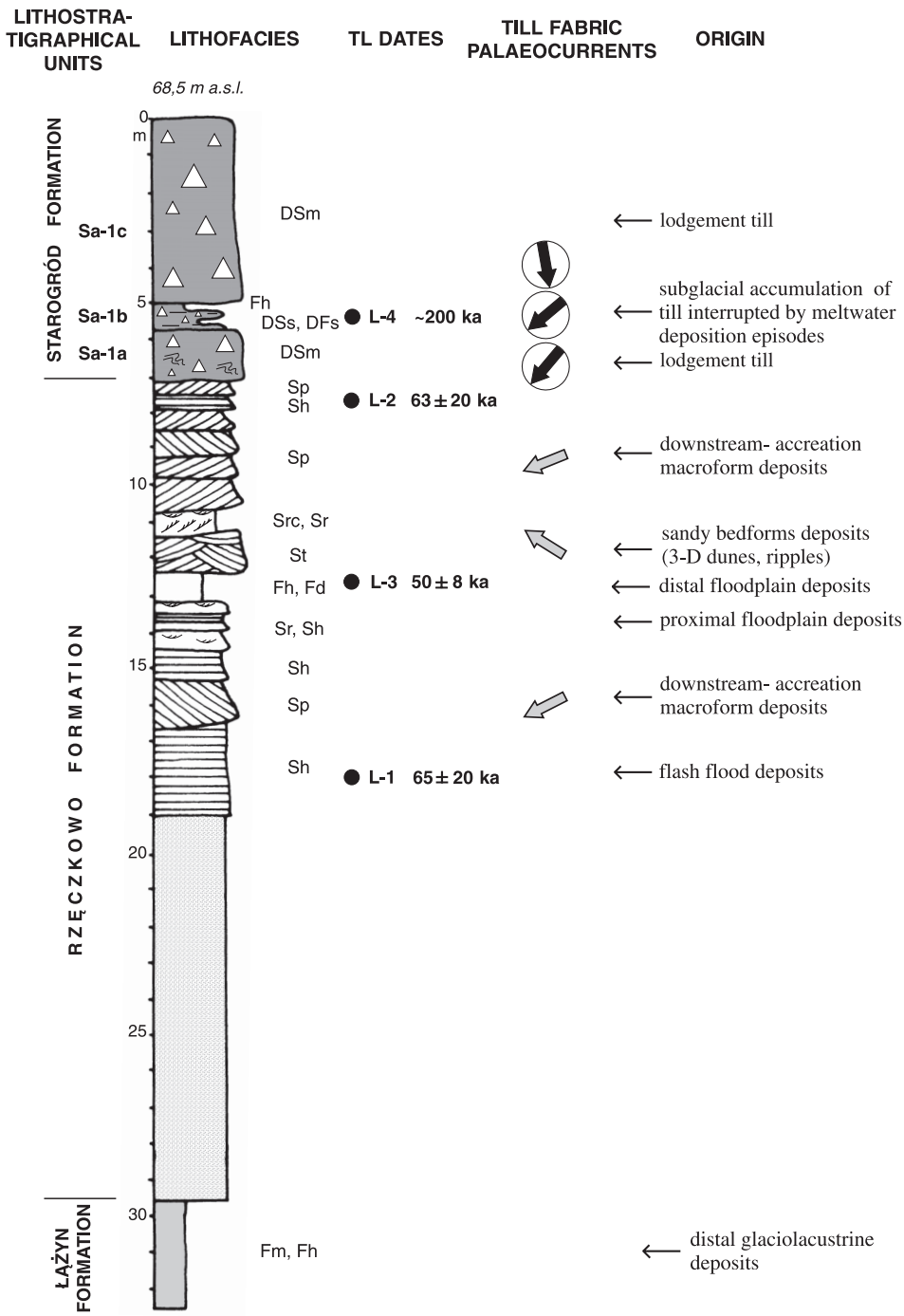


Fig. 4. Lithostratigraphy and sedimentology of the Vistulian deposits at Łążyn section.

Explanations in Fig. 3.

exposing along the scarp of the SW part of the Chełmno Lakeland. It is characterised by distinct till fabric (N and NNE directions) (Figs. 3 and 4). This diamicton is interpreted as a lodgement till.

Depositing above this till, glaciolacustrine member Sa-2 consists of parallel laminated and massive clays and silts (Fh, Fm), and ripple cross-laminated fine sands (Sr) of up to 3.5-m thickness. These sediments were accumulated in the environment of a shallow proglacial lake.

The highest member of Starogród formation (Sa-3) comprises massive brownish clay-rich diamicton of up to 8-m thickness. This diamicton constitutes the surface of moraine plateau. It is interpreted as a lodgement till, somewhere covered with ablation deposits.

Thermoluminescence (TL) dating: methods and results

Six samples from Rzęczkowo and Łążyn sections were dated by TL method (Tab. 1). Four samples taken from fluvial sands and silts of Rzęczkowo formation: R-2 at Rzęczkowo profile and L-1, L-2 and L-3 at Łążyn profile. One sample L-4 taken from stratified diamicton at Łążyn profile and one R-1 from glaciolacustrine silts of member Sa-2 at Rzęczkowo profile.

The sediments from Łążyn and Rzęczkowo sites were investigated using the quartz inclusion technique and the regeneration method including optical bleaching of the sediments before the excitation of the regenerated TL. The samples were bleached with help of the bleach simulator (equivalent to the daylight illumination) for 100 hours (Oczkowski & Przegiętka 1998a). All the TL measurements were carried out by the Riso TL/OSL equipment (model TL-DA-12) using 15 mg aliquots in argon atmosphere and with U340 emission filter set. The heating of the samples L-4, R-1 and R-2 was performed with heat rate of 4°C/s up to 500°C without any prior preheating procedure. In the case of the samples L-1, L-2 and L-3 preheating at 220°C for 40 s and subsequent heating with rate of 10°C/s were applied. The final results were obtained by the averaging of several (5–15) glow curve measurements. The high-resolution gamma spectrometry by means of the Canberra System 100 spectrometer served as a tool for

Table 1. TL dates of deposits from Rzęczkowo and Łążyn sections.

Section	Sample	Depth [m]	Lithology	TL age [ka]
Rzęczkowo	R-1	3.30	glaciolacustrine silts	74 ± 11
	R-2	8.86	fluvial sands	49 ± 6
Łążyn	L-1	18.1	fluvial sands	65 ± 20
	L-2	7.6	fluvial sands	63 ± 20
	L-3	12.6	fluvial silts	50 ± 8
	L-4	5.5	diamicton	~200

the annual dose determination for wide set of samples from the both profiles (Oczkowski & Przegiętka 1998b).

The basis of TL dating of sediments is the assumption that the TL of mineral was bleached by sunlight before its deposition. Our previous investigations (Oczkowski & Przegiętka 1998a) show that the bleaching is not complete and one can detect so called residual TL even after very long (>100 hr) sunlight operation. Accordingly, assuming good light exposure of dated material, the level of the residual TL after 100 hr of bleaching was used in the regeneration method. However, the results of TL investigations, show that the assumption of effectiveness of the optical bleaching before deposition for the samples L-4 and R-1 is doubtful. If the residual TL is actually higher than this assumed, then the obtained data can be treated only as the upper limits of the real deposit age.

The sample L-4 is very specific diamicton layer, which can be found in several sections in the southern part of the Lower Vistula region (Wysota *et al.* 1996). It can be easily recognised for its pinky colour. It has been early found that this deposit had an exceptionally high natural radioactivity. This is also the reason for our detailed investigations of this layer by the gamma spectrometry (Oczkowski & Przegiętka 1998b). It turned out that the layer is not homogeneous. The values of the annual doses obtained in our standard way (not taking into account the homogenity) for five subsequent layers from 0.5 m thick unit (with

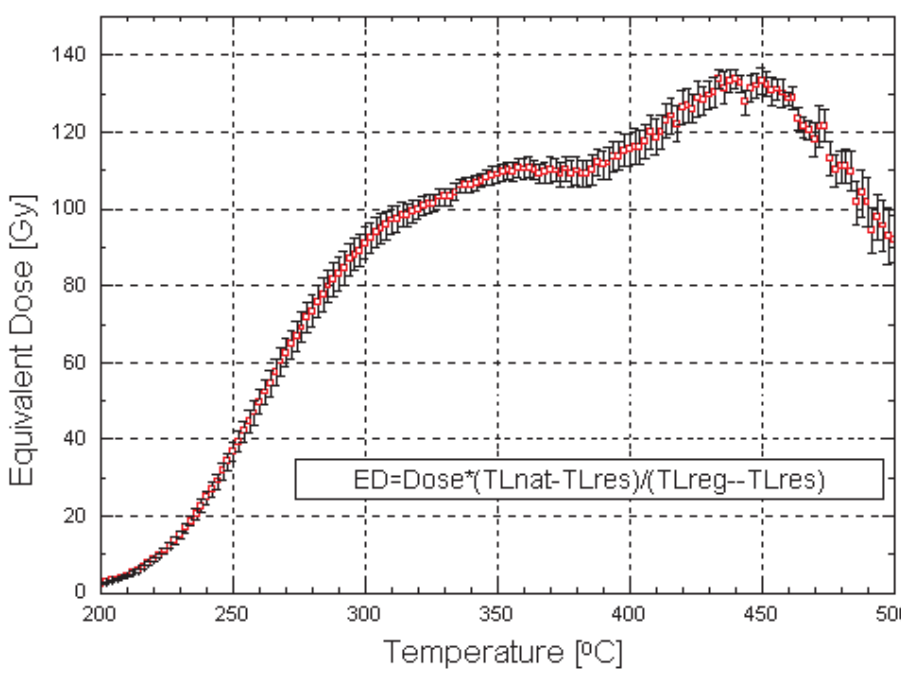


Fig. 5. The plateau test curve of sample R-1.

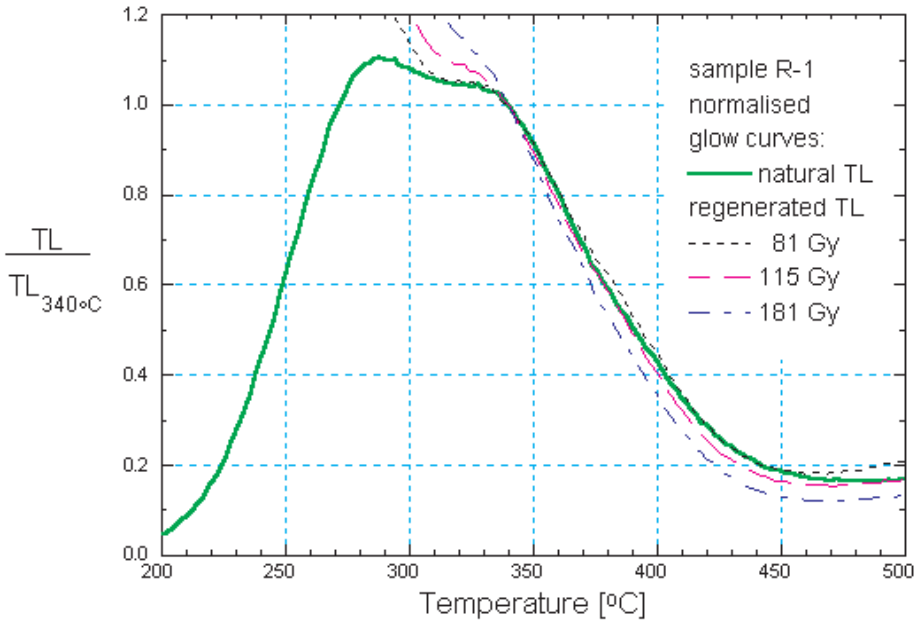


Fig. 6. The normalised glow curves of natural and regenerated TL of sample R-1 demonstrating the difference between natural and regenerated curve.

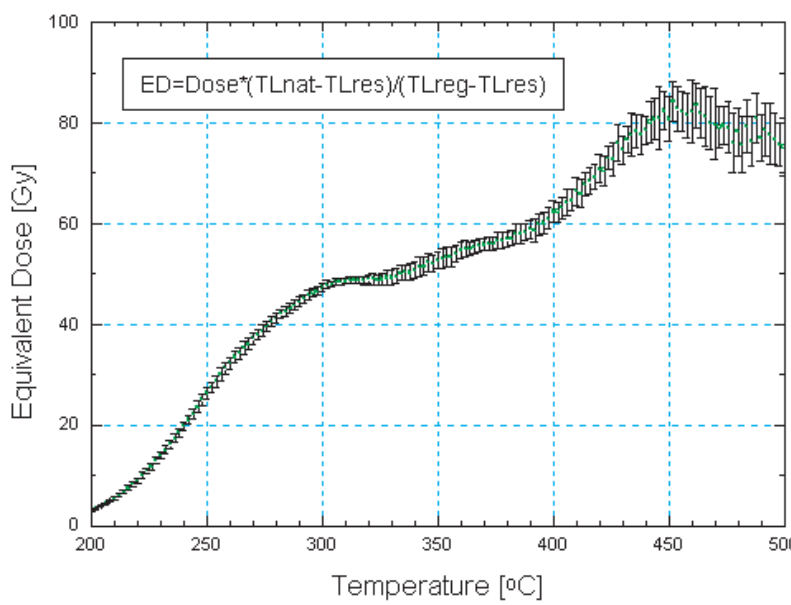


Fig. 7. The plateau test curve of sample R-2.

the step of 10 cm) differ one from another by two or more then two times. Hence, for the 0.5 m thick unit we obtained dose rates ranging from 6 to 15 mGy/a. Some problems concerning the estimation of the temperature region connected to the stable TL have also arisen for the sample L-4. The shape of the plateau test curve is unusually complicated and shows few plateau areas giving as a result different equivalent doses. Anyway, trying to estimate the age of the sample we obtained approximately value of 200 ka. It suggests that the material was probably not suitable bleached prior to the burial. All this problems confirm our earlier suggestions that diamicton should not be dated by means of the TL method.

For the sample R-1 the upper limit of age is 74±11 ka. It also seems that this sediment was not effectively bleached prior to the deposition. The first clear plateau of the plateau test curve (Fig. 5) is seen in the temperature region connected with the TL peak known as a weakly bleachable peak of quartz glow curve. The regeneration of the natural glow curve shape by the regenerated curves is also not satisfactory (Fig. 6). In the region above 350ºC the natural TL signal is higher than regenerated TL even for the doses significantly higher than the estimated equivalent dose. The age of sample R-1 can be probably reduced by detailed investigations of its bleaching features.

The preliminary investigations of sample R-2 indicated the age of about 77 ka. However, the detailed measurements lead to the lower result. The plateau test curve shows three plateau areas (Fig. 7). The first one is positioned in the temperature region 310–330ºC, connected to the easy bleachable TL peak of quartz (Jungner 1994). For this reason it was only the one region taken into account for equivalent dose determination and it gave the age of 49±6 ka.

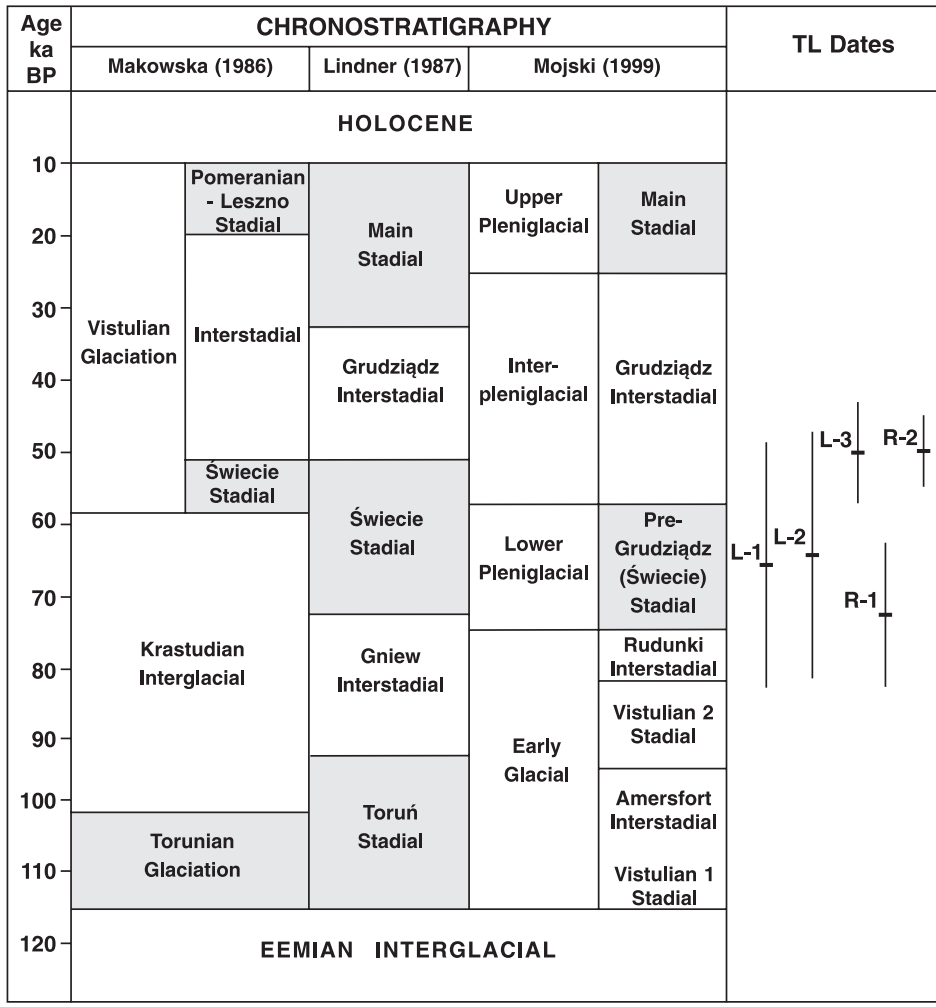
The other samples: L-1, L-2 and L-3 did not give similar problems.

Conclusions

Three major glacial events are represented in the analysed sequence of the Vistulian deposits. Łążyn formation (La) is related to the first advance of the ice-sheet whose extent is very difficult to describe. Results of lithostratigraphic investigation show that the ice-sheet did not reached the Rzęczkowo and Łążyn region. Position of Łążyn formation between the formation of the Lower Vistula region and Rzęczkowo formation indicates that it could form during the Early Glacial (Tab. 2). Overlying 2 younger glaciogenic members (Sa-1 and Sa-2) are related with the second advance of the ice-sheet during the Lower Pleniglacial (the Świecie Stadial), and the highest glacial member Sa-3 corresponded to the last advance of the ice-sheet during the Upper Pleniglacial (the Main Stadial). So far Rzęczkowo formation has been related to the Gniew Interstadial (Tab. 2) (Wysota *et al.* 1996).

However, the obtained TL dates (especially for the samples R-2 and L-3) indicate that chronostratigraphic position of the analysed lithostratigraphic units

Table 2. Chronostratigraphic position of TL dates from Rzęczkowo and Łążyn sections.



can be younger than it was previously expected (Wysota *et al.* 1996). It is presumed that Rzęczkowo formation can represent the Grudziądz Interstadial and underlying Łążyn formation can correspond to the Świecie Stadial (Tab. 2). Therefore the whole Starogród formation can be related with the Main Stadial.

Further dating of the Rzęczkowo formation and members Sa-2 of the Starogród formation deposits in other sites north of Rzęczkowo and Łążyn profiles constitute the key to a better understanding of chronostratigraphy of the Vitulian Glaciation in the the Lower Vistula region.

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