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Palynology of biogenic sediments of the Eemian Interglacial at Krzyżówki near Koło, central Poland

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Palynologic analysis of biogenic sediments from the borehole at Krzyżówki near Koło indicated an incomplete interglacial succession. Preserved fragments of the section prove that deposition was initiated in the late glacial of the Middle Polish Glaciation (Saalian). Above there is a discontinuous Eemian succession and a part of the early Vistulian Interstadial, covered with sediments containing pollen of non-forest vegetation of the Vistulian. Unclear is a top part of the section, in which there are pollen grains of deciduous trees (from the optimum of the Eemian Interglacial). They are presumably redeposited but their derivation remains open.

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Key words: central Poland, Quaternary, Eemian Interglacial, palynostratigraphy.

INTRODUCTION

Analyzed biogenic deposits were collected from a drilling core, described by Grażyna Szałamacha for the *Detailed Geologic Map of Poland* in the scale of 1:50 000, sheet Koło. The site is located about 2 km to the north-west from the town Koło, in the Koło Basin (Fig. 1).

Palynologic examination concerned the sediments of two beds, the lower (depth 25.05–23.50 m) and the upper (22.50–20.60 m) ones. Medium-grained sands with admixture of organic matter (with a thin layer of organic matter without pollen) separated these beds from each other.

METHOD

Sampling of a drilling core at Krzyżówki was done in March 1996 at the Geological Enterprise in Łódź. The samples were collected at every 5–10 cm from a wet sediment. Laboratory analysis started with treatment of each sample with hydrofluoric acid for 48 hours, to get rid of silica. Thistreatment was applied also to a peat contaminated with small mineral grains, presence of which made counting of sporomorphs more difficult. Then, calcium carbonate in a silty gyttja was dissolved with hydrochloric acid. All samples were boilt with 10% KOH and subjected to acetolysis.

Most analyzed samples indicate low content and somewhat destructed sporomorphs. Pollen grains seem to have been partly destructed due to varying water level during and after deposition. Considerable admixture of sand made collection of samples from depth of 21.3 to 21.5 m to be unreasonable.

The oldest analyzed sample is a silt from depth of 27.3 m (sample 1). Its pollen spectrum indicates low content of sporomorphs, their bad preservation and abundant redeposited ones (pre-Quaternary sporomorphs, among others of *Nyssa* and *Sequoia*), and also presence of marine plankton (Hystrichosphaeridae: 3 specimens per 4 cm^2). Among the Quaternary specimens *Pinus* (20 pollen grains), *Betula* (17), *Alnus* (7), *Carpinus* (1), *Tilia* (1), Cyperaceae (8), Ericaceae (2), Gramineae (1), *Filipendula* (1) and single sporomorphs of Polypodiaceae, *Pteridium* and *Sphagnum* were identified at 4 cm^2. Such a pollen spectrum is typical for glacial and glaciolacustrine sediments (Z. Janczyk-Kopikowa, 1996). This spectrum, due to a lack of statistically correct data, could not be presented in a pollen diagram.

Results of palynologic analysis of the other samples are presented in a pollen diagram (Fig. 2), based on the percentage

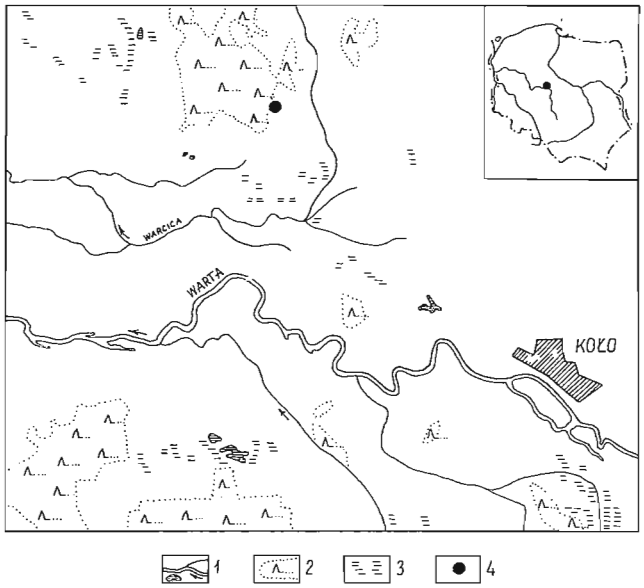

Fig. 1. Location sketch of the examined section Krzyżówki

1 — river and lake, 2 — forest, 3 — bog, 4 — section Krzyżówki

contents. Calculations were based on the total of 100% which is composed of pollen of trees and bushes (AP), and herbs (NAP). Pollen of water and swamp plants, and spores, as well as algae (*Pediastrum*) and sporomorphs in a secondary deposit were calculated in reference to the total AP+NAP. In a pollen diagram, local pollen zones (L PAZ) were distinguished and correlated with biostratigraphy of the Eemian Interglacial (Tab. 1), prepared for the Konin region (R PAZ after K. Tobolski, 1991).

Lithology of the section after G. Szałamacha (1998):

Depth in m	Lithology
0.30–2.30	Vari-grained sands, yellow (HCl+).
2.30–2.40	Pebbles (2–7 cm in diameter) of Scandinavian rocks.
2.40–20.60	Fine- to coarse-grained sands with gravel at the bottom, grey-yellow and grey.
20.60–22.50	Brown peat, loose, with small branches and bark of trees, with shells of snails, sandy in top and bottom.
22.50–23.50	Medium-grained sands, grey, laminated with organic matter (HCl–).
23.50–24.30	Brown peat.
24.30–25.05	Gyttja with mollusc shells, grey (HCl+).
25.05–25.60	Grey-green silts.
25.60–28.20	Grey silts and sands (HCl+).
28.20–30.00	Pebbles of Scandinavian rocks.
30.00–35.10	Creataceous marls.

POLLEN ANALYSIS

Pollen zones in the section Krzyżówki could not be distinguished easily. Sediments have been presumably deposited in an oxbow lake, what influenced deformation and resulted in incomplete sequence. The section has undoubtedly sedimentary hiatuses and translocated fragments of deposits. In the pollen diagram, 11 local pollen zones (LPAZ) were distinguished, numbered from the bottom towards the top of the section and indicated by the symbol **K** (Fig. 1).

The **zone K1** — *Artemisia-Betula nana-Juniperus* L PAZ (sample 2, depth 25.05 m). AP is equal to 64.1% and NAP to 35.9%; predominant is *Artemisia* (19%). There are also Chenopodiaceae (3.6%), Cyperaceae (2.6%), *Empetrum* (0.5%) and *Helianthemum* (0.5%).

The **zone K2** — *Betula* L PAZ (sample 3, depth 24.9 m; sample 4, depth 24.7 m). Predominant is *Betula* (46.6 and 46.5%), and *Pinus* (25.5 and 27.5%). There is rare pollen of *Ulmus* and *Corylus*. Among the bushes, there is *Juniperus* (4.6 and 1.9%), *Hippophaë* (0.8 and 0.2%) and *Betula nana* type (1.9 and 1.4%). The total of NAP is still high (20.7 and 21.3%), and is mainly composed of *Artemisia* (13.0 and 10.1%), Gramineae (9.2 and 2.9%) and Cyperaceae (2.6 and 2.5%).

The **zone K3** — *Quercus* L PAZ (sample 5, depth 24.65 m), in which *Quercus* (25.9%) is the predominant among the deciduous trees. Content of NAP pollen distinctly decreased (9.4%) if compared with the zone K2.

The **zone K4** — *Quercus-Corylus* L PAZ (samples 6–9, depth 24.60–24.45 m). Pollen spectra of this zone are predominated by *Corylus* (maximum to 26.6%) and *Quercus* (still high content — to 24.4%). *Ulmus* (maximum 1.7%, mean 0.9%) and *Fraxinus* (maximum 1.1%, mean 0.6%) occur regularly. Percentage content of NAP is below 10%.

The **zone K5** — *Pinus-Betula-Quercus* L PAZ (samples 10–12, depth 24.40–24.35 m). There is *Pinus* (49.5–54.3%), *Betula* (14.9–20.2%) and *Quercus* (9.2–18.2%). *Ulmus, Corylus* and *Fraxinus* are still present but less abundant than in the zone K4. Content of herbs is equal to about 10%.

The **zone K6** — *Pinus*-Cyperaceae L PAZ (samples 13–23, depth 24.30–23.10 m). Among the trees, there is predominant pollen of *Pinus* (64.5–79.2%). Regular curve is formed by *Picea* (2.5–10.1%), *Alnus* (2.5–5.2%) and *Carpinus* (0.3–1.4%). NAP is equal from 5.6 to 21.2%, including Cyperaceae (1.2–11.4%).

The **zone K7** — *Betula-Pinus*-NAP L PAZ (samples 24–27, depth 22.20–21.90 m). Herbs reach to 32.1%. Among the trees predominant is *Betula* (37.4%), then *Pinus* (57.9%), whereas taxons of thermophilous trees occur occasionally or in small contents.

The **zone K8** — Cyperaceae-Gramineae-*Pinus* L PAZ (samples 28–30, depth 21.8–21.6 m) with low contents of *Pinus* (48–30%), *Betula* (9.4–4.8%) and *Alnus* (3.7–0.2%). Herbs reach their maximum in this zone (NAP 68.2%); among them the predominant are Cyperaceae, Gramineae and heliophilous plants as *Artemisia,* Chenopodiaceae, Caryophyllaceae and Ericaceae.

The **zone K9** —*Pinus*-NAP L PAZ (sample 31, depth 21.5 m) with predominant *Pinus* (72.3%) and NAP (10.6%).

The **zone K10** — *Corylus* L PAZ (samples 32–35, depth 21.25–21.0 m) is predominated by pollen of *Corylus* (25.0–48.1%), accompanied by *Alnus* (to 14%), *Quercus* (13.8%), *Tilia* (2.7%), *Ulmus* (2.1%) and *Picea* (1.9%). Total of NAP is equal to 5.7–8.8%.

Table 1

Pollen zones of the Eemian succession in the section Krzyżówki (K L PAZ), compared with regional pollen zones for the Konin region (R L PAZ after K. Tobolski, 1991)

	Period	Jóźwin/76 (K. Tobolski, 1991)		Krzyżówki			Period
		Pollen assemblage zone					
		R PAZ		L PAZ			
Eemian succession	III	7	*Pinus*		6	*Pinus*-Cyperaceae	III
		6	*Picea-Abies*				
	II	5	*Carpinus*				II
		4	*Corylus*		4	*Quercus-Corylus*	
		3	*Quercus*		3	*Quercus*	
	I	2	*Pinus-Betula*				I
		1	*Betula*		2	*Betula*	

The **znone K11** — *Pinus* L PAZ (samples 36–39, depth 20.90–20.60 m). Spectrum of this zone resembles the one of the zone K6 L PAZ. Undoubtedly, predominant is *Pinus* (70.6–82.4%). Among other trees the most abundant are: *Alnus, Picea* and *Betula*. Other taxons occur occasionally. Content of NAP in this zone is the lowest for the whole section (4.7–6.3%)

LOCAL VEGETATION AND BIOSTRATIGRAPHY

Palynologic analysis indicated that in a bottom part of the lower bed (K1), there are pollen grains characteristic for a late glacial tundra vegetation. Presence of *Betula nana* type, *Hippophaë rhamnoides* and *Juniperus communis* proves local occurrence of bush-like tundra. The main role was played by photophilous plants of *Artemisia*, Chenopodiaceae, Cyperaceae, *Empetrum* and *Helianthemum*. Such pollen assemblage permits to refer the zone K1 to the late glacial of the Middle Polish Glaciation (Saalian).

The next zone (K2) represents loose communities of birch forest with admixture of pine, numerous bushes and herbs, similarly as in the preceding zone. *Artemisia* and Chenopodiaceae are still predominant. Particularly significant is presence of *Selaginella selaginoides*, indicating wet habitat and cool-cold climate (K. Rotnicki, K. Tobolski, 1965). Correlation with regional zones, distinguished for Poland (K. Mamakowa, 1989) and the Konin region (K. Tobolski, 1991), proves that the presented vegetation is typical for initial part of the Eemian Interglacial.

After the phase with birch forest, there is predominance of oak (K3) that indicates development of oak trees with increasing participation of hazel. There is also elm, ash and alder, with assistance of *Hedera helix* which is considered for a thermophilous species. This zone can be correlated with the third zone of the Eemian Interglacial (3 R PAZ), distinguished for the Konin region (K. Tobolski, 1991). Therefore, the pine-birch zone seems to be absent in the diagram (2 R PAZ *Pinus-Betula*). It could be due to low deposition rate, thus a sampling interval of 10 cm was presumably too large to detect transformation of birch forest into pine-birch one.

The next zone (K4) presents hazel communities, corresponding to climatic optimum of the Eemian Interglacial (4 R PAZ). In these communities there are thermophilous deciduous trees (oak, elm and ash), but linden and hornbeam (typical elements for a younger part of the middle Eemian Interglacial) are absent.

The overlying zone (K5) seems to represent deformed deposits, due to abundant destructed pollen grains and single sporomorphs in secondary deposit. They are common at the boundary of silty gyttja and peat, where presumably erosion and deposition occurred simultaneously. Such phenomenon resulted in absence of deposits from the second part of the optimum and a decline of the Eemian Interglacial. This hiatus seems to have been the effect of erosion.

Sediments of the zone K6 represent a final part of the interglacial when pine forest predominated. Low content of herbs indicates considerable density of pine communities. Pollen of Cyperaceae comes presumably from a local source. Except for pine, there was also spruce and wet places were overgrown by alder. Sandy layer (0.4 m thick) in the upper part of the zone K6, indicates that a peat was flooded by a river.

A peat on these sands (0.6 cm thick), already represents the Vistulian Glaciation. It is a limnic peat as indicated by pollen of water plants (*Typha latifolia, Myriophyllum spicatum* and *Sparganium*) and algae (*Pediastrum*). The latter proves a lack or insignificant water flow during deposition of peat. Around the reservoir there was a steppe with trees, mainly birch, and with herbs (Cyperaceae, *Artemisia*). Spectrum of this zone (K7) is different from the one of the zone

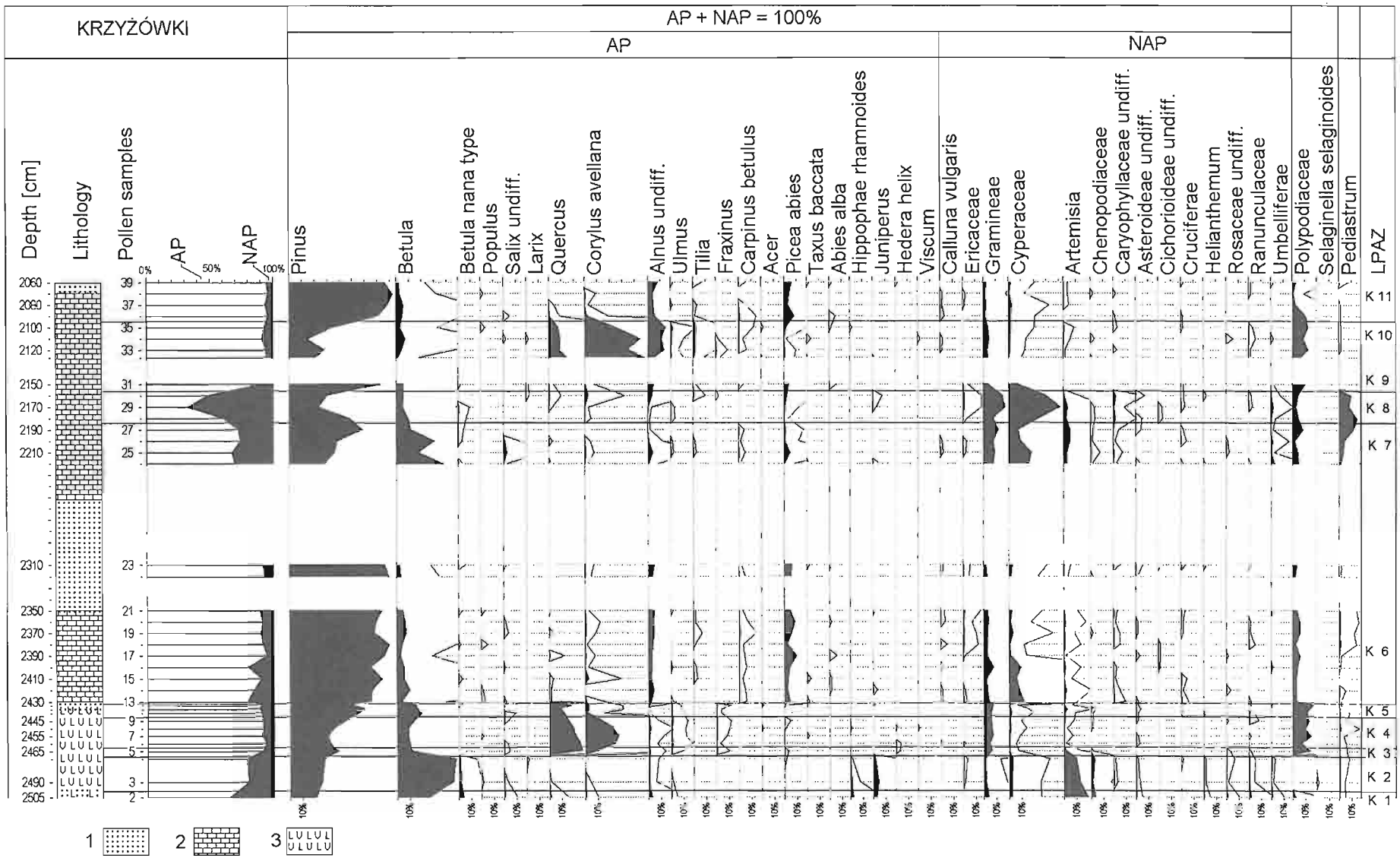

Fig. 2. Simplified pollen diagram of biogenic sediments from Krzyżówki

1 — sands, 2 — peat, 3 — silty gyttja

K6 due to increased participation of herbs and birch, and a drop of pine.

The next zone (K8) indicates absolute predominance of herbs (to 68.2%), mainly Cyperaceae and abundant Gramineae, *Artemisia,* Chenopodiaceae and Caryophyllaceae. Spectrum of this zone indicates replacement of a forest by plants of open areas.

Different vegetation is presented by a spectrum from a peat which, due to considerable admixture of sand, could not been successively collected. Deposition of peat was accompanied presumably by sparse forest with predominant pine, admixture of birch and spruce (K9). Fragmentary succession of the Vistulian in the section Krzyżówki makes difficult correlation of the early Vistulian, either with the neighbouring sites Władysławów (K. Tobolski, 1991) and Zofiówka (T. Kuszell, 1997), as well as with regional stratigraphy (K. Mamakowa, 1988). A peat from the zone K10 was formed when communities of thermophilous forest occurred in the vicinity, the latter composed mainly of oak, hazel and linden. There was also a mistletoe in this forest. Wet soils were occupied by patches of alder forest with admixture of elm, and rare participation of hornbeam and spruce. Such vegetation corresponds to the optimum of the Eemian Interglacial and seems to continue plant succession of the zone K4.

This illogical succession of sediments in an oxbow lake can be due to various reasons. Dislocation of sediments within a section during collection of samples is one of them, although it is excluded by the geologist and by detailed lithologic analysis. The other is a conclusion that sediments of the climatic optimum were deposited in the same time in a lake (silty gyttja) and at a lake edge (peat). Due to erosion, sediments could be washed away and peat slipped down onto deposits of the early Vistulian.

In general picture, a pollen succession of the section Krzyżówki suggests presence of two superposed warm intervals (zones K4 and K10). In spite of a predominant deciduous forest, their pollen spectrum is different from each other, the same as the sediment. Interpretation of this phenomenon is presented above. But it should added that possible presence of an older interglacial, preceding the Eemian one and with similar pollen succession, has been postulated in several references (O. P. Kondratiene, 1973; K. M. Krupiński, L. Marks, 1985; K. Erd, 1987; Z. Janczyk-Kopikowa, 1991).

The zone K11 is not a reasonable continuation of the interglacial succession too. Predominance of pine forest in this zone, with admixture of spruce and occasional photophilous taxons, resembles vegetation of the zone K6.

CONCLUSIONS

In the site Krzyżówki there is incomplete and dislocated pollen succession, the latter being due to sedimentary hiatuses caused presumably by water erosion. Diagnostic features of the optimum of the Eemian Interglacial (successive maxima of *Quercus* and *Corylus*) suggest that sediments from the section Krzyżówki have been deposited from a late glacial of the Middle Polish Glaciation (Saalian), through the Eemian Interglacial until the early Vistulian.

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ANALIZA PALINOLOGICZNA OSADÓW BIOGENICZNYCH INTERGLACJAŁU EEMSKIEGO W PROFILU KRZYŻÓWKI W REJONIE KOŁA, POLSKA ŚRODKOWA

Streszczenie

Analizowane osady pobrano z otworu wiertniczego Krzyżówki, położonego około 2 km na NW od Koła w Kotlinie Kolskiej (fig. 1). Metodą analizy pyłkowej przebadano 1 próbkę z głębokości 27,30 m oraz 38 próbek z głębokości 20,60–25,05 m (fig. 2), a uzyskane spektrum zespołów pyłkowych porównano z regionalnymi poziomami z regionu konińskiego (tab. 1). W spektrum charakteryzującym osad z głębokości 27.30 m zidentyfikowano taksony roślin egzotycznych wskazujące na ich redepozycję. Wyniki badań palinologicznych pozostałych próbek przedstawiono na uproszczonym diagramie pyłkowym, który podzielono na 11 lokalnych poziomów pyłkowych (K LPAZ). Są one poziomami nie zawsze powiązanymi, ponieważ górne granice poprzedniego poziomu rzadko są równocześnie dolną granicą następnego poziomu, co świadczy o przerwach w sedymentacji. Najstarszy poziom reprezentuje późnoglacjalne zbiorowiska tundrowe zlodowacenia środkowopolskiego, najmłodszy zaś powstał we wczesnym vistulianie w czasie panowania lasów sosnowych z niewielkim udziałem świerka.

Sukcesja interglacjalna jest niepełna i wskazuje na występowanie w osadzie licznych luk sedymentacyjnych wynikających zapewne ze zniszczenia osadów przez wody rzeczne. Zachowany fragment osadów z cechami diagnostycznymi optimum interglacjalu eemskiego (kolejność kulminacji *Quercus* i *Corylus*) świadczy, że osady profilu Krzyżówki powstawały w okresie późnoglacjalnym zlodowacenia środkowopolskiego, w interglacjale eemskim i we wczesnym vistulianie. Niejasna jest pozycja stratygraficzna stropowej części profilu, w której zachowały się ziarna pyłku lasu liściastego (z optimum interglacjału eemskiego). Jest to zapewne osad na wtórnym złożu, ale jego geneza jest sprawą otwartą.