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Pleistocene marine deposits and their bearing on the stratigraphy of the Younger Pleistocene in Dolne Powiśle (North Poland)

During Younger Pleistocene, beginning with Eemian Interglacial the Dolne Powiśle region was repeatedly covered by transgressions of the Baltic Basin seas. Marine deposits are formed in separated horizons and recorded in different geological and stratigraphical situations. In few cases lithology, thickness, fauna content and range of deposits allowed to define them index stratigraphic horizons of the Younger Pleistocene in the region. Till now three marine horizons have been determined index ones i. e. Tychnowy Horizon (which belongs to Eemian) as well as Elbląg and Krastudy horizons which represent Krastudy Interglacial. Krastudy Interglacial is younger than Eemian and was prior to Toruń Glaciation.

INTRODUCTION

During last twenty years geological research on the Quaternary of northern Poland contributed many new informations on the geological structure of the region. Extremely interesting results concern the area along the Lower Vistula valley between Toruń and Baltic Sea (Fig. 1). The above area has a historical name of Dolne Powiśle however it covers different morphologic units. The present study deals mainly with the Lower Vistula valley (including delta and surrounding postglacial uplands) and Elbląg Elevation which partly consists of glaciotectonically deformed Quaternary deposits. Dolne Powiśle region, including the section of the Lower Vistula surroundings up to Płock, is considered the stratotype area of the Vistulian Glaciation because of well developed Young Pleistocene sequence. Moreover the northern part of the region was several times covered by marine transgressions which

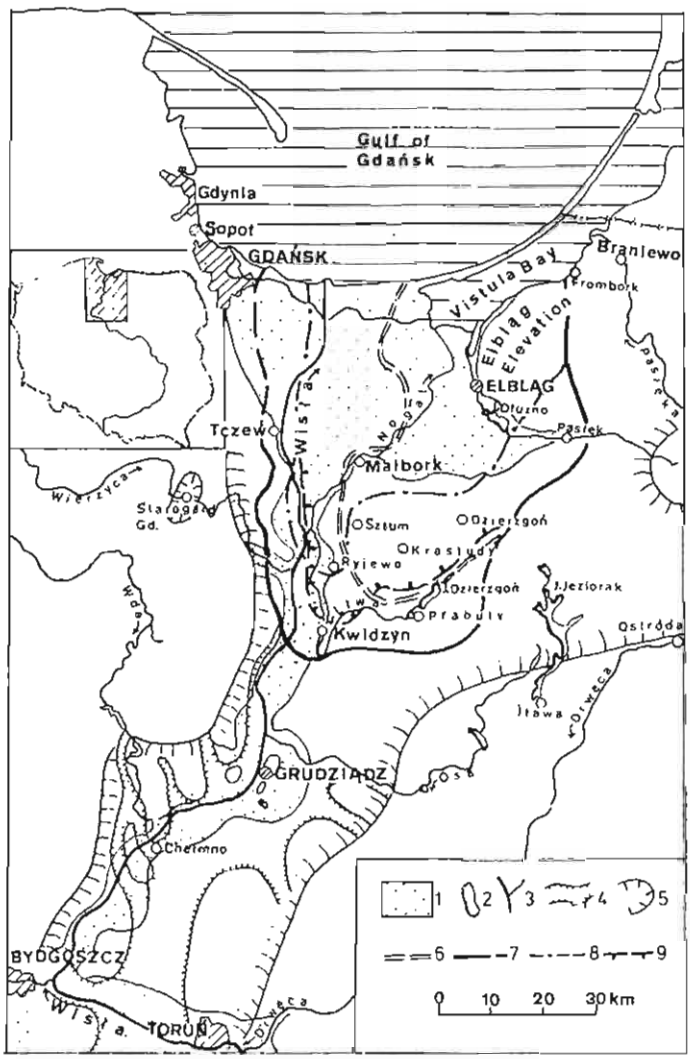


Fig. 1. Extents of Pleistocene seas, Toruń Glaciation till and of Eemian Interglacial river valleys in Dolne Powiśle

1 – Wisła valley and delta (with sand-bar); 2 – lakes; 3 – rivers; 4 – valleys of Eemian Interglacial; 5 – extent of Toruń Glaciation till; extents of Pleistocene seas: 6 – Sztum Sea, 7 – Tychnowy Sea; supposed extents of: 8 – Elbląg Sea, 9 – Krastudy Sea

Zasięgi mórz plejstoceńskich, gliny zwałowej zlodowacenia toruńskiego oraz dolin rzecznych interglacjału eemskiego na Dolnym Powiślu

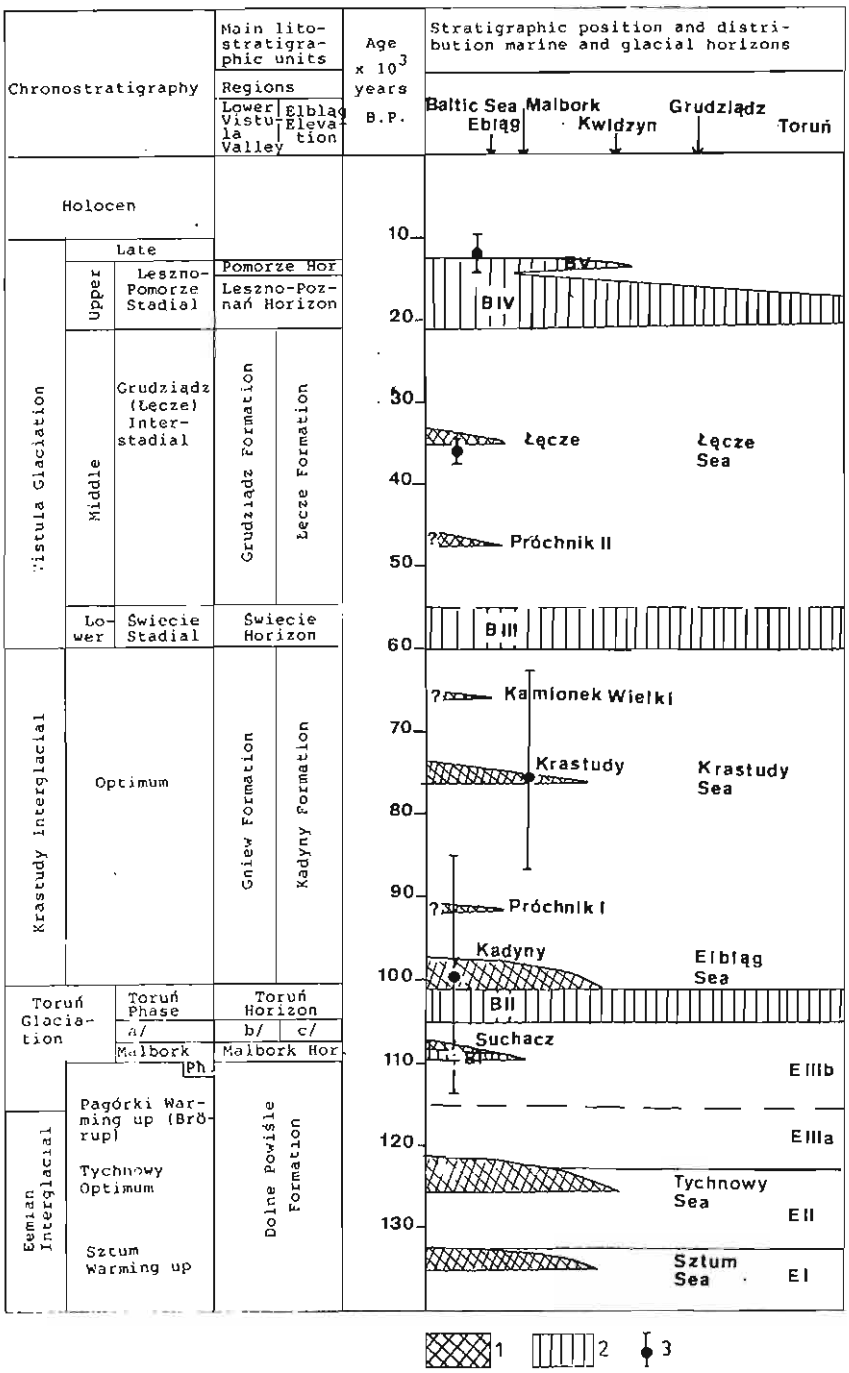
1 – dolina i delta Wisły (wraz z mierzeją); 2 – jeziora; 3 – rzeki; 4 – doliny interglacjału eemskiego; 5 – zasięg gliny zwałowej zlodowacenia toruńskiego; zasięgi mórz plejstoceńskich: 6 – sztumskiego, 7 – tychnowskiego; przypuszczalne zasięgi mórz: 8 – elbląskiego, 9 – krastudzkiego

caused the origin of separate marine horizons within different geological units. Beginning with the Eemian Interglacial the marine deposits are of high importance for the stratigraphy of the Younger Pleistocene in Dolne Powiśle region. Basing on their geological position two chronostratigraphic units have been defined i. e. Krastudy Interglacial (younger than Eemian) and Toruń Glaciation which separates Eemian from Krastudian (A.Makowska, 1986*b*). The present paper deals also with the above new chronostratigraphic units.

GENERAL GEOLOGICAL SITUATION

In Dolne Powiśle region the Quaternary cover is built of lithologically and stratigraphically differentiated deposits. In thickness it ranges from 20 m in the south (Toruń vicinity) to 300 m in the north (Elbląg Elevation). The Quaternary processes were highly influenced by tectonics and geological setting of sub-Cenozoic basement. The described area is situated on the boundary of two major tectonic units i. e. East European Platform (in the north) which is covered with Palaeozoic and Mesozoic deposits, and Palaeozoic Platform (in the south) which was folded and uplifted together with its Permomesozoic cover during Alpine orogeny and involved in the structures of Central Poland Anticlinorium and Marginal Trough. The boundary between major units crosses the region from NW to SE in the vicinity of Grudziądz as a Teysseyre-Tornquist Zone. During almost all Quaternary period both major units tended to move vertically in opposite directions i. e. the East European Platform was consequently sinking while the Central Poland Anticlinorium was continuously uplifting together with the Marginal Trough. Tectonic movements influenced other geological processes including river erosion, denudation and accumulation. Moreover during the Youngest Pleistocene they controlled the range of marine transgressions (A.Makowska, 1982). Thus the movements caused considerable thickness of Quaternary deposits in the north and increased erosion or denudation in the south. Unstability of sub-Cenozoic basement is reflected in the relief of Quaternary substrate. To thenorth of Teysseyre-Tornquist Zone it is formed in a broad depression generally smoothed by exaration and situated about 70–90 m below sea level. Separated depressions of erosional origin are not deeper than 120–140 m b.s.l. there. To the south it forms a gentle slope which continues as a series of the Central Poland Anticlinorium uplifts (20–40 m above sea level). The uplifts are cut by erosional valleys of Younger Pleistocene age (A.Makowska, 1982).

Due to above situation the Quaternary sequence is most completed in the north. In the Older and Middle Pleistocene complex there are three glaciations recorded there i. e. the oldest one represented by single till sheets infilling few deepest depressions of the basement, South-Polish Glaciation and Middle-Polish Glaciation divided in places by fluvial deposits of Cromerian and Mazovian interglacials. In the vicinity of Kwidzyn the Middle-Polish deposits are subdivided by lacustrine organic


Chronostratigraphy
Main litostratigraphic units
Regions
Lower Vistula Valley
Elbląg Elevation
Age x 10³ years B.P.
Stratigraphic position and distribution marine and glacial horizons
Baltic Sea
Malbork
Grudziądz
Ebląg
Kwidzyn
Toruń
Holocen
Late
Upper
Middle
Lower
Vistula Glaciation
Leszno-Pomorze Stadial
Grudziądz (Łęcze) Interstadial
Świecie Stadial
Pomorze Hor
Leszno-Poznań Horizon
Grudziądz Formation
Łęcze Formation
Świecie Horizon
Krastudy Interglacial
Optimum
Gniew Formation
Kadyny Formation
Toruń Glaciation
Toruń Phase
a/
Malbork
Ph
Toruń Horizon
b/
c/
Malbork Hor.
Eemian Interglacial
Pagórki Warming up (Brörup)
Tychnowy Optimum
Sztum Warming up
Dolne Powiśle Formation
10
20
30
40
50
60
70
80
90
100
110
120
130
BV
BIV
Łęcze
Łęcze Sea
Próchnik II
BIII
Kamionek Wielki
Krastudy
Krastudy Sea
Próchnik I
Kadyny
Elbląg Sea
BII
Suchacz
EIIIb
EIIIa
Tychnowy Sea
EII
Sztum Sea
EI
1
2
3

series of interglacial type (A.Makowska, 1977). The Older and Middle Pleistocene complex occupy northern and central parts of the region. To the south in the zone of uplifted basement they are considerably reduced or totally removed. Generally only separated till sheets of Middle-Polish Glaciation are found there. The Mazovian Interglacial is here represented by fluvial deposits which remained in single narrow valleys.

During Younger Pleistocene the rate of movements of the basement gradually reduced. However they have not terminated till now. The Young Pleistocene deposits, as far as the period of Eemian–Late Vistulian is considered, covered the whole region including the area of uplifted basement in the south which is composed of Tertiary and Cretaceous sediments there. The cover thickness exceeds 100 m, and in the north (Elbląg Elevation) it reaches 200 m. The Young Pleistocene sequence is extremely diversified as it is composed of interglacial deposits of different age and origin and of five till layers defined formerly as BI–BV horizons (Fig. 2).

The most distinguish feature of this sequence is the presence of marine deposits which appear in different stratigraphic positions. They are recorded in the northern part of Dolne Powiśle, both in the Vistula valley and in glacial uplands adjoining it from the east as well as in Elbląg Elevation where they are involved in very complicated glaciotectonic structures. Till now this type of deposits has not been recorded in any other site in Poland.

In Dolne Powiśle the marine deposits are considered index horizons in common with glacial ones and refer to the stratigraphic subdivision of Young Pleistocene.

GEOLOGY AND STRATIGRAPHY OF THE YOUNG PLEISTOCENE SEQUENCE AND THE SIGNIFICANCE OF MAIN MARINE HORIZONS

Both Eemian and post-Eemian deposits compose the Young Pleistocene sequence in the region. The latter are subdivided into Toruń Glaciation, Krastudy Interglacial and Vistulian Glaciation due to the reasons described above.

E e m i a n I n t e r g l a c i a l . In the beginning of seventies Eemian deposits were found in the region described and then defined as Dolne Powiśle Formation (A.Makowska, 1979, 1986*b*). They infill broad depressions of the basement which is

Fig. 2. Chronostratigraphy of marine and glacial horizons of the Younger Pleistocene in Dolne Powiśle

1 – marine horizons; 2 – horizons of till; 3 – TL dates of marine and lacustrine deposits; EI, EII, EIIIa, EIIIb – valley series; horizons of till: BI, BII – Toruń Glaciation, BIII, BIV, BV – Vistula Glaciation; a – Knybawa Interphase, b – Knybawa Layers, c – Suchacz Formation

Chronostratygrafia osadów morskich i glacjalnych na Dolnym Powiślu

1 – poziomy morskie; 2 – poziomy glin zwałowych; 3 – datowania osadów morskich i jeziornych metodą TL; EI, EII, EIIIa, EIIIb – serie dolinne; poziomy glin zwałowych: BI, BII – zlodowacenia toruńskiego, BIII, BIV, BV – zlodowacenia wisły; a – interfaza Knybawy, b – warstwy z Knybawy, c – formacja Suchacza

wanting underlies the entire Quaternary cover in the south. The basement is composed of Tertiary deposits in the south and of Middle-Polish Glaciation tills partly covered with younger ice-dam deposits to thenorth of Grudziądz (A.Makowska 1979, 1982). Eemian profile comprises marine and continental deposits. The former are composed of diversified valley sediments which infilled well developed drainage valley system both in the south and north of the region. The main valley crossed the region from Toruń to Kwidzyn and extended towards Sztum and Malbork. It was a broad, mature valley comparable in size to the contemporary Vistula valley. Infilling deposits have been subdivided into three series according to the interglacial cycle. The lowest is built of channel sediments, the middle is composed of channel and lateral sediments including ox-bow intercalations, and of lacustrine sediments, and the uppermost is built of channel sediments and ice-dam deposits which close up the interglacial cycle. The middle series is best developed and contains ox-bow organic deposits. Numerous pollen analyses confirmed their Eemian age (Z.Janczyk-Kopikowa, 1970; A.Makowska, 1979).

Marine deposits are known from the northern part of the region and range the vicinity of Kwidzyn in the south (Fig. 1).

A complete, composed profile of Eemian consists of two marine horizons intercalated and covered by continental, dominantly fluvial deposits (Fig. 2). The lower marine horizon overlies periglacial and extraglacial accumulations.

In the Elbląg Elevation the profile begins with red clays of periglacial origin which were accumulated in lakes situated in Baltic depression after deglaciation. At the Lower Vistula ice-dam deposits replacetthem in the form of clays and varved silts which originated in local ice-dam basins. During the first marine transgression the above deposits were covered with clays and silts of S z t u m H o r i z o n which is recorded in the deep parts of Eemian substrate. To thesouth the first marine horizon reached Sztum and Dzierzgoń (Fig. 1). Its deposits contain foraminifers and molusces remnants there. In the Dzierzgoń vicinity (Nowiny, Krastudy) among undestroyed molusc shells some boreal-lusitanian specimens have been identified. The thickness of the first marine horizon does not exceed 2 m and its top barely reaches 20 m b.s.l. Usually it is overlain by middle fluvial valley series described above. All over the region the middle valley series consists of channel and lateral deposits which include organic layers (peat or gyttja) with fresh-water molusces shells. The second marine transgression is expressed the T y c h n o w y H o r i z o n of clays and silts predominantly with admixture of foraminifers, molusc shells and other marine fauna remnants. It is situated between 0 and 20 m b.s.l. and the fauna assemblage is similar to the relevant assemblages found in Eemian marine basins in Germany, Netherlands and Denmark. According to the results of pollen analyses and expertises this transgression happened in the Ee phase of Eemian, and the recession took place in the middle of the Eh phase (Z.Janczyk-Kopikowa, 1970, 1976; A.Makowska, 1979, 1986*b*). Afterwards the sea has been converted on lakes. On the ground of pollen analyse of the lacustrine deposits in Pagórki (Elbląg Elevation) has been recognized

the Warming up one which has been correlated with Brörup Interstadial (Z. Janczyk-Kopikowa, 1991) – Fig. 2.

The Tychnowy Horizon is the best described, most important and best developed marine horizon in the region. It is also a main index horizon within the Younger Pleistocene and entire Quaternary suite in the region and adjacent territories.

In the general profile the Tychnowy Horizon is overlain by the following fluvial deposits which were accumulated due to consequent burrowing of retreating sea by river deltas during the third period of valley sedimentation.

T o r u ń G l a c i a t i o n . Two till horizons belong to this period in the Dolne Powiśle region. The lower one BI is found only in marginal parts of the Vistula delta. The upper one BII spreads over the whole region up to Toruń in the south. Formerly both tills were defined as stadial representatives (A.Makowska, 1980). The lower one (usually 1–2 m thick) is intercalated with sands. It bears some features of underwater sediment. It is accepted that the till was accumulated during the transgressive stage of the glaciation. Then the ice-sheet covered only major post-Eemian marine depressions not fulfilled with delta accretions. After the ice-sheet retreat the sea invaded the region once again. The sea transgression is expressed by thin layer of clay with *Portlandia arctica* Gray found in one site at Suchacz (Vistula Bay side). Most probably the sea kept the bounds of the region Vistula Bay. Thus the deposits are of no stratigraphic significance. Several meters thick delta sands cover the marine horizon and close up the intermorainic sequence. The most important till layer is the second (younger – BII) one which represents a distinct regular glaciation of the region. The till is spread all over Dolne Powiśle up to Toruń (Fig. 1) and the name of the glaciation is derived from the name of the city. To the West the till extends not far the Vistula valley, and to the east spreads on the adjacent Mazurian and Warmia regions. Within the region described the till layer occurs as an uninterrupted cover about 10 m thick thus undoubtedly separates Eemian from Krastudy Interglacial (Fig. 2). It is worthy of emphasis that formerly this till horizon was assumed to be of Middle-Polish age and consequently Eemian Interglacial was reported to cover it in the region described (R.Galon, 1934).

K r a s t u d y I n t e r g l a c i a l . This period is characterized by diversified geological processes in Dolne Powiśle especially by repeated marine transgressions. Some deposits accumulated during it were formerly interpreted as Eemian ones (R.Galon, *op. cit.*). Misinterpretations concerned Elbląg Clays (Yoldia Clays) which were frequently defined as Eemian deposits e. g. by P.Woldstedt (1969) and recently by T.Nilsson (1983). Actually the present author determined their position as a younger than Eemian (Fig. 2) as they are separated from it with a distinct horizon of upper — BII (in places also lower — BI) till of Toruń Glaciation (A.Makowska, 1986*a,b*; A. Makowska, W. Rabek, 1990). Moreover there are other marine horizons in Dolne Powiśle and their features are typical of interglacial conditions of sedimentation. Marine horizons appear in intermorainic series exceeding 60 m of thickness. At the Lower Vistula they are defined as Gniew Formation and in Elbląg Elevation

as Kadyny Formation. The most probable general sequence of marine deposits can be described as below. In the north, Kadyny Formation begins with red clays accumulated in Baltic Basin after deglaciation as it was at the beginning of Eemian. The southern boundaries of the basin are followed by the contemporary limits of the Vistula delta. Then the region was flooded with the sea which was responsible for the accumulation of at least 15 m thick series of E l b l ą g C l a y s . Foraminifers and molusces shells contained there are typical of cold arctic sea which gradually became a boreal one. According to the results of pollen analysis of samples from Nadbrzeże (T.Przybylski, *fide* B.Halicki, I.Brodniewicz, 1961) it is supposed that the sea could continue to exist during warmer periods. However because of extremely complicated glaciotectonic deformations in Elbląg Elevation it is not definitely proved. There are frequently found lacustrine clays, silts or sands with fresh-water molusces remnants above marine deposits. Their occurrence is connected with gradual retreating of the sea. Finally the sea has been burried with river delta sands up to tens of meters of thickness. Kadyny Formation contains at least two marine horizons above Elbląg Clays. The lower one is defined a Próchnik I Layer and the upper one is defined a Kamionek Wielki Layer. They represent two short transgressions and the second one took place at the decline of interglacial. Because of the thickness, particular development and the fauna contained, Elbląg Clays are the important marine horizon in the Dolne Powiśle region. In the northern part of the region, especially in Elbląg Elevation where they crop out, they have an index significance. Due to TL dating their age has been determined at 99±14 ka BP (A.Bluszcz, 1984*a*).

Contrary to Kadyny Formation, Gniew Formation has a continental character at the Lower Vistula. It begins with varved clays (over 20 m thick) overlain with thick sandy series of ice-dam, fluvioglacial and fluvial origin. In the north, close to the Vistula delta (within the range of Eemian marine transgression) another marine horizon has been recorded in two sites — at Krastudy and at Kamionka (A.Makowska, 1986*a,b*, 1990). It is situated in the lower part of sandy series or directly on varved clays. The horizon is built of 10 m thick silts containing molusces fauna distinctly different from the Elbląg Clay assemblage. The fauna resembles the Eemian Sea assemblages because of boreal-lusitanian or purely lusitanian specimens occurrence. This fact was the base for the assumption on another marine transgression defined a K r a s t u d y S e a t r a n s g r e s s i o n . According to the features of deposits, their range and fauna contained it is evidenced that the transgression happened during optimum of the interglacial period which has been defined a Krastudy Interglacial. Climatic conditions were similar to Eemian period then, and most probably the Krastudy Sea was continuation of Elbląg Sea which occupied the northern part of the region at the beginning of the interglacial. Consequently both transgressions represent probably two phases of activity of one sea basin which existed in the Baltic depression then. However the problem requires further investigations, Krastudy Horizon is undoubtedly of high significance for the stratigraphy of Young Pleistocene Dolne Powiśle region. Due to TL dating the age of deposits has been deter-

mined at 75±12 ka BP (A.Bluszcz, 1984*b*). At the decline of the interglacial, alike the Eemian Sea, the Krastudy Basin was burried with river delta deposits and then covered with fluvioglacial accumulations. The fluvioglacial cover is represented by sandy series both in north and south parts of the region and forms a uniform layer there.

V i s t u l i a n G l a c i a t i o n . In Dolne Powiśle this period is represented by two main till layers which are separated from each other by intermorainic series of different (up to tens of meters) thickness all over the region.

Both upper and lower horizons were accumulated during two different stadials i. e. Świecie Stadial (older) and Leszno-Pommeranian Stadial (younger). The stadials mentioned above are separated by Grudziądz (Łęcze) Interstadial which in turn is subdivided into lower rank units.

Ś w i e c i e S t a d i a l . During this period the lower till horizon and diversified watermorainic, fluvioglacial and kame type deposits were accumulated. The till layer is spread all over the region and extends further in all directions. To the south it ranges the vicinity of Inowrocław, and to the east it is reported from Warmia and Mazurian District. It illustrates a wide range of the ice-sheet in northern Poland which in places is comparable to the maximum extent of the younger stadial.

G r u d z i ą d z (Ł ę c z e) I n t e r s t a d i a l is represented by intermorainic series of different thickness and composition. At the Lower Vistula and in Elbląg Elevation it is known as Grudziądz Formation and Łęcze Formation respectively. At the Lower Vistula it is built of fluvioglacial, ice-dam and fluvial deposits but in Elbląg Elevation there are also lacustrine sediments containing organic intercalations. Moreover marine deposits were found there. They are represented by silt layers (1.0–2.0 m thick) with marine molusces shells which usually overlie lacustrine deposits containing fresh-water fauna. In one site due to ^{14}C dating the age of lacustrine deposits has been determined at 35.1±1.5 ka BP (M.F.Pazdur, 1981). Marine fauna has been recognized in two sites and the assemblages recorded are different. They probably represent two different transgressions. According to ^{14}C dating the younger one has been correlated with Denekamp Interstadial from Netherlands.

L e s z n o - P o m m e r a n i a n S t a d i a l . During this period the upper till horizon and all types of deposits related to the decline of glaciation were accumulated. In Dolne Powiśle region the upper till is spread continuousely and extends up to the limits of the Vistulian Glaciation in Poland (Leszno—Płock—Augustów line). In the northern part of Dolne Powiśle the till is subdivided into two layers in places according to transgressive oscillations of Pommeranian Phase which is generally of retreating character.

CONCLUSIONS

In Dolne Powiśle both development and stratigraphy of Young Pleistocene deposits illustrate particularely combined processes which controlled the geological history of the region. Beginning with Eemian Interglacial the northern part of the region was permanently situated within the range of the Baltic Basin and was subjected to repeated marine transgressions. Marine periods were interrupted by emerging of the area when continental processes prevailed and the region was denudated, eroded or accreted with fluvial and lacustrine deposits. The sedimentation was related to the base level of the nearby sea. Besides marine and continental processes the region in Young Pleistocene was at least three times totally glaciated. Glacial periods are represented by till horizons, glacial and extraglacial deposits. They are all separated from each other by different deposits accumulated in quickly changeable sedimentary environments, including marine ones. The above described diversity of deposits within the Young Pleistocene sequence provides unique prospects of research on Young Pleistocene stratigraphy in Dolne Powiśle. Moreover as in barely few places in the Peribaltic zone the history of Baltic Sea can be investigated in this region. In both cases there is a particular role of marine deposits which due to results of continued research can become a perfect index horizon not only for local stratigraphy but also for broad parts of north-eastern Europe. According to current knowledge on geology of Dolne Powiśle three marine horizons are of index rank. The first — Tychnowy Horizon — is spread from Vistula Bay throughout Elbląg Elevation to Kwidzyn at the Lower Vistula (Fig. 1). It separates Young Pleistocene deposits from the Old Pleistocene ones. The second — Elbląg Horizon — covers northern and western parts of Elbląg Elevation up to Ryjewo at the Lower Vistula (Fig. 1). The third — Krastudy Horizon — probably ranges Sztum, Dzierzgoń and Kwidzyn vicinities (Fig. 1). The two latter represent recently defined Krastudy Interglacial which is younger then Eemian.

The results of investigations on Dolne Powiśle briefly commented above allowed to emphasize two main conclusions.

1. Baltic Basin was occupied by the sea during at least two interglacial periods and one interstadial period. Comparable to Holocene, marine environments were gradually changing their character from arctic to boreal and lusitanian during climatic optimum then were again becoming cooler and retreated.

2. Most of transgressions in the region happened after Eemian, between Toruń ice-sheet retret and the first Vistulian Glaciation (Świecie Stadial — Fig. 2). Because of the number and range of marine transgressions (e. g. Elbląg and Krastudy transgressions) as well as because of the occurrence of lusitanian specimens within Krastudy Sea deposits, the period has been defined the interglacial. It is separated from

the Eemian by Toruń Glaciation and hence younger than it. In Dolne Powiśle it has been named Krastudy Interglacial.

The problems of marine transgressions in Dolne Powiśle as well as the stratigraphy of Younger Pleistocene there undoubtedly need further investigations. Possibly the future results will confirm and extend the above conclusions however they can be modified corrected as well according to eventually obtained new data.

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REFERENCES

BLUSZCZ A. (1984*a*) – Sprawozdanie z wykonania pomiaru wieku metodą termoluminescencyjną w Lab. TL Inst. Fiz. Pol. Śląskiej w Gliwicach dla próbki z Kadyn Ka-60 (GdTl-30). Arch. Państw. Inst. Geol. Warszawa.

BLUSZCZ A. (1984*b*) – Sprawozdanie z wykonania pomiaru wieku metodą termoluminescencyjną w Lab. Inst. Fiz. Pol. Śląskiej w Gliwicach dla próbki z Cierpięt (Krastud) Cie-23, Cie-24, Cie-25 (GdTL-82, GdTL-83, GdTL-84). Arch. Państw. Inst. Geol. Warszawa.

GALON R. (1934) – Dolina dolnej Wisły, jej kształt i rozwój na tle budowy geologicznej dolnego Powiśla. Bad. Geogr., **12–13**, p. 1–112.

HALICKI B., BRODNIEWICZ I. (1961) – La stratigraphie du Pléistocéne supérieur dans la région peribaltique méridionale. Bull. Acad. Pol. Sc. Ser. Sc. Geol. Geogr., **9**, p. 163–169, nr 3.

JANCZYK-KOPIKOWA Z. (1970) – Analiza pyłkowa osadów z obszaru doliny dolnej Wisły. Arch. Państw. Inst. Geol. Warszawa.

JANCZYK-KOPIKOWA Z. (1976) – Analiza pyłkowa osadów w Nowinach. Arch. Państw. Inst. Geol. Warszawa.

JANCZYK-KOPIKOWA Z. (1991) – Interglacjał eemski i wczesny Vistulian w Pagórkach. Prz. Geol.

MAKOWSKA A. (1977) – Poziom interglacjalny wśród osadów zlodowacenia środkowopolskiego w Dolinie Dolnej Wisły. Kwart. Geol., **21**, p.769–785, nr 4.

MAKOWSKA A. (1979) – Interglacjał eemski w Dolinie Dolnej Wisły. Studia Geol. Pol., **63**.

MAKOWSKA A. (1980) – Late Eemian with Preglacial and Glacial part of Vistulian Glaciation in the Lower Vistula region. Quatern. Stud., nr 2, p. 37–55.

MAKOWSKA A. (1982) – Palaeogeographic environment for Eemian marine transgressions on the Lower Vistula. Biul. Inst. Geol., **343**, p. 31–50.

MAKOWSKA A. (1986*a*) – Nowy plejstoceński poziom morski oraz ślady morza holsztyńskiego na Dolnym Powiślu.Kwart. Geol., **30**, p. 609–628, nr 3.

MAKOWSKA A. (1986*b*) – Morza plejstoceńskie w Polsce — osady, wiek i paleogeografia. Pr. Inst. Geol., **120**.

MAKOWSKA A. (1990) – Nowe stanowisko plejstoceńskich osadów morza krastudzkiego na Dolnym Powiślu. Kwart. Geol., **34**, p. 465–488, nr 3.

MAKOWSKA A., RABEK W. (1990) – Osady morskie interglacjału eemskiego i pozycja stratygraficzna iłów elbląskich (yoldiowych) na podstawie otworów w Pęklewie i Pagórkach (Wzniesienie Elbląskie). Kwart. Geol., **34**, p. 305–324, nr 2.

NILSSON T. (1983) – The Pleistocene. Geology and life in the Quaternary ice age. D. Reidel Publ. Company. Doordrecht (Holland), Boston (USA), London (England).

PAZDUR M.F. (1981) – Sprawozdanie z wykonania pomiarów wieku metodą C-14 w Lab. Inst. Fiz. Polit. Śląskiej w Gliwicach dla próbki z Łęcza p. 40 (Gd-1326). Arch. Państw. Inst. Geol. Warszawa.

WOLDSTEDT P.(1969) – Handbuch der stratigraphischen Geologie. II. Stuttgart.

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PLEJSTOCEŃSKIE OSADY MORSKIE I ICH ROLA W STRATYGRAFII MŁODSZEGO PLEJSTOCENU DOLNEGO POWIŚLA (POLSKA PÓŁNOCNA)

Streszczenie

Badania czwartorzędu prowadzone w ostatnich dwudziestu latach na Dolnym Powiślu i w jego najbliższym sąsiedztwie przyniosły interesujące wyniki w zakresie poznania osadów młodoplejstoceńskich. Kompleks osadów tego wieku, poczynając od interglacjału eemskiego po schyłek zlodowacenia wisły, osiąga na tym obszarze znaczne, nie spotykane w innych rejonach Polski miąższości dochodzące lokalnie do 200 m. Charakteryzuje się bogatym i zróżnicowanym wykształceniem osadów zarówno lądowych (rzecznych i jeziornych), jak i morskich, występujących w północnej części obszaru, która podlegała w młodszym plejstocenie wielokrotnym transgresjom morskim (fig. 1). Ponad szeroko rozprzestrzenioną serią osadów eemskich, nazwaną tu formacją dolnopowiślańską, spoczywa młodsza grupa osadów, wśród których znajduje się pięć poziomów glin zwałowych, trzy o zasięgu dochodzącym do południowych granic obszaru oraz dwa występujące lokalnie w północnej jego części, oznaczone przez autorkę symbolami BI–BV (fig. 2). Gliny rozdzielone są seriami międzymorenowymi nazwanymi nad dolną Wisłą i w rejonie Wzniesienia Elbląskiego kolejno od starszych do młodszych formacjami Suchacza i Knybawy, Gniewu i Kadyn oraz Grudziądza i Łęcza (fig. 2). W formacjach międzymorenowych północnej części obszaru obok osadów lądowych występują osady morskie o różnym zasięgu przestrzennym, tworzące tu kilka odrębnych poziomów litostratygraficznych. Niektóre z nich mają charakter poziomów przewodnich zarówno dla tego obszaru, jak też i dla szerszej strefy perybałtyckiej. Mogą też odgrywać podobną rolę w nawiązaniach z innymi obszarami Polski. W interglacjale eemskim utworzyły się dwa poziomy morskie: starszy — sztumski utworzony na początku interglacjału i młodszy — tychnowski, który powstał w wyniku największej transgresji morskiej na tym obszarze, jaka miała miejsce w optimum i w okresie pooptymalnym interglacjału eemskiego (fig. 1). Poziom ten jest najważniejszym poziomem przewodnim na Dolnym Powiślu, oddzielającym wyraźnie osady starszego plejstocenu od osadów młodszych. Koreluje się on z morskimi osadami interglacjału eemskiego Holandii, Niemiec i Danii, przez co jego przewodnia rola nabiera uniwersalnego znaczenia. Największa liczba poziomów morskich występuje w formacjach Gniewu i Kadyn, znajdujących się między glinami zwałowymi poziomów BII i BIII (fig. 2). Ustalono, że w tej sytuacji stratygraficznej znajdują się iły elbląskie (yoldiowe), których wiek odnoszony był wcześniej do interglacjału eemskiego. Znajdują się one w dolnej części obydwu formacji i, jak świadczy zawarta w nich fauna, powstały w okresie transgresji chłodnego morza, które dotarło prawdopodobnie do okolic Ryjewa nad dolną Wisłą. Iły elbląskie ze względu na swoje szerokie rozprzestrzenienie oraz charakterystyczne wykształcenie litologiczne i zawarte w nich mięczaki, mogą obecnie pełnić rolę ważnego poziomu przewodniego dla dolnej części kompleksu poeemskiego. W formacji Gniewu nad dolną Wisłą, w Krastudach, a ostatnio w okolicach Kwidzyna, stwierdzono inne osady morskie z fauną malakologiczną bardziej ciepłolubną niż fauna iłów elbląskich. Fauna ta wskazuje, że osady krastudzkie są młodsze od iłów elbląskich i muszą pochodzić z optymalnego okresu międzyglacjalnego. Również przypuszczalny zasięg transgresji morskiej, w czasie której powstały te osady, świadczy o ciepłym okresie, zbliżonym klimatycznie do interglacjału eemskiego. Na podstawie obecności tych dwu najważniejszych poziomów morskich w osadach formacji Gniewu i Kadyn przyjęto, iż powstały one w interglacjale, nazwanym krastudzkim. Jak na to wskazuje profil osadów, interglacjał ten był młodszy od eemu. Obydwa okresy rozdzielało zlodowacenie toruńskie, w czasie którego powstała glina zwałowa poziomu BII docierająca do okolic Torunia, podesłana lokalnie glina poziomu BI, nie przekraczającą w swym zasięgu południowych granic delty Wisły.