

## Maximum limit of the Vistulian Glaciation in the vicinity of Nidzica, southwestern Mazury Lakeland

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Maximum limit of the Vistulian Glaciation in the southwestern Mazury Lakeland was determined on the basis of detailed geomorphologic and geologic fieldworks. The main obstacle for the advancing ice sheet were the end moraines, formed during the Mława Stadial of the Wartanian Glaciation. In spite of lacking tills and morainal features of the last glaciation, a maximum limit of the ice sheet of the Vistulian Glaciation was determined in this area, basing on southern limit of glacial channels, lakes and kettle holes. On the Nidzica Plateau which was a forefield of the ice sheet during the Vistulian Glaciation, there are depressions with biogenic sediments of the Eemian Interglacial, surrounded by patches of older till and its residual lag concentrates.

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### INTRODUCTION

Maximum limit of the last glaciation is a principal geomorphologic-geologic problem for the southwestern Mazury Lakeland (Fig. 1). In the vicinity of Nidzica it runs almost west-east, therefore corresponds with the southern boundary of the Mazury Lakeland and the first-rank watershed between drainage basins of the Vistula and Pregel Rivers. To the west, a maximum limit of the last glaciation turns quite rapidly to the south whereas eastwards, it is obliterated by a vast outwash area. New data on the maximum limit of the ice sheet of the Vistulian Glaciation in the southwestern Mazury Lakeland have been supplied recently by mapping of the author (W. Morawski, in print *a, b*) and the others (D. Gałązka, L. Marks, in print; M. Lichwa, in print).

A strip of high end moraines in the Nidzica Plateau (after S. Z. Różycki, 1972*b*) was the main obstacle for the advancing ice sheet of the Vistulian Glaciation. Except for the Lake Kownatki in the west (Fig. 2), there are, however, neither glacial deposits nor morainal features of the last glaciation in the maximum ice sheet limit zone. In turn, the northern edge of the Nidzica Plateau is highly disintegrated in the west and

in the centre of the area — with erosive outliers surrounded by outwash terraces. Thus, determination of the maximum ice sheet limit of the Vistulian Glaciation could be done on the basis of palaeogeographic analysis, using detailed geologic and geomorphologic data (Fig. 2). Among them, there are: drainage pattern with lakes and kettle holes, and glacial channels. In the Nidzica Plateau to the south, larger depositional features are indicated as well as till covering and its residuum (Fig. 2). In the northern area which was occupied by ice sheet of the Vistulian Glaciation, neither glacial features nor sediments are indicated as they occur in the west only and do not play any role in delimitation of the ice sheet edge.

### EXTRAGLACIAL AREA

The Nidzica Plateau and particularly end moraines are the main landforms in forefield of the ice sheet of the Vistulian Glaciation. In the western part of the area, near Gardyny (beyond the map) and Szkotowo, the end moraines reach to 220–240 m a.s.l. (Fig. 2). The Nidzica Plateau is located to the south of the hills that acted as the obstacle for the ice sheet,

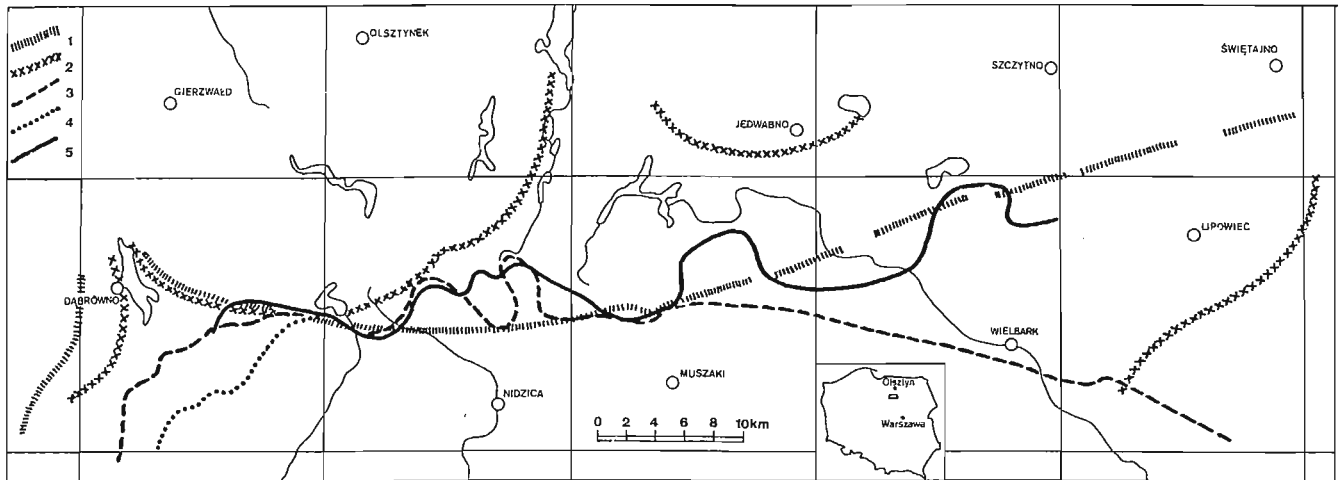


Fig. 1. Maximum ice sheet limit of the last glaciation in the southwestern Mazury Lakeland after: 1 — L. Roszko (1968), 2 — S. Z. Różycki (1972*b*), 3 — A. Mańkowska and W. Słowański (1978), 4 — D. Gałzka and L. Marks (in print), 5 — the author (cf. Fig. 2); marked are sheets of the *Detailed Geologic Map of Poland*, scale 1:50 000

and it is covered with small patches of till, deposited during the Mława Stadial of the Wartanian Glaciation (W. Morawski, in print *a, b*). In most part of the area, the till is replaced by its residuum, composed of characteristic boulder-gravel lag concentrate. The latter is to 1.5 m thick, but occasionally reduced to large boulders only, occurring directly on older glaciofluvial sands. The sketch (Fig. 2) presents together: till patches to several metres thick, till covers to 2 m thick and bouldery residual layer. All these indicate that a till has covered presumably the whole plateau in this area and its gradual degradation started with ice sheet retreat of the Mława Stadial, then continued during the Eemian Interglacial, the Vistulian Glaciation and the Holocene. Presence of this stony cover on sandy plains makes their interpretation as outwash terraces of the Vistulian Glaciation impossible.

On the Nidzica Plateau and inside depressions which are now incorporated into the drainage pattern, there are no outwash terraces connected with the maximum limit of the ice sheet during the Vistulian Glaciation. Flat bottoms of dry valleys and of the Szkotówka and Nida River valleys are filled with deluvial and alluvial sediments of the Holocene. Such observations coincide with conclusions of L. Roszko (1968) who noted complete absence of outwash in the maximum ice sheet limit zone corresponding, according to her, to the Leszno Stadial. She explained it with shortage of meltwaters and glacial material.

To the east of Szkotowo the main edge of the Nidzica Plateau runs south-eastwards to Nidzica (Fig. 2). At its foot there is the highest outwash terrace in this area (175–185 m a.s.l.), formed during ice sheet retreat of the Vistulian Glaciation. Erosive outliers are emerging from this terrace — primarily they have been presumably large end moraines, composed of sands with gravels, with small patches of till. These hills reach 215 and 209 m a.s.l. to the north of Nidzica, and 189 m a.s.l. near Orłowo. On the outliers there are neither glacial sediments of the Vistulian Glaciation nor traces of glacial erosion, they must have acted therefore as the obstacle which could not have been passed across by an ice sheet.

In a small area, half-way between Orłowo and Wały, the ice sheet presumably reached the plateau edge, the latter reaching over 210 m a.s.l. (Fig. 2). In the area Wały–Muszaki, the plateau is represented by the erosive outlier, surrounded by three outwash plains at 140–155 m a.s.l. Within this outlier there is an outstanding depositional feature of Złote Góry, reaching to over 230 m a.s.l. Its sandy-gravel deposits are over 80 m thick. To the north of Wały, there is the outlier of Jastrzębia Góra, reaching to 190 m a.s.l. (Fig. 2), which has been previously interpreted as the end moraine of the last glaciation (A. Mańkowska, W. Słowański, 1978). It is composed of sands with gravels, about 50 m thick, including also inserts of boulders and flow tills. Research boreholes done during the last few years, made reliable correlation of geology of the outliers and the Nidzica Plateau possible (W. Morawski, in print *a, b*; W. Morawski, K. Kenig, 1998, 1999). The outlier of Jastrzębia Góra is surrounded by an erosive socle with a thin outwash cover, located at 140–150 m a.s.l., interpreted previously as the depositional outwash terrace, formed during ice sheet retreat of the last glaciation (A. Mańkowska, W. Słowański, 1978). Between outliers of Złote Góry and Jastrzębia Góra near Wały, there is a depositional outwash terrace at about 140 m a.s.l. It spreads southwards, with its surface beneath 135 m a.s.l. near another erosive outlier of Góra Róg (Fig. 2).

Determination of the maximum limit of the Vistulian Glaciation further to the east is more difficult, due to intensive erosion and mantling with outwash sediments during ice sheet retreat. No end moraines of this glaciation were found and Zielone Góry to the north of Wielbark (Fig. 2), reaching to 172 m a.s.l., is most probably the erosive outlier with similar geologic structure and origin as the other ones.

The Nidzica Plateau to the south of the maximum ice sheet limit of the Vistulian Glaciation (Fig. 2) is a wavy area with small undulations only. There are distinct traces of long-lasting denudation and linear erosion. The drainage pattern, except for the Nida and the Szkotówka, is composed of small dry or perennial valleys. Almost all kettle holes have been

drained and there are no lakes. Similar drainage pattern is also typical for the described erosive outliers.

Besides the well known sites of the Eemian sediments at Nidzica (*cf.* A. Mańkowska, W. Słowański, 1978), four new localities with biogenic sediments of the Eemian Interglacial were found in dry valleys on the Nidzica Plateau (Fig. 2). Detailed mapping enabled univocal determination of stratigraphy, excluding any covering by glacial deposits of the Vistulian Glaciation (W. Morawski *et al.*, 1998, 1999).

All the presented data suggest that ice sheet of the Vistulian Glaciation has not advanced onto the Nidzica Plateau and the erosive outliers in its forefield. The presented maximum ice sheet limit could have been, however, overpassed by narrow glacial lobes. The latter occupied then the depressions between the end moraines. Such lobe could erode a lowering for the outwash valley to the north of Muszaki, between the outlier Złote Góry and the plateau. Erosion of this lobe and burial of ice blocks by outwash deposits could result in development of the Lake Zawadzkie, about 12 m deep. It is located to the south of Muszaki, i.e. 10 km to the south of the maximum ice sheet limit, at the outwash terrace formed during retreat of the ice sheet of the Vistulian Glaciation.

#### GLACIATED AREA

A morainic plateau of the Vistulian Glaciation occupies the western part of the described area and it is located generally at lower altitude than the Nidzica Plateau. The landscape is completely different, with small and steep-sloped moraines, deep glacial channels and numerous lakes (Fig. 2). Besides the lakes, there are also numerous depressions with peats or deluvia at the bottom. Only some of these depressions, mainly in channels, are incorporated into a very poorly developed drainage system. The presented maximum ice sheet limit of the Vistulian Glaciation (Fig. 2) is generally very close to the main watershed between drainage basins of the Vistula and Pergel Rivers.

End moraines of the maximum limit occur along the southern shore of the Lake Kownatki. Then they run further to the west being low, narrow and ridge-like hills. Their small dimensions indicate very poor deposition in a frontal zone of the ice sheet. Larger end moraines were formed during ice sheet retreat and occur further to the north, in the zone Grunwald–Waplewo–Jedwabno–Szczytno. The ice sheet body contained therefore some glacial debris only what fully coincides with a conclusion of L. Roszko (1968). She postulated that ice sheet was thin at its maximum limit and started retreating quite soon, thus only a thin till cover could be formed.

However, a widely branched system of glacial channels indicates intensive erosion under the ice in its marginal zone. Glacial channels are a significant tool to delimit maximum limit of an ice sheet. It seems worth-mentioning that this area has the undoubted high density of channels, equal to about 35 km per 100 km<sup>2</sup> what is, according to S. Majdanowski (1947), a typical phenomenon for an outer ice sheet zone. Southern

ends of glacial channels are also good markers of the ice edge, e.g. curves of the Łyna channel to the west and of the Koniuszyn channel to the east (Fig. 2). These curves indicate that ice streams, when reaching obstacle at ice sheet margin, changed direction of their flow towards lower areas.

The maximum ice sheet limit is also indicated by terminal basins. The most outstanding is the basin of the Lake Kownatki in western part of the area (Fig. 2). It was formed due to intensive glacial erosion at the ice edge, which was dammed by end moraines near Szkotowo on the Nidzica Plateau. The other is the terminal basin of the Lake Szoby Małe to the north of Wielbark (Fig. 2) where ice sheet was halted by end moraines of Zielone Góry.

Between outliers of Jastrzębia Góra and Zielone Góry on outwash terraces, directions of glacial channels and therefore, maximum ice sheet limit of the Vistulian Glaciation is delimited roughly on the basis of occurrence of kettle holes, filled with lakes and peatbogs.

#### GLACIOTECTONIC DEFORMATIONS

They are common at the maximum ice sheet limit of the Vistulian Glaciation (W. Morawski, in print *a*, *b*). At Jankowice, the deformed Tertiary deposits occur at depth of a dozen metre at the plateau edge to the west of the study area. At Szkotowo there are folds within the Miocene–Oligocene complex (E. Ciuk, 1972). To the west of Nidzica at Szerokopaś, there are outcrops of the Pliocene clays, considered by A. Mańkowska and W. Słowański (1978, 1980) for a glacial raft within the Quaternary sequence. Basing on new data (W. Morawski, in print *b*), they are presumably the glaciotectionic deformations.

A large outcrop of the Tertiary deposits is known from a vicinity of Łyna and Orłowo (E. Ciuk, 1968). This glaciotectionic diapir has been presumably formed by pressure of ice sheet edge on silts and clays of the Tertiary, saturated with water through a deeply incised subglacial Łyna channel (W. Morawski, in print *b*). Intensive glaciotectionic deformations to over 200 m depth (top of the Tertiary deposits) were noted also in the research borehole Wysokie to the north of Orłowo, at the western edge of the Łyna channel (*op. cit.*).

#### STRATIGRAPHIC DISCUSSION

The study area is a subject of a three-fold discussion on the main regional geologic principles. The first one deals with maximum ice sheet limit of the Vistulian Glaciation (Fig. 1), the second is stratigraphic rank of this limit and the third — stratigraphic-palaeogeographic role of the Nidzica Plateau.

At present, the first item is more clear due to detailed geological mapping of a vaster area (W. Morawski, in print *a*, *b*; D. Gałązka, L. Marks, in print; M. Lichwa, in print). It introduced new ideas, especially if compared with the *Geologic Map of Poland* in scale of 1:200 000 (A. Mańkowska, W.

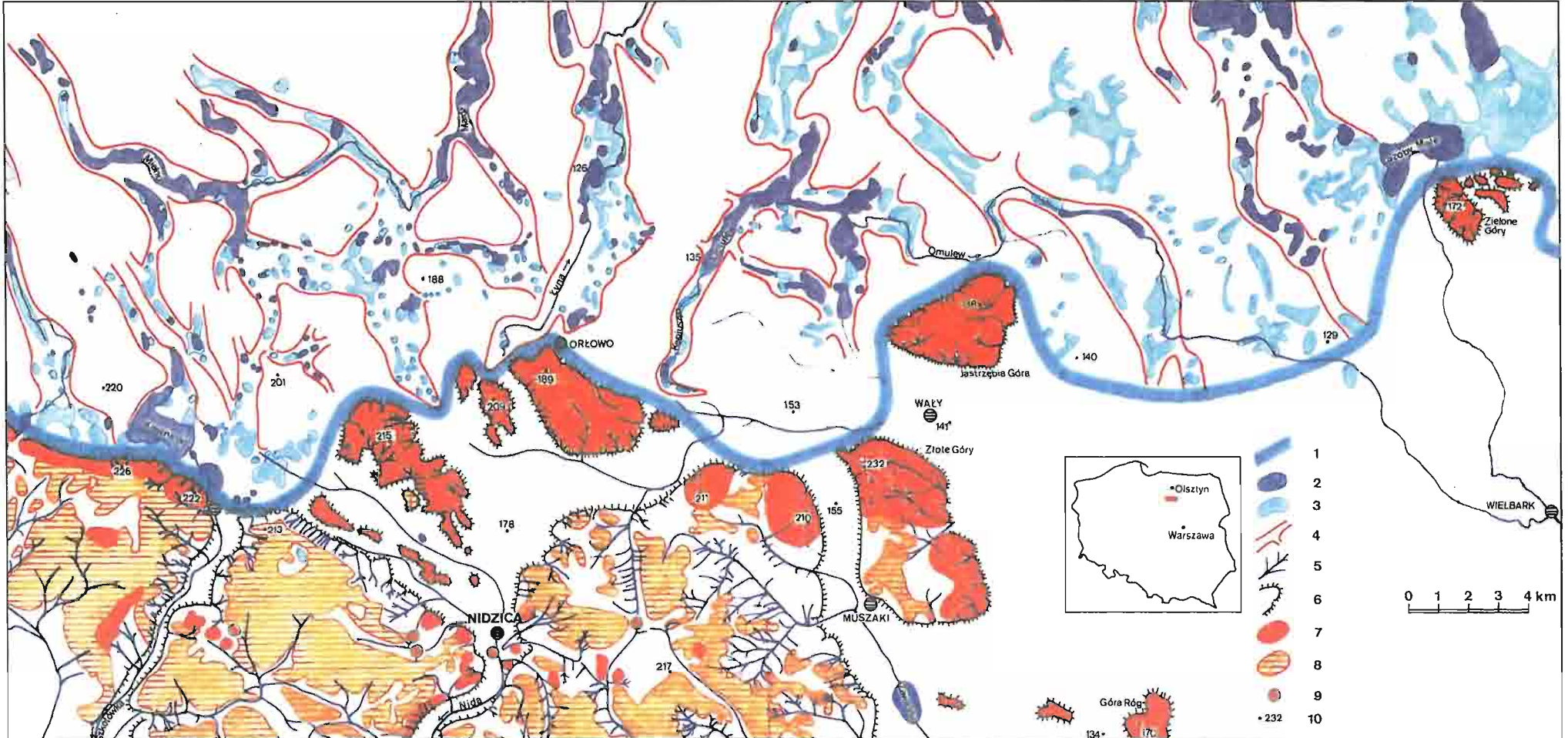


Fig. 2. Selected geologic and geomorphologic features in the maximum limit zone of the Vistulian Glaciation in the southwestern Mazury Lakeland

1 — maximum ice sheet limit of the Vistulian Glaciation, 2 — lakes, 3 — kettle holes and terminal basins, 4 — glacial channels, 5 — drainage pattern and present rivers, 6 — edges of the Nidzica Plateau and erosive outliers, 7 — end and dead-ice moraines of the Wartanian Glaciation, 8 — till of the Mława Stadial of the Wartanian Glaciation and its residuum, 9 — sites with biogenic deposits of the Eemian Interglacial, 10 — altitude in metres a.s.l.

Słowański, 1978). The previously distinguished end moraines in the vicinity of Orłowo, the hills Jastrzębia Góra (W. Morawski, in print *a, b*) and Zielone Góry (M. Lichwa, in print) are not the end moraines of the last glaciation (A. Mańkowska, W. Słowański, 1978). They are erosive outliers, deposits of which correspond to the ones of the Nidzica Plateau. Except for results of geologic and geomorphologic mapping, such interpretation is also backed up by research boreholes, results of lithologic analysis (W. Morawski, K. Kenig, 1998, 1999) and the mentioned curves of subglacial channels of the Łyna and the Koniuszyn. These curves prove that outliers acted as obstacles to the advancing ice sheet, thus favoured glacial and meltwater erosion, but not a glacial deposition. The idea that the Lake Szoby Małe to the north of Wielbark is a terminal basin of the maximum ice sheet limit of the last glaciation speaks for a need of stratigraphic revision in the area further to the east.

The second item is a rank of the ice sheet limit. It is undoubtedly the maximum ice sheet limit of the glaciation, the fact which is accepted by most of the authors. The authors data fully support such interpretation.

The third item is a stratigraphic location of the Nidzica Plateau, i.e. the one to the south of the described maximum ice sheet limit. Age of end moraines in the vicinity of Przasnysz and Mława, and therefore of the plateau between Mława and Nidzica, has been a subject of discussion for many years. The opinion that the end moraines near Mława were formed during the last but one glaciation has been already formulated by W. Nechay (1927) and S. Lencewicz (1927). B. Halicki (1950) demarcated a limit of the penultimate glaciation in the vicinity of Nidzica, and connected development of the plateau in question with the Warta Stage of the Middle Polish Glaciation. Z. Michalska (1961, 1967) suggested possible connection of the end moraines in the vicinity of Mława and Przasnysz with maximum limit of the oldest stadial of the last glaciation. She underlined controversial character of such proposal and found the area to the north of Mława, i.e. in the vicinity of Nidzica and Szczytno, to be the most prospective. However, the Quaternary complex is reduced there: meltwater runoff during retreat of ice sheet of the last glaciation has destroyed older landforms and mantled the area with younger glaciofluvial deposits. The statement of Z. Michalska (*op. cit.*) that B. Halicki seemed to suggest a limit of the last but one glaciation (the Vth, i.e. the North Polesie Glaciation) in the vicinity of Mława and Przasnysz, thus these end moraines can be connected with a maximum limit of this glaciation, is completely unjustified. B. Halicki (1950) mentioned the Mława and Przasnysz end moraines, looking for a continuation of the North Polesie Glaciation in the territory of Poland but on his published map, a maximum limit of this glaciation is completely disrupted in the eastern Mazury Lakeland.

R. Galon and L. Roszkówna (1961), and then L. Roszko (1968) demarcated a limit of the last glaciation (Leszno Stadial) in the vicinity of Dąbrówno–Nidzica–Muszaki along the northern edge of the Nidzica Plateau (Fig. 1). The later research was recapitulated by S. Z. Różycki (1972*a, b*) who accepted a maximum limit of the last glaciation (GIVmax.) near Nidzica, and connected development of the Nidzica Plateau with the Mława Stadial of the Middle Polish Glacia-

tion (GIII+3). A similar maximum limit of the last glaciation was presented in numerous monographs (e.g. R. Galon, L. Roszkówna, 1967; R. Galon, 1972; J. E. Mojski, 1985) as well as maps and atlases of the Quaternary of Poland. The same interpretation prevails also in more recent studies, particularly the ones on ice sheet limits during the last glaciation (L. Marks, 1988, 1991).

Previously, the most detailed map of the described area was the *Geologic Map of Poland* in scale of 1:200 000, sheet Olsztyn (A. Mańkowska, W. Słowański, 1978, 1980). On this map, a maximum limit of the last glaciation was indicated near Nidzica and the Nidzica Plateau was composed of deposits of the North Mazovian Stadial of the Middle Polish Glaciation. The mentioned authors (*op. cit.*) indicated that in the area of Dąbrówno–Nidzica, a till at the surface of the Nidzica Plateau forms patches, underlain by glaciofluvial sands. These patches occur at palaeoelevations, composed of the underlying deposits, and are completely absent in depressions. Such fact proves long degradation of the plateau surface, since the Eemian Interglacial until the Holocene. This conclusion is fully supported by fieldworks of the author who distinguished zonal thinning of till patches and their transformation into a stony residual layer.

In the cited discussion, particularly important are the Eemian biogenic deposits in the Nidzica Plateau. Besides the Eemian deposits of the channel lake in Nidzica (*op. cit.*), covered with outwash sediments of the last glaciation, a single site only was known from the plateau at Sewerynow to the west of Nidzica (K. Szczepanek, 1962). Detailed mapping (W. Morawski, in print *a, b*) succeeded with four new sites of biogenic deposits, ascribed by palynology to the Eemian Interglacial (W. Morawski *et al.*, 1998, 1999). These deposits fill depressions in the plateau surface, being occasionally mantled with deluvia only what seems to be a definite argument for connecting the Nidzica Plateau with the Wartanian Glaciation.

Renewed revision of the maximum limit of the last glaciation in this area has been suggested recently. D. Gałązka and L. Marks (in print) translocate maximum ice sheet limit of the Vistulian Glaciation to the west of Szkotowo more southwards, onto the Nidzica Plateau (Fig. 1). Hills at the northern edge of the plateau, according to the present author acting as the obstacle to ice sheet of the Vistulian Glaciation, could have been mantled with deposits flowing from the ice sheet edge, possibly also on the plateau surface outside these hills (Z. Michalska, 1975). Presence of such extraglacial deposits seems, however, insufficient to move the maximum ice sheet limit further to the south. It does not seem reasonable as well, to connect development of some landforms at this plateau with the Vistulian Glaciation. These landforms, probably dead-ice moraines, are quite common on the Nidzica Plateau in the area Szkotowo–Nidzica–Muszaki. They are composed of sands with gravels and boulders, exposed only at tops of hills, and their slopes are covered with till patches or residual remains of the Mława Stadial. This residual layer covers occasionally also the tops of hills what makes them resemble fresh glacial landforms of the Vistulian Glaciation. In turn, dry valleys that form a combined drainage pattern on the plateau are incised in glaciofluvial sands that underlie a till of

the Mława Stadial and are locally covered with residual boulders, therefore their interpretation as outwash deposits formed during ice sheet retreat of the Vistulian Glaciation seems highly improbable. Flat bottoms of these valleys are composed of deluvial and partly also alluvial sands of the Holocene which cannot be interpreted as outwash series either. More southern maximum ice sheet limit of the Vistulian Glaciation to the west of Szkotowo is also contradicted by petrographic analysis of gravels from tills (S. Lisicki, 1998).

S. Lisicki (*op. cit.*) correlates a till on the Nidzica Plateau as the one of the Świecie Stadial of the Vistulian Glaciation. On the other hand, he considers the maximum ice sheet limit discussed in this paper, for a maximum limit of a till of the younger, i.e. the Leszno–Poznań Stadial of the Vistulian Glaciation. Similar suggestion on limit of the Świecie Stadial as far south as the Mława end moraines was proposed by D. Gałazka *et al.* (1998). Such concept means that maximum ice sheet limit of the Vistulian Glaciation would be demarcated by the Mława end moraines, and the commonly accepted maximum ice sheet limit would be of the lower, i.e. stadial rank, whereas biogenic sediments in the plateau depressions with pollen of the Eemian Interglacial should be referred to an interstadial.

All these drastic proposals should be, however, according to the author, treated as hypotheses that stimulate further research only. Revision of the previous opinions could be possible if a site with Eemian sediments overlain by a till was found on the plateau between Mława and Nidzica, or if the two Eemian Interglacial vegetation successions were distinguished in place of the present single one what, according to K. Mamakowa (1989) does not seem possible.

## CONCLUSIONS

Correlation of numerous borehole sections and palynologic analysis of deposits of the Eemian Interglacial prove that the Nidzica Plateau was formed during the Middle Polish Glaciation (Saalian) and the presented maximum ice sheet limit is connected with the Vistulian Glaciation.

The Nidzica Plateau formed an obstacle which could not be overpassed by ice sheet of the Vistulian Glaciation; thus, its maximum limit runs along the line: Kownatki–Szkotowo–Orłowo–Złote Góry–Jastrzębia Góra–Zielone Góry.

Erosive outliers to the north and north-west of Nidzica, surrounded by outwash terraces formed during ice sheet retreat of the Vistulian Glaciation, are fragments of the Nidzica Plateau.

The denuded Nidzica Plateau with its complex drainage pattern, covered with till and its stony residuum, contacts in the north with fresh glacial landscape with numerous glacial channels, lakes and kettle holes — such rapid change in landscape suggests that the distinguished boundary represents a maximum glaciation limit.

In a zone of the maximum ice sheet limit of the Vistulian Glaciation there are intensive glaciotectionic deformations reaching as deep as the Oligocene.

Ice sheet of the Vistulian Glaciation contained scarce morainic material in its maximum limit zone; therefore, neither outstanding landforms nor any outwash plain could be connected with this maximum limit.

Outwash terraces and other large landforms have not developed until retreat phases of the Vistulian Glaciation.

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## MAKSYMALNY ZASIĘG LĄDOŁODU ZLODOWACENIA WISŁY W REJONIE NIDZICY NA POJEZIERZU MAZURSKIM

### Streszczenie

W dotychczasowych opracowaniach maksymalny zasięg lądolodu ostatniego zlodowacenia w rejonie południowo-zachodnich Mazur był wyznaczony głównie na podstawie danych geomorfologicznych (fig. 1). Szczegółowe prace geologiczno-zdjęciowe wykonane dla opracowania kolejnych arkuszy *Szczegółowej mapy geologicznej Polski* w skali 1:50 000 dostarczyły nowych danych umożliwiających uściślenie linii maksymalnego zasięgu lądolodu zlodowacenia wisły na odcinku Dąbrówno–Nidzica–Muszaki–Wielbark (fig. 2) oraz potwierdziły, że położona na południe od niej Wysoczyzna Nidzicka została uformowana w stadiale mławy zlodowacenia warty.

W zachodniej części terenu zaporą dla lądolodu był pas wzgórz morenowych w rejonie Szkotowa. Ku wschodowi, na przedpolu wysoczyzny występują ostańce erozyjne z niej wyodrębnione, uważane dotychczas za moreny czołowe maksymalnego zasięgu lądolodu ostatniego zlodowacenia. Stanowiły one pierwotnie ciąg dużych form akumulacyjnych — prawdopodobnie moren czołowych, powstałych w okresie zlodowacenia warty. Jest możliwe, że pomiędzy te formy (ostańce) wkroczyły ku południowi wąskie loby czy jezory lodowe.

Powierzchnia Wysoczyzny Nidzickiej jest zerodowana i zdenudowana. Charakteryzuje ją rozbudowana sieć drenażu, w który zostały włączone wszystkie zagłębienia bezodpływowe. Na obszarze tym brak jezior. W suchych dolinkach stwierdzono występowanie osadów organogenicznych, bez

przykrycia osadami glacygenicznymi, datowanych palinologicznie na interglacjal eemski.

Obszar na N od linii maksymalnego zasięgu lądolodu zlodowacenia wisły leży niżej niż Wysoczyzna Nidzicka. Cechuje go bardzo żywa rzeźba polodowcowa, z licznymi jeziorami i zagłębieniami bezodpływowymi, przeważnie nie włączonymi w bardzo słabo rozwiniętą sieć drenażu. Na obszarze tym występuje wyjątkowo gęsta sieć rynien subglacjalnych, których południowe zakończenia znaczą zasięg czasy lodowej. Zakończenia rynien Łyny i Koniuszynu wykazują charakterystyczne wygięcia spowodowane zmianą kierunku płynięcia strumieni lodowych napotykających zaporę.

W strefie maksymalnego zasięgu lądolodu zlodowacenia wisły był ubogi w materiał morenowy i nie pozostawił znaczących form akumulacyjnych, a na przedpolu brak poziomu sandrowego związanego bezpośrednio z tym zasięgiem. Duże formy akumulacyjne występujące na północ od omawianego obszaru znaczą etapy recesyjne zlodowacenia wisły, zaś związane z nimi tarasy sandrowe tworzą na omawianym obszarze 6 poziomów. W strefie maksymalnego zasięgu lądolodu występują silne deformacje glacytektoniczne (nasunięcia i wyciśnięcia), sięgające osadów oligocenu.

Zdaniem autora, powyższe fakty przeczą opublikowanym ostatnio propozycjom (S. Lisicki, 1998; D. Gałązka i in., 1998) dotyczącym powstania wysoczyzny pomiędzy Mławą a Nidzicą w stadiale świecica zlodowacenia wisły i obniżenia — do stadialu — rangi omawianego zasięgu lądolodu.