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NOTES ON THE ORIGIN OF LATE-GLACIAL LACUSTRINE DEPOSITS IN NORTH-EASTERN POLAND

Abstract

Late-glacial silty-clayey deposits dating back to the Younger Dryas are of common occurrence in NE Poland. The present writer examined the mineralogical and grain-size composition of the deposits as well as the content of $CaCO_3$ and organic substance. The deposits are of eolian origin and were laid down under periglacial conditions during periods when a compact vegetation cover was lacking.

Palynological investigations of lacustrine deposits, carried out by the present writer in NE Poland, throw some light on the climatic conditions and the vegetation existing in the Late Glacial and the Holocene. These conditions are also reflected in the character of the sediments of that period.

H. Gross (1943) in his description of vegetal and climatic conditions in the Masurian Lake District mentions the character of late-glacial deposits. According to Gross tundra peats developed in Masuria during the Bölling, muds and peats in the Alleröd, while clays (Ton) were deposited during the cold Dryas periods.

Numerous samples collected by the present writer in NE Poland have confirmed the formation of clayey deposits during the cold Dryas periods but so far no tundra peats have been discovered. On the other hand, stratified calcareous gyttja was accumulated in the Alleröd (deposits not mentioned by Gross).

The deposits in the area of the Great Masurian Lakes reveal a striking difference between deposits of cold periods like the Younger Dryas (clayey deposits) and those of Preboreal times (calcareous gyttja). In the Suwałki Lake Region, on the other hand, no distinct boundary is noticeable between deposits of cold and warmer periods, whereas the Preboreal calcareous gyttja contains a considerable admixture of quartz fines. Moreover, an admixture of fine quartz particles was recognized in the top part of contemporaneous lake deposits.

In view of the fact, that in the NE Poland silty-clayey deposits of the Younger Dryas occur most commonly, in fairly thick beds, closer attention was paid to the deposits of this period. These deposits, identified as to age by pollen analysis were subjected to the following examinations.

Areometric analyses according to Casagrande method were made in order to determine grain size gradation of the Younger Dryas deposits from the lakes: Kruklin, Mamry, Śniardwy and Mikołajki in the Masurian Lake District, at Osowa in the Suwałki Lake Region, from Lake Sajno at Augustów, and of deposits from the Biebrza pradolina. Deposits characterized by a marked carbonate content were given a 24-hour bath in a 10% HCl solution, in order to eliminate the carbonates; afterwards the grain size composition of the remaining material was analyzed.

To determine the mineral composition, X-ray examinations were made; the Younger Dryas deposits from Lake Kruklin were analyzed. Mineral composition was determined by the X-ray powder method, making tests from the samples as a whole and, separately, from the loamy fraction; the clay fraction had been separated out by sedimentation in water. The X-ray patterns of the whole sample and of its clayey fraction were made, using an X-ray apparatus of type Tur M 60 in a camera for spectral analyses of rotating crystals, with an inner diameter of 57.5 mm. Cu radiation with a Ni filter was applied. The time of exposure was 10 hours, with a voltage of 40 kV and a current intensity of 15 μA [1].

The calcium carbonate content was obtained by means of Passon's method, and the organic matter established by oxidation according to Tiurin.

In the NE Poland lacustrine deposits of the Younger Dryas, like clays, are fairly common; this may be explained by the fact, that most of the water basins developed during the Alleröd (Stasiak 1963, 1965). In some places, e. g. eastern shore of Lake Wągiel, lacustrine deposits of the Younger Dryas are very thin (Stasiak 1963); in Lake Kruklin they are about 80 cm thick, and in the old channel of the lake Sajno at Netta their thickness is more than 1 m.

Lacustrine deposits range from light-grey through darker shades to a bluish colour. The deposits are stratified, with layers 1—3 cm in thickness. In Lake Kruklin the deposits reveal alternatively dark and light-coloured 1 cm thick layers. In this place, the colour depends on the content of organic matter (Stasiak 1963). In the darker bands organic matter may reach as much as some 20%, while in the light-coloured layers its content is ca. 3 to 4 % (Tab. I). An increase of organic matter in clays may be the result of penetrating roots of paludinal plants growing during later periods in these places.

[1] I am greatly indebted to Dr. Alina Falkiewicz for gratuitously making the mineralogical analyses.

Air-dried deposits, with a small content of carbonates, show a tendency toward fissuring into thin horizontal plates. The quantity of calcium carbonate found in the Younger Dryas deposits varies in different lakes. While in lakes Kruklin, Mamry and Śniardwy this quantity is small (up to about 4%), it is much larger in other lakes (e.g. Lake Mikołajki ca. 15%, Lake Sajno ca. 16%, the Biebrza pradolina more than 30%). Younger lake deposits seem to contain less carbonates.

Table I

Grain size composition, and content of $CaCO_3$ and of organic matter in the Younger Dryas lacustrine deposits

	grain size, mm in per cent						content in %	
	skeletons	1—0.5	0.5—0.1	0.1—0.05	0.05—0.002	<0.002	$CaCO_3$	C organic
lakes:								
Kruklin I	—	—	1	9	68	22	1.8	17.93
Kruklin II	—	—	0.3	13	56.7	30	0.0	3.04
Śniardwy	—	—	14	8	53	24	0.0	3.00
Osowa I	—	—	—	4	74	22	36.0	14.92
Osowa II	—	—	—	15	66	19	10.5	16.4
Mikołajskie	13.6	4.5	12.5	23	37	23	15.5	22.8
Mamry	—	2.0	31.7	26	31.3	10	4.0	4.07
river:								
Biebrza I	—	0.4	26	13	39	21.6	20.0	20.7
Biebrza II	—	0.5	16.5	27	30	26	32.0	3.04
Biebrza III	—	—	10	17	47	26	15.5	5.5

From the grain size analyses (Tab. I, and Fig. 1) it appears that silty particles (0.05—0.002 mm) are abundant in the lacustrine deposits. Samples of the material from the Biebrza valley as well as from Lakes Mikołajki and Mamry reveal less content of silt particles. With the exception of the sample from Lake Mamry, the 0.002 mm clay size fraction is from ca. 20 to 30%. Although the samples had been taken from the shore zone of the lakes, skeleton particles were found only in the sediments of Lake Mikołajki. It seems probable that solifluxion movements occurred in two localities (samples from Lakes Mikołajki and Mamry).

According to pedological classification (Musierowicz 1951), the deposits examined are nearly all of clay size. Finest particles, of 0.002 mm in size constitute more than 80% of total of lacustrine deposits (excepting samples from Lakes Mikołajki and Mamry). Sediments from the Biebrza pradolina contain less of these fine particles.

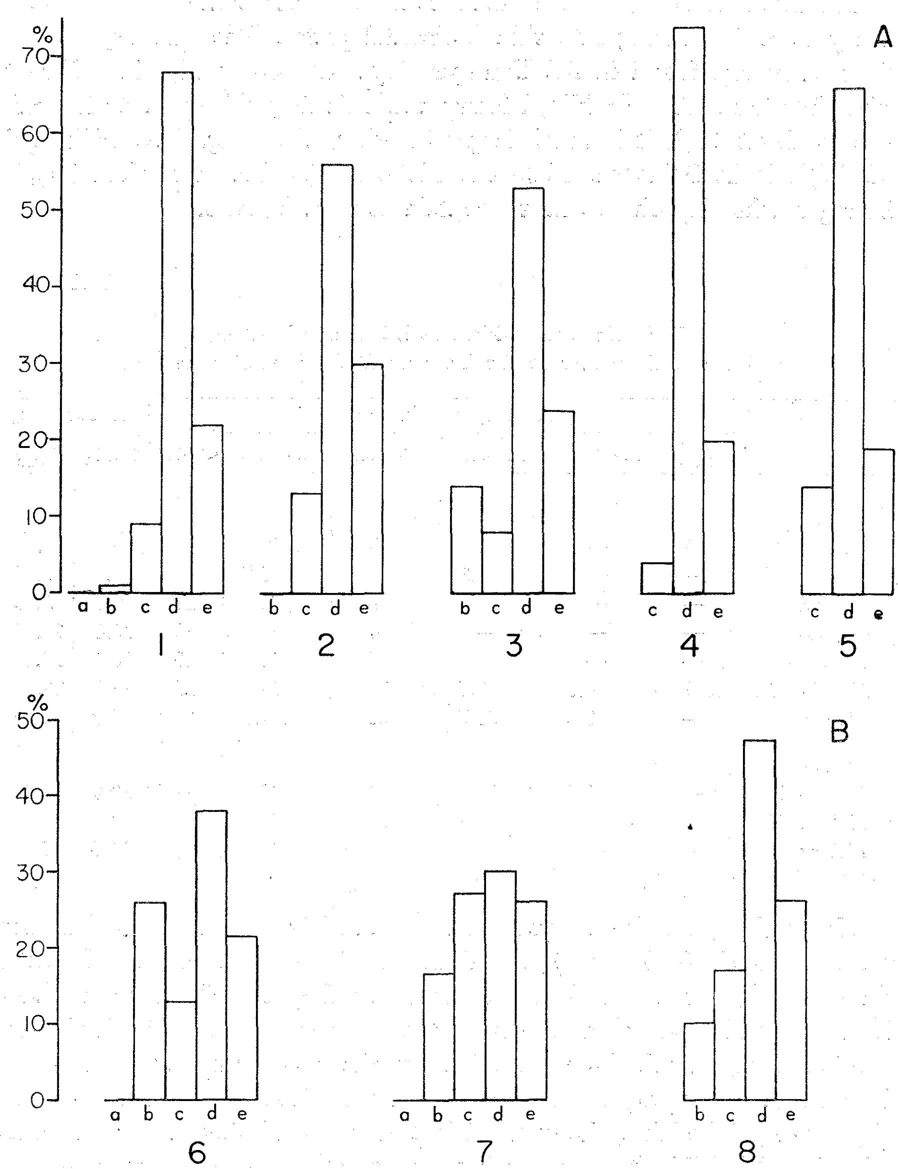

Fig. 1. Mechanical composition of Younger Dryas deposits

A — lakes: 1, 2 — Kruklin; 3 — Śniardwy; 4, 5 — Osowa; B — river: 6, 7, 8 — Biebrza
a — 1—0.5 mm; b — 0.5—0.1 mm; c — 0.1—0.05 mm; d — 0.05—0.002 mm; e — <0.002 mm

But according to our engineering classification [2], only such a deposit which contains fraction more than 30% of the 0.002 mm in size is regarded as clay. In the examined deposits the clayey particles predominate, and in the strict sense of the official classification this deposits is no clay at all.

H. Maruszczak (1960) described periglacial cover deposits occurring in the Masurian Lake District which in grain size are markedly different from the examined Younger Dryas deposits. In the covering deposits mentioned by Maruszczak, the clay size fraction (<0.002 mm) predominates, whereas in the described lacustrine sediments content of the coarser silty fraction (0.05—0.002 mm) was remarkable. In samples containing a larger quantity of calcium carbonate (Tab. I) $CaCO_3$ microaggregates are 0.5—0.0003 mm, whereas in the lacustrine deposits of Lake Kruklin dating from the Holocene (Stasiak 1966), carbonates were most often found in microaggregates of 0.1 mm in diameter.

X-ray examination (Tab. II) of lacustrine deposits show a dominance of quartz in the whole sediment, and in the clayey fraction were identified: (a) illite as a dominant component, (b) montmorillonite in small quantities, (c) kaolinite, (d) insignificant admixture of quartz.

According to R. E. Grim (1953) illite is a dominant component in the clayey size fraction of the lacustrine deposits, and their mineral composition depends on the mineral composition of the material accumulated in lakes. Grim emphasizes that kaolinite increases in amount when carbonate accumulation does not exist in lakes because $CaCO_3$ renders impossible the formation of kaolinite. In Lake Kruklin, for example, the carbonate content is indeed very small (from 0.0% to 2%).

Investigations of trace elements made by the spectral method (Stasiak 1965) have indicated that late-glacial sediments contain a greater variety of trace elements than late Holocene and recent deposits. In the Younger Dryas sediments from Lake Kruklin, such trace elements as V, Ni and Zn occur — unknown from recent deposits — and in somewhat greater amounts Cr, Li and Ti may also be found.

It was further noticed, that any changes in vegetation recorded by plant pollen have been accompanied by changes in the character of the lacustrine deposits. During forestless periods, when the ground was covered with barely a scanty vegetation (i. e. in Dryas time) — in all places examined by the present writer — clayey deposits with sparse amount of plant pollen were accumulated in the lakes.

During the Alleröd, a compact tree and shrub cover developed in the Masurian Lake District (Stasiak 1963). At the same time no clay

[2] Classification of soils on building sites, Polish Standard PN-54/B-02480.

Table II

Powder patterns of clay samples from Lake Kruklin

total sample			clay size fraction		
No. of line	d in Å	J	No. of line	d in Å	J
1	4.48	1	1	14.72	10
2	4.30	6	2	9.88	9
3	3.85	1	3	7.03	7
4	3.95	10	4	5.75	3
5	3.28	3	5	4.98	2
6	3.00	2	6	4.50	7
7	2.92	4	7	4.29	6
8	2.58	5	8	3.51	4
9	2.48	5	9	3.36	10
10	2.30	3	10	3.23	3
11	2.15	3	11	2.99	1
12	2.00	3	12	2.88	1
13	1.83	7	13	2.58	9
14	1.69	3	14	2.42	5
15	1.55	3	15	2.37	5
16	1.51	2	16	2.25	3
17	1.46	2	17	2.12	4
			18	1.99	5
			19	1.81	4
			20	1.66	4
			21	1.54	4
			22	1.50	4
			23	1.37	2
			24	1.30	2

deposits were accumulated in lakes, whereas calcareous and detritus gyttja and peats developed in them, as well as sandy gyttja in the littoral zone. The consequence of the cooling of climate during the Younger Dryas, the forests disappeared, and there was no compact vegetation cover; and under such conditions mineral clay deposits began to accumulate in lakes. In Preboreal time when the climate became warmer and moist again, calcareous gyttja was laid down in the lakes.

Somewhat different conditions were in the Suwałki Lake region. Palynological examinations revealed, that in all probability climate was much drier here than in the region of the Great Masurian Lakes in Alleröd and Preboreal time. In the deposits of a profile from Osowa (8 km NW of Suwałki) analyses disclosed that both calcareous gyttja from the Alleröd and from Preboreal time contain a considerable admixture of quartz dust. This seems to prove a lack of compact vegetation cover during Alleröd and Preboreal times caused by a dry climate.

Hence, the silty-clayey lacustrine deposits from the late-glacial period must have been of eolian origin and — locally in littoral parts — displaced by solifluxion.

According to recent studies of the contamination of the atmosphere (Juda & Brudziński 1961), the degree and the type of vegetation has a considerable influence on air purity. Terrains covered by forests or grass prevent secondary blowing away of dusts previously deposited. In all grain size analyses of Younger Dryas deposits, the 0.5—0.006 mm particles, called „normal dust" in examinations of air pollution, constituted 70—80%, while the rest was dust of colloidal particles (clay size particles).

Characteristic of a periglacial environment — and undoubtedly under such conditions was the region discussed during the Younger Dryas — is the occurrence of dust (Dylik 1954). Commonly, dust develops due to frost weathering which, in Dylik's opinion (1952), is „the most powerful and effective agent surpassing all other forms of weathering known in other climatic environments". Processes of this kind must have taken place in NE Poland principally during Dryas time (the Oldest, the Middle and the Younger Dryas). Fine particles were abundant in the top part of the ground surface and were easily carried off into the atmosphere, unless a soil covered with vegetation ensured stabilization of this finely disintegrated material.

Dust, or dust as admixture in the top layers of the soil cover, are of common occurrence in the areas discussed. J. Wolaniecki (1958) described podsol soils developed on dust deposits in the region of Łomża.

Under periglacial conditions during cold periods, while the ground was covered with a scanty vegetation only, fine particles were blown out into the atmosphere and accumulated in water basins. These wind-blown particles became the source material in the formation of silty-clayey lacustrine deposits commonly encountered.

An admixture of quartz dust particles, observed in the top layer of deposits of Lake Mamry, confirms the eolian origin of the late-glacial deposits. In 1963 samples of a 6 m profile [3] taken from a depth of 32 m in Lake Mamry were analysed. In the 35 cm thick top part of the profile there was found a considerable admixture of dust particles very much resembled dusts discovered in late-glacial deposits. Okruszko (1960) mentions an increased ash content and occurrence of quartz dust particles in the top layers of living peat bogs. The occurrence of dusts in the

[3] The profile constitutes a part of unpublished paper prepared by J. Kondracki, K. Więckowski and the present writer.

top part of Lake Mamry deposits should be ascribed to changes of the landscape introduced by man. Dust size particles became deposited as soon as the oak-elm forests disappeared and the land was brought under cultivation. Agricultural activities involving seasonal uncovering of the top soil created conditions, under which dusts were swept up into the air, what is confirmed by presence of fines in recent lacustrine and peat deposits.

The sequence of clayey lacustrine deposits may be also an evidence of the character of the ancient lakes. In the Masurian Lake District, most of the lakes are dated from the Alleröd. In lakes developed at the beginning of the Alleröd, peat appears as a bottom deposit (Lake Wągiel; Stasiak 1963, Lake Mikołajki — Więckowski), overlain by calcareous gyttja (Lake Wągiel) and clay in top. Other lakes like Mamry, Tałty, and a part of Lake Kruklin, that came into existence at the decline of the Alleröd, lack of peat and gyttja at the bottom; here the clays overlie directly fluvioglacial deposits.

The lakes originated due to melting of dead ice blocks mantled by mineral material. Since melting proceeded from the top downward the lakes in the initial stage formed shallow extensive flood waters, usually of

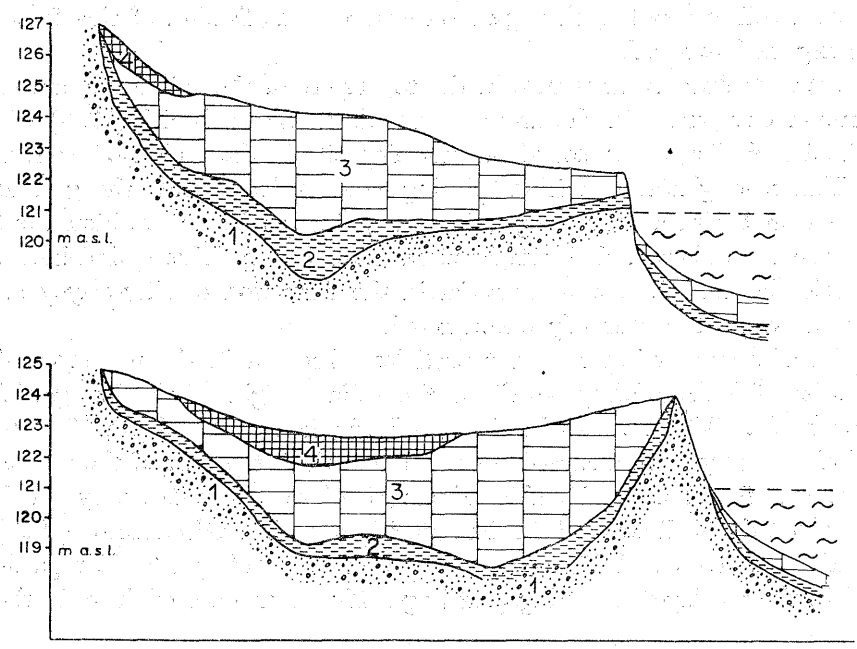

Fig. 2. Geological cross sections of Kruklin's lake shore

1. gravel and sand; 2. clay (loamy-clay); 3. lacustrine chalk; 4. peat

much wider extent than the present day lakes. Clays deposited in these lakes can be found at distances up to several hundred meters from recent lake shores. The entire lake basin is underlain with late-glacial deposits, as illustrated in cross sections of the shore zone of Lake Kruklin (Fig. 2).

Deepening of the lakes gradually took place in the Holocene, as the dead ice blocks melted away. Apart from a few exceptions, this process ended during the Boreal.

Translated by K. Jurasz

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UWAGI O GENEZIE PÓŹNOGLACJALNYCH OSADÓW JEZIORNYCH W PÓŁNOCNO WSCHODNIEJ POLSCE

Streszczenie

Na obszarach północno wschodniej Polski stosunkowo dobrze wykształcone są osady jeziorne przypadające na okres młodszego dryasu, osiągając niekiedy miąższość ponad 1 m. Granica pomiędzy osadami młodszego dryasu a osadami innych okresów cieplejszych (Alleröd, okres preborealny) w Krainie Wielkich Jezior Mazurskich jest bardzo ostra, natomiast jest ona mniej wyraźna na Pojezierzu Suwalskim.

Zbadano skład granulometryczny, mineralogiczny, zawartość substancji organicznej i $CaCO_3$ w jeziornych osadach młodszego dryasu oraz w osadach z pradoliny Biebrzy.

Z określonego areometrycznie składu mechanicznego osadów wynika, że dominuje frakcja pylasta 0.05—0.002 mm. Pod względem składu granulometrycznego jeziorne osady młodszego dryasu różnią się od opisanych przez H. Maruszczaka (1960) utworów pokrywowych Wzgórz Szeskich. Badania mineralogiczne metodą rentgenograficzną wykazały, że frakcja pyłowa składa się głównie z kwarcu, iłowa natomiast z illitu oraz domieszek: montmoryllonitu, kaolinitu i kwarcu.

Z obserwacji zależności pomiędzy pokryciem terenu przez roślinność widoczną w diagramach pyłkowych a charakterem osadu wynikałoby, że osad jest pochodzenia eolicznego. Powstał on w warunkach peryglacjalnych, gdy brak było zwartej pokrywy roślinnej w otoczeniu zbiorników jeziornych. Obficie występujący na powierzchni pył mineralny powstały w warunkach wietrzenia mrozowego w klimacie peryglacjalnym, porywany do atmosfery a następnie opadły na dno zbiorników wodnych, stał się materiałem wyjściowym do powstawania pylasto-ilastych osadów mineralnych charakterystycznych dla osadów jeziornych pochodzących z młodszego dryasu.

Obecnie brak zwartej pokrywy roślinnej w wyniku działalności człowieka, głównie uprawy roli, powoduje okresowe odsłanianie gleby, co stwarza warunki do porywania do atmosfery pyłu kwarcowego obserwowanego ponownie w znacznej domieszce we współczesnych osadach jeziornych.