ACTA PALAEOBOTANICA
27 (1): 269—276, 1987

K. R. LANKAUF

RESULTS OF PHYSICAL AND CHEMICAL STUDIES ON LAKE STRAŻYM DEPOSITS (BRODNICA LAKE DISTRICT)

Wyniki badań fizykochemicznych osadów jeziora Strażym (Pojezierze Brodnickie)

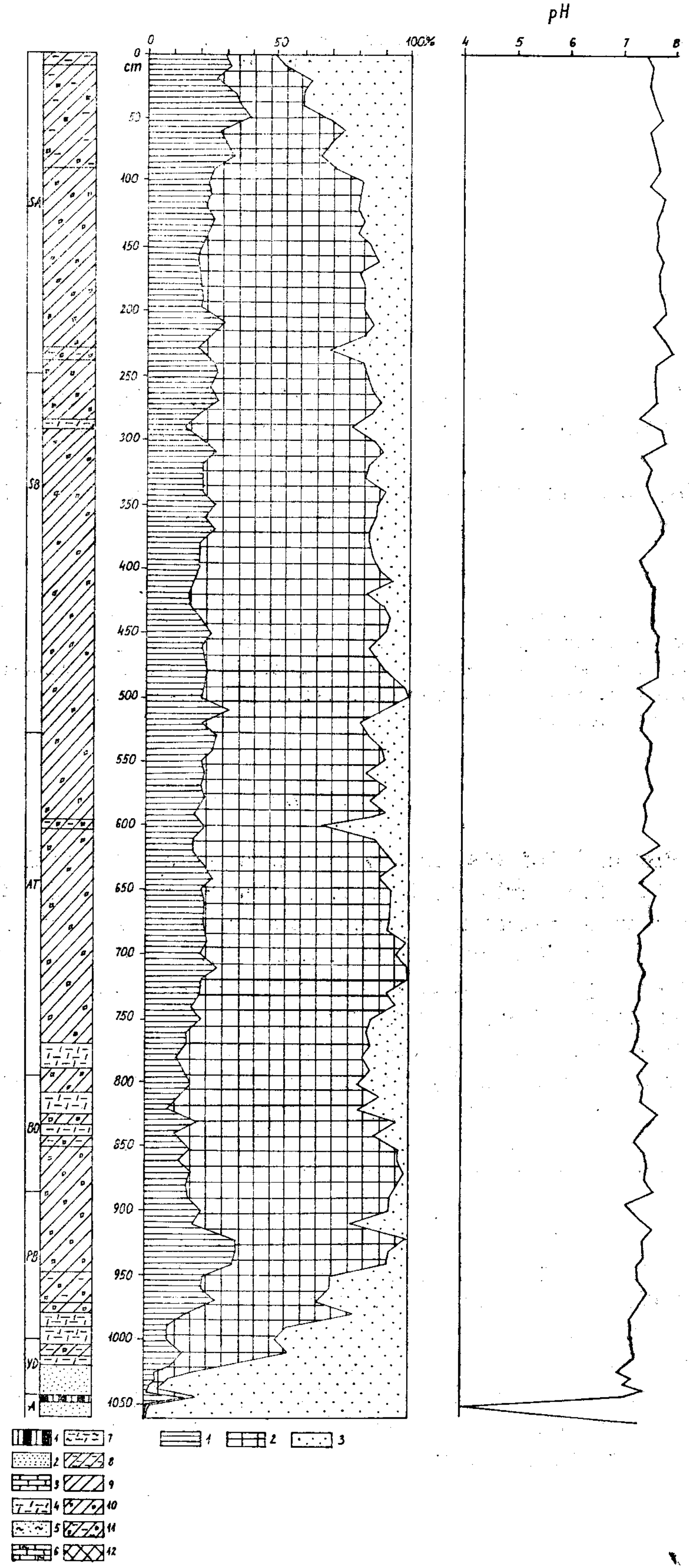
ABSTRACT. The studies comprised 248 sediment samples of Lake Strażym, including the whole profiles 3 and 6 and the upper part of profile 1. For each sample, contents of organic matter, carbonates and mineral parts was determined. The pH index was also established. Sedimentation rate was characterized in particular periods of the Late Glacial and Holocene in the shallow and deep parts of the lake.

METHODS

The studies included 248 samples from profiles collected with Więckowski's piston corer. Profile numbering is quoted after Niewiarowski (this volume). Samples from three meters of sediment from profile 1 collected at 10 cm intervals were analysed (30 samples): 5.4 m from profile 3 at 5 cm intervals (108) and 10.6 m from profile 6 at mostly 10 cm intervals (110 samples). For each sample the following tests were made:

a) carbonate contents by Scheibler's volumetric method,
b) organic matter contents by burning method. After drying at 105°C, the samples were burnt in muffle furnace at 550°C. In this way the loss on ignition may be approximately calculated (Więckowski 1966),
c) mineral non-carbonate matter contents. It was calculated as the supplementation up to 100% of percentages obtained by summing up organic matter and carbonates contents (Markowski 1980). The mineral portion comprises mostly quartz, feldspar and clay minerals,
d) pH by means of electronic pH-meter.

Classification of deposits was based on Rzepecki's classification (1983). The age estimations were based on palynological studies carried out by Noryśkiewicz (this volume) and radiocarbon datings quoted by Niewiarowski (this volume). Duration of particular periods in the Late Glacial and Holocene are adopted according to Starkel (1977).



pH
4 5 6 7 8
0 50 100%
0 cm 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1050
SA
SB
AT
BO
PB
YD
A
1 2 3 4 5 6 7 8 9 10 11 12
1 2 3

HISTORY OF DEVELOPMENT OF LAKE STRAŻYM DEPOSITS

Decline of the Late Glacial

In all three analysed profiles, in the bottom part of deposits a thin layer of peat was discovered. Palynological data and radiocarbon datings show its Alleröd age. Sandy deposits underlying peat: are fine-grained sands in profile 6 (Fig. 1) and sands with large amount of organic matter in profile 3 (Fig. 2). No pollen was found in these deposits. These are probably deposits of a lake of older generation or of newly-forming basin. The great amount of organic matter (22%) in sands of profile 3 suggests that they are Alleröd lake deposits.

As has been said, a thin layer of peat lies on the sands. In the end of the Alleröd, as a result of quickly melting buried ice, peat settled down and the lake deepened, especially in its central part, represented by deposits in profile 6.

During the Younger Dryas, in the part of the lake represented by profile 3, a 52 cm layer of fine-grained sands was deposited. In the bottom the sands contain over 8% of organic matter — perhaps this may be attributed to washing away of peat. In the middle of the sand layer, percentage of organic matter falls below 1% to rise in the top to about 3%. Also carbonates increase their percentage in the top of sands to about 8%. This sediment composition indicates gradual overgrowing of deposits which is further confirmed by palynological analyses (Noryśkiewicz, this volume). This also means that in that marginal part, there had existed during the Younger Dryas a stable lake. In the central part of the lake the Younger Dryas deposits are differently formed giving even more evidence about the existence of a deep basin during that time. Initially, fine-grained sands with silt had settled on flooded peat. One can notice in the sands the amounts of organic matter and carbonates increasing upwards. There is a layer of lacustrine marl on sands, then calcareous — silty gyttja and again marl. Similar instance of carbonate deposits formation at the end of the Younger Dryas is described by Stasiak (1963, 1971). Sedimentation rate during the Younger Dryas was 0.6 mm/year.

The Pre-Boreal Period

During the Pre-Boreal period buried ice continued to melt out in some lakes which caused the lake level to fall (Stasiak 1963, Starkel 1977). However, assuming that buried ice in Lake Strażym channel melted out as early as the end of the Alleröd (Niewiarowski, this volume), the Pre-Boreal water level

←

Fig. 1. Content of organic matter, mineral part and carbonates in profile 6. 1 — organic matter; 2 — carbonates; 3 — mineral part. Lithology: 1 — peat; 2 — sand; 3 — lacustrine chalk; 4 — lacustrine marl; 5 — sand with organic matter; 6 — lacustrine organic chalk; 7 — lacustrine organic marl; 8 — clayey gyttja; 9 — silty gyttja; 10 — calcareous gyttja; 11 — clayey-calcareous gyttja; 12 — organic gyttja

decline could have been the result of a relatively dry climate at the beginning of that period (Starkel 1977); the shallowing of the lake proceeded as a result of rapidly progressing sedimentation.

The deposits of Lake Strażym represented in profiles 3 and 6 show great similarity which proves its physical-chemical and biological uniformity. Initially two levels of calcareous gyttja containing about 15—17% organic matter are

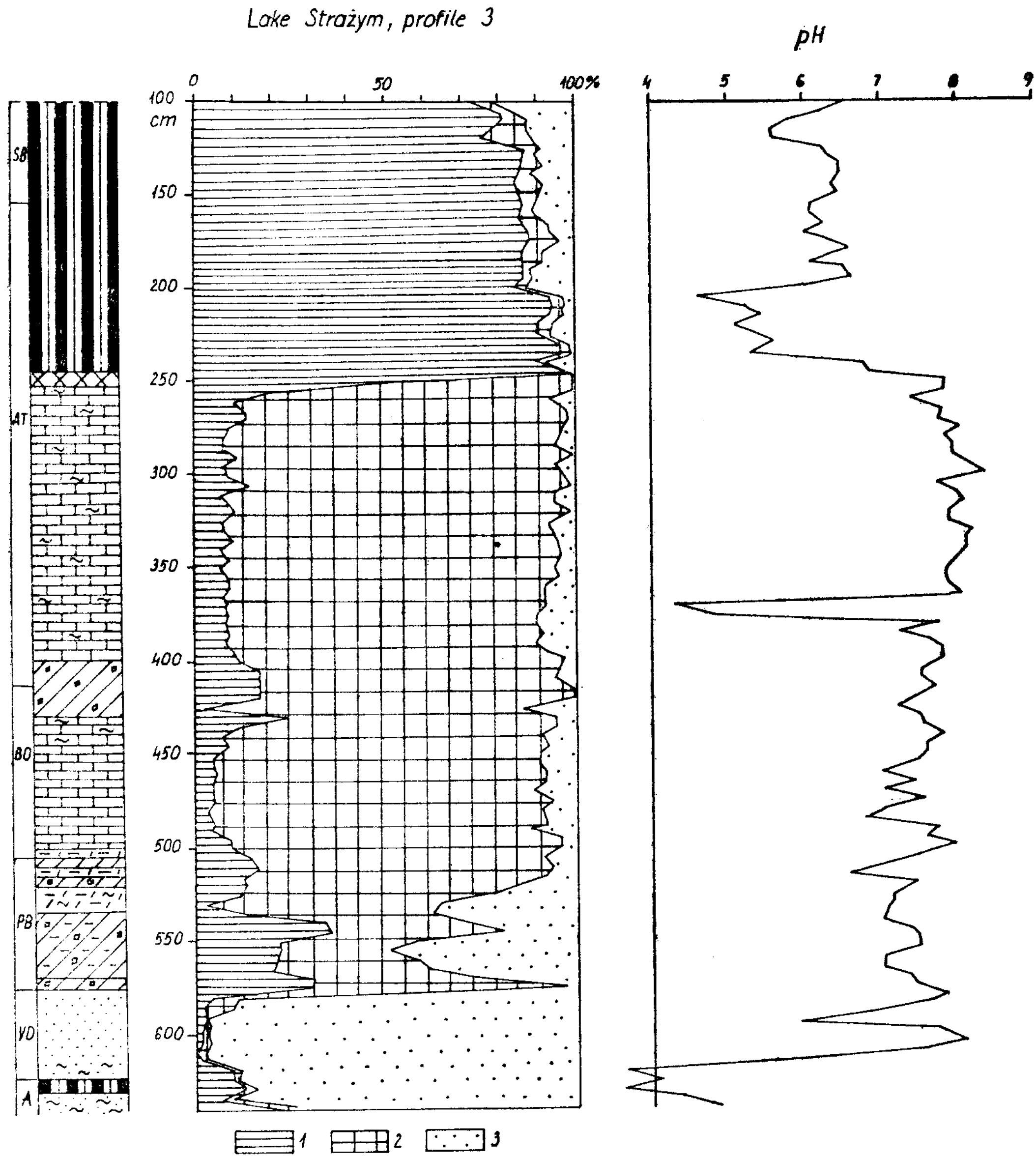


Fig. 2. Content of organic matter, mineral part and carbonates in profile 3 (explanation of symbols as in Fig. 1)

found, covered with silty-calcareous gyttja with higher proportion of organic matter which proves a quick development of vegetation in the catchment area and abundant biological life in the lake. Very characteristic and almost identical in both profiles being discussed is the next gyttja layer where organic substance content is high, exceeding 30%. The differences are found in the content of mineral matter. This distinctive culmination of organic matter percentage is probably a proof of shallowing of the lake, but mainly through a quick rise of sedimentation rates. At this time lake bottom elevation is an island with developing peatbog (Niewiarowski, this volume). Perhaps the culmination of organic substance percentage in deposits from the two profiles results from partial washing away of the peat. Deposits lying above correspond well with each other but surely represent different parts of the lake in terms of depth. In the shallower part of the lake, lacustrine chalk and marl begin to deposit and such type of sediment is deposited rather in shallow water (Prusinkiewicz & Noryśkiewicz 1975) while gyttja in the deeper part of lake. Increase of mineral particles in the gyttja was probably caused by supply of the material from rivers reaching the lake. Sedimentation rate in both profiles was quick; 0.75 mm/year in profile 3 and as much as 1.21 mm/year in profile 6. It is possible that in this profile mineral matter supply was greater because of the lake eastern shore abrasion. The values obtained are much higher than those given in the literature (Stasiak 1963, Więckowski 1966).

The Boreal period

The borderline between the Pre-Boreal and Boreal periods in the two profiles is marked by increase of carbonate contents up to over 80% and distinctive decrease of mineral part content. Noryśkiewicz (this volume) draws the palynological border between the two periods in profile 6 at the depth of 880 cm, and in profile 3 at 500 cm. Deposits characterictics clearly show that both parts of the lake still differ in their depths. In profile 6 subsequent layers of gyttja and lacustrine marl with high carbonate contents and variable amount of organic and especially mineral matter are found. During that time in profile 3, the sediments typical of a shallow basin like lacustrine chalk were deposited. Small amount of organic matter in profile 3 is caused either by high $CaCO_3$ amounts helping quick decomposition of organic matter (Więckowski 1966) or by chemical precipitation of carbonates when the colder underground water containing carbonic acid met the waters of the shallow basin (Prusinkiewicz & Noryśkiewicz 1975). Worth noting is the identical sedimentation rate of 1 mm/year in both profiles. At the end of the Boreal period, water level rises slightly which is reflected in profile 3 by calcareous gyttja.

The Atlantic period

The start of the Atlantic period in Lake Strażym is marked by change of sediment into the more deep-water calcareous gyttja (profile 6). In the deeper part of the lake, from the depth of 780 cm a homogenous calcareous gyttja was deposited at a rate of about 0.8 mm/year. Percentage of organic matter is about 20% and carbonate content 60—70%. Percentage of mineral parts is very variable, from total absence to several tens percent. A particularly characteristic feature is increasing content of mineral matter at the depth of 590—610 cm (sample from 600 cm depth — over 33%). The sudden increase of mineral part percentage registered at several places in the profile is perhaps connected with increased erosion in the catchment area caused by appearance of man activity and corresponds to increased vegatation related to this activity (Noryśkiewicz, this volume). For the first time and quite distinctly this coincidence occurs at the depth of 600 cm.

In the same time in the part of the lake represented by profile 3 the situation was quite different. For a great part of the Atlantic period, in increasingly shallow due to growing sedimentation rate, and very quiet basin (indicated by deposits homogenity and small percentage of mineral part) there forms lacustrine organic chalk containing over 80% $CaCO_3$ and generally less than 10% organic substance. The sediment growth at 0.6 mm/year rate leads to total shallowing of this part of the lake and formation of peatbog. Radiocarbon dating of peatbog was 5920 years BP (Niewiarowski, this volume). The peat at 205—245 cm depth contains maximum amounts of organic matter — over 90%.

The pH decreases as peat is accumulating, down to slightly acid reaction. This, and a large amount of swamp plants (Boińska, this volume) indicates land-marshy character of the peatbog. Increased percentage of carbonates (up to 7%) and especially mineral parts at the end of the Atlantic period suggests periodical flooding of peatbog or its partial submergence.

The Sub-Boreal period

The lake deposit in the deep part is still homogenous calcareous gyttja and some oscillations of mineral contents may be possibly related to human activity phases distinguished by Noryśkiewicz (this volume). The sedimentation rate is still fast, about 0.9 mm/year.

In the part represented by profile 3 peat continues to form up to more or less Mid-Subboreal when water level in the lake rises and peat is flooded.

The Sub-Atlantic period

In the deep part of the lake also during the Sub-Atlantic period there form deposits similar to the older ones. Only from the depth of 90 cm towards the top the decrease of $CaCO_3$ below 50% is noticeable, the organic and mineral parts increasing, and the deposit becomes clayey-calcareous gyttja. This is probably related to human activity causing change of lake trophy and increasing erosion in the catchment area.

In the shore part of the lake, rise of water level and peat flooding is manifested. The dating of peat top in profile 1 at about 4750 years BP (Niewiarowski, this volume) and the young — Sub-Atlantic age of overlying sand from shore abrasion (Fig. 3) permits to believe that the rise of water level and increased waving led to wash-off of peat top and to the sedimentation of 60 cm sand layer. Subsequent rise of lake level causes initially accumulation of sandy deposits but with large percentage of organic substance which corresponds with the data from profile 6 and confirms lake trophy increase; later 40 cm layer of clayey gyttja was deposited.

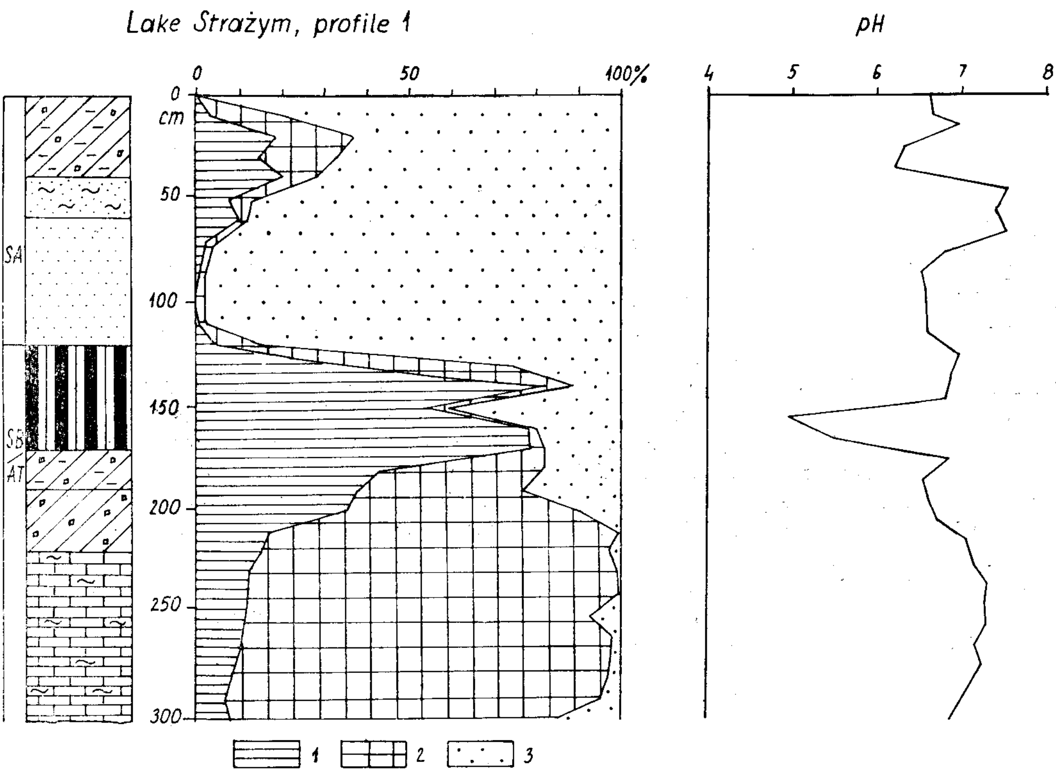


Fig. 3. Content of organic matter, mineral part and carbonates in profile 1 (explanation of symbols as in Fig. 1)

Sediment analysis shows that deposits from profile 6 representing the deep part of the lake were formed at the similar rate throughout entire Holocene in a relatively deep and stable basin. Profile 3 represents an almost complete cycle of the Holocene development of the shallower part of the lake where terrestrial conditions existed temporarily. Profile 1 representing the shore zone has stratigraphic hiatuses caused by shore processes.

ACKNOWLEDGEMENTS

I should like to thank Dr. B. Noryśkiewicz and Prof. W. Niewiarowski for valuable remarks during working out the results. The pH determination was performed by Mrs. E. Pilecka-Chmurzyńska, and $CaCO_3$ and organic substance contents by Mr. P. Proszek. I extend my wholehearted gratitude to both of them for their help.

University of Toruń, Institute of Geography, ul. Fredry 6/8, 87-100 Toruń
Instytut Geografii UMK

REFERENCES

Boińska U. 1987. Analysis of macrofossils in bottom deposits of Lake Strażym. Acta Palaeobot., 27 (1): 305—310.

Markowski S. 1980. Struktura i właściwości podtorfowych osadów jeziornych rozprzestrzenionych na Pomorzu Zachodnim jako podstawa ich rozpoznawania i klasyfikacji. PTPNoZ, Oddz. Ziemi Lubuskiej, Mat. pokonferencyjne. Gorzów Wlkp.—Zielona Góra.

Niewiarowski W. 1987. Development of Lake Strażym (Brodnica Lake District, Northern Poland) during the Late Glacial and Holocene. Acta Palaeobot., 27 (1): 251—268.

Noryśkiewicz B. 1987. History of vegetation during the Late Glacial and Holocene in the Brodnica Lake District in the light of pollen analysis of Lake Strażym deposits. Acta Palaeobot., 27 (1): 283—304.

Prusinkiewicz Z. & Noryśkiewicz B. 1975. Geochemiczne i paleopedologiczne aspekty genezy kredy jeziornej jako skały macierzystej północnopolskich rędzin (summary: Geochemical and paleopedological aspects of the origin of lake chalk as the parent rock for the Northern Poland rendzinas). Acta Univ. N. Copernici, Geogr., 11: 115—127.

Rzepecki P. 1983. Klasyfikacja i główne typy litologiczne osadów jeziornych (summary: Classification and the principial lithological types of the lacustrine sediments) Zesz. Nauk. AGH, Geol., 9 (1): 73—94.

Starkel L. 1977. Paleogeografia holocenu. PWN, Warszawa.

Stasiak J. 1963. Historia jeziora Kruklin w świetle osadów strefy litoralnej (summary: History of Kruklin Lake as revealed by the deposits of its littoral zone). Inst. Geogr. PAN, Prace Geogr., 42.

— 1971. Holocen Polski Północno-Wschodniej. Rozpr. Uniw. Warsz., 47.

Więckowski K. 1966. Osady denne jeziora Mikołajskiego (summary: Bottom deposits of Lake Mikołajki). Inst. Geogr. PAN, Prace Geogr., 57.