

1. INTRODUCTION



Lake Gościąg situated in central Poland (Figs 1.1, 1.2B) contains one of the longest and best preserved sequences of annually laminated sediments known from central Europe. It forms a unique archive of environmental history during the last 15,000 years recorded on the calendar timescale. The nearest localities of varved lacustrine sediments of similar quality and time span are known from the crater lakes in the Eifel area, Germany (Zolitschka 1989, Negendank 1989 and following papers). In other central European sites containing such type of sediments, the annually laminated series cover shorter time sections (Merkt 1971, Lotter 1989 and fol-

lowing, and others). More frequently, the continuous series of varved gyttjas occur in lakes of northern Europe, as reported from N. Sweden (Renberg 1976 and following) or N. Finland (e.g. Simola 1977, Saarnisto 1985, Tolonen 1980, and other papers), but they do not include Late-Glacial times.

Lake Gościąg belongs to a complex of four connected lakes (Na Jazach lake system) (Fig. 1.2C) located in a small Gostynińskie Lake District formed in the marginal part of last Scandinavian ice sheet (Fig. 1.2A,B), which, because of a distance of less than 80 km from Warsaw, is readily visited by scientists from Warsaw University.

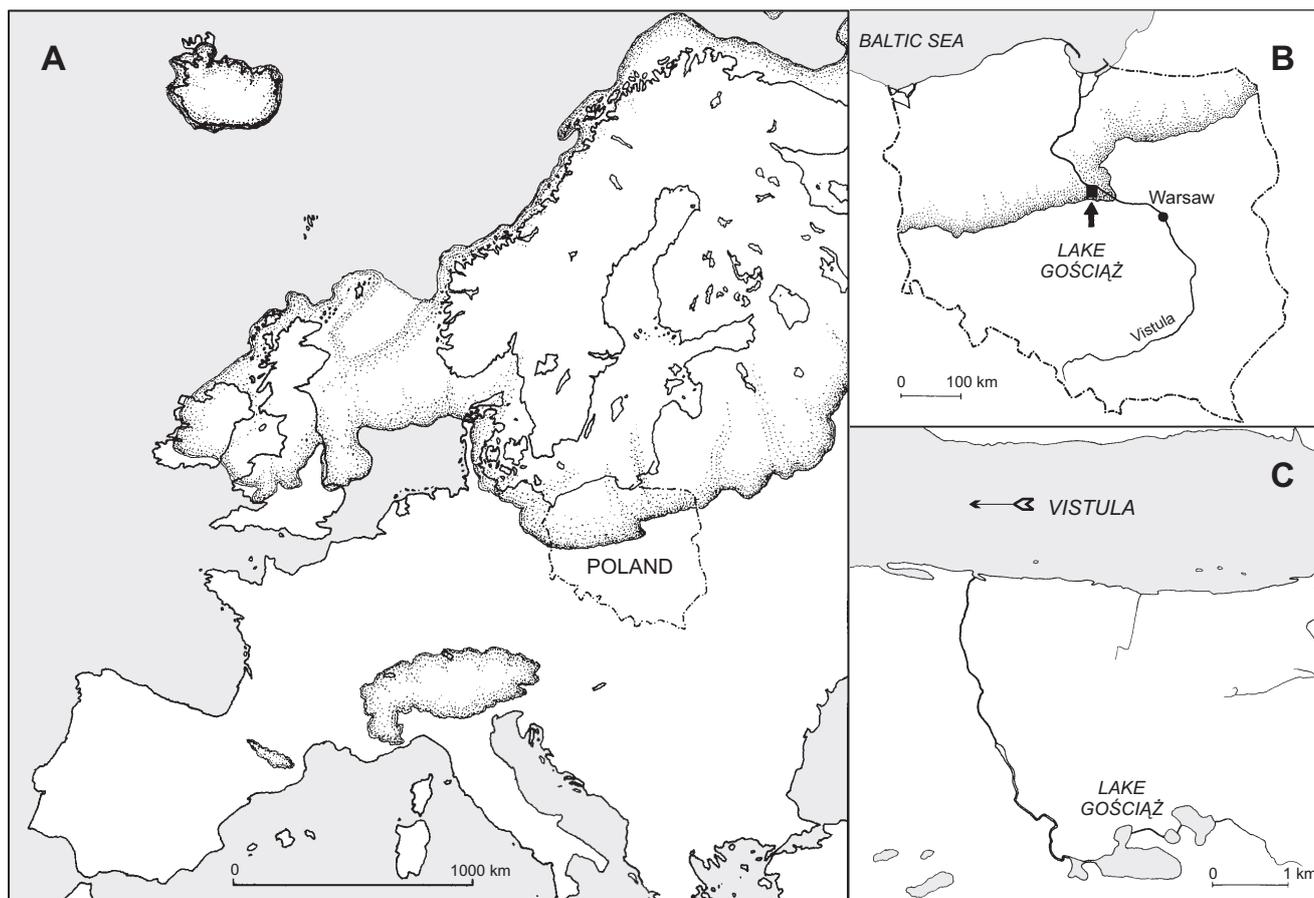


Fig. 1.2. Maps showing geographical situation of Lake Gościąg, central Poland. A – position of Poland with regard to the general extent of the last glaciation in Europe, B – situation of Lake Gościąg towards the maximum glacier lobe in the region of Vistula River valley, C – position of Lake Gościąg within the Na Jazach lakes system including its connection with Vistula River.

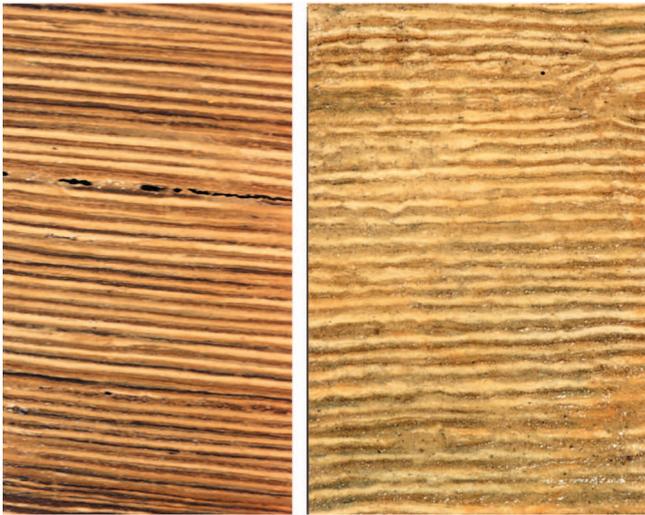


Fig. 1.3. Examples of annually laminated sediment from the lake-centre cores. Left – Preboreal varves, right – Subboreal varves. Mean thickness of laminae ca. 1 mm. (Phot. T. Goslar).

During the student field course in spring 1985 lead by Dr. B. Wicik (Institute of Geography, Warsaw University) and Dr. K. Więckowski (Institute of Geography and Spatial Organization, Polish Academy of Sciences), the first

core, 15.85 m long and laminated in its full length (Fig. 1.3), was obtained from the centre of Lake Gościąg. The rough attempt by Dr. Więckowski to count the laminae number gave the result of $12,600 \pm 600$ (Ralska-Jasiewiczowa et al. 1987, Więckowski 1993). It supported the supposition that the laminae are annual and the whole profile covers the full Holocene, entering also into the Late-Glacial. None of other seven lakes cored by Więckowski and Wicik in the Gostynińskie Lake District revealed such a sediment sequence, though in some of them the periodical lamination covering shorter sediment sections was found.

The uniqueness of the discovery stimulated the interest of scientists of different specialities. In 1987, from the initiative of Prof. L. Starkel, a multidisciplinary team for the studies of Lake Gościąg led by Prof. M. Ralska-Jasiewiczowa and affiliated to the National Committee for Quaternary Research, Polish Academy of Sciences was organized, the preliminary project draft was outlined in its first shape and the field works began (Fig. 1.4). The project aimed to achieve, by cooperation of scientists representing different fields of palaeoecology, geophysics, sedimentology, and other geosciences, the model of environmental and climatic changes during the Late-Glacial



Fig. 1.4. Historic picture of the working-team from the coring campaign in 1987 when the basic reference profiles were collected. The following members of Lake Gościąg project are present on it (from the left): 1 – A. Walanus, 2 – B. Wicik, 4 – K. Więckowski, 5 – M. Ralska-Jasiewiczowa, 8 – P. Sandgren. We missed then T. Goslar, main creator of the Lake Gościąg varve chronology, so he appears in the upper left corner of the picture. (Phot. A. Walanus).



Fig. 1.5. Freezing sampler (“cold-finger” tube type), covered with frozen sediment. (Phot. A. Walanus).

and Holocene representative for eastern-central Europe, grounded on a precisely built-up calendar timescale. In addition, the construction of full calendar chronology over the last 13,000 years could offer the possibilities to verify the chronological scales used hitherto, the radiocarbon timescale included. To understand well the past changes, the genuine and detailed knowledge of the recent environment of the area and of the lake hydrologic and eco-systems was also required, as well as the information on the history of past human settlements in the region. As the existing source data appeared deficient or absent, special investigations on these subjects were also planned.

The field works and first laboratory analyses started since 1987 were partly supported by funds from the Central Program of Basic Research (CPBP): No 03. 13 “Evolution of the environment of Polish Territory” (field coring, ^{14}C dating and varve counting, mineralogy) and No 04.04. “Flora and vegetation, their changes and endangerments” (recent flora and vegetation, lake hydrobiology), and partly from the budgets of W. Szafer Institute of Botany, Polish Academy of Sciences and other participating institutions. However, the financial situation of the project was very difficult, delaying the systematic progress of all works. After the financing system for science was changed in Poland in 1991, a complex grant lead by Prof. M. Ralska-Jasiewiczowa was allocated to the project “Record of environmental and climatic changes during the Holocene in the annually laminated lake sediments” by the State Committee for Scientific Research (Project No 6 0252 91 01, the realization time 01.11.1991–30.09.1994). The grant was used entirely for supporting the field and laboratory works in different participating disciplines. Besides, the investigations of a few particular colleagues were supported from individual SCSR grants: T. Goslar – No 6 6410 91 02 (Calibration of radiocarbon time scale in the Late Glacial), T. Kuc – No 6 6252 91 01 (The influence of anthropogenic factors on the concentra-

tion of stable and radioactive isotopes in the atmosphere), P. Wachniew – No 2 2393 91 02 (The isotopic composition of calcareous lake sediments as indicator of climatic change). The funds appeared, however, insufficient to enable the full execution of analyses as originally planned. It affected first of all the chemical/mineralogical and diatom analyses, which have been performed incompletely and still need continuation.

In spite of these and still other shortages that will be mentioned later, most of the field and laboratory research has been executed. The full scope of investigations on recent environmental conditions of the lake system and of the surrounding region has been completed; the archaeological surface survey of area around the lake was done and supported with excavations at selected sites. The calendar chronology of annually laminated lake sediments has been established and confirmed with the representative series of AMS ^{14}C datings. Based on this chronology the sequence of various environmental changes has been reconstructed with the average time resolution of 50 yr.

The strategy of palaeoecological studies was as follows: the analyses of cores from the central lake deep and also from the western deep in their Late-Glacial part, per-



Fig. 1.6. Example of top sediment (around AD 1920–1930) collected by freezing technique. (Phot. T. Goslar).



Fig. 1.7. Lake Gościąg in summer time (Phot. R. Young).

formed on continuous varved sediment sequences, were focused first of all on regional changes. Highest importance was attached here to the precise dating of recorded events. The studies on cores from the lake margins and from neighbouring depressions were focused mostly on local changes of ecosystems and on hydrologic changes. They formed an individual study (D. Demske 1995), meant to be published in the second part of the Lake Gościąg monograph. As it appeared, however, the marginal cores contained non-laminated sediments deposited during the older part of the Late-Glacial which were absent from the lake centre, where the sedimentation processes started during the late Allerød only. Therefore, the results of analyses from some of marginal cores (pollen, plant macrofossils, Cladocera) have been used to complete the sequence of events recorded in Lake Gościąg before the sediments in its central parts started to accumulate.

Some gaps in the project completion should still be mentioned:

- Several frostless winters (global warming?!) disturbed the realization of full transect of drillings across the lake;

- The palaeomagnetic investigations failed due to inadequate core collection and lack of proper field equipment (Sandgren 1993);

- Various environmental maps are based on the old cartographic materials because our efforts to get the up-

dated topographic survey of the lake and its surroundings (1:500) were accomplished very late;

- The pollen-analytic reconstructions lack the short time-span studies based on very fine annual sample resolution that would show the detailed sequence of vegetational changes following events like a rapid change of climate, the expansion of a tree species (e.g. *Alnus*), the spread of a disease (*Ulmus* fall), or drastic human action. These deficiencies, resulting from the lack of time and personnel are planned to be completed and presented later;

- The fine resolution chemical/pollen-analytic analyses of the top sediments from frozen cores (Figs 1.5, 1.6) reach by now back to ca. AD 1660, but with a recently recovered frozen core they should be extended back to ca. AD 1000.

Some detailed topics of the Lake Gościąg project (e.g. the radiocarbon and calendar chronologies of the Younger Dryas cold period, vegetation development during the later part of Late-Glacial, impact of Mesolithic and Neolithic man on the environment, fine resolution studies of top sediments, Late-Glacial and Holocene water-level changes in the lake) have already been described in international journals (Goslar et al. 1993, 1995, in print, Ralska-Jasiewiczowa & van Geel 1992, Ralska-Jasiewiczowa et al. 1992, Starkel et al. 1996). The results of some studies (e.g. of varve chronology of the Lake

Gościąg sediments, stable-isotope composition of modern lake water and sediments) were used indirectly in publications, but these studies themselves have never been described in detail. Such complete studies as e.g. the development of vegetation throughout the whole Late Glacial and Holocene are published now for the first time.

The scope of this book, which we call "A Monographic Study, Part I" is to document, as fully as possible, all the data collected till now. Therefore, partly because of limited space and partly because in some topics it would be premature, we decided not to discuss in detail the reference of our study to the relevant regional or global elaborations, but we focused our discussion on the evolution of the Lake Gościąg area itself, in a rather local scale. This volume will thus serve as a background for further studies and more general discussion, which we plan to develop in the coming parts of the monograph.

We would like to acknowledge here those persons whose enthusiastic help and support were crucial for the overall progress of the Lake Gościąg study, beyond the particular subjects of individual chapters.

First, we'd like to recall the excellent job of Drs. K. Więckowski and B. Wicik (Fig. 1.4), collecting the sediment cores during several winter campaigns. It was due to them that the laminated sediment for analyses was available at all.

We would like to express our cordial thanks to the authorities of the Włocławsko-Gostyniński Landscape Park (Fig. 1.7), who permitted us to undertake our activities within the area, for their interest and universal help during the multiseasonal fieldwork. We are especially grateful to the Director of the Landscape Park, Mr. Andrzej Drozdowski, whose enthusiasm and personal engagement greatly influenced the effectiveness of our coring campaigns.

We'd like to stress the enormous effort of the late Prof. Mieczysław F. Pazdur[†], Gliwice Radiocarbon Laboratory, Silesian Technical University, Poland, who stimulated and supported financially the elaboration of radiocarbon and varve chronologies of the Lake Gościąg sediments. In our early attempts to work with the sediments, we benefited by the kind help of Dr. Josef Merkt, Niedersächsisches Landesamt für Bodenforschung, Hannover, Germany, and Prof. Matti Saarnisto, University of Oulu, Finland, who shared with us their experience in interpreting the annual sediment structures and retrieving the cores of soft sediments in the frozen *in situ* form. The photographic documentation, separation of samples, collection of frozen cores, and many computational analyses and execution of palaeoecological diagrams were done with the valuable help of Dr. Adam Walanus and Dr. hab. T. Goslar, Silesian Technical University, Gliwice, Poland. When collecting the sediment samples, we also had the kind assistance of Mrss. Danuta Moszyńska-Moskwa, Zofia Tomczyńska, and Małgorzata Zurzycka, W. Szafer

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REFERENCES

- Demske D. 1995. Development of the local environment at Lake Gościąg (central Poland) during Late Vistulian and Holocene: vegetation, hydrological changes and influence of man. Ph.D. Thesis, W. Szafer Institute of Botany, Polish Academy of Sciences, Cracow.
- Goslar T., Kuc T., Ralska-Jasiewiczowa M., Rózański K., Arnold M., Bard E., van Geel B., Pazdur M. F., Szeroczyńska K., Wicik B., Więckowski K. & Walanus A. 1993. High-Resolution Lacustrine Record of the Late Glacial/Holocene Transition in Central Europe. *Quaternary Science Reviews* 12: 287–294.
- Goslar T., Arnold M., Bard E., Kuc T., Pazdur M. F., Ralska-Jasiewiczowa M., Rózański K., Tisnerat N., Walanus A., Wicik B. & Więckowski K. 1995. High concentration of atmospheric ¹⁴C during the Younger Dryas. *Nature* 377: 414–417.
- Goslar T., Ralska-Jasiewiczowa M., van Geel B., Łącka B., Szeroczyńska K., Chróst B. & Walanus A. in print. Anthropogenic changes in the sediment composition of Lake Gościąg (central Poland), during the last 330 yrs. *Journal of Palaeolimnology*.
- Lotter A. F. 1989. Evidence of annual layering in Holocene sediments of Soppensee, Switzerland. *Aquatic Sciences* 51(1): 19–30.
- Merkt J. 1971. Zuverlässige Auszählungen von Jahresschichten in Seesedimenten mit Hilfe von Gross-Dünnschliffen. *Archiv für Hydrobiologie* 69: 145–154.
- Negendank J. F. W. 1989. Pleistozäne und holozäne Maarsedimente der Eifel. *Zeitschrift der deutschen geologischen Gesellschaft* 140: 13–24.
- Ralska-Jasiewiczowa, Wicik B. & Więckowski K. 1987. Lake Gościąg – a site of annually laminated sediments covering 12000 years. *Bulletin of Polish Academy of Sciences, Earth Sciences* 35(2): 127–137.
- Ralska-Jasiewiczowa M. & van Geel B. 1992. Early human disturbance of the natural environment recorded in annually laminated sediments of Lake Gościąg, central Poland. *Vegetation History and Archaeobotany* 1: 33–42.
- Ralska-Jasiewiczowa M., van Geel B., Goslar T. & Kuc T. 1992. The record of the Late Glacial/Holocene transition in the varved sediments of Lake Gościąg, central Poland. *Sveriges Geologiska Undersökning Ca* 81: 257–268.
- Renberg I. 1976. Annually laminated sediments in Lake Rudetjärn, Medelpad province, northern Sweden. *Geologiska Föreningens i Stockholm förhandlingar* 98: 335–360.

- Saarnisto M. 1985. Long varve series in Finland. *Boreas* 14: 133–137.
- Sandgren P. 1993. Palaeomagnetic and mineral magnetic investigations of the laminated sediments in Lake Gościąż and the soils in its catchment, central Poland. *Polish Botanical Studies, Guidebook Series* 8: 127–144.
- Simola H. 1977. Diatom succession in the formation of annually laminated sediment in Lovojärvi, a small eutrophicated lake. *Annales Botanici Fennici* 14: 143–148.
- Starkel L., Pazdur A., Pazdur M. F., Wicik B. & Więckowski K. 1996. Lake level and groundwater level changes in the Lake Gościąż area, Poland – palaeoclimatic implications. *The Holocene* 6(2): 213–224.
- Tolonen K. 1980. Comparison between radiocarbon and varve dating in lake Lampellonjärvi, South Finland. *Boreas* 9: 11–19.
- Więckowski K. 1993. The up-to-date state of recognition of bottom sediments in the Na Jazach lakes according to their macroscopic features. *Polish Botanical Studies, Guidebook Series* 8: 77–92 (in Polish with English summary).
- Zolitschka 1989. Jahreszeitlich geschichtete Seesedimente aus dem Holzmaar und dem Meerfelder Maar (Eifel). *Zeitschrift der deutschen geologischen Gesellschaft* 140: 25–33.