Geological Quarterly, Vol. 36, No. 2, 1992, p. 233–244

Maria Danuta BARANIECKA, Krystyna KONECKA-BETLEY, Leszek SOWIŃSKI

Late glacial at the turn of the San Glaciation and the Ferdynandów Interglacial in the open mine "Bełchatów"

The late glacial at the turn of the San Glaciation and the Ferdynandów Interglacial, studied in the sections Ławki II and Ławki I in the open mine "Bełchatów", indicates wavy-like climatic changes. Four waves with milder climate and three waves of returning coolings were distinguished on the basis of changing lithology, traces of chemical and weathering processes, initial and well developed soils, plant remains and pollen analysis. Presence of remains of water plants corresponds with initial deposition phase of lake sediments. There are also loesses deposited in water. Several types of tundra vegetation were distinguished. Upper part of till of the San Glaciation was dated at about 596 ka and sediments of the described late glacial period — at 563 ka.

INTRODUCTION

Sediments of the Ferdynandów Interglacial are of considerable interest for Quaternary geologists and palaeobotanists. Geological setting of this interglacial influences also the more general subdivisions of the Quaternary in the Polish Lowland. Any less significant and interesting are the phenomena during the interglacial itself, and at the turn of the glaciation and the interglacial. The paper presents evolution of postglacial landscape and entering of vegetation on a mineral substrate.

The mine "Bełchatów" is the westernmost locality in Poland where sediments of the Ferdynandów Interglacial are noted. They were studied in the site "Buczyna pod brukiem" (A. Hałuszczak, M. D. Baraniecka, 1982; M. D. Baraniecka, A. Hałuszczak, 1982) and ascribed to this interglacial on the basis of pollen analysis (Z. Janczyk-Kopikowa, 1982), through correlation to the section at Ferdynandów (Z. Janczyk-Kopikowa, 1975; Z. Janczyk-Kopikowa et al., 1981). A pollen diagram from the site "Buczyna

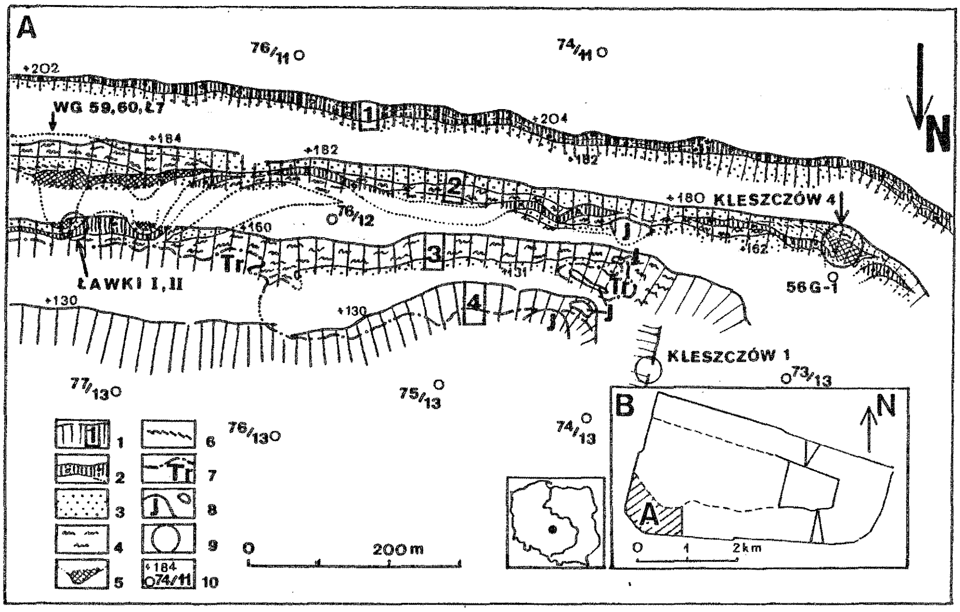

Fig. 1. Geological setting in southwestern part of the Bełchatów open mine in 1988–1990 after L. Sowiński (1990), slightly simplified (A), and location of the studied area against the pit outline (B)

1 — exploitation escarps with successive number; 2 — tills; 3 — sands of various origin; 4 — silts and clays; 5 — lake sediments; 6 — peats and sandy peats; 7 — lower boundary of the Quaternary (Tr — Tertiary); 8 — Jurassic: outcrops within younger deposits; 9 — examined fragments of escarps, research sites; 10 — altitudes in m a.s.l. and boreholes

Sytuacja geologiczna w południowo-zachodniej części odkrywki kopalni Bełchatów (stan z lat 1988–1990) wg L. Sowińskiego (1990), nieco uproszczona (A) oraz lokalizacja rejonu badań na tle zarysu tej odkrywki (B)

1 — skarpy eksploatacyjne z kolejnym numerem; 2 — gliny zwałowe; 3 — piaski różnej genezy; 4 — mułki i iły; 5 — osady jeziorne; 6 — torfy i torfy piaszczyste; 7 — dolna granica czwartorzędu (Tr — trzeciorzęd); 8 — jura, wychodnie w obrębie osadów młodszych; 9 — badane fragmenty skarp, stanowiska badawcze; 10 — wysokości w m n.p.m. i otwory wiertnicze

pod brukiem" has been published lately (Z. Janczyk-Kopikowa, 1991). Sediments of the Ferdynandów Interglacial age were also studied at sites WG 59, 60 and Ł 7 in southern edge of the mine near Ławki (D. Krzyszkowski, 1987; D. Krzyszkowski, T. Kuszell, 1987).

Western margin of the lake basin (D. Krzyszkowski, 1987) was analyzed in sections Ławki II and Ławki I (Fig. 1). These mentioned previously peats and peaty shales were noted at bottom of lake sediments and accompanied by fossil mollusc shells in the vicinity (near Kleszczów). Connection of the section with geological setting near Ławki (Fig. 1) was done by L. Sowiński (1990). The studies were connected with examination of palaeosoils (K. Konecka-Betley, 1987*a*, *b*) and pollen (Z. Janczyk-Kopikowa, 1990). Abundant and well preserved pollen grains with only rare redeposited sporomorphs seem to reflect vegetation composition of the studied interval.

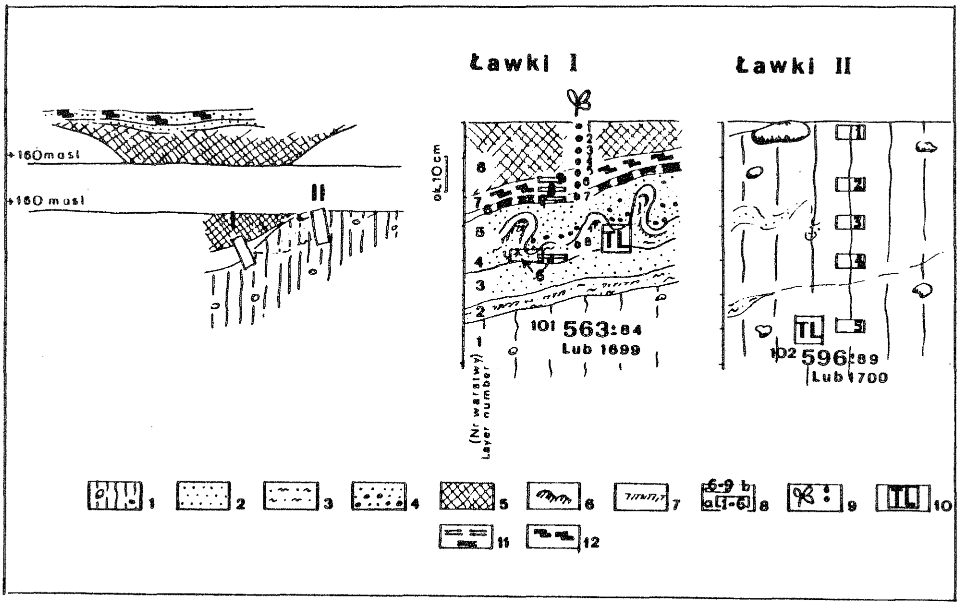

Fig. 2. Sections of research sites Ławki I and Ławki II, and their schematic location on the 3rd exploitation escarp (below 160 m a.s.l.).

1 — till; 2 — sands; 3 — silty sands; 4 — sands with gravel; 5 — lake sediments; 6 — poorly developed palaeosoil; 7 — streaks of organic matter-initial vegetation (soil?); 8 — sampling sites to pedologic studies: a — full analyses, b — determinations of carbon content; 9 — sampling sites to pollen analysis; 10 — sampling sites and results of determination of the age (in ka); 11 — peaty shales; 12 — peats

Profile stanowisk badawczych Ławki I i Ławki II oraz schematyczne położenie ich na trzeciej skarpie eksploatacyjnej (poniżej 160 m n.p.m.).

1 — glina zwałowa; 2 — piaski; 3 — piaski zamulone; 4 — piaski ze żwirem; 5 — osady jeziorne; 6 — słabo rozwinięta gleba kopalna; 7 — smugi substancji humusowej (gleba inicjalna?); 8 — miejsca pobrania próbek do badań gleboznawczych: a — analizy pełne, b — oznaczenia zawartości węgla; 9 — miejsca pobrania próbek do analizy pyłkowej; 10 — miejsca pobrania próbek i wyniki oznaczania wieku (w tysiącach lat); 11 — łupki torfiaste; 12 — torfy

RESEARCH SITES ŁAWKI II AND ŁAWKI I

Two small sections in bottom of lake sediments were distinguished. The section Ławki II (Fig. 2) comprises top part of till under the lake sediments whereas the section Ławki I (Fig. 2) — the sediments that separate till from the lake series. Examination of these sites indicated the processes, unknown in other sites of the Ferdynandów Interglacial where sections start with development of a forest-tundra sequence.

Ł a w k i I I . A till (Fig. 2) is generally grey, only fragmentarily red in the top where poor weathering is indicated. Certain mobility of some components e.g. of iron, was however noted (Table 1), expressed by "free" Fe_2O_3 in top samples (nos 1–3). In the top (samples nos 1–2) there is distinctly more phosphorus (P_2O_5). The value of

Table 1

Some phisico-chemical properties of sands (layer 4) and till, contents of carbon in peats, peaty shale and sands

Profiles Sediments	Sample no.	pH		C %	Al_2O_3+ Fe_2O_3 %	Al_2O_3 %	Fe_2O_3 %	Fe_2O_3 % free	Fe_2O_3 % in alu-mosilica-tes binding	Loose of calcina-ting %	P_2O_5 mg/100 g soil
		H_2O	KCl		extractable in 20% HCl						
Ł a w k i I											
peats top	9	–	–	12.60	–	–	–	–	–	–	–
peats bottom	8	–	–	16.72	–	–	–	–	–	–	–
peaty shale	7	–	–	10.62	–	–	–	–	–	–	–
sands (layer 4)	6	2.50	2.00	0.52	3.43	1.94	1.49	1.13	0.36	3.99	30.23
Ł a w k i I I											
	1	6.85	5.60	0.10	5.60	3.25	2.35	0.70	1.65	2.34	114.50
	2	7.83	7.27	0.10	6.17	3.95	2.22	0.63	1.59	2.78	141.38
till	3	7.63	7.12	0.11	5.91	2.88	2.03	0.57	1.46	2.41	100.07
	4	7.80	7.31	0.11	4.31	2.97	1.34	0.42	0.92	1.47	89.31
	5	7.64	7.11	0.33	5.43	3.81	1.62	0.33	1.29	4.82	99.84

Table 2

Extractable in 20% HCl elements of sands (layer 4) and till

Profiles Sediments	Sample no.	Ca	Mg	K	Na	Cu	Zn	Mn	Ni	Pb	Cr
		%				mg/kg soil					
Ławki I sands (layer 4)	6	0.08	0.10	0.15	0.01	4.4	14.0	70.0	trace	trace	12.0
Ławki II											
	1	0.18	0.33	0.47	0.02	11.0	29.0	152.0	20.0	18.0	12.0
till	2	2.45	0.85	0.56	0.08	12.4	32.8	276.0	26.0	18.0	14.0
	3	3.48	1.09	0.53	0.11	12.4	27.6	288.0	22.0	20.0	28.0
	4	1.29	0.43	0.33	0.06	7.4	19.0	148.0	12.0	trace	20.0
	5	3.21	0.74	0.48	0.09	9.4	25.8	198.0	22.0	16.0	32.0

pH is slightly lower in the sample no. 1. Microelements (Table 2) indicate insignificant changes in till top. The upper sample (no. 1) contains less Zn, Mn and Ni than the lower sample. Grain size composition (Table 3) is typical for tills. The middle sample (no. 3) resembles only a sandy till what is connected with inserts noted in the exposure (Fig. 2), just near the sampling site. Therefore insignificant changes in till top indicate postglacial initial soil processes on ice-free land surface where poor vegetation could develop.

Ławki I. The following sediments were examined at till palaeoslope (Fig. 2).

Layer no.	Simplified description
8	Lake silts (bottom part of a larger series).
7	Compressed peat.
6	Peaty shale (bottom part of peat).
5	Vari-grained sands (in sunk niches) — runoff to a lake.
4	Lake silty sands with organic matter.
3	Fine- and medium-grained sands of laminar water flow.
2	Fine-grained sands with insert of silty sand, containing insignificant traces of organic matter.
1	Till.

The section indicates gradual environmental changes on till surface, wavy-like entering of vegetation, increasing soil water content and finally, development of a lake. Pollen analysis enabled to distinguish successive vegetation types.

Layer 1 forms substrate in the section Ławki I, composed of grey till, top part of which was described already for the section Ławki II.

Layer 2 overlies a till and was formed during the first flooding with surface waters, when quite gentle deposition of very fine-grained silty sands occurred. Occasionally development of poor initial vegetation was noted, traces of which are represented by organic matter of indeterminate composition. The presence of organic matter indicates a first slight decline of glacial climatic conditions.

Layer 3 indicates increased inflow of sands and still gentle deposition. Mineral material is slightly coarser (medium- and fine-grained sands), but organic matter is completely absent. Precipitation and runoff have probably increased, whereas climate got cooler.

Layer 4 presents deposition of fine-grained sands and slower influx of material. Sands are muddy and occasionally with much humus what indicates scarce vegetation and poor soil processes. Muddy sands contain 0,52% of carbon (Table 1, sample no. 6). Such content of carbon corresponds to an initial soil processes. It reflects simultaneously distinct mobilization of iron (free Fe 1.13%, Table 1, sample no. 6) what indicates weathering processes. Pollen analysis (Fig. 3, palynological sample no. 8) proves presence of arctic carex tundra.

Vegetation of this and of the following layers was defined with pollen zones distinguished by palaeobotanists. The described zone could be therefore defined as SALIX (28.4%, max [1]) – CYPERACEAE (13.2%, max) one. *Salix* predominates *Betula* (18.4%) in the layer 4, and the latter indicates presence of dwarf birch pollen. In relation to the previous layers, this one proves the second wave of decline glacial climatic conditions.

Layer 5 presents slowing down of weathering and development of soils, finally interrupted with intensive superficial drainage. Mantling with coarse mineral material (sand with gravel), devoid of organic matter occurred what indicates colder climate again. The layer 5 encloses sinking features developed due to varied density in a silty-organic cover of the layer 4. Such structures were favoured by returning cold glacial environment. At contact with the overlying peaty shale, the sand contains fine ferruginous inserts.

Layer 6 is composed of peaty shale that starts deposition during the interval with continuous development of plants. Increased moisture favoured spreading of dense vegetation cover. Black earths has developed and due to changing water relations, was gradually transformed into a shallow peaty soil on mineral substrate. Carbon content in peaty shale is equal 10.62% (Table 1, sample no. 7). Compression of the layer 6 occurred not only due to later loading by overlying layers (overlying peat layers are also compressed), but also due to chemical processes at contact of organic and mineral material. This process is expressed by black-rusty colour of the bottom part of peaty shale and afore-mentioned ferruginous precipitation in top of sand. Pollen composition (Fig. 3, palynological sample no. 7) in shale indicates tundra vegetation. This pollen zone is to be defined as SALIX (14.4%) — HELIANTHEMUM (4%, max) one and forms second type of arctic tundra vegetation. In this case there are numerous horsetails (*Equisetum*, 13,5%, max), although not in such contents as the *Cyperaceae* previously. Contents of *Salix* is twice lower as - and *Betula* is over twice large as in the layer 4. The layer 6 represents successively already the third, stronger wave of decline glacial climatic conditions.

---

[1]At characteristic percentage values the words *max* and *min* indicate maximum or minimum contents of a given taxon in all samples that were pollen analyzed in the section.

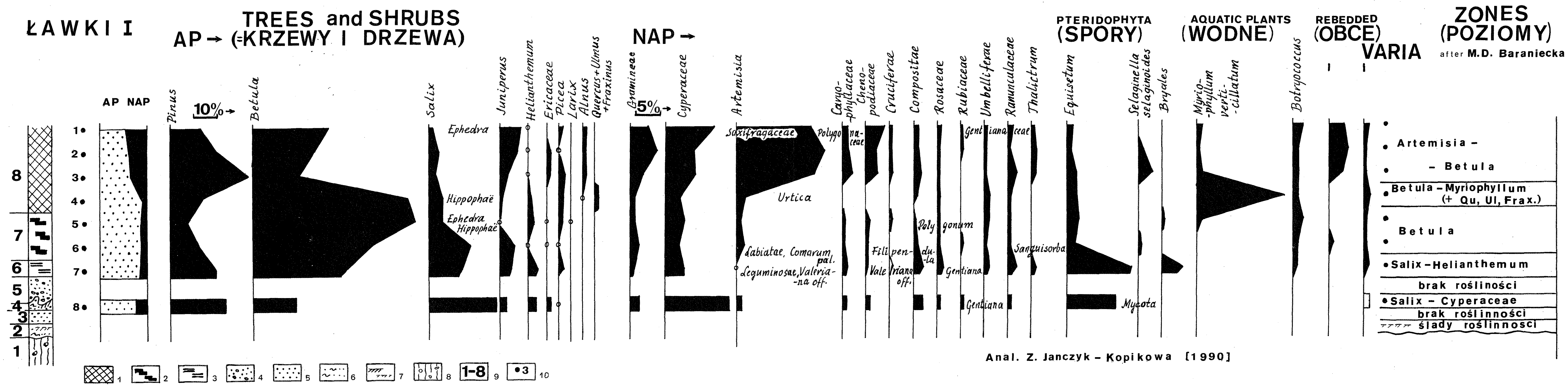

Fig. 3. Diagram of vegetation composition in the section Ławki I, based on analyses of Z. Janczyk-Kopikowa (1990)
1 — lake sediments; 2 — peats; 3 — shales; 4 — sands with gravel; 5 — sands; 6 — silty sands; 7 — soil, plant remains; 8 — till; 9 — number of layers described in the text; 10 — numbers of palynological samples

Diagram składu roślinności w profilu Ławki I (na podstawie analiz Z. Janczyk-Kopikowej, 1990)
1 — osady jeziorne; 2 — torfy; 3 — łupki; 4 — piaski ze żwirem; 5 — piaski; 6 — piaski zamulone; 7 — gleba, ślady roślinności; 8 — glina zwałowa; 9 — numery wartsw opisane w tekście; 10 — numery próbek palinologicznych

Table 3

Grain size composition of sands (layer 4) and till

Profiles Sediments	Sample no	>1 mm	1–0.5	0.5–0.25	0.25–0.1	0.1–0.05	0.05–0.02	0.02–0.005	0.005–0.002	<0.002	Total		
											1–^1	0.1–0.02	<0.02
Ł a w k i I sands (layer 4)	6	–	2.4	20.2	33.4	8	18	14	–	4	56	26	18
Ł a w k i II till	1	9.0	7.9	17.0	29.1	9	8	11	9	9	54	17	29
	2	9.0	4.8	12.7	25.5	14	8	13	9	13	43	22	35
	3	11.6	6.3	14.3	29.4	10	10	14	8	8	50	20	30
	4	8.7	9.4	20.4	28.2	9	8	8	7	10	58	17	25
	5	4.1	3.6	9.8	32.6	10	9	12	6	17	46	19	35

Layer 7 (peats) indicates rise of groundwater level and growing of peatbog conditions. In a middle part of the organic layer carbon content reaches its maximum value of 16.72% (Table 1, sample no. 8). In top this content decreases to 12.6% (Table 1, sample no. 9) what can indicates on later mineralization of peat. Compressed peats still possess plants (Fig. 3, palynological samples nos 6 and 5) of arctic provenance, even if they contain the cold-resistant fern *Selaginella selaginoides* (0.4%). But the sediment, also a pollen analysis indicates rise of water level. Plankton (*Botryococcus* 1.6%) and single water plants (*Myriophyllum verticillatum* 0,8%) appear. Terrestrial plants also change. The pollen zone can be named the BETULA (50.8%, or even 69.2%, max) one. There are not so many non-trees (NAP) as in the layers 4 and 6 i.e during preceding waves of milder thermic conditions. The palynological sample no. 6 (lower in peats) correlates to lower layers with abundant pollen of *Salix* (17.2%). Willow content does not reach significant values in any higher layer.

Layer 8 (lake silts) indicates general change of hydrographical conditions. A depression bottom mantled with peats was gradually filled with water. Weathering processes were interrupted (?decreased carbon content in peat top, Table 1). Growing of plants in a peatbog has been finished. In remaining water reservoir decalcified lake silts were deposited. Horizontal stratification of sediments proved presence of gentle sedimentary environment. Rusty streaks in lower part of grey silts indicated variation of water level during flooding with water. Silts are beige slightly

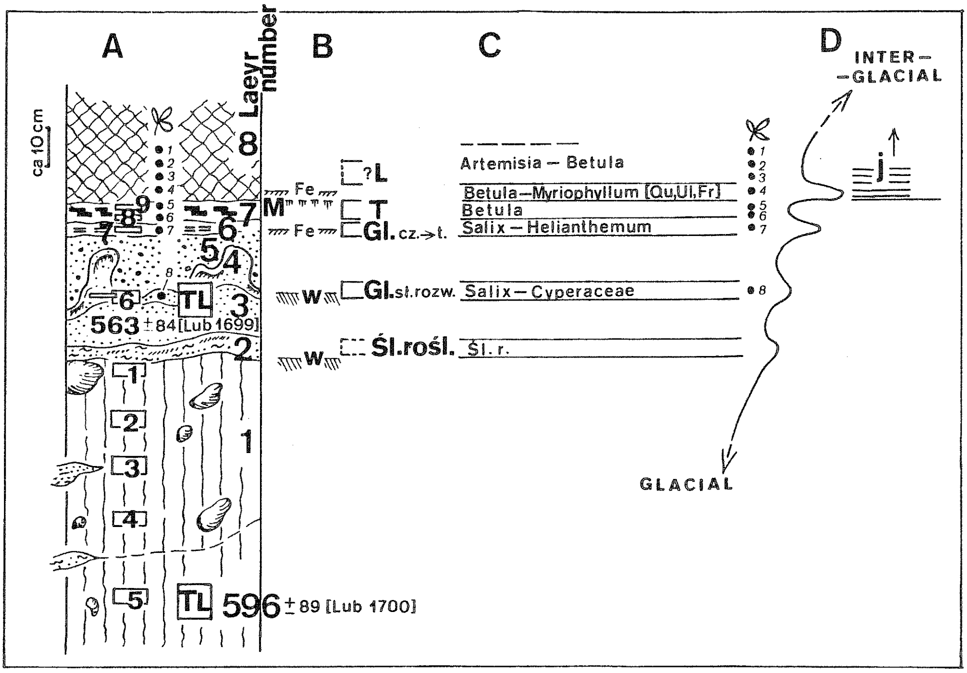

Fig. 4. Late glacial processes in the sections Ławki I and Ławki II

A — geological section; lithological symbols, numbers of layers and sampling as in Fig. 2; B — chemical processes and soils: W — initial weathering processes, Fe — rusty horizons (Fe precipitation), M — peat mineralization, Śl.r. — traces of vegetation (initial soil?), Gl.sł.rozw. — poorly developed arctic soil, Gl.cz.→t. — blacke earths soil transformed into peaty soil, T — peatbog, ? L — probable loesses, stratified, deposited in water; C — development of vegetation: pollen zones; D — climatic variation at transition from glaciation to interglacial; j — lake formation

Przebieg procesów schyłku glacjału w profilach Ławki I i Ławki II

A — profil geologiczny; oznaczenia litologiczne, numery warstw i opróbowanie jak na fig. 2; B — procesy chemiczne i gleby: W — zaczątkowe procesy wietrzenia, Fe — poziomy rdzawe (wytrącanie żelaza), M — mineralizacja torfu, Śl.r. — ślady roślinności (gleba inicjalna?), Gl.sł.rozw. — słabo rozwinięta gleba arktyczna, Gl.cz.→t. — gleba czarnoziemna przekształcona w glebę torfową, T — torfowisko, ? L — przypuszczalne lessy warstwowane, osadzone w wodzie; C — rozwój roślinności: poziomy pyłkowe; D — wahania klimatu na przejściu od glacjału do interglacjału; j — powstanie jeziora

higher what with predominant silty fraction resembles a water-deposited loess. Four samples were collected from silts for palynological examination (Fig. 3, nos 4, 3, 2, 1). All they represent the lowest, bottom part of reservoir sediments. Analysis of these samples indicates further changes of climatic and water conditions.

The zone represented by the palaeobotanical sample no. 4 should be treated separately as pollen-zone. The pollen spectrum was found to be "least cold" among the studied eight samples. Sporomorph assemblage indicates presence of trees and considerable decrease in content of non-tree pollen (8.8%, min). In this case elements with higher light demands (*Ephedra* and *Helianthemum*) disappear. Among trees birch predominates while pine is very rare. This zone cannot be therefore considered as a pine-birch one which begins spreading of forests in most complete interglacial sites. On the other hand only insignificant amount of *Picea* pollen (2%) is noted. There are however single pollen of *Quercus, Ulmus* and *Fraxinus* but they are noted in this very sample only. This zone is distinguished as the BETULA—MYRIOPHYLLUM (18%, max) one. Such distinct presence of *Myriophyllum verticillatum*, with trace content in some lower and higher samples indicates insignificant warming (interphase) amidst overlying and underlying glacial floras. This interphase is the fourth wave of decline glacial climatic conditions. Such "warming" resulted presumably in quicker thawing and surface mass movements, what in turn enabled release of pollen from Tertiary rocks that had been entirely frozen previously. Such alien pollen does not appear until the "warming" phase.

The upper part of the layer 8 (Fig. 3, palynological samples nos 3, 2, 1) proves return of tundra but of another one than before development of the lake. Maximum is reached by *Artemisia* (18.8%, max). Other elements of NAP are simultaneously also quite varied and abundant e.g. *Cyperaceae* and *Gramineae* (5.6%, max). There are considerable and mutually changing values of pine and birch. This zone was defined as the ARTEMISIA—BETULA one and represents steppe-like tundra. Similar vegetation with abundant *Artemisia* is noted in bottom samples of the section Wola Grzymalina 59 (D. Krzyszkowski, T. Kuszell, 1987), in sections "Buczyna pod brukiem" and Sosnowica (Z. Janczyk-Kopikowa, 1991), where it is located at the zone F1, at the forest-tundra phase, at the pollen period, when forests spred wider. Results of studies in the section Ławki I supplement palaeontological and geological stratigraphic inventory of an "intraglacial" period before the beginning of the interglacial in a palynological sense, in this case Ferdynandów Interglacial.

STRATIGRAPHIC SETTING AND AGE OF EXAMINED SEDIMENTS

The described section presents final part of a glacial period, the so-called cataglacial. Variation of thermic conditions was noted i.e. four successive phases with gradually milder glacial conditions and three returns of cold climate. They are reflected in geological section, by more and more intensive symptoms of accumulated organic substance, by development of soils, and in vegetation composition determined on the basis of pollen analysis (Fig. 3). In connection with terms used in younger stratigraphical units, this period constitutes the so-called late glacial. In the studied case it forms a late part of the San Glaciation as proved by geological setting in the mine "Bełchatów". Sections of the Ferdynandów Interglacial in the mine overlie the lower (bi- or even tripartite) glacial complex (A. Haluszczak, 1982), located above the Ist and IInd cycles of glacial deposition (K. Brodzikowski, 1982) or above the two formations of Folwark and Kuców, each of them containing a till (D. Krzyszkowski, 1987).

Sediments from the sections Ławki II and Ławki I were TL (termoluminiscention method) dated in the Lublin laboratory (J. Butrym, 1989). Upper part of till (TL sample no. 102) from the section Ławki II was dated at 596±89 ka (Lub 1700). Late glacial silty sands (layer 4) of the TL sample no. 101 from the section Ławki I were dated at 563±84 ka (Lub 1699). What approximately corresponds to the less precise previous determinations of age of bottom sediments of the Ferdynandów Interglacial in the mine (M. D. Baraniecka, 1987) and age of a bottom series of this interglacial in the stratotype locality at Ferdynandów dated (J. Rzechowski, 1986), at 543±65 ka (Lub 130). Datings of sediments from the sections Ławki II and I correspond also with a boundary of the San (eventually San 1) Glaciation and the Ferdynandów Interglacial in more general stratigraphical schemes (M. D. Baraniecka, 1990; L. Lindner, 1991).

CONCLUSIONS

The age of the till (top part) of the San Glaciation was determined at 596±89 ka. Decline of this glaciation was dated at 563±84 ka.

1. The late glacial is represented by very thin sediments. Environmental conditions change in wavy-like manner, traces of which are visible, although they are relatively poorly developed and occur in thin layers.

2. Presence of poor, initial vegetation (soil?) in the layer 2, poorly developed tundra soil (layer 4), and soil (layer 6) were noted. The latter was at first of black earths type, then transformed into a shallow peaty soil on mineral substrate and growing later as peatbog (layer 7), which got mineralized in the top.

3. Different tundra types and variants were noted: shrubs-herbaceous one with *Cyperaceae* variant in tundra soil (layer 4), variant with predominating horsetail (*Equisetum*) in shale (layer 6) and steppe-like tundra (*Artemisia*) in upper part of lake silts.

4. Palaeohydrological changes were recorded in sediments and by pollen analysis. In bottom of lake sediments and above the mineralized peat, there is "a warming" (bottom of layer 8, palynological sample no. 4) determined on the basis of overground vegetation and abundant water elements of *Myriophyllum verticillatum*.

5. Arguments and results of individual research methods perfectly supplement one another and confirm macroscopic features of geological sections. Climatic changes are also presented in graphic-tabular form (Fig. 4).

6. It is possible at present to correlate results of examination of the sections Ławki I and Ławki II with the next research sites located further to the west, near Kleszczów. Remains of mollusc fauna were found in section Kleszczów 1 at the other site with lake sediments, presumably the sediments of Ferdynandów Interglacial (site Kleszczów 4) were found there (Fig. 1).

7. The described late glacial period between the San Glaciation and the Ferdynandów Interglacial indicates many similarities to the so-called late glacial at the turn of

the Last Glaciation and the Holocene. The age difference between them is equal about half a million years.

Translated by Leszek Marks

Zakład Kartografii Geologicznej
Państwowego Instytutu Geologicznego
Warszawa, Rakowiecka 4
Katedra Gleboznawstwa
Szkoły Głównej Gospodarstwa Wiejskiego
Warszawa, Rakowiecka 26/30
Zakład Geologii Stosowanej
Instytutu Nauk Geologicznych
Uniwersytetu Wrocławskiego
Wrocław, Uniwersytecka 19
Received: 23.10.1991

REFERENCES

BARANIECKA M. D. (1987) — Krytyczny przegląd datowań bezwzględnego wieku osadów czwartorzędowych z kopalni węgla brunatnego "Bełchatów". In: Czwartorzęd rejonu Bełchatowa. II Sympozjum Kom. Bad. Czwart. PAN, p. 69-80. Wrocław–Warszawa.

BARANIECKA M. D. (1990) — Propozycja nowelizacji stratygrafii czwartorzędu dla Szczegółowej Mapy Geologicznej Polski 1:50 000 w świetle głównych wyników badań stratygraficznych ostatnich 20 lat. Kwart. Geol., **34**, p. 149–165, nr 1.

BARANIECKA M. D., HAŁUSZCZAK A. (1982) — Stanowisko osadów organicznych "Buczyna pod brukiem" na przekroju Buczyna. In: Czwartorzęd rejonu Bełchatowa. I Sympozjum Kom. Bad. Czwart. PAN, p. 248–251. Wrocław–Warszawa.

BRODZIKOWSKI K. (1982) — Problemy wykształcenia modelu sedymentacyjnego okresów glacjalnych w rowie tektonicznym. In: Czwartorzęd rejonu Bełchatowa. I Sympozjum Kom. Bad. Czwart. PAN, p. 66–103. Wrocław–Warszawa.

BUTRYM J. (1989) — Datowanie termoluminescencyjne próbek osadów czwartorzędowych z kopalni węgla brunatnego w Bełchatowie. Zakład Geogr. Fiz. UMCS. Lublin.

HAŁUSZCZAK A. (1982) — Zarys budowy geologicznej czwartorzędu w rejonach Piaski oraz Buczyna–Chojny. In: Czwartorzęd rejonu Bełchatowa. I Sympozjum Kom. Bad. Czwart. PAN, p. 14–35. Wrocław–Warszawa.

HAŁUSZCZAK A., BARANIECKA M. D. (1982) — Sytuacja geologiczna i rozprzestrzenienie serii "Buczyna". In: Czwartorzęd rejonu Bełchatowa. I Sympozjum Kom. Bad. Czwart. PAN, p. 119–123. Wrocław–Warszawa.

JANCZYK-KOPIKOWA Z. (1975) — Flora interglacjału mazowieckiego w Ferdynandowie. Biul. Inst. Geol., **290**, p. 5–96.

JANCZYK-KOPIKOWA Z. (1982) — Flory kopalne rejonu Bełchatowa. In: Czwartorzęd rejonu Bełchatowa. I Sympozjum Kom. Bad. Czwart. PAN, p. 36–40. Wrocław–Warszawa.

JANCZYK-KOPIKOWA Z. (1990) — Orzeczenie dotyczące próbek ze stanowiska Ławki I. Arch. Państw. Inst. Geol. Warszawa.

JANCZYK-KOPIKOWA Z. (1991) — The Ferdynandów Interglacial in Poland. Kwart. Geol., **35**, p. 71–79, nr 1.

JANCZYK-KOPIKOWA Z., MOJSKI J. E., RZECHOWSKI J. (1981) — Position of the Ferdynandów Interglacial, Middle Poland, in the Quaternary stratigraphy of the European Plain. Biul. Inst. Geol., **335**, p. 65–79.

KONECKA-BETLEY K. (1987*a*) — Pedologiczne aspekty powstawania poziomów organicznych serii Czyżów, Buczyna i Chojny w kopalni "Bełchatów". In: Czwartorzęd rejonu Bełchatowa. II Sympozjum Kom. Bad. Czwart. PAN, p. 105–108. Wrocław–Warszawa.

KONECKA-BETLEY K. (1987*b*) — Geochemiczne właściwości środkowopolskich glin zwałowych odsłonięcia Bełchatów. Spraw. Bad. Nauk., nr VII, Kom. Bad. Czwart. PAN, p. 102–103. Warszawa.

KRZYSZKOWSKI D. (1987) — Charakterystyka oraz interpretacja paleogeograficzna osadów formacji "Czyżów". In: Czwartorzęd rejonu Bełchatowa. II Sympozjum Kom. Bad. Czwart. PAN, p. 35–46. Wrocław–Warszawa.

KRZYSZKOWSKI D., KUSZELL T. (1987) — Nowe stanowisko interglacjału ferdynandowskiego w odkrywce Bełchatów. In: Czwartorzęd rejonu Bełchatowa. II Sympozjum Kom. Bad. Czwart. PAN, p. 125–134. Wrocław–Warszawa.

LINDNER L. (1991) — Problemy korelacji głównych jednostek stratygraficznych czwartorzędu środkowo--zachodniej Europy. Prz. Geol., **39**, p. 249–253, nr 5–6.

RZECHOWSKI J. (1986) — Pleistocene till stratigraphy in Poland. In: Quaternary glaciations in the northern Hemisphere. Quatern. Sc. Rev., **5**, p. 365–372. Pergamon Press. Oxford-New York-Toronto-Sydney-Frankfurt.

SOWIŃSKI L. (1990) — Stanowisko faunistyczne i florystyczne w południowo-zachodniej części odkrywki kopalni węgla brunatnego Bełchatów. Zakład Geol. Stos. Uniw. Wrocł. Wrocław.

Maria Danuta BARANIECKA, Krystyna KONECKA-BETLEY, Leszek SOWIŃSKI

SCHYŁEK GLACJAŁU MIĘDZY ZLODOWACENIEM SANU A INTERGLACJAŁEM FERDYNANDOWSKIM W KOPALNI BEŁCHATÓW

Streszczenie

W kopalni Bełchatów znaleziono osady schyłku glacjału (kataglacjał, późny glacjał) w pozycji geologicznej między zlodowaceniem sanu a interglacjałem ferdynandowskim. Badania przeprowadzono w profilach Ławki II i Ławki I (fig. 1, 2). Falowe zmiany klimatyczne (termiczne) objawiają się jako 4 fale względnego ocieplenia, ściślej łagodzenia warunków arktycznych oraz przedzielające je 3 fale nawrotu chłodu (fig. 4). Podstawą ich wyróżniania były zmiany następstwa osadów (fig. 2, tab. 3), ślady procesów wietrzeniowych i glebowych oraz występowanie zaczątkowej roślinności i jej rozwój (tab. 2, 3, fig. 4). Stwierdzono związek obecności szczątków (fig. 3) roślin wodnych (*Myriophyllum verticillatum)* i początku akumulacji osadów jeziornych. Możliwa jest obecność lessów akumulowanych w wodzie (fig. 4). Wyróżniono kilka typów roślinności (fig. 3) schyłku glacjału: tundrę krzewinkowo-zielną z dominującymi turzycami, tundrę krzewinkowo-zielną z obfitością skrzypów oraz arktyczną tundrę stepową z formą *Artemisia.* Wiek badanych osadów (fig. 4) określono metodą termoluminiscencji. Stropowe części gliny zwałowej kształtowały się około 596 tys. lat temu. Osady zaliczone do schyłku glacjału mają około 563 tys. lat. Możliwe jest obecnie nawiązanie profili Ławki II i Ławki I do innych stanowisk badawczych (fig. 1) położonych koło Kleszczowa, gdzie znaleziono mięczaki (profil Kleszczów 1) i następne miejsce występowania osadów jeziornych, zapewne ferdynandowskich (Kleszczów 4). Opisany schyłek glacjału wykazuje liczne analogie do tzw. późnego glacjału poprzedzającego holocen. Jest natomiast starszy o około pół miliona lat.