ZESZYTY NAUKOWE POLITECHNIKI ŚLĄSKIEJ 1996
Seria: MATEMATYKA-FIZYKA z. 80 GEOCHRONOMETRIA 14 Nr kol. 1331

Dariusz KRZYSZKOWSKI, Anna PAZDUR

TIME CONTROL OF THE WEICHSELIAN PLENIGLACIAL LACUSTRINE SEDIMENTATION AT JAROSZÓW, SOUTHWESTERN POLAND; PRELIMINARY DISCUSSION

Summary. The Weichselian sequence of the Jaroszów quarry contains lacustrine deposits. Lake sedimentation occurred in three shallow basins, with deposition at first of clastic material and during the late phases with deposition of organic material, loess (redeposited) and lacustrine marl. The lacustrine sequence was deposited during the Middle and Upper Pleniglacials of the Middle Weichselian (oxygene isotope stages 3 and 2), as the extreme radiocarbon datings are: > 50 300 yrs BP (infinite date) and 14 760±220 yrs BP, with several finite dates between them.

CHRONOLOGIA SEDYMENTACJI WISTULIAŃSKICH OSADÓW JEZIORNYCH Z JAROSZOWA, POLSKA POŁUDNIOWO-ZACHODNIA

Streszczenie. Seria vistuliańska w odkrywce Jaroszów zawiera poziom osadów jeziornych. Osady te były deponowane w trzech płytkich zbiornikach, gdzie początkowo był osadzany tylko materiał klastyczny, a w późniejszych fazach materiał organiczny, less (redeponowany) i kredy jeziorne. Osady jeziorne były akumulowane w czasie środkowego i górnego pleniglacjału (środkowy Vistulian) ostatniego zlodowacenia (okresy izotopowe 3 i 2 wg stratygrafii oceanicznej). Skrajne daty ^{14}C wynoszą: powyżej 50 300 lat BP (data nieskończona) i 14760±220 lat BP, a pomiędzy nimi wydatowano dodatkowo kilka poziomów organicznych.

1. Introduction

The Jaroszów quarry is located at the Sudetic Foreland, Southwestern Poland, and only 40 km west of city of Wrocław. The Pleistocene sequence comprises several fluvial

and glacial series, and, in the uppermost part, several outcrops of lacustrine deposits (Krzyszkowski 1993; Krzyszkowski et al. 1995). The lacustrine deposits are usually 3–5 m thick and occur in a form of isolated lenses, presumably ancient lake basins (fig. 1). Three lake basins have been hitherto documented. All of them have similar stratigraphy with generally four units:

- the lowermost laminated silts and gravels, which laterally interfinger with the fluvial gravels of the Lower Member of the Upper Fluvial Series of the Jaroszów section (Krzyszkowski 1993),
- the middle massive silts with occasional thin laminae of organic detritus (< 0.5 cm) and in places with discontinuous and deformed gravel beds; the latter represent, most probably, the solifluction units formed on the basin slopes,
- the upper unit with alternating beds of silt (loess), clay, fine sand and organic deposits (organic detritus, peat, organic mud, lacustrine marl). Organic beds form layers of deposits formed *in situ* as well as deformed deposits, most probably, redeposited from other parts of the basin. Some organic layers are formed of charcoal,
- the uppermost lacustrine marl (calcareous gytja), with two subfacies of the brown marl (lower) and white marl (upper).

All units, except the lowermost silts and gravels, contain organic layers. Massive silts and lacustrine marl contain only very thin laminae of organic detritus, whereas the upper unit contains organic beds up to 30 cm thick. The uppermost lacustrine marl is up to 1 m thick.

The lake basin are small; lateral extent does not exceeds 30 m. The lacustrine sequence is overlain by fluvial gravels, from the Upper Member of the Upper Fluvial Series of the Jaroszów section (Krzyszkowski 1993). detailed description of sediments and their possible origins are discussed separately (Krzyszkowski et al. 1995); this paper discusses only radiocarbon dates and possible chronostratygraphy.

2. Radiocarbon dating

Several radiocarbon dates have been obtained in the „central" and „eastern" basins (Krzyszkowski et al. 1995) (Table 1). All dates from the eastern basin are in superposition (one section), whereas the central basin has been sampled in three sites (fig. 1).

Organic layers from the „massive silt unit" have three open dates: > 50 300 yrs BP (Gd-11031), > 39 700 yrs BP (Gd-7567), > 47 500 yrs BP (Gd-10116),and one finite date:

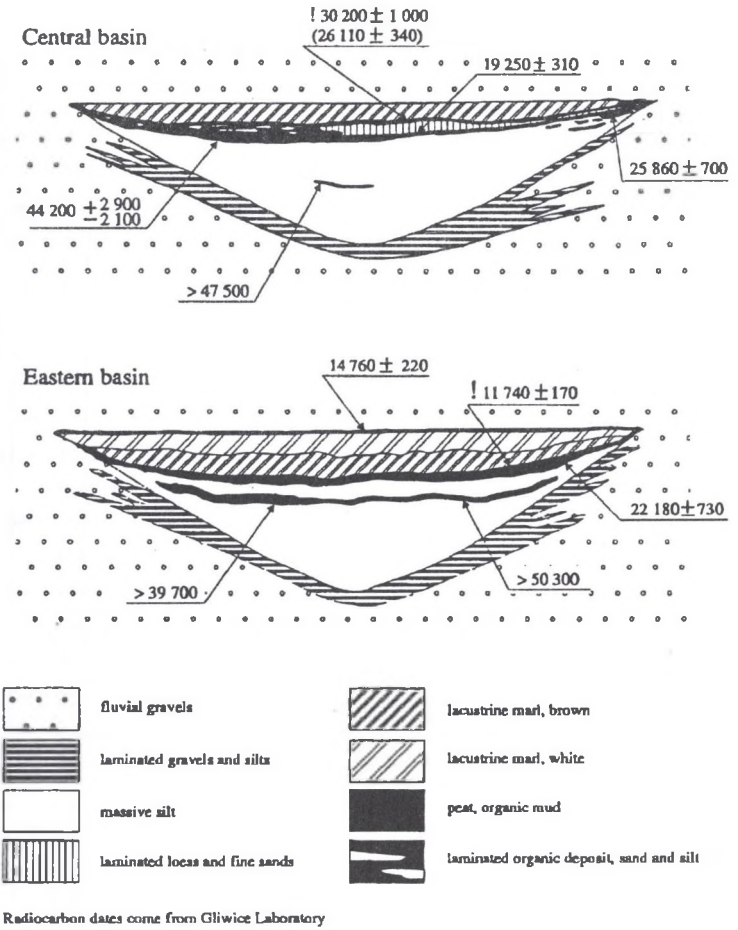

Fig. 1. Generalized sediment succesion in the Weichselian lake basins at Jaroszów, with position of samples with radiocarbon datings

Rys. 1. Zgeneralizowana sukcesja osadów ze zbiorników wistuliańskich w Jaroszowie, z lokalizacją próbek datowanych metodą radiowęglową

44 200$^{+2900}_{-2100}$ yrs BP (Gd-11032) (fig. 1). The last one has been sampled at the boundary between the lower and upper units and organic (black) deposit contained several thin laminae of light deposit (calcareous gytja) (fig. 1). The age of sample is somewhat older than expected from its position in the sequence, probably due to calcareous contamination.

The organic layers of the upper unit have been dated in two sites of the central basin and in one site of the eastern basin. The central basin has got dates: 25 860±700 yrs BP

Table 1

List of radiocarbon datings of Weichselian lacustrine sequence at Jaroszów quarry, southwestern Poland

Lab. No.	Sample	Sediment	Age BP
central basin, site 1 (1992)			
Gd-10030	C/45	black clayey peat	30 200±1000
Gd-10121	C/45p	black clayey peat	26 110±340 (revised)
Gd-10015	C/40	charcoal	19 250±310
central basin, site 2 (1993)			
Gd-10117	S/335	peat	25 860±700
central basin, site 3 (1994)			
Gd-11032	S/329	organic mud and calcareous gyttja	$44\ 200^{+2900}_{-2100}$
Gd-10116	S/328	organic detritus (peat)	> 47 500
eastern basin (1994)			
Gd 9350	S/334	brown organic mud	14 760±220
Gd-9348	S/333	peat	11 740±170
Gd-9347	S/332	peat	22 180±930
Gd-11031	S/331	peat (+ charcoal)	> 50 300
Gd-7567	S/330	peat (+ charcoal)	> 39 700

(Gd-10117) in an isolated position in the marginal part of the basin and two dates in superposition from the central part of this basin: 19 250±310 yrs BP (Gd-10015) near the lower boundary of the unit and 30 200±1000 yrs BP (Gd-10030) near its upper boundary (fig. 1). The lower organic layer is formed in majority of charcoal. The upper organic layer is represented by organic mud (black clay). This layer contacts from the top and bottom with highly calcareous deposits, including sediments containing syderite (Jędrysek et al. 1995). Moreover, the organic mud is strongly deformed. Renewed dating, with special preparation of the sample enabling removal of insoluble carbonates, has given 26 100±340 yrs BP (Gd-10121). Thus, the reversed chronology is preserved, and it is supposed that the upper organic layer does not represent *in situ* deposited layer. The eastern basin has got two dates from the upper unit, represented here by a 30 cm thick peat layer. The lowermost part of peat layer is 22 180±930 yrs BP (Gd-9347) and the uppermost peat is 11 740±170 yrs BP (Gd-9348). The latter date is highly unexpected, taking into account the dating of the lowermost part of the peat layer (fig. 1). Possible error is difficult to explain, as the date is twice younger than expected age of the discussed organic layer. It must be stressed out, however, that the peat contains very high amount of mellanterite

(macroscopically visible), what indicates chemical instability and present–day chemical processes in the sediment. Also, the peat layer is overlain by a 1–2 cm thick laminae strongly cemented by iron (getite documented by X–ray analysis), and above it, by thick lacustrine marl (fig. 1).

The uppermost part of the lacustrine sequence has been dated in the eastern basin, where brown organic mud has occurred at the top of lacustrine marl (fig. 1). Its radiocarbon date is 14 760±220 yrs BP (Gd-9350).

The most controversial dating, with reversed chronologies, come from the upper unit of the lacustrine sequence. This may correspond with the highly variable lithologies and chemical composition of deposits in this unit. New datings are necessary.

3. Time control and sedimentation rates

The radiocarbon dates obtained from the lacustrine sequences at Jaroszów give quite an unique time control and show that lakes analysed existed continuously during the Middle and Upper Pleniglacial of the Weichselian (van Staalduinen et al. 1979; Behre 1989), (oxygene isotope stages 3 and 2; Shackleton and Opdyke 1973) (fig. 2).

Altough the lower boundary of the pure lacustrine sequence (massive silt unit) cannot be dated precisely, it seems that its age may be assumed to about 64 000 yrs BP, i.e. the begining of Middle Pleniglacial and stage 3 of the oxygene isotope stratigraphy (fig. 2). In this case, the lowermost unit of the laminated silts and gravels and the lower fluvial gravels were deposited, most probably, during the Lower Pleniglacial. The beginning of deposition of the upper unit, with loess and thick organic beds (peat, organic mud), also cannot be precisely estimated (fig. 2). It may be placed at the beginning of stage 2 of the oxygene isotope stratigraphy (33 000 yrs BP) or at 27 000 yrs BP, where is usually placed the boundary between Middle and Upper Pleniglacial of the Weichselian sequences of central Poland (Krzyszkowski 1990) or at any position between these two dates. The boundary between upper unit and the uppermost lacustrine marl is, most probably, around the 19 000 yrs BP (fig. 2).

The sedimentation of the upper unit took place at the time when Scandinavian Ice Sheet advanced into central Poland (33 000 - 21 000 / 19 000 yrs BP), whereas the uppermost unit was deposited during the partial ice–sheet decay (21 000 / 19 000 - 14 500 yrs BP) (Kozarski 1986). The latter period represents also the coolest Weichselian climatic ocilation, what is documented in oxygene curves of marine deposits (Shackleton and Opdyke 1973, 1976), in continuous pollen diagrams of southern countries (Woillard 1978; Folieri et al. 1990, 1993; Tzedakis 1993) and in lithostratigraphic sequences of the glaciated areas containing deposits suitable nor for pollen analysis (no pollen at all) neither for radiocarbon dating (Goździk and Pazdur 1987).

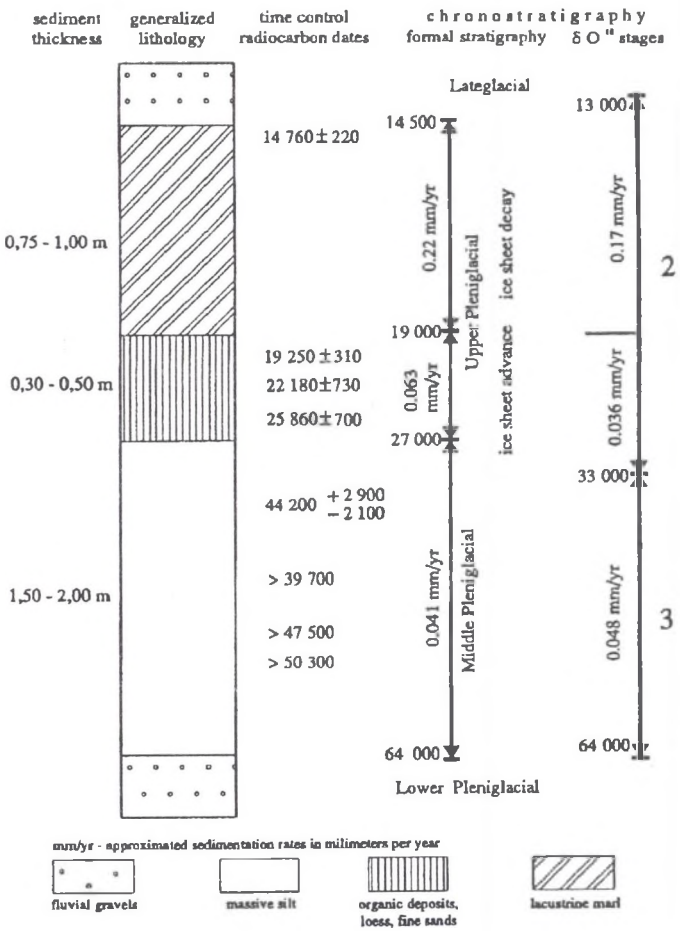

Fig. 2. Time control, chronostratigraphy and sedimentation rates of the Weichselian lacustrine sequence at Jaroszów (formal stratigraphy after van Staalduinen et al. 1979 and Behre 1989; $\delta^{18}O$ stages after Shackleton and Opdyke 1973, 1976)

Rys. 2. Chronologia, stratygrafia i prędkość sedymentacji dla wistuliańskich osadów jeziornych w Jaroszowie (stratygrafia formalne za van Staalduinen et al. 1979 i Behre 1989; okresy $\delta^{18}O$ za Shackleton and Opdyke 1973, 1976)

Pollen analysis of the analysed lacustrine sequence have indicated (Krzyszkowski et al. 1995) that during the ice sheet advance (33 000-21 000 / 19 000 yrs BP), the Jaroszów region was occupied in part by pine–birch forest, and generally the vegetation represented open forest to tundra–forest conditions (NAP 40-50%), although these parts of the se-

quences which have got a dates around 19 000 / 21 000 yrs BP did not contained pollen at all, suggesting the most severe conditions (Krzyszkowski et al. 1995). It must be stressed that the maximum extent of the Weichselian ice–sheet was that time only 100 km northwards of Jaroszów. In turn, during the partial decay of the ice–sheet (21 000 / 19 000 - 14 5000 yrs BP) climatic conditions were at first (lower part of lacustrine marl) similar as before (open forest to forest/tundra), and became soon milder (uppermost part of lacustrine marl), with dense pine–birch forest and only 20% of herbs. The oxygene and carbon isotope investigations (Jędrysek et al. 1995) have shown the coolest climatic conditions in a layer dated back to 19 250±310 yrs BP, although geochemical and mineralogical data from the same layer suggest processes typical rather for temperate conditions and sufficient plant production in the lakes. Moreover, the lacustrine marl was deposited + + continuously during the time between 19 250±310 and 14 760±220 yrs BP, which correspond with the younger part of stage 2 in the oxygene isotope stratigraphy and which is supposed to represent an extremally cold conditions (Shackleton and Opdyke 1973, 1976). Thus, if our dates are correct, the Jaroszów sequence gives new data, suggesting much more mild conditions than hitherto were assumed in the region investigated. They suggest also a rapid forest expansion simultaneously with the ice–sheet decay.

A good time control in the Weichselian lacustrine sequence at Jaroszów make possible to calculate sedimentation rates. Both middle and upper units of the Weichselian lacustrine sequence are characterized by very slow sedimentation rates, which are around 0.05 mm/year, what well correspond with cold climate that time. Sedimentation rates rapidly increased in the uppermost lacustrine marl, to about 0.2 mm/year, what well correspond with climatic amelioration and expansion of vegetation cover (fig. 2).

References

Behre K-E., 1989, Biostratigraphy of the last glacial period in Europe, Quaternary Science Reviews 8, 25–44.

Folieri M., Magri D., Narcisi B., 1990, A comparison between lithostratigraphy and palynology from the lacustrine sediments of Valle di Castiglione (Roma) over last 0.25 Ma. Memoirs of the Italian Geological Society 45, 889–891.

Folieri M., Magri D., Narcisi B., 1993, Palaeoenvironmental investigations on long sediment cores from volcanic lakes of Lazzio (central Italy) – an overview. In: J.F.W. Negendank and B. Zolitschka (eds.), Paleolimnology of European Maar Lakes, Lecture Notes in Earth Sciens 49, Springer–Verlag, 95–107.

Goździk J., Pazdur M.F., 1987, Rozkład częstości dat ^{14}C z terenu Polski w przedziale czasu 12–45 tysięcy lat BP i jego konsekwencje paleogeograficzne. Zeszyty Naukowe Politechniki Śląskiej, s. Matematyka–Fizyka, Geochronometria 4, 27–42.

Jędrysek M.O., Krzyszkowski D., Hałas S., 1995, Wstępne badania izotopowe zmienności warunków klimatyczno–limnologicznych w okresie sedymentacji wistuliańskich osadów jeziornych w Jaroszowie. Przegląd Geologiczny 43 (2), 147–150.

Kozarski S., 1986, Timescales and the rhytm of Vistulian geomorphic events in the Polish Lowland. Czasopismo Geograficzne 57, 247–270.

Krzyszkowski D., 1990, Middle and Late Weichselian stratigraphy and palaeoenvironments in central Poland. Boreas 19, 333–350.

Krzyszkowski D., 1993, Sedymentacja fluwialna, glacifluwialna i glacjalna w dorzeczu Strzegomki na Przedgórzu Sudeckim. In: K. Mastalerz (ed.) Baseny sedymentacyjne: procesy, osady, architektura; przewodnik II krajowego spotkania sedymentologów, Wrocław 4-7 września 1993, 7–35.

Krzyszkowski D., Choma-Moryl K., Kuszell T., Malkiewicz M., Pazdur A., 1995, Vistuliańskie osady jeziorne w Jaroszowie, Przedgórze Sudeckie: wstępne wyniki i perspektywy badań. Przegląd Geologiczny 43 (2), 141–146.

Shackleton N.J., Opdyke N.D., 1973, Oxygene Isotope and Palaeomagnetic Stratigraphy of Equatorial Pacific Core V28-238: Oxygene Isotope Temperatures and Ice Volumes on 10^5 Year and 10^6 Year Scale. Quaternary Research 3, 39–55.

Shackleton N.J., Opdyke N.D., 1976, Oxygene–Isotope and Paleomagnetic Stratigraphy of Pacific Core V28-239: Late Pliocene to latest Pleistocene. Geological Society of America, Memoir 145, 449–464.

Staalduinen van C.J., Adrichem Boogaert van H., Bless M.J.M., Doppert J.W.Chr., Harsveldt H.M., Montfrans van H.M., Oele E. Wermuth R.A., Zagwijn W.H. 1979, The Geology of the Netherlands: Quaternary. Mededelingen rijks geologische dienst 31–2, 34–46.

Tzedakis P.C., 1993, Long term tree populations in northwest Greece through multiple Quaternary climatic changes. Nature 364, 437–440.

Woillard G. M., 1978, Grand Pile Peat Bog: a continuous pollen record for the last 140,000 years. Quaternary Research 9, 1–21.

Streszczenie

Odkrywka kopalni Jaroszów znajduje się na Przedgórzu Sudeckim, około 40 km na zachód od Wrocławia. Pleistoceńskie osady odkrywki zawierają kilka serii fluwialnych i glacjalnych oraz, położonych w obrębie górnej części serii, kilka odsłonięć osadów jeziornych. Grubość warstw osadów w odsłonięciach wynosi zwykle 3–5 m. Są one widoczne w formie soczewek, wypełniających stare zbiorniki jeziorne. Wszystkie zbiorniki posiadają podobną stratygrafię, zawierającą cztery jednostki: najniżej położone mułki i żwiry na przemian laminowane; mułki masywne; mułki, piaski i osady organiczne oraz położona w górnej części kreda jeziorna. Wszystkie jednostki, z wyjątkiem piasków i żwirów zawierają warstwy organiczne.

Datowaniom radiowęglowym poddano próbki osadów zawierających materię organiczną. Dla mułków masywnych uzyskano trzy wyniki datowania, wskazujące na starą materię organiczną zawartą w osadzie, o wieku poza zasięgiem datowania radiowęglowego (>50300, >47500, >39500BP) oraz datę skończoną 44200^{+2900}_{-2100}BP. Wieki warstw organicznych jednostki górnej wynoszą odpowiednio: 26100±340, 25860±700, 22180±930 oraz 19250±310 BP. Najwyższą część sekwencji (górny poziom kredy jeziornej) posiada wiek 14760±220BP. Uzyskane wyniki datowań wskazują, że sedymentacja kredy jeziornej miała miejsce w ciągu środkowego i górnego pleniglacjału wistulianu (3 i 2 stadium izotopowe tlenu). Analizy pyłkowe wskazują na roślinność typową dla tundry w tym okresie.