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THE REFLECTION OF CLIMATIC CHANGES AND HUMAN ACTIVITY ON SEDIMENTS OF SMALL FORECARPATHIAN TRIBUTARIES OF THE VISTULA RIVER NEAR CRACOW, POLAND

INTRODUCTION

Serafa (Srawa), Zabawka and Podłężanka are small rivers of the lenght about 15 km belonging to the Vistula tributaries between Cracow and Niepołomice. River drainage basins of the area 28.5 km^2 (up to the connection with the Drwień), 17.0 km^2 and 37.7 km^2 (up to the railway bridge in Podłęże), respectively, cover the region of Wieliczka-Gdów Upland (Klimek and Starkel 1972) covered by loess and elevated to 290–300 m a.s.l. between Wieliczka and the Raba valley (Fig. 1). Considerable, rough like, closing of these valleys divide the edge of Carpathians Foreland the hight of which surpasses 400 m a.s.l. The network of perennial creeks is limited to main valleys. The rainy, summer floods prevail while the melted ones are more rare.

Geomorphological mapping of upper parts of the Zabawka and the Podłężanka basins by L. Starkel (1960) allowed to establish a set of forms and processes modelling of the slopes and river beds. Relief which developed on the Miocene sediments has the Pliocene background but it was strongly transformed and covered by loess during the Pleistocene and the Holocene. The widespread solifluction covers (older than Alleröd) are covered by the Holocene delluvia connected with the agricultural activity. Locally, small fragments of the Vistulian alluvial plains are preserved in the valley connections. The valleys were renewed in the Holocene and the cut of the bottom reaches 5–8 m.

THE AIM AND THE RESEARCH METHODS

In the 90's, the research programme on the Late Glacial and the Holocene evolution of the small Forecarpathians valleys was conducted in the connection with the previous research of the Vistula valley near Cracow (Kalicki 1991).

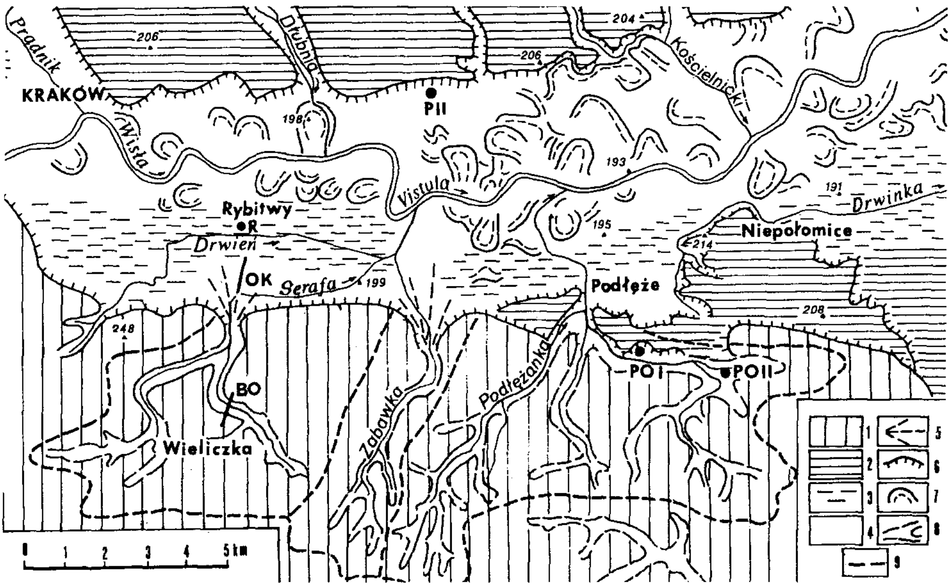

Fig. 1. Geomorphological sketch of study area. 1 — Wieliczka-Gdów Upland and Wieliczka Forecarpathian Foreland, 2 — high, Pleistocene Vistula terraces, 3 — Vistula flood plain (Late Glacial depression), 4 — Vistula flood plain with abandoned channels, 5 — alluvial fans, 6 — scarps, 7 — Vistula abandoned channels, 8 — Forecarpathians valleys, 9 — watersheds of Forecarpathians basins; Study sites: BO — Bogucice, OK — Osiedle Kolejowe, PO — Podłężanka, P II — Pleszów II, R — Rybitwy

Ryc. 1. Szkic geomorfologiczny obszaru badań. 1 — Wysoczyzna Wielicko-Gdowska i Pogórze Wielickie, 2 — wysokie, plejstoceńskie terasy Wisły, 3 — dno doliny Wisły (obniżenia późnoglacjalne), 4 — dno doliny Wisły ze starorzeczami, 5 — stożki napływowe, 6 — krawędzie, 7 — starorzecza Wisły, 8 — doliny pogórskie, 9 — wododziały zlewni pogórskich; Stanowiska badawcze: BO — Bogucice, OK — Osiedle Kolejowe, PO — Podłężanka, P II — Pleszów II, R — Rybitwy

As the research area, the Holocene alluvial fan and lower part of the Serafa river and the middle section of the Podłężanka valley were chosen where some borings were made with mechanical drill "Geomeres". The grain size of fine sediments was checked with the aerometric method and the laser Fritsch method, and the coarse ones, with the sieve method, the contents of the organic substance with the method of roasting in the laboratory of Department of Geomorphology and Hydrology of Mountains and Uplands, Institute of Geography and Spatial Organization Polish Academy of Sciences in Cracow by Jolanta Sala. The Folk-Ward parameters of grain size destribution calculated on the basis of the laser analyses are further, in this paper, marked with a asterisk since they differ from the results achieved by the aerometric analysis (comp. Nicieja 1996, Konert and Vandenberghe 1997).

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THE SERAFA VALLEY

Two drilling cross sections were made in the river valley: the transverse one through the valley bottom near Bogucice and the longitudinal one through the alluvial fan at the mouth of the Serafa valley up to the Vistula valley near Osiedle Kolejowe (Fig. 2).

BOGUCICE CROSS SECTION

The cross section lies around 2 km below Wieliczka center (Fig. 2). The flat valley bottom of the width up to 200 m is elevated about 4 m above the river level. The Serafa flows in a narrow cut under the southern, gentle valley slope built of Lower Tortonian clays. The northern steep slope is formed by the Upper Tortonian Bogucice sands (Gradziński 1972).

The structure of the valley floor was recognized in three borings (Fig. 3). The thickness of the Quaternary sediments surpasses 11 m and several members can be distinguished within its range. The lowest of the thickness surpassing 9 m are built of silty muds ($Mz = 6.0–6.8\varphi$) very badly sorted ($\delta_I = 2.0–2.4$) grey, with sporadic organic remains. The comparative grain size analyses of the upper part of this member near the valley slope (profile BO III) made with the Fritsch laser method gave a little bit different results. Here, the sediments are coarser ($Mz^* = 5.4–6.2\varphi$) and, somehow, better sorted ($\delta_I^* = 1.5–2.0$).

In all three borings this member ends with organic, silty muds ($Mz = 6.0–6.4\varphi$; $Mz^* = 5.7–5.9\varphi$), very badly and badly sorted ($\delta_I = 2.1–2.2$; $\delta_I^* = 1.6–1.8$) which, upwards change in two drillings into peaty, silty muds ($Mz = 5.9\varphi$; $Mz^* = 5.8\varphi$) badly sorted (δ_I and δ_I^* equal 1.8). The thickness of these organic sediments is about 0.3 m and their top lies the most shallow near the Serafa river bed (profile BO I), and the deepest in the axis of the valley (profile BO II). The ^{14}C dating of the top of peaty muds gave the age 11,580 ± 80 BP (Gd-7,382).

Above, there are more varied sediments of the thickness 2–5 m. Several sequences of vertical accreation can be distinguished in them (from 2 in the profile BO I up to 6 in the profile BO II), of which, each is characterized by fining upwards. In several cases such a sequence starts from silty sands or sandy silts (profile BO II), however, most often of silty muds ($Mz = 6.5\varphi$; $Mz^* = 5.6–5.9\varphi$) very badly, and badly sorted ($\delta_I = 2.4$; $\delta_I^* = 1.5–1.7$). These sediments turn upwards to clayey muds ($Mz = 8.0\varphi$) and clayey-silty muds ($Mz^* = 6.4–7.3\varphi$) very badly, and badly sorted ($\delta_I = 2.6$; $\delta_I^* = 1.7–1.8$), sporadically, into organic muds (profile BO II). The sediments of this member show the episodic character of transportation and diminishing of the transporting power, and in the Forecarpathians, the Holocene alluvia of similar character were described by L. Starkel (1960).

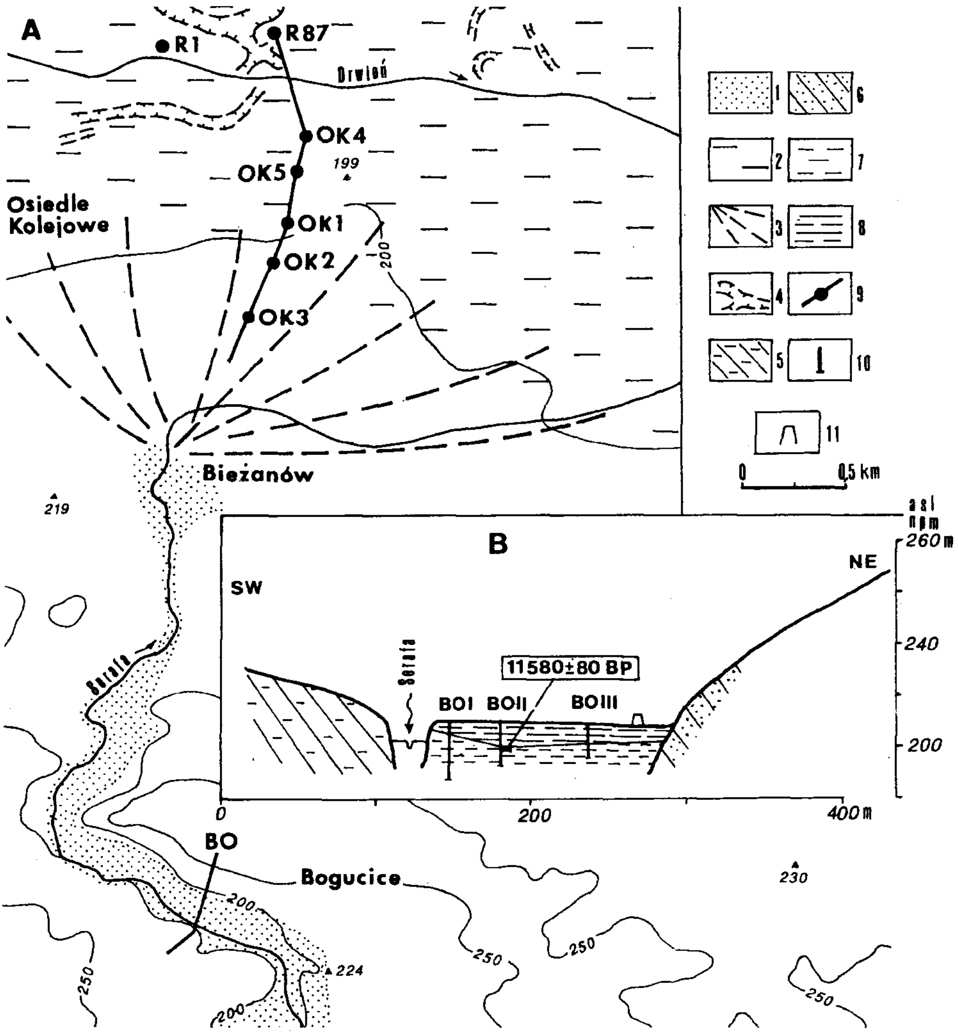

Fig. 2. Topographic sketch of the study section of the Serafa valley (A) and the geological cross section at the Bogucice site (B). 1 — Serafa valley floor, 2 — Late Glacial depression of the Vistula flood plain, 3 — alluvial fan, 4 — abandoned channels, 5 — Miocene clay, 6 — Miocene sand (Bogucice member), 7 — Vistulian silty muds, 8 — Holocene clayey and silty muds, 9 — borings and cross sections, 10 — borings, 11 — railway mound; Sites and borings: BO — Bogucice, OK — Osiedle Kolejowe, R — Rybitwy

Ryc. 2. Szkic topograficzny badanego odcinka doliny Serafy (A) i przekrój geologiczny na stanowisku Bogucice (B). 1 — dno doliny Serafy, 2 — późnoglacjalne obniżenia w dnie doliny Wisły, 3 — stożek napływowy, 4 — starorzecza, 5 — iły mioceńskie, 6 — mioceńskie piaski bogucickie, 7 — vistuliańskie mułki pylaste, 8 — holoceńskie mułki ilaste i pylaste, 9 — wiercenia i przekroje, 10 — wiercenia, 11 — nasyp kolejowy; Stanowiska i wiercenia: BO — Bogucice, OK — Osiedle Kolejowe, R — Rybitwy

In the upper part of profiles (from 70 cm in the lying near the river bed profile BO I up to 30 cm in the most distant from the Serafa profile BO III) the change of the sequence from the simple (fining upwards) one to the reversed one occurs. The sediments upwards become coarser (Mz decrease about 0.4–1.3φ) though their sorting is not changed. It is characteristic for overbank deposits of the last 1000 years and might be connected with the human activity (comp. Kalicki 1996b).

THE SERAFA ALLUVIAL FAN — OSIEDLE KOLEJOWE SECTION

The Forecarpathians Vistula tributaries pour their alluvial fans into wide, Late Glacial depressions which continue along the southern slope of the Vistula valley between Cracow and Niepołomice (Kalicki 1991). The characteristic features of the morphology of these alluvial fans are, seen on the maps in the scale 1:10,000, linearly stretched elevated zones marking the previous course of the river beds (comp. Gębica 1995). The recent course of the Zabawka and the Podłężanka rivers inconsistent with these zones, which can be connected with the avulsion or their antropogenic regulation.

The bigest Serafa alluvial fan, at the mouth of its valley at the Forecarpathians, was poured to the wide Drwień depression (comp. Kalicki 1992a). In the morphology of this very flat alluvial fan (slope about 1‰) there are seen elongated and radialy placed four elevated zones probably marking various courses of the Serafa river bed during the development of the fan. Two of them the most distinct. One accompanies the recent river bed, along the second, of the direction N–S, the research cross section of the lenght of about 900 m has been located. Three borings were done on the alluvial fan, and two further within the Drwień depression. The cross section was prolonged to the lying on the left bank of the Drwień river profile Rybitwy R/87 (it was newly analysed and dated), and which, together with the profile Rybitwy R1 characterizing the age and the structure of the Drwień depression (comp. Kalicki 1992a). It allows to analyse the stages of accumulation of the alluvial fan, also, the relation between its sediments and the alluvia of the braided Vistula of the Drwień depression (Fig. 4 A, B).

The oldest stage was connected with the functionning of the braided Vistula which, while flowing along the Drwień depression, accumulated gravel--sandy alluvia (gravel of the diameter 2 cm, maximum up to 6.5 cm) of various degree of sorting: from the moderately good one to the very bad one (Mz = –0.8 to 2.1φ; $\delta_I = 0.6 - 2.8$ in profiles OK4, OK5 and R/87). However, the sediments of the alluvial fan coming from this period (profiles OK1–OK3), though similarly sorted ($\delta_I = 0.7 - 2.2$), are decidedly more sandy (Mz = 0.9 – 2.9φ) and, locally, silty with gravel of the diameter up to 0.5 cm (maximum up to 2 cm). The finer fractions came from washing away of the Miocene clays and sands in the Serafa drainage basin. At some places (profile OK1) the alluvial fan is covered over 1 m with badly sorted sands (Mz = 2.0φ; $\delta_I = 1.4$). Up to the present, dating of peats in the profile R1 has shown that the braided channel sediments of the Vistula in the Drwień depression are older than 11,920 ± 170 BP (Kalicki 1992a). The similar age was also shown in the dating of the peaty silts in the profile R/87: 11,630 ± 140 BP (Gd-9,024). However, dating 13,200 ± 200 BP (Gd-6,497) of organic clays overlying the sandy sediments, allows to connect the oldest stage of formation of the Serafa alluvial fan with the end of the Pleniglacial.

The consecutive stages of the alluvial fan accumulation are marked in the fossil depression on its surface (profile OK2). At that time the type of fan sedimentation was considerably changed. On the alluvial fan fine and very fine sediments accumulated divided by organic layers.

On Pleniglacial sandy sediments there lies half meter thick member of organic clays changing upwards to clayey muds (Mz = 7.5φ) very badly sorted (δ_I = 2.7). The accumulation of these sediments occured in Bölling to which shows the date 13,200 ± 200 BP coming from the bottom of this member.

The next phase of accumulation of the alluvial fan is marked by sandy muds (Mz = 5.8φ) very badly sorted (δ_I = 2.5) of the thickness 0.5 m. This phase is closed by the layer of peaty muds the bottom of which was doubly dated at 11,950 ± 150 BP (Gd-4,982) or at 11,830 ± 130 BP (Gd-6,842) (the same sample in two independent sets), and the top was dated at 11,460 ± 160 BP (Gd-6,660). It allows to connect the accumulation phase with the Older Dryas and the stabilization period with the Alleröd.

Next phase of accumulation of the alluvial fan starts with clayey muds (Mz = 7.2φ) and ends with sandy muds (Mz = 5.1 – 5.5φ) very badly sorted (δ_I = 2.5 – 3.5). The whole member of the thickness 0.7 m has a reversed sequence (coarsing upwards). They are covered by a layer of organic clays the bottom of which was dated at 8,750 ± 170 BP (Gd-9,026) and the top at 7,570 ± 250 BP (Gd-9,025). It allows to connect the phase of accumulation with the Younger Dryas and the Eoholocene.

There is a lack of the alluvia fan accumulation in the Mezoholocene. At this time there was depositing of clayey muds of the Vistula river in the Drwień depression functioning as the backswamp (Kalicki 1991, 1992a). This vertical accreation achieved the rate high enough in the Early Atlantic that the elevations in the lower parts of the Serafa alluvial fan built of the Pleniglacial sands (profile OK1) were covered by a thin layer of muds (Mz = 7.7φ). In the period of lower frequency of floods organic clays (Mz = 8.3φ) accumulated in this part of the alluvial fan which were dated at 5,970 ± 120 BP (Gd-6,496). Covering of them by very clayey muds can be connected with the phase of increase of the Vistula activity and the avulsion of its bed in the vicinity of the Drwień depression (comp. Kalicki 1991, 1992a, 1992b). Simultaneously, the lower parts of the Serafa alluvial fan (profiles OK5 and OK1) were included in the area of the Vistula backswamp in which clayey muds (Mz = 8.3–9.2φ) sedimented for a long time reaching considerably big thickness 0.6–0.8 m.

The first sign of the renewed increase of accumulation on the Serafa alluvial fan is the change of the grain size of sediments in its lower part (profiles OK5 and OK1). Clayey muds, typical for the whole Drwień depression, became now even more silty (Mz = 6.7 – 7.5φ) and a little bit better sorted (δ_I drops below 3).

Above this layer occurs a distinct change of the type of sedimentation on the alluvial fan (profiles OK1–OK3). These are strongly varied sandy-silty sediments and in the profiles 3 to 4 fining upwards sequences can be distinguished which prove the vertical accreation. These sediments reach the thickness of about 4 m at the top and about 2 m at the base of the alluvial fan. This member may be divided into two parts. The lower part of the thickness 1.5–2.5 m consists of silty sands (Mz = 2.6 – 4.1φ) badly, and very badly sorted (δ_I = 1.5 – 3.0) interbedded with sandy muds and silty muds (Mz = 4.3 – 6.7φ) even less sorted (δ_I = 1.9 – 3.3). The upper part of the thickness 0.3–1.5 m is built by weakly varied sandy muds badly and very badly sorted (δ_I = 1.7 – 2.2). The tendency of fining of the sediments from the top of the alluvial fan to its base is marked (Mz increases from 5.0–5.1φ to 5.4–5.7φ). The age of this member may be dated only indirectly (profile OK2 younger than 7,570 ± 250 BP; profile OK1 considerably younger than 5,970 ± 120 BP) and may be connected with the Subboreal and the Subatlantic.

THE PODŁĘŻANKA VALLEY

In the middle reach the Podłężanka flows in the section around 3 km wide (0.3–0.7 km) in the depression of the direction SE–NW. In the relief two distinct semicircular widenings which cut the northern slope can be marked. The floor of this depression of the slope 0.2‰ is filled with a vast peatbog of the area 99 ha (Fig. 5). Before the conducting of the melioration (years 1955/56 and 1964) the floor had constantly been swampy and, partly (Warzechowiec) water stagnated through the whole year forming a little pond. Melioration caused the drying of the floor and the Podłężanka river bed became deeper about 0.5 m (Lipka et al. 1975).

In the years 1972–1974 one more longitudinal and three lateral sections across a peatbog were done (Lipka et al. 1975). It was established that peats on 3/4 of their surface are covered by mineral sediments. Mean thickness of peats amounts to 2 m (max. 3.6 m) and they are locally underlayered by sediments of carbonat gyttja the thickness of which oscillates from 0.2 to 2.8 m. In the bed sands and clays occur (Lipka et al. 1975).

In the 80's several borings and outcrops were done in the vicinity of the cross section I–II, III–IV and in the most eastern part of peatbog where profiles Pł17 and Pł40 were located (Nalepka-Paperz oral information). Only bottom parts of the profiles Pł17 and Pł40 were fit for the palynological analysis, since in the upper layers of peats there was the lack of pollen (Nalepka 1991, 1993, 1994). The pollen diagrams and datings (profile Pł17 — 12,650 ± 200 and 11,850 ± 170 BP; profile Pł40 — 11,420 ± 150 BP) allowed to establish that the accumulation of gyttja and peats in the profile Pł17 (depth 3.27–2.33 m) occured from the Oldest Dryas to the beginning of the Alleröd, however, peats and clays in the profile Pł40 (depth 3.43–3.08 m) — from the Oldest Dryas to the beginning of the Bölling.

In 1993 two research borings were done. The first PO I was located on the cross section III–IV of K. Lipka et al. (1975) and had a task to recognize the structure of semicircular widening of the bed. The second drilling PO II was situated in the most eastern part of the peatbog in the area of borings Pł17 and Pł40 (Nalepka 1991, 1993, 1994) and its goal was to seek variety of sedimentation types in the border parts of the peatbog since, up till now, it has not been registered in the central part of the peatbog (Fig. 5).

PROFILE PO I

Under a thin layer of black, organic silty-sandy muds (up to 40 cm) lie, up to 8.0 m, sandy silts and silty sands, grey coloured. It is puzzling why there is lack of agreement between the profile PO I with the cross section by K. Lipka et al. (1975), where alder peats in this area reach the thickness of about 1 m (Fig. 5). Silty sediments may be interpreted as the alluvia of the fossil terrace preserved in semicircular cuts and covered with growing peats. The lack of boring directly under the slope of the valley didn't allow to state if there existed a palaeochannel.

PROFILE PO II

The profile is situated in the most eastern part of the peatbog opposite to the mouth of the Samica valley up to the parallel of latitude depression in which the river changes its name to the Podłężanka. The Quaternary sediments, thickness of which is only 3 m, lie on the erosional top of the Miocene clays on which gravel of the diameter 1,5 cm was found (Fig. 5).

In the Quaternary sediments several members can be distinguished. The lowest (depth 3.10–2.12 m) are built of grey, silty muds ($Mz^* = 5.7 - 5.9\varphi$), very badly sorted ($\delta_I^* = 2.0 - 2.2$) with the organic substance, and in the upper part, the medium sands with silts ($Mz^* = 2.8\varphi$) very badly sorted ($\delta_I^* = 2.4$), gray-beige coloured. Above (depth 2.12–1.62 m) a member of organic sediments occurs (the contents of organic substance 15.5–57.0%). In the upper and lower part of this member peaty silts occur, though, in the middle part — peats. The bottom of the peat was dated at 12,090 ± 120 BP (Gd-11,017), and the top at 11,610 ± 100 BP (Gd-11,019). The third member (depth 1.62–1.22 m) is built by clastic sediments — silty muds ($Mz^* = 5.5 - 6.4\varphi$) badly sorted ($\delta_I^* = 1.7 - 1.9$) with the strata of silty fine sands. The highiest member are peats which, upwards, are more and more silty (the contents of the organic substance decrease from 58–68% down to 47–18%) and they change into organic muds. The growth of peats started in the beginning of the Holocene and their bottom was dated at 9,180 ± 100 BP (Gd-11,018).

DISCUSSION AND CONCLUSIONS

The study in the Serafa and the Podłężanka valleys allow for wider generalizations in connection with the results of the earlier research in the region of Cracow.

The datings in the Podłężanka valley allow to state that both the semicircular cuts of its slopes and preserved in them fossil terrace built of a series of sandy silts and silty sands, and locally covered by the Holocene peats is older then the Late Vistulian. The analagous series of silts in the Serafa valley (Bogucice cross section) comes from the similar period since it is older from Alleröd (11,580 BP).

The oldest date from the bottom of the Vistula valley (simultaneous with the datings from Pleszów II — Kalicki 1992b) proves that the Vistula even in the Younger Pleniglacial was deeply cut and its sediments are found on the whole width of the bottom of the valley (Kalicki 1991). The tributaries refer to this cut. In the Podłężanka valley a deep incision descending 5–6 m below the recent surface of the bottom (comp. the cross sections of Lipka et al. 1975) had been cut even before the Oldest Dryas since the bottom of sediments filling it was palynologically dated at this period (comp. Nalepka 1991, 1994). The intensive erosion in the Forecarpathians basins enabled these tributaries to pour sandy alluvial fans interfingering with gravel-sandy alluvia of the braided Vistula (eg. the Serafa fan at Osiedle Kolejowe site). The research on the Z. Śnieszko (1985, 1987) indicate the intensive cut in the valleys of the upland Vistula tributaries which occured before the Late Glacial.

In sediments of the Forecarpathian tributaries the climatic changes of the Late Glacial are marked by the change of the type of sedimentation. The warmer periods (Bölling, Alleröd, Eoholocene) of richer vegetation were the phases of stabilization of processes both in basins and on alluvial fans, so, organic layers come from these periods. In the periods of cooling when the vegetation was more open the accumulation of clastic sediments occured. The Older Dryas is marked in the sediments of the Serafa alluvial fan (sediments older than 11,950–11,830 BP). The Younger Dryas is marked on this alluvial fan by the member of clastic deposits dating at the period between 11,460 and 8,750 BP. In this member the gradual coarsening of sediments initially occurs and later two simple sequences of the alluvia accreation can be noticed. Also, on the peatbog in the Podłężanka valley a distinct change of the type of sedimentation (a member of clastic sedimentation between the datings 11,610 and 9,180 BP) occured in this period. A gradual change of organic sediments to the clastic ones and, next, back to the organic ones proves that it was not the simple depositional episode but the period of a different type of sedimentation. The Younger Dryas in the Vistula valley caused the change of the river pattern from the meandering to the braided one (Kalicki 1991, 1992a, 1992b) and in the Vistula overbank deposits the increase of the fluvial activity was marked by the coarsening of levee sediments or interruping of organic accumulation in the abandoned channels and in the backswamps (comp. Kalicki 1996b). The intensive overbank accumulation in this period (muds older than 9,850 ± 210 BP) was described in the lowest section of the Raba valley (Alexandrowicz, Wyżga 1992) and also in several other valleys of the southern Poland (Starkel, Gębica 1995).Thus, the changes in the Younger Dryas occured both in the big fluvial systems like the Vistula and in the small ones like the Serafa or the Podłężanka. It is even more interesting to notice that this period is very poorly marked in the palynological diagrams from the western parts of the Sandomierz Basin (for this period, there are mainly diagrams from the Podłężanka peatbog) as only "a slight opening of Pinus forest with Betula and Picea and, maybe, very slight opening bushes of Juniperus" which was conditioned by the local climate different from the Śląsko-Krakowska Upland (Nalepka 1994).

However, in the Eo- and Mezoholocene there was a lack of the crucial changes of the type of accumulation on the alluvial fan and the bottom of the Serafa and the Podłężanka valleys both having a dense vegetation cover. What results from this is that the Holocene phases of the intensified fluvial activity (comp. Starkel 1983) well marked in the whole section of the Vistula river valley near Cracow (Kalicki 1991, 1996c) and noticeable even on the one site (Kalicki, Starkel 1996) are not marked in the small Forecarpathian valleys. Simultaneously, new data coming from the Drwień depression (profiles R/87) shows that big floods on the Boreal/Atlantic border covered the whole valley bottom leading to the change of the type of sedimentation both in the backswamps (8,890 ± 120 BP) and in the ones lying under the opposite scarp of the flood plain paleochannel (Nowa Huta — 8,860 ± 160 BP; Kalicki 1992b). These floods, however, did not reach the Serafa alluvial fan which was a little bit higher. Also, the floods of the Serafa must have been small sized in this period because the accumulation of organic sediments occured on this fan in this period (8,750–7,570 BP). Thus, the intensive accreation of fan of small valeys is missing here (8,390–7,785 BP) known from the Wisłoka tributaries (Alexandrowicz et al. 1981, Czyżowska and Starkel 1996). The lower parts of the Serafa alluvial fan were covered by the Vistula overbank deposits only in the Atlanic and the organic sediments were covered by muds in this area (profile OK1) at the end of a consecutive phase of the intensified Vistula activity (5,970 ± 120 BP) after the channel avulsion in the vicinity of the Drwień depresssion (comp. Kalicki 1992b, Kalicki, Zernickaya 1995). The examples quoted above are fully in agreement with the scheme of the phase of intensified activity elaborated on the basis of the research in the Vistula valley near Cracow for river valleys with wide floodplains (Kalicki 1996a).

Only in the Subboreal and in the Subatlantic a rapid change occurs probably connected with the human activity and the agricultural cultivation of the loess slopes. In the Podłężanka basin a gradual increase of mineral substance in peats occurs which finally leads to the covering of the peatbog in the valley bottom by the humus clays (the top of profile PO II). However, in the Serafa mouth and, also probably in the other valleys, the intensive stage of accreation of the alluvial fans occured the sediments of which considerably differ from the ones deposited in the Eo- and Mezoholocene. The introduction of sediments of a young alluvial fan into the area of the Late Glacial backswamps was also described at the Uszwica mouth (Gębica 1995) and the changes in the type of sedimentation also occured in the bottoms of the little upland valleys in this period (Alexandrowicz 1988, Rutkowski 1991).

The results of research on Forecarpathian tributaries of the Vistula are crucial from the point of view of discussion on the subject of reflection of the climatic changes and of human activity on sediments of valleys of various size. The traces of the increased fluvial activity during the whole period of the Late Glacial and the Holocene can be found in large Central European valleys (Starkel, Gębica 1995, Starkel 1995, Kalicki 1996c). In the investigated small Forecarpathian valleys the reflection on the Late Glacial climatic changes is found, however, the reflection on the period of the full forestation in the Eo- and Mezoholocene is missing. Only the antropogenic deforestation in the Neoholocene caused the almost complete change of the type of sedimentation in small valleys. However, the influence of human activity was so strong that the reflection on climatic changes in these valleys in this period is missing.

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STRESZCZENIE

T. Kalicki

ZAPIS WAHAŃ KLIMATU I DZIAŁALNOŚCI CZŁOWIEKA W OSADACH MAŁYCH POGÓRSKICH DOPŁYWÓW WISŁY KOŁO KRAKOWA

W dolinach pogórskich, miąższe serie mułkowo-piaszczyste starsze od późnego Vistulianu budują kopalną terasę Podłężanki (profil PO I) i wypełniają dolinę Serafy (przekrój Bogucice — osady starsze niż 11 580 BP)(ryc. 1, 2, 3, 5). Serie te zostały rozcięte jeszcze w młodszym pleniglacjale, czego dowodzą paleobotaniczne datowania spągu osadów organicznych w dolinie Podłężanki (Nalepka 1991, 1994) i radiowęglowe osadów w dnie doliny Wisły (13 260 BP w Pleszowie i 13 200 BP na stożku Serafa — Kalicki 1992b). Intensywna erozja w zlewniach pogórskich umożliwiała sypanie przez te dopływy piaszczystych stożków napływowych zazębiających się ze żwirowo-piaszczystymi aluwiami roztokowej Wisły (stożek Serafy — Osiedle Kolejowe)(ryc. 4).

W badanych małych dolinkach pogórskich znajdujemy zapis tylko późnoglacjalnych wahań klimatycznych, natomiast brak jest takiego zapisu dla okresu pełnego zalesienia w eo- i mezoholocenie. Okresy cieplejsze (bölling, alleröd i eoholocen), z bogatszą szatą roślinną były fazami stabilizacji procesów zarówno w zlewniach jak i na stożkach, i z tych okresów pochodzą warstwy organiczne. W okresach ochłodzeń (starszy i młodszy dryas), przy rozrzedzonej roślinności, zachodziła akumulacja osadów klastycznych na stożku Serafy (osady starsze niż 11 950–11 830 BP i ogniwo pomiędzy 11 460 a 8750 BP) i na torfowisku w dolinie Podłężanki (ogniwo pomiędzy 11 610 a 9180 BP)(ryc. 4, 5). Holoceńskie fazy wzmożonej aktywności fluwialnej, dobrze czytelne w całym odcinku Wisły koło Krakowa (Kalicki 1991, 1996c), doprowadzały do zmiany typu sedymentacji w obniżeniu Drwienia (profil R/87 — 8870 BP), a następnie w dolnej części stożka Serafy (profil OK1 — 5970 BP), natomiast nie zaznaczyły się one w małych dolinkach pogórskich (ryc. 4).

Dopiero antropogeniczne wylesienie w neoholocenie spowodowało niemal całkowitą zmianę typu sedymentacji w małych dolinkach. W zlewni Podłężanki stopniowo wzrastała ilość substancji mineralnej w torfach, co doprowadziło ostatecznie do przykrycia zatorfionego dna doliny przez gliny próchniczne (strop profilu PO II — ryc. 5). Równocześnie u wylotu dolin następowało intensywne nadbudowywanie stożków napływowych, których osady różnią się zasadniczo od składanych w eo- i mezoholocenie (ryc. 4).

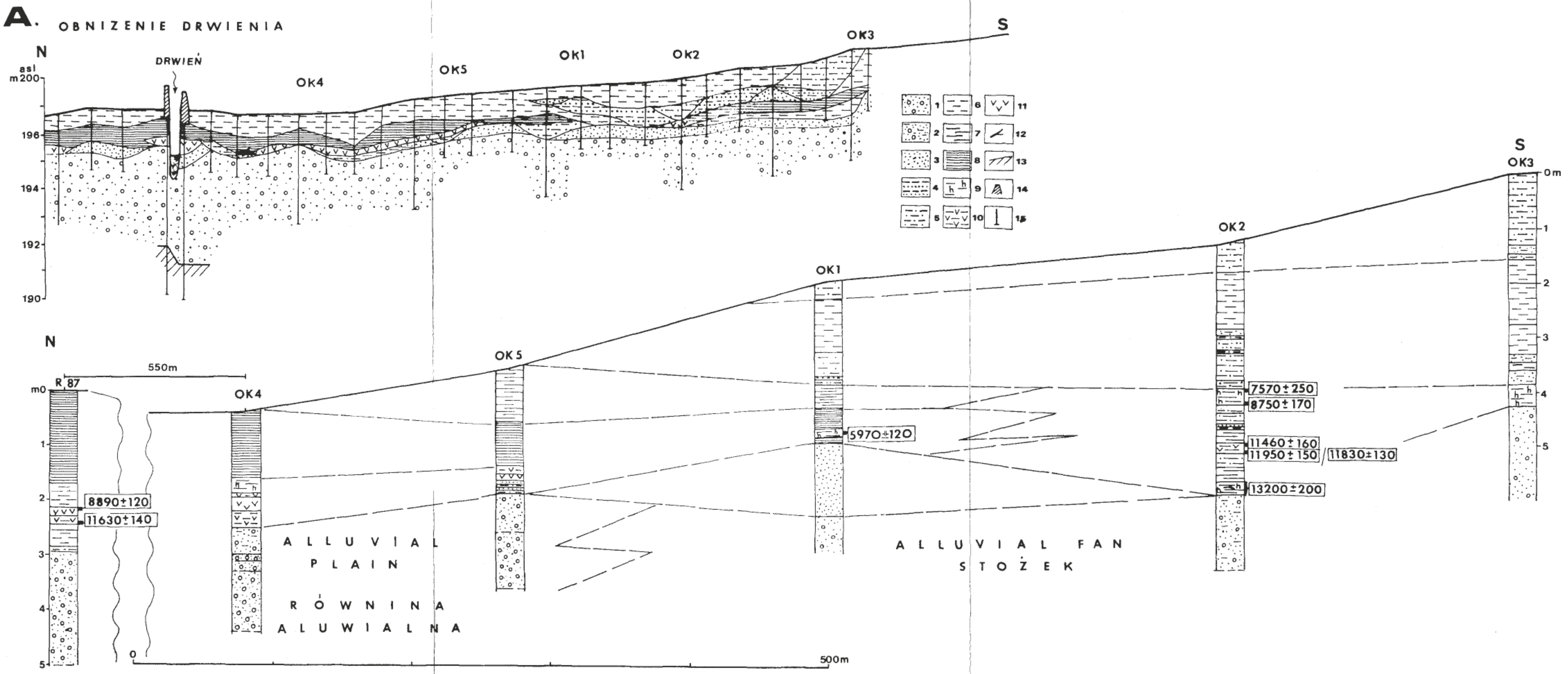

Fig. 4A. General and detail geological sections across the Serafa alluvial fan and Drwień depression (Osiedle Kolejowe–Rybitwy). 1 — gravels with sands, 2 — gravel with sands and silty admixture, 3 — sands, 4 — sands interbedded silts, 5 — sandy silts, 6 — silts, 7 — clayey silts, 8 — clays, 9 — organic silts, 10 — peaty silts, 11 — peats, 12 — woods, 13 — substratum: Miocene clay, 14 — dikes, 15 — borings

Ryc. 4A. Generalny i szczegółowy przekrój przez stożek Serafy oraz obniżenie Drwienia (Osiedle Kolejowe–Rybitwy). 1 — piaski ze żwirami, 2 — piaski ze żwirami, zaglinione, 3 — piaski, 4 — piaski przewarstwione mułkami, 5 — mułki piaszczyste, 6 — mułki pylaste, 7 — mułki ilaste, 8 — iły, 9 — mułki organiczne, 10 — mułki torfiaste, 11 — torfy, 12 — drewna, 13 — podłoże: iły mioceńskie, 14 — wały przeciwpowodziowe, 15 — wiercenia

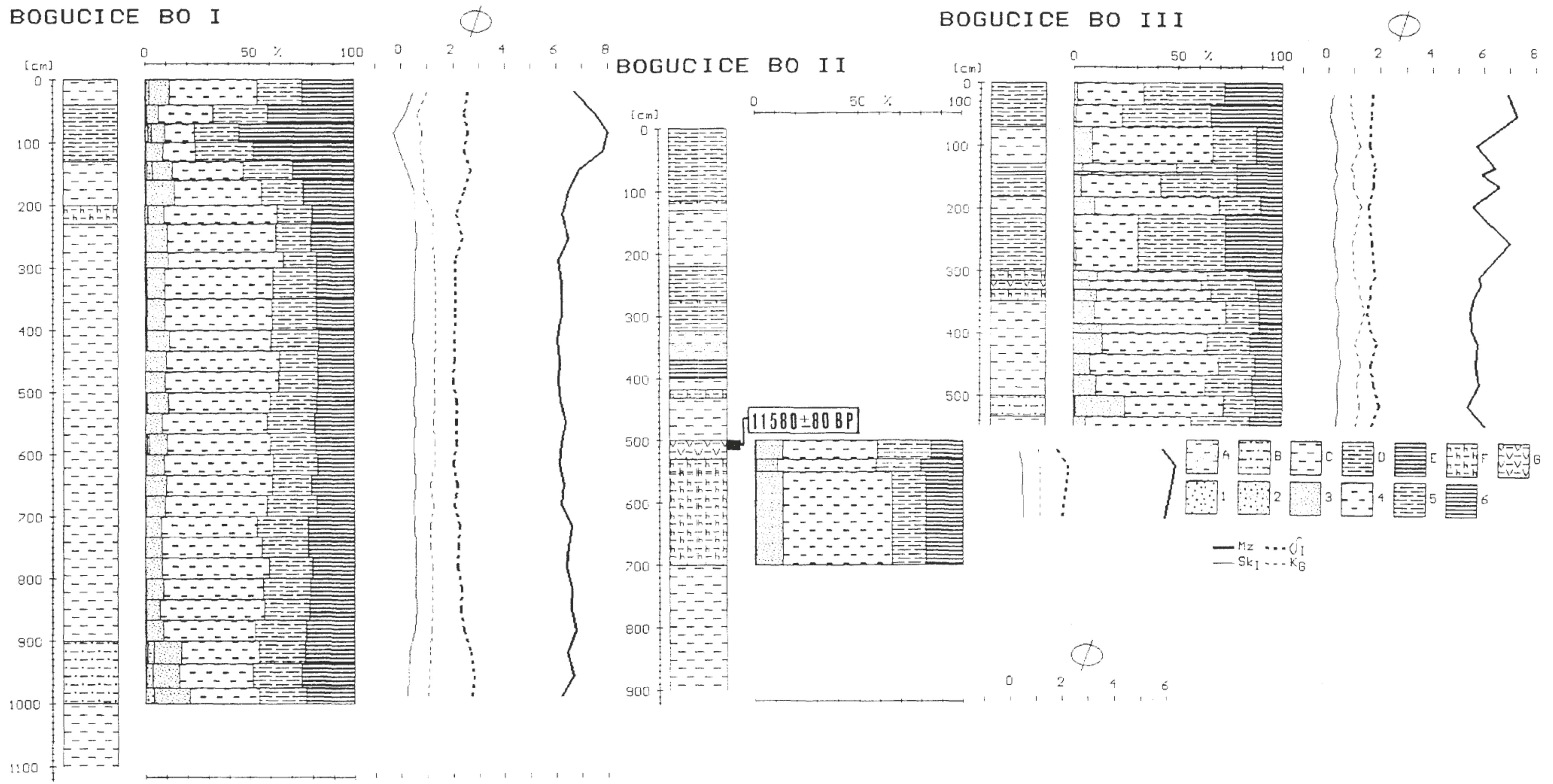

Fig. 3. Bogucice profiles: grain size composition with Folk-Ward's distribution parameters. A — silty sands, B — sandy silts, C — silts, D — clayey silts, E — clays, F — organic silts, G — peaty silts; Fractions: 1 — coarse sand, 2 — medium sand, 3 — fine sand, 4 — coarse and medium dust, 5 — fine dust, 6 — clay; Mz — mean size diameter, δ_I — standard deviation, Sk_I — skewness, K_G — kurtosis

Ryc. 3. Profile Bogucice: skład granulometryczny ze wskaźnikami Folka-Warda. A — piaski zaglinione, B — mułki piaszczyste, C — mułki pylaste, D — mułki ilaste, E — iły, F — mułki pylaste, organiczne, G — mułki torfiaste; Frakcje: 1 — piaski gruboziarniste, 2 — piaski średnioziarniste, 3 — piaski drobnoziarniste, 4 — pyły grubo- i średnioziarniste, 5 — pyły drobnoziarniste, 6 — iły; Mz — średnia średnica ziarna, δ_I — odchylenie standardowe, Sk_I — skośność, K_G — kurtoza

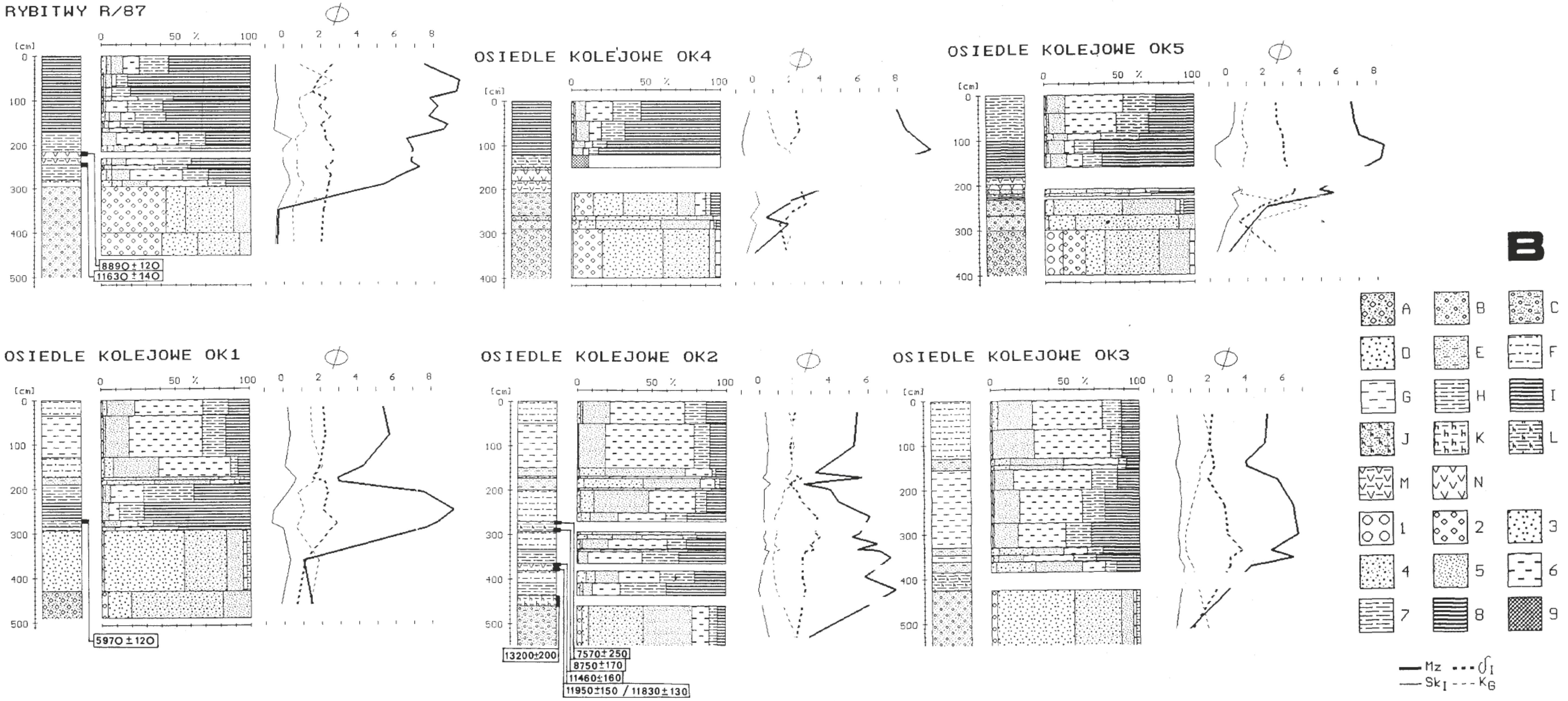

Fig. 4B. Study profiles with grain size composition with Folk-Ward's distribution parameters and organic substance content. A — gravels with sands, B — sands with single gravel, C — sands with single gravel and silty admixture, D — sands, E — silty sands, F — sandy silts, G — silts, H — clayey silts, I — clays, J — organic silty sands, K — organic silts, L — organic clayey silts, M — peaty silts, N — peats; Fractions: 1 — coarse gravel, 2 — fine gravel, 3 — coarse sand, 4 — medium sand, 5 — fine sand, 6 — coarse and medium dust, 7 — fine dust, 8 — clay, 9 — organic substance content, Mz — mean size diameter, δ_I — standard deviation, Sk_I — skewness, K_G — kurtosis

Ryc. 4B. Badane profile ze składem granulometrycznym, wskaźnikami Folka-Warda i zawartością substancji organicznej. A — żwiry z piaskami, B — piaski z pojedynczymi żwirami, C — piaski z pojedynczymi żwirami, zaglinione, D — piaski, E — piaski zaglinione, F — mułki piaszczyste, G — mułki pylaste, H — mułki ilaste, I — iły, J — piaski, zaglinione organiczne, K — mułki pylaste, organiczne, L — mułki ilaste, organiczne, M — mułki torfiaste, N — torfy; Frakcje: 1 — żwiry gruboziarniste, 2 — żwiry drobnoziarniste, 3 — piaski gruboziarniste, 4 — piaski średnioziarniste, 5 — piaski drobnoziarniste, 6 — pyły grubo- i średnioziarniste, 7 — pyły drobnoziarniste, 8 — iły; 9 — zawartość substancji organicznej, Mz — średnia średnica ziarna, δ_I — odchylenie standardowe, Sk_I — skośność, K_G — kurtoza

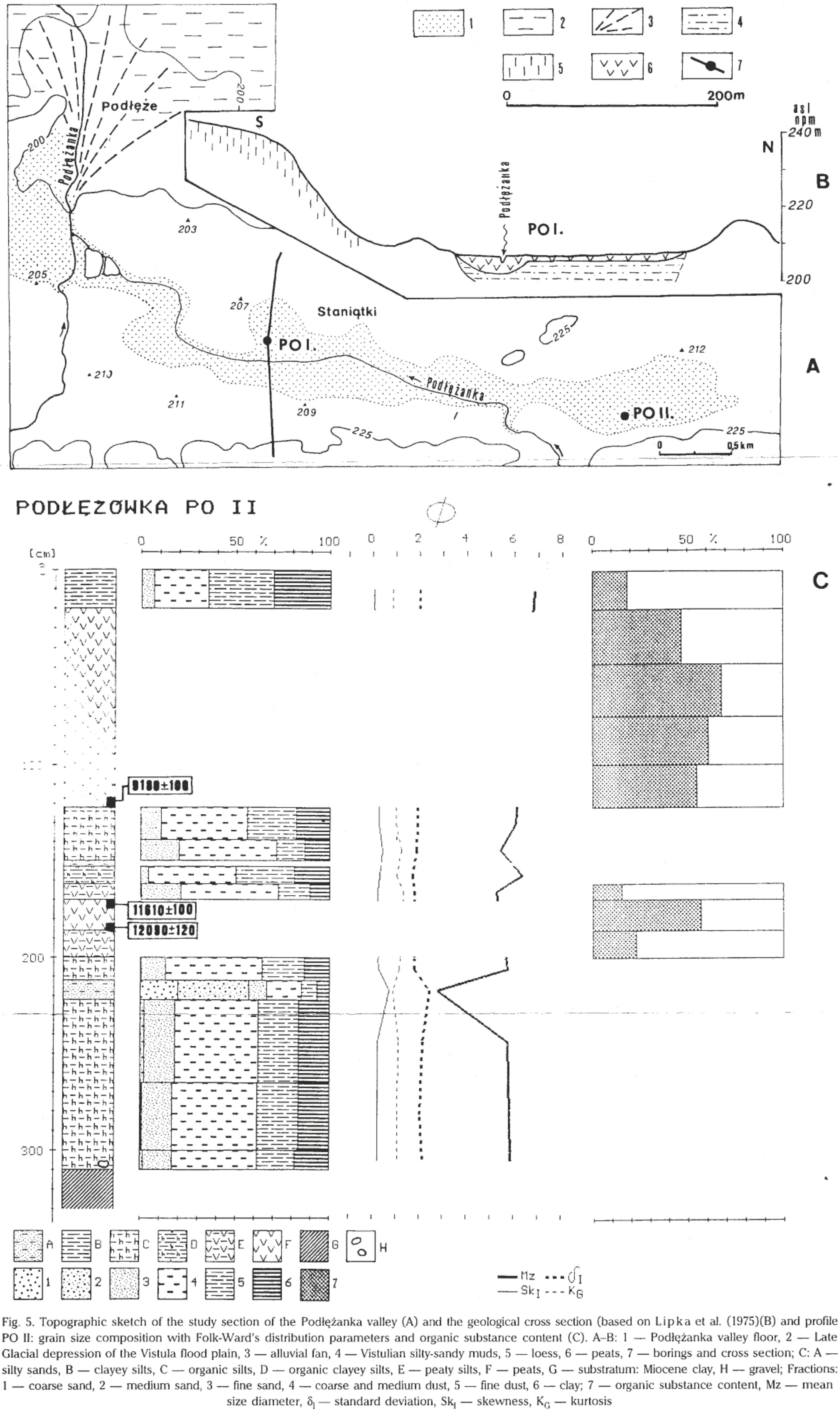

Fig. 5. Topographic sketch of the study section of the Podłężanka valley (A) and the geological cross section (based on Lipka et al. (1975)(B) and profile PO II: grain size composition with Folk-Ward's distribution parameters and organic substance content (C). A–B: 1 — Podłężanka valley floor, 2 — Late Glacial depression of the Vistula flood plain, 3 — alluvial fan, 4 — Vistulian silty-sandy muds, 5 — loess, 6 — peats, 7 — borings and cross section; C: A — silty sands, B — clayey silts, C — organic silts, D — organic clayey silts, E — peaty silts, F — peats, G — substratum: Miocene clay, H — gravel; Fractions: 1 — coarse sand, 2 — medium sand, 3 — fine sand, 4 — coarse and medium dust, 5 — fine dust, 6 — clay; 7 — organic substance content, Mz — mean size diameter, δ_I — standard deviation, Sk_I — skewness, K_G — kurtosis

Ryc. 5. Szkic topograficzny badanego odcinka doliny Podłężanki (A) i przekrój geologiczny oparty na badaniach K. Lipka i in. 1975 (B) oraz profil PO II: skład granulometryczny ze wskaźnikami Folka-Warda oraz zawartość substancji organicznej (C). A–B: 1 — dno doliny Podłężanki, 2 — późnoglacjalne obniżenia w dnie doliny Wisły, 3 — stożek napływowy, 4 — vistuliańskie mułki pylasto-piaszczyste, 5 — lessy, 6 — torfy, 7 — wiercenia i przekrój; C: A — piaski zaglinione, B — mułki ilaste, C — mułki pylaste organiczne, D — mułki ilaste organiczne, E — mułki torfiaste, F — torfy, G — podłoże: iły mioceńskie, H — żwiry; Frakcje: 1 — piaski gruboziarniste, 2 — piaski średnioziarniste, 3 — piaski drobnoziarniste, 4 — pyły grubo- i średnioziarniste, 5 — pyły drobnoziarniste, 6 — iły; 7 — zawartość substancji organicznej, Mz — średnia średnica ziarna, δ_I — odchylenie standardowe, Sk_I — skośność, K_G — kurtoza