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STAGES OF EROSION/DENUDATION VALLEY DEVELOPMENT
IN LATE GLACIAL AND HOLOCENE
WITH THE DRY VALLEY IN THE BONDYRZ REGION
(TOMASZÓW ROZTOCZE) AS AN EXAMPLE

Abstract

Studies of the dry valley situated on the left side of the Wieprz River valley (Tomaszów Roztocze) were carried out. A system of forms and deposits related to the stages of valley development in Late Glacial and Holocene was found. The results of sedimentological and chronostratigraphic analyses allowed to distinguish a few stages of the valley evolution. The presented lithostratigraphic complexes confirm the geomorphological processes occurring in the valley from Plenivistulian to Neoholocene.

INTRODUCTION

Tomaszów (Central) Roztocze is a central mesoregion of the Roztocze ridge constituting a southern part of the Lublin Upland. The western part of the mesoregion belongs to the basin of the upper Wieprz River whose valley assumes the WNW direction in this part. The erosion-denudation valleys reaching the Wieprz valley are a characteristic element of the relief of the Tomaszów Roztocze western part. These forms are of various sizes from relatively small and simple to large and extensively branched forming joint systems. This great differentiation of the valleys reflects morphology of the Wieprz Valley which is distinctly asymmetric in the so called "Roztock" part. The left side is short (up to 2 km), higher (relative height up to 120 m) and quite steep. The right side is longer (up to a few kilometers) and a bit lower – relative relief reaches 90–95 m (Fig.1).

Dry valleys on both sides of the Wieprz valley show distinct morphological differences. On the left side they are more strongly incised and have narrow bottoms (up to 300 m). The valleys cutting the right side are not so deep and their flat or slightly concave bottoms are much broader. An important factor responsible for different morphology of these forms

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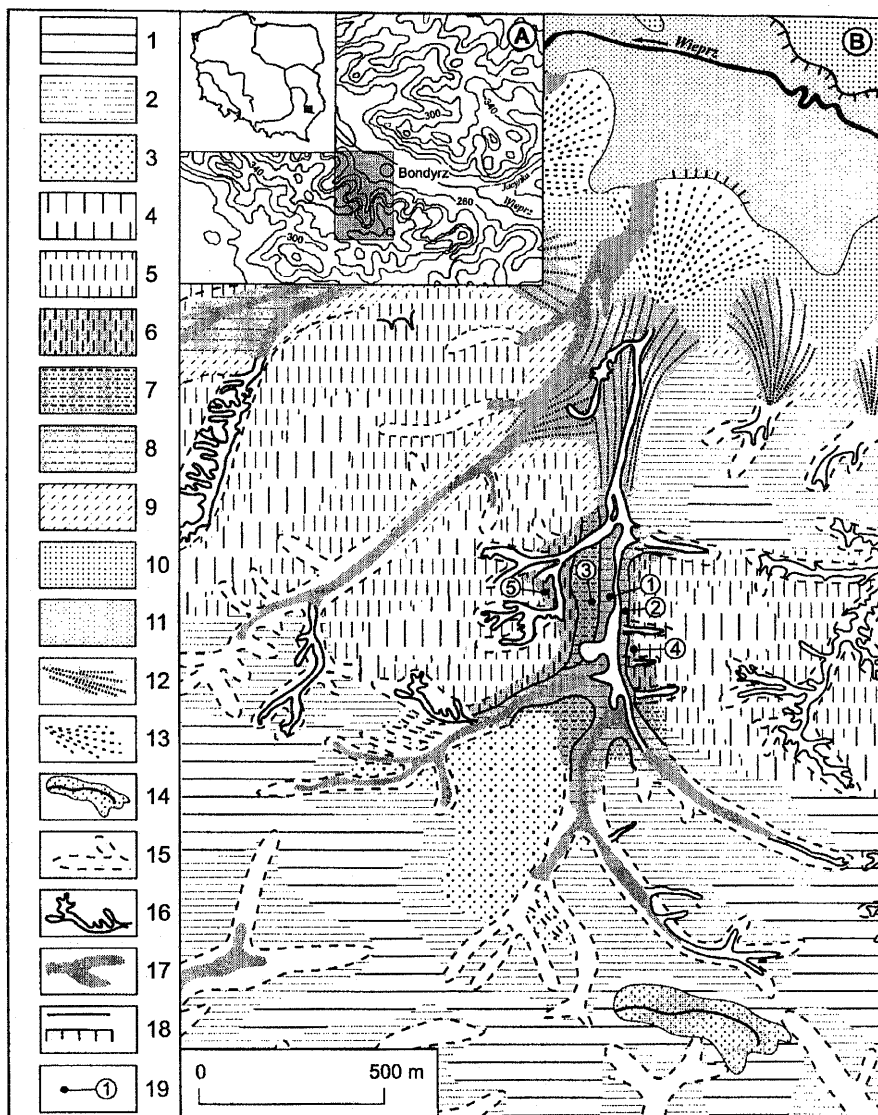


Fig.1. A – Location of the studied valley; B – Geomorphological map of the erosion-denudation valley in the Bondyrz region (Tomaszów Roztocze)

1. top surfaces; 2. slopes with a thin eluvial cover; 3. fluvioglacial sands (Sanian); 4. loessy top surfaces; 5. slopes covered by loess; 6. loess terrace (T1); 7. sandy-silty terrace (T2); 8. silty-sandy terrace (T3); 9. slope-foot deluvia; 10. higher terrace (Vistulian); 11. flood terrace (Holocene); 12. Vistulian alluvial fans; 13. Holocene alluvial fans; 14. dunes; 15. bottoms of erosion-denudation valleys; 16. gullies; 17. bottoms of Holocene troughs; 18. erosion edges; 19. location of the studied profiles

is the occurrence of a loess cover as a compact patch on the left side of the Wieprz valley, between Guciów and Namule (MARUSZCZAK 1995). Loesses of a few to several meters thickness build up slopes and top surfaces. Loesses are favourable for the development of young erosion forms.

The examined form is situated on the eastern part of a valley complex cutting the left side of the Wieprz valley reaching the area close to the church in Bondyrz (Fig. 1). The valley of a length of about 2.5 km is meridionally oriented. Its slopes are asymmetric – the right one is short (about 500 m) and quite steep (30°), the left one is longer (1 km) and more gentle (15°). Lower Maestrichtian gaizes occurring in the basement are exposed within the top surfaces (340–360 m a.s.l.) and slopes in the southern part of the valley (Fig. 1 and 2). A flat top surface is covered by aeolian sands with well developed dunes. In the central and northern parts of the valley

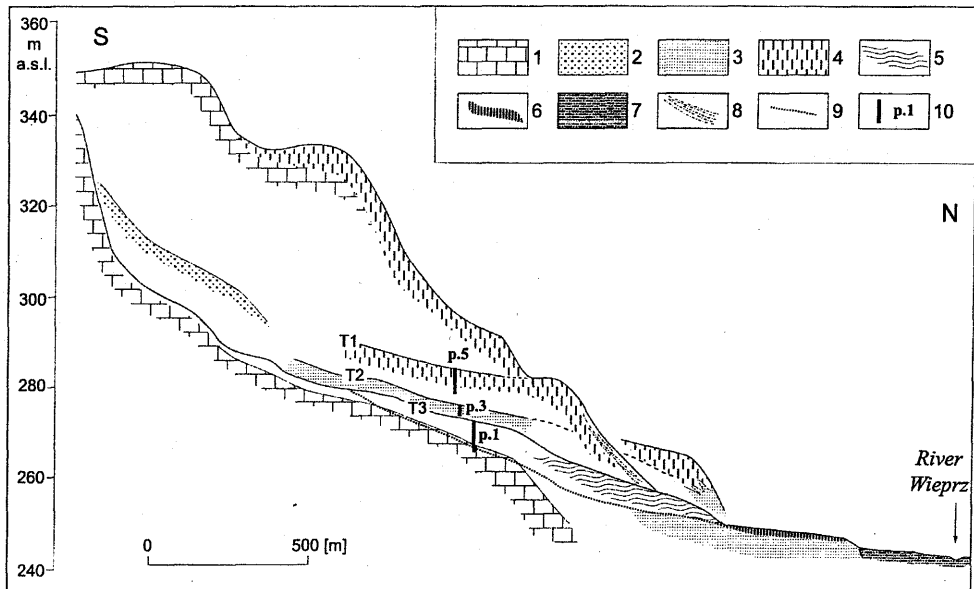


Fig. 2 Longitudinal profile of the dry valley in the Bondyrz region (western slope);

1 bedrocks (gaize); 2. fluvioglacial deposits (Sanian); 3. sandy deposits; 4. loesses; 5. deposits building the Plenivistulian alluvial fan; 6. deposits building the Holocene alluvial fan; 7. flood terrace deposits; 8. deluvial deposits; 9. level of contemporary gully bottom; 10. profile location.

the top surfaces and slopes are covered by loesses (Fig. 3). Moreover, a small area is occupied by fluvioglacial sand residua (KURKOWSKI, 1996). The valley bottom is cut by young erosion forms of gully and road ravine types. Vast alluvial fans were formed on the surface of higher terraces in the Wieprz valley.

Detailed geomorphological studies in the valley under consideration concentrated on the accumulation levels well preserved in its central part (Fig. 3) (GAWRYSIK, ZAGÓRSKI, 1998). The following were distinguished:

- level T1 – loess (Plenivistulian), 15–16 m above the gully bottom,
- level T2 – sandy-silty (Plenivistulian), 9–10 m above the gully bottom,
- level T3 – silty-sandy (Early Holocene), 6–7 m above the gully bottom.

CHARACTERISTICS OF DEPOSITS

In five examined profiles several lithologic complexes were found connected with successive stages of valley development which, based on the chronological criteria, were denoted alphabetically as complexes A–I (Fig. 2, 3, 4).

Directly on the Cretaceous bedrock there are deposited yellow and grey fine-grained sands with the admixture of the medium-grained sand fraction forming complex A of moderate sorting (δ_1 0.74) (profile 1). In the floor it is mixed with sharp-edged rubble of local rocks (gaizes) which gradually disappears (Fig. 3). The sands, strongly disturbed by cryoturbation structures, make the upper part of the complex. These are load structures of the pocket type filled with medium and fine-grained sands of a characteristic blue color (in a wet condition) and veins with strongly cemented hardpan.

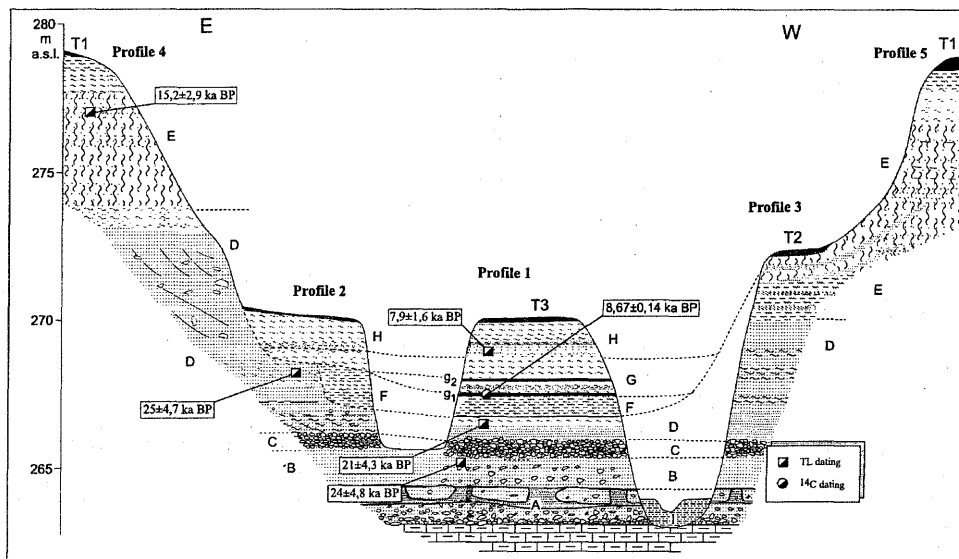


Fig. 3 Geological cross section of the dry valley in the Bondyż region (Tomaszów Roztocze). Description in the paper.

On the erosion roof of complex A marked with a layer of iron oxides a 0.9 m layer (complex B) of laminated fine-grained sands is situated with the admixture of medium-grained sands (Fig. 4; Pl. 1). In the floor, the sands of blue-grey colour are found (profile 1). The middle part consists of two layers of grey-yellow sands with the inserts of gaize rubble. However, in the upper part interbeddings of blue and blue-yellow sands occur. They were dated at 24 ± 4.8 ka BP using the TL method. The average diameter of grains ranges from 1.95 to 2.08 and the sorting index (δ_1 0.74–0.93) in-

indicates the average sorting. The sediment was formed at great changeability of the environment energy (Fig. 4). The coarse-grained material (gaize rubble) was deposited in the first stage. Then at gradually decreasing energy, the finer sediment could be deposited. This cycle was

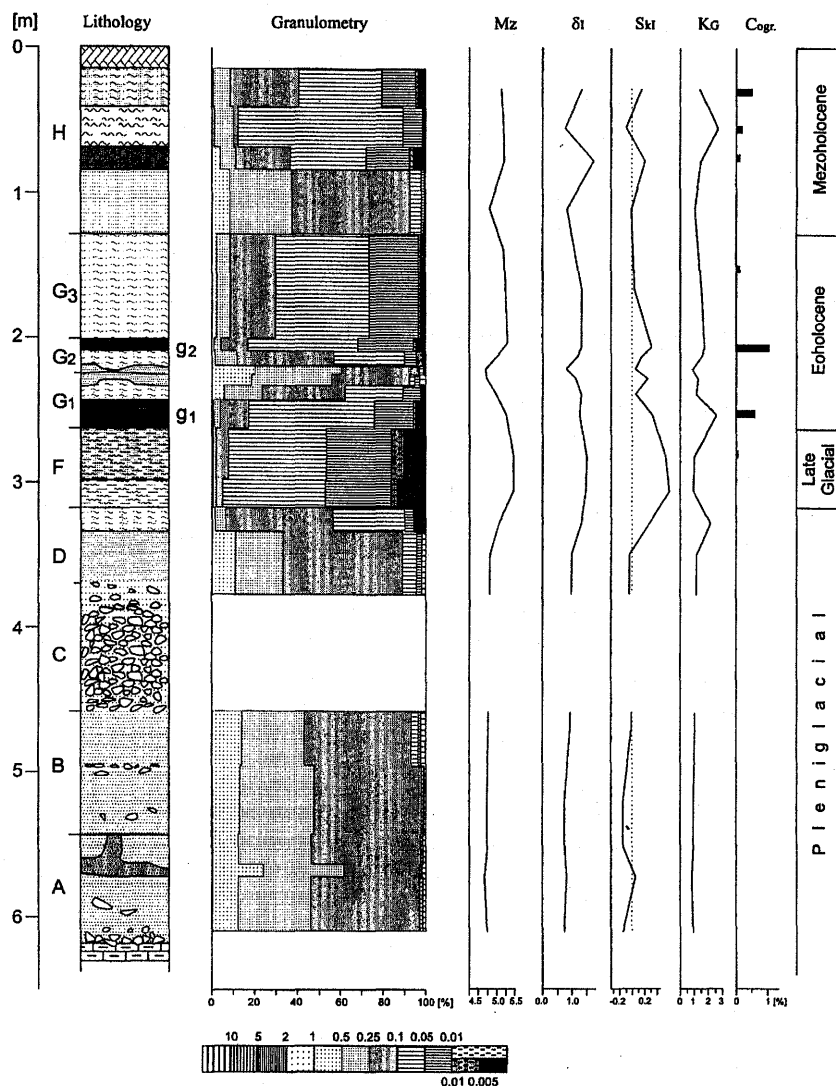


Fig. 4 Lithology, grain-size distribution, graining indices and stratigraphy of the deposits building the accumulation level T3 (profile 1). Description in the paper.

repeated several times. Negative values of skewness ($Sk_{-0.01-0.01}$) indicate unfavourable conditions for deposition of silty and clayey fractions whose amount does not exceed 2.3% in the lower part and 7.3% in the upper one.

Complex C covering the complex B is formed by a layer of 1 m thick solifluction rubble (carbonate-free gaizes, single fragments reacted to HCl) mixed with coarse and medium-grained sands cemented with iron oxides (profile 1; Pl. 1, 2).

Above the solifluction layer in profile 1 a grey and grey-blue fine-grained sand is found changing into light-grey fine-grained silty sands towards the roof (complex D) (Fig. 4; Pl. 2). This part of the complex shows distinct lamination, slightly disturbed by fine frost structures of the elementary ice veinlet type, determined as a result of permafrost occurrence (KLATKOWA, 1996). The age of these forms was TL dated at 21 ± 4.3 ka BP. The deposit sorting changes towards the roof from the average (δ , 0.98) to the weak one (δ , 1.31). The roof of the complex D was eroded in the axial part of the valley. The remaining parts are exposed in profiles 2 and 3 and in the floor of profile 4. In profile 2 on the layer of solifluction rubble (complex C) grey-yellow medium-grained sands are deposited which are silty with weak and average sorting (δ , 1.45–0.92) in the lower part. Their TL age was determined at 25 ± 4.7 BP (Fig. 3). The sand is covered by grey-yellow sandy silt with rusty interbeddings changing into fine and coarse-grained sands with the admixture of silty fraction. The sorting index is from 1.31 to 1.13 and indicates weak sorting, whereas the conditions were favourable rather for washing away fine-grained fractions (Sk , –0.01).

Complex D deposits form an accumulation level T2 on the other side of the contemporary gully (profile 3) (Fig. 3). These are mainly medium and fine-grained sands with silty sand interbeddings. A thick layer of complex D forming an accumulation level in the valley is exposed in the road incision about 150 m south of the profile 1. It is built of medium and fine-grained sands of yellow-grey colour and of average sorting (δ , 0.79). Rusty interbeddings of indistinct lamination, inclined towards the valley axis, are found in the sands. The value of the average grain diameter is 2.04. The amount of the fraction below 0.1 mm does not exceed 7%.

The roof of sandy deposits was also found in profile 4 (Fig. 3). Grey and yellow fine-grained sand with the admixture of silty fraction, is found under the complex E. The deposit sorting is much weaker (δ , 1.66) but the average grain diameter (M_z) is 3.49.

Complex E is built mainly of grey-yellow sandy loesses with very differentiated amounts of 0.1 – 0.01 mm fraction (40.7 – 79.7%) and of fine sand (11.4 – 41.2%). The average grain size is from 3.37 to 4.90 in the roof part of the complex, where the percentage of clayey fractions increases significantly (up to 15.9%). Sorting in the whole complex is stable and weak (δ , 1.1–1.66). In the upper part of loesses (decalcified) well formed horizons of lessivé soils are found (profile 4). Carbonate loess appears at a depth of 1.4 m. In this part of the profile there are also found rare carbonate

concretions. The loess age (profile 4) was determined at 15.2 ± 2.9 ka BP using the TL method.

Profile 5 situated on the opposite slope of the valley covered with a series of over 5 m thick silty deposit, is characterized by a little different structure (Fig. 3). This is a grey and yellow sandy loess with rusty inserts and with an increasing number of sandy interbeddings towards the floor. In the upper part of the profile, similar to profile 4, there is a horizon of lessivé soil. Decalcification of the complex reaches a depth of 1.9 m. Towards the bottom of the valley sandy loesses change into carbonate-free deluvial and deluvial-alluvial loesses with sandy interbeddings which build up level T2.

Complex F deposits fill the trough depressions eroded in the sandy deposits of complex D (profile 1; Fig. 3 and 4; Pl. 2). These are massive and strongly gleyed clayey muds of a thickness of 0.6 m. In the lower part they are a little brighter and laminated but in the upper part they are more strongly gleyed with faded lamination. The complex is characterized by an average grain diameter (M_z) from 4.86 to 4.90 and weak sorting (δ_1 1.47–1.49). It was formed at a lower dynamic activity of the environment favourable for finer fraction deposition (S_k 0.60–0.54) and in high moisture (gleying). The presence of organic carbon (0.09%) was observed here.

Above complex F cut due to erosion and washing away, deluvial deposits were deposited with two horizons of soil sediments (complex G) (profile 1; Pl. 3). In the lower horizon (G_1) of a thickness of 0.2 m, the organic material g_1 (C_{org.} 0.66%) was mixed with bright grey silty sand (Fig. 3 and 4) in which fragments of dry-rot wood, dated at 8.67 ± 0.14 ka BP by 14C method, were found. The organic layer g_1 is covered by blue-yellow silty sands. In the lower parts, the disturbances resembling ripple marks occur but towards the top they pass into horizontal stratification. In the roof of complex G_1 medium and fine-grained sands occur in yellow-rusty colour with abundant dark spots. The average grain diameter (M_z) decreases upwards from 2.92 to 1.92, and δ_1 from 1.31 to 1.12 (weak sorting). This indicates one sedimentation cycle connected with strong surface erosion in the valley bottom and deposition of soil deluvia removed from the slopes.

On complex G_1 a 0.2 m layer (G_2) of bright grey medium and fine-grained sand is situated as well as grey-blue silty sand. The sands are characterized by a distinct oblique lamination of disturbed character. The value of index M_z ranges from 1.76 to 3.14 but sorting is average (δ_1 0.79) and weak (δ_1 1.19). In the roof there is a 0.2 m thick organic layer (g_2 – C_{org.} 1.10%) with distinct signs of displacement.

Complex G_3 is built of grey-blue sandy silt of a thickness of 1 m (Fig. 4; Pl. 3, 4). In the lower part it is laminated with rusty inserts becoming more uniform and strongly gleyed with rusty colour penetration towards

the roof. The average grain diameter is 3.81 and the index is δ_1 1.33 (weak sorting). Disappearance of lamination in the upper part of the complex indicates the period of bottom stabilization and intensification of pedogenesis.

Complex G deposits are covered by bright grey sand (complex H) with a significant admixture of fine-grained sand fraction of slightly disturbed lamination (Pl. 4). Its age was TL determined at 7.9 ± 1.6 ka BP. The value of M_z index is 2.2, but the deposit sorting is just average (δ_1 0.82). During deposition the surface wash caused the removal of silty and clayey fractions ($Sk_1 - 0.01$) whose amount did not exceed 7.9%. In profile 1 the sands are covered by silty-sandy, weakly sorted (δ_1 1.74) deluvia, changing upwards into silts and sandy silts. The average grain diameter shows small changeability (3.81–3.62) but the value of index δ_1 increases towards the roof (δ_1 0.76–1.34 – median sorting reverts to weak).

Complex H constitutes a bedrock for the contemporary soil developed in the roof. Its development was possible at the time of bottom stabilization and beginning of grooving erosion which caused the formation of gullies. The gully bottoms undergo aggradation and are filled with sandy muds of deluvial-alluvial facies (complex I).

STAGES OF VALLEY DEVELOPMENT

From the collected materials an attempt was made to reconstruct the valley development. The authors distinguished four periods:

Pleniglacial period. The oldest found deposits (complex A) represent the stage of valley aggradation at the early Upper Pleniglacial (Main Stadial). It was preceded by a period of strong erosion which led to removal of older deposits from the valley bottom in the end of Middle Pleniglacial (the turn of Grudziądz Interstadial and Main Stadial) (SUPERSON, 1996). The advancing aggradation of the valley affected intensive washing processes, particularly along the valley which formed a series of sands with involitionally disturbed stratification (complex B).

During the later stage more severe climatic conditions led to the formation of a solifluction cover developed as strongly cemented with iron oxides coarse-grained sands with gaize rubble (complex C). Most fragments are sharp-edged which indicates the delivery of the material directly from denudated slopes.

After deposition of the solifluction complex, the valley was filled again with a thick series of sandy deposits (complex D) as a result of intensive blowing of material along the courses of the so-called sandy streams (BURACZYŃSKI, 1997; SUPERSON, 1987/88, 1996). Sandy deposits of complex

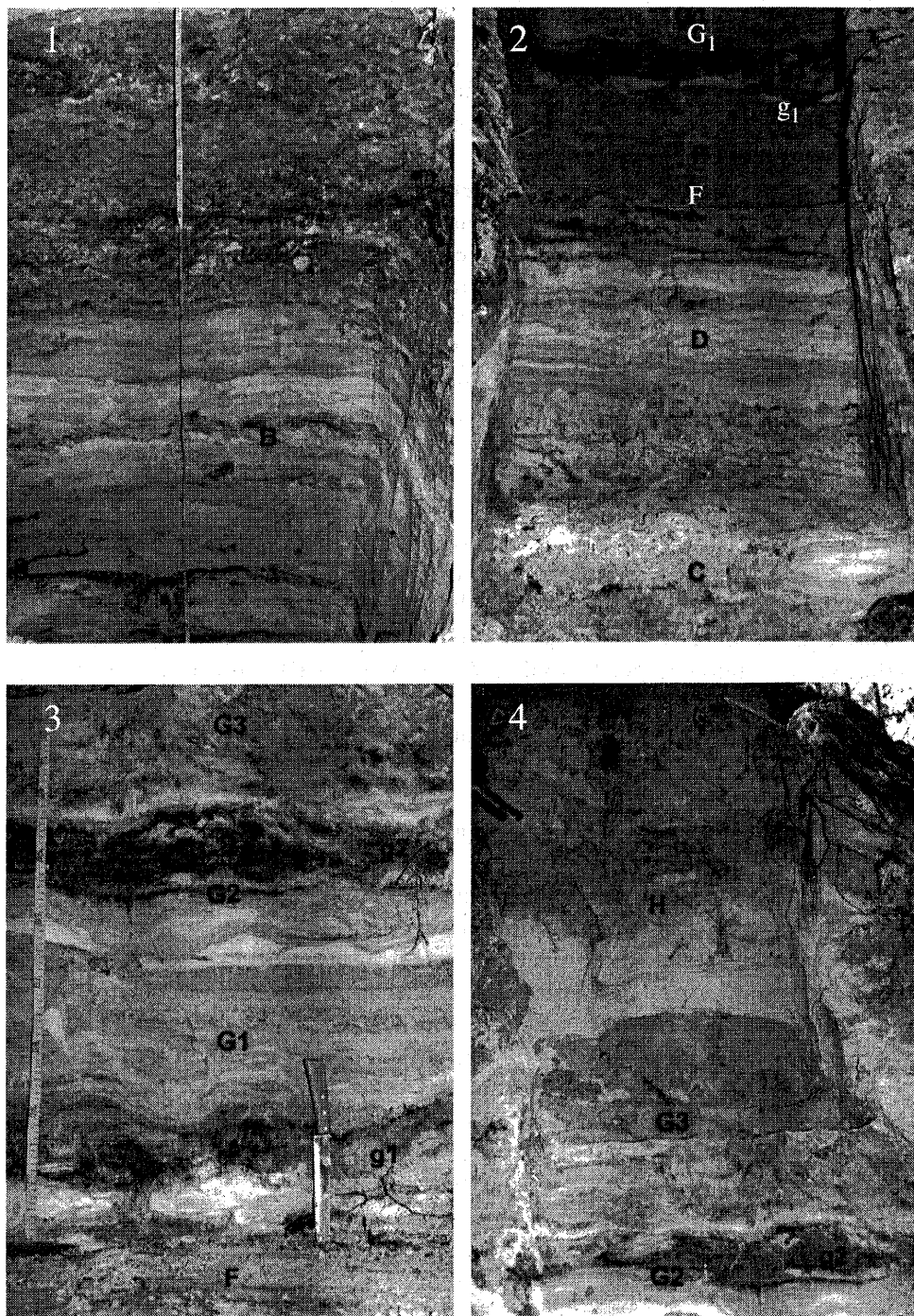
D were formed in two ways: on the slopes as aeolian-deluvial covers forming an accumulation level T2 (profiles 3 and 4) and aeolian – alluvial ones in the valley bottom (profile 1), laminated and disturbed by the structures of the elementary ice veinlet type (Fig. 3). Vast areas of alluvial fans were formed in the valley mouth (BURACZYŃSKI, 1997; JAHN, 1956; SUPERSON, 1996) (Fig. 1 and 2).

In the next stage at the end of Plenivistulian on the valley slopes were accumulated carbonate loesses (accumulation level T1). A part of aeolian material was redeposited and leached due to washing and solifluction processes and was accumulated in the valley bottom. The sandy deposits underlying the loesses were translocated which caused interfingering of loess and sandy deposits as found in the accumulation level T2 (profile 3). A great amount of sandy fractions in the loesses can constitute evidence for the close transport of aeolian material probably within the distance from the valley bottom to the slope.

Late Glacial Stage started with a period of strong grooving erosion which led to the dissection of level T2 and to the formation of erosion gully (Fig. 3). This phase is correlated with the warming of the Alleröd Interstadial (MARUSZCZAK, 1998). After the period of intensive erosion, probably during the period of Younger Dryas cooling, the accumulation of muddy deposits took place (complex F). The effect of valley transformation in this period were forms of the erosion – denudation valley type filled with denudation products (MARUSZCZAK, 1998).

Early Holocene Stage. In the early phase, probably in the Preboreal period, intensification of pedogenesis took place. The evidence of this is strong gleying and a lack of lamination of muddy deposits of complex F and the presence of organic carbon (0.09 %) (Fig. 4). Two series of soil sediments (complex G) are deposited directly on the eroded roof of the complex F. In the lower part, a wood fragment of the deciduous tree, probably of the *Alnus*¹ is preserved. It allows to determine the phase of sediment accumulation coming from the soil cover degradation after the Preboreal period. This is in agreement with pollen analysis made for the peatbog in Krasnobród nearby where, it was stated, the *Alnus* succession started in the Boreal period (BAŁAGA, 1998). The upper horizon of the soil sediment g₂ is covered by sandy muds which are indistinctly laminated in the lower part, and pass towards the roof in the gleyed ones without lamination (Fig. 4). These features of the deposit indicate next period of valley bottom stabilization and development of pedogenesis, after which the profile upper part was eroded. Erosion in the valley bottom could be

¹ Preliminary identification of tree species was made by dr M. KRAPIEC in the Laboratory of Dendrochronology, Academy of Mining and Metallurgy, Cracow



Pl. 1-4. Profile of the building the accumulation level T3. The distinguished lithologic complexes are marked with letters. Description of the complexes in the paper

connected with strong processes of surface washing after which deposition of fine-grained sand and sandy muds of complex H falling on the beginning of the Atlantic period took place.

Late Holocene Stage. In the first phase of valley modelling, dissection of the lowest accumulation level (T3) and gully system development took place. Human activity, which was an impulse for creation of young erosion forms, played a significant role in this stage. Maybe this phase falls on the X–XI centuries when in the valley of the upper Wieprz intensification of colonization development took place (BURACZYŃSKI, 1997; MARUSZCZAK, 1997, 1998; ZOLL-ADAMIKOWA, 1974).

Translation by M. Charmas and T. Grzesik

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