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MARIA KRYSOWSKA-IWASZKIEWICZ, WITOLD ZUCHIEWICZ (CRACOW)

SLOPE-WASH DEPOSITS OF THE ZAKLICZYN DEPRESSION, WEST CARPATHIANS: SEDIMENTOLOGICAL AND MINERALOGICAL ASPECTS

INTRODUCTION

The paper discusses sedimentological and mineralogical properties of slope-wash (deluvial) deposits, occurring on the southern flank of the Zakliczyn Depression in the Outer West Carpathians. Unusually great thickness of these deposits and their relation to other morphological features, like Middle through Late Quaternary fluvial terraces, provide a good opportunity for palaeogeographic reconstruction of that area.

GEOMORPHIC SETTING

The Zakliczyn Depression (205—250 m a.s.l.) belongs to the Wieliczka Foothills mesoregion (Klimaszewski 1946; Gilewska 1986), forming a part of the West Beskidy Foothills (Figs. 1, 2). In southern part of the Depression, above the terraced Dunajec River valley floor, there rise flat-topped ridges (275—325 m a.s.l.), dissected by dendritic and trellis network of V-shaped valleys and gullies (Fig. 3). Further to the south, NW—SE, NNE—SSW and ENE—WSW trending ridges occur, being overtopped by mound-like summits of Patria, Mogiła, and Styr. The western boundary of the area studied forms a Dunajec river bend at Filipowice, the eastern boundary follows the Paleśniczanka stream valley. The central part of the southern margin of the Depression at Stróże is occupied by a meander spur showing planated crest (260—265 m a.s.l.).

GEOLOGIC SETTING

The southern part of the Zakliczyn Depression is eroded within flysch deposits of the Silesian Nappe (Fig. 2). These are mainly Paleogene rocks that build the Uszew — Zakliczyn syncline. Between Stróże and Brzozowa, Upper Cretaceous-Paleogene rocks crop out, composing the near Zakliczyn anticline. Along northern slopes of the Mogiła, Patria and Styr ridges, a narrow belt of Lower through Middle Cretaceous rocks occurs, being accompanied by Upper Cretaceous deposits on the south. These sequences form the imbricated Czchów anticline (Książkiewicz 1972).

The Lower and Middle Cretaceous sequence includes the Upper Cieszyn shales, Godula beds and Lgota beds, whereas ridge-forming, thick-bedded Godula and lower Istebna beds are of Upper Cretaceous age. The meander spur at Stróże is composed of Senonian-Palaeocene sandstones and shales of the upper Istebna beds. The Eocene Ciężkowice sandstones crop out near Filipowice, whilst the Oligocene Krosno beds can be traced to the south of Stróże and close to Wola Stróska (Burtan *et al.* 1981).

One of main fault zones, oriented ENE—WSW, runs south of the Dunajec river bed; subordinate faults (N—S) are noticeable to the east of the Paleśniczanka stream valley (Książkiewicz 1972).

QUATERNARY DEPOSITS: STATE OF RESEARCH

Quaternary deposits of the area in question include Pleistocene and Holocene alluvia, alluvial fan deposits, landslide colluvia, solifluction-deluvial covers, loess, erratic boulders and cobbles, calcareous tufas and regolith covers (Fig. 3).

Quaternary fluvial and fluvioglacial covers of the Stróże—Zakliczyn area were studied by Smoleński (1920) and Klimaszewski (1937, 1948, 1961). The former author described „impoverished" fluvial gravel series, composed of granitic and quartzitic cobbles, exposed at a height of 260 m above the Dunajec valley floor (472 m a.s.l.) at Bieśnik, close to the Paleśniczanka stream. Klimaszewski (1973, 1948), in turn, distinguished a flight of 4—6 m, 8—15 m, 20—25 m, 45—55 m and 80—90 m terraces of the Dunajec river. The three highest terraces were considered to be related to the so-called „high infilling" of the Dunajec valley during the transgression, stagnation and recession of the antepenultimate (Cracovian) icesheet. Deposits exposed in SW part of the Stróże meander spur (Fig. 4) were interpreted (Klimaszewski 1961) as forming one sedimentary sequence, being composed of slope-wash deposits overlain by fluvioglacial gravels and the so-called „mixed gravels" (330—260 m a.s.l.) including, besides local rocks, also Scandinavian material, and deposited during the icesheet recession. The basal slopewash deposits (13—23 m above the Dunajec river

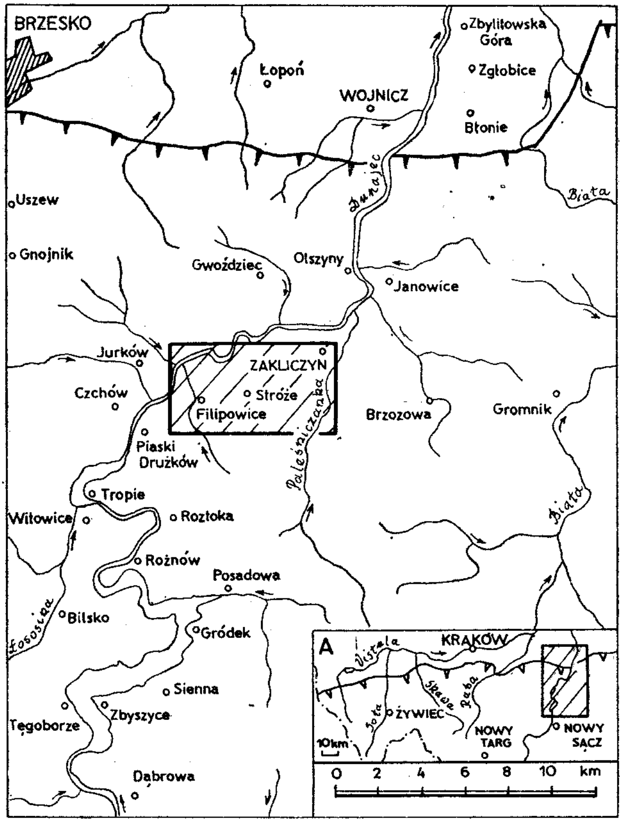

Fig. 1. Localization sketch. Hatchured rectangle marks the area shown in Figs. 2 and 3, thick barbed line — Carpathian border thrust

Ryc. 1. Szkic lokalizacyjny. Szrafura wyznacza obszar przedstawiony na Ryc. 2 i 3, linia ząbkowana — główne nasunięcie Karpat fliszowych

bed) were thought to represent anaglacial phase of the Cracovian glacial stage, whereas the overlying gravel series would have represented a pleniglacial period of glacifluvial deposition of the same stage. During the icesheet recession, the ancient Dunajec river was supposed to have been directed to the neighbouring Biała Dunajcowa drainage basin via the Siemiechów Depression, situated shortly east of Zakliczyn. Sandy loams forming intercalations within gravel series at Stróże were reported (Klimaszewski 1937) to have contained bones of a „large diluvial animal", exploited up completely at the close of the 19th century.

In more recent times, the Stróże site has been associated with either Middle-Polish (Starkel 1980, Burtan *et al.* 1981) or South—Polish (Starkel 1984) glacial stages.

FLUVIAL DEPOSITS

Fluvial deposits build Holocene terraces, 2—3 m and 5—6 m high, occupying vast, flat valley floor in the western part of the Zakliczyn Depression (Fig. 3). Pleistocene terraces have been preserved along the southern margin of the Depression, as well as on the meander spur at Stróże.

The Last Glacial (Vistulian) terrace step, overlain sometimes by alluvial fans of right-hand tributaries to the Dunajec river, rises at 8—10 (15) m of relative height, attaining the largest extent between Wesołów and Zakliczyn (Figs. 2, 3). This is an accumulational and erosion-accumulational terrace, displaying uneven rock socle that can be traced at heights ranging from +6 to —7 m in relation to the present river bed. Thickness of alluvia changes from 5 to 17 m, increasing within fossil channels.

Fragments of terraces formed during the penultimate glacial stage are preserved on western slopes of the Stróże meander hill and south of Zakliczyn, on western side of the Paleśniczanka stream valley. Their relative heights diminish eastwards, from 23—29 m to 20—25 m. The gravel series at Stróże, underlain by sandy and sand-silty slope-wash deposits, cut at 20—22 m above the Dunajec river bed, has been assigned by Klimaszewski (1937, 1948, 1961) to the antepenultimate (Cracovian) glacial stage.

A vast flat crest of the Stróże meander spur is composed in its southern part (Fig. 3) of a gravel series (Figs. 4, 7), cropping out at 32—36 m, 34—40 m and 42—45 m of relative heights, i.e., up to 262 m a.s.l. This series comprises cobbles of flysch- and Tatra-derived rocks, resting on a rock socle, 28—34 m high. These deposits form, hence, a higher alluvial series, above which erratic material and, according to Klimaszewski's (1937, 1948) description, patches of „mixed gravels" can be found. The series can be associated with the Sanian (Elsterian-2) glacial stage.

On top of the Ostra Góra Mt., in northern part of the Stróże spur, as well as at feet of slopes of the Patria—Mogiła ridge, poorly preserved gravel series can be traced, being composed of the flysch- and Tatra-derived material and devoid of erratic cobbles. The gravels occur within height interval of 50—54 to 55—58 m (up to 274—280 m a.s.l.), their rock socles being situated at 48 to 54 m above the present Dunajec river bed. We consider this series as one belonging to the Nida (Elsterian-1) glacial stage (Figs. 3, 4).

Above Pleistocene terrace steps, flat-topped ridges of the Ciężkowice Foothills rise up, being levelled at 90—100 m, 130—150 m and 170—220 m of relative height. These flats refer to the riverside (Early Quaternary), foothills (Late Pliocene?) and intramontane (Early Pliocene?) planation surfaces.

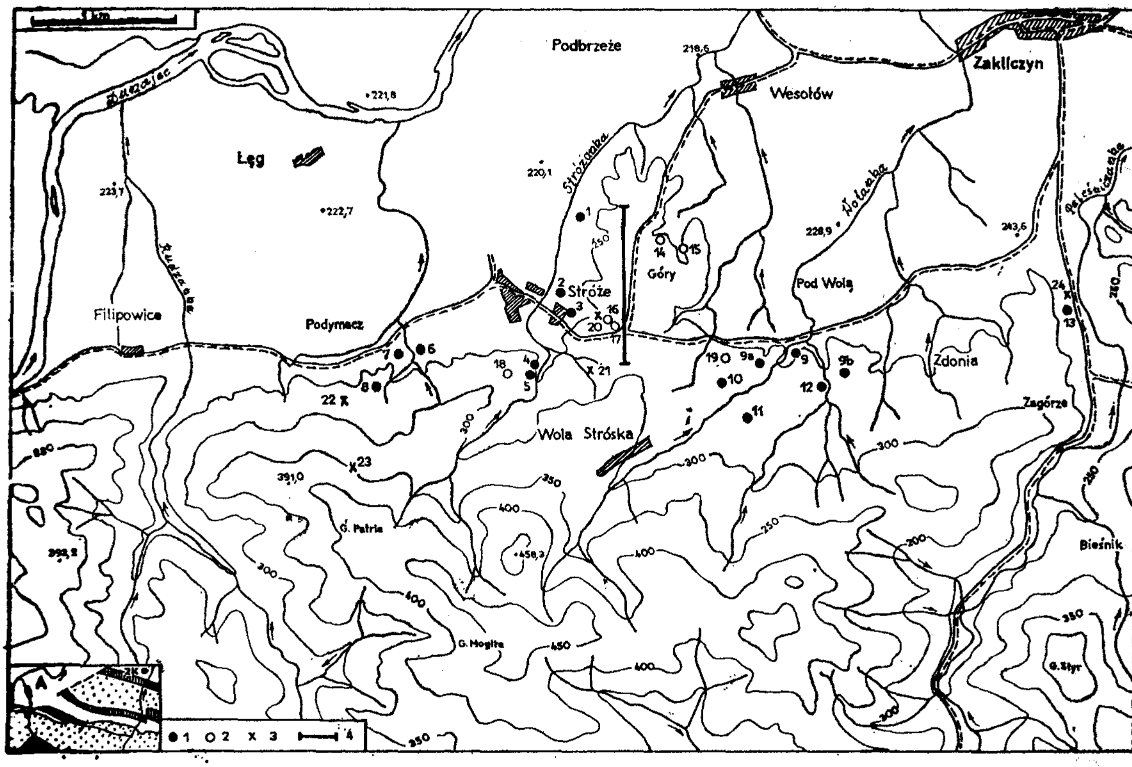

Fig. 2. Topography of the southern part of the Zakliczyn Depression: 1 — sections studied in detail, 2 — localization of samples of Quaternary deposits, 3 — localization of samples of solid rocks, for which heavy mineral composition has been determined (23 — lower Istebna sandstones, Cretaceous, 24 — Istebna sandstones, Cretaceous-Palaeocene, 20 — upper Istebna shades, Palaeocene, 22 — Ciężkowice sandstones, Eocene, 21 — Krosno sandstones, Oligocene), 4 — section shown in Fig. 4. A — simplified geological sketch, based on Burtan *et al.* (1981): white areas — Oligocene, vertical hatchure — Palaeocene-Eocene, dotted areas — Cretaceous, dashed lines — faults, barbed line — over thrust, ZK — Zakliczyn

Ryc. 2. Topografia południowej części Kotliny Zakliczyńskiej: 1 — analizowane profile, 2 — lokalizacja próbek utworów czwartorzędowych, 3 — lokalizacja próbek skał podłoża, analizowanych pod względem składu minerałów ciężkich (23 — dolne piaskowce istebniańskie, kreda, 24 — piaskowce istebniańskie, kreda-paleocen, 20 — górne łupki istebniańskie, paleocen, 22 — piaskowce ciężkowickie, eocen, 21 — piaskowce warstw krośnieńskich, oligocen), 4 — profil przedstawiony na Ryc. 4. A — uproszczony szkic geologiczny (wg Burtan *et al.*, 1981): obszar niezaszrafowany — oligocen, szrafura pionowa — paleocen/eocen, kropki — kreda, linie przerywane — uskoki, linia ząbkowana — nasunięcie; ZK — Zakliczyn

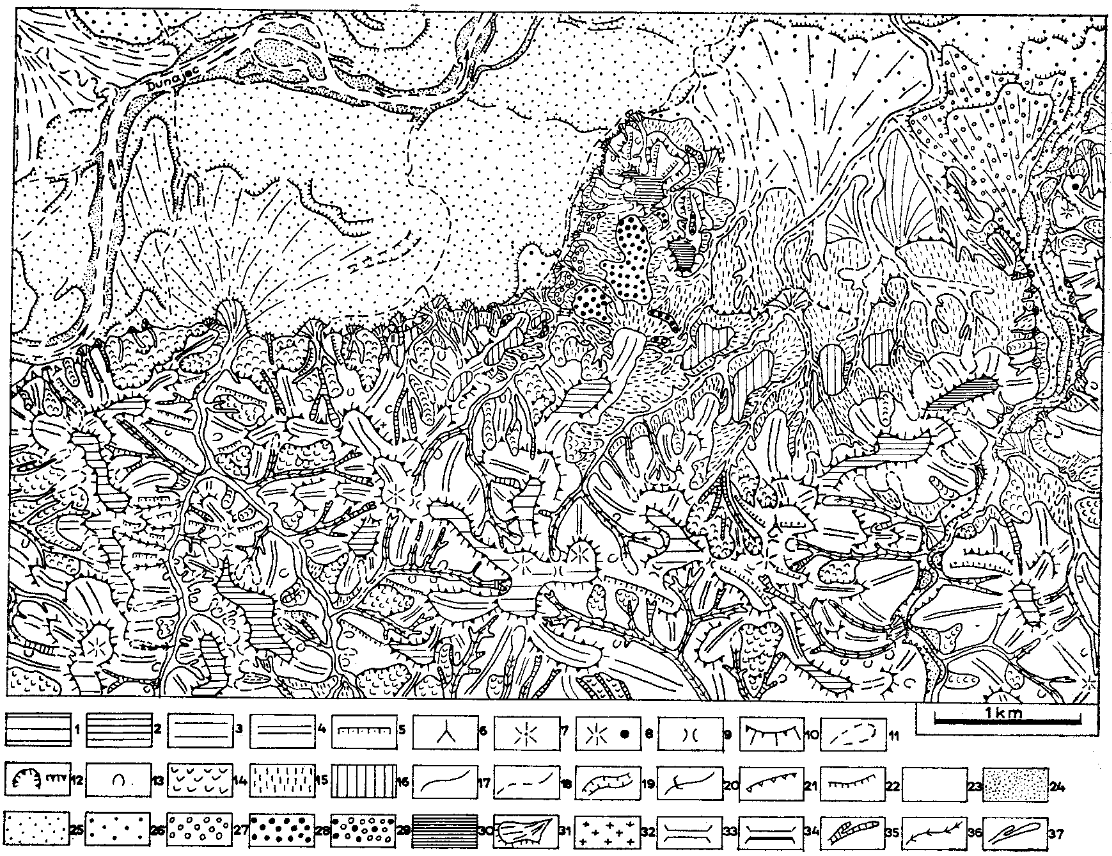

Fig. 3. Geomorphic sketch of the southern part of the Zakliczyn Depression. Fragments of planation surfaces: 1 — intramontane (Early Pliocene?), 2 — foothills (Late Pliocene?), Ridges formed at intersection of valley sides: 3 — broad and rounded, 4 — narrow and rounded, 5 — isoclinal ridges. Summits: 6 — cone-like, 7 — mound-like, 8 — dome-like (large, small), 9 — passes (cols), 10 — structural escarpments, 11 — dellen, 12 — scars and steps of landslides and landslumps, 13 — small landslides and landslips, 14 — landslide colluvia, 15 — solifluction-deluvial covers, 16 — loess-like deposits, 17 — river beds cut into solid rocks, 18 — river beds cut into alluvia, 19 — abandoned channels, 20 — hanging valley steps, 21 — river cliffs, 22 — terrace risers, 23 — sedimentary infill of small valleys. Terraces: 24 — Holocene floodplains, 25 — higher Holocene terraces, 26 — Vistulian, 27 — Middle-Polish (?Wartanian), 28 — Sanian, 29 — Nidanian, 30 — Early Quaternary; 31 — alluvial fans, 32 — erratic boulders and cobbles. Sides of structural water-gaps: 33 — symmetrical, 34 — asymmetrical. Small valleys: 35 — gullies, 36 — V-shaped valleys, 37 — flat-bottomed valleys

Ryc. 3. Szkic geomorfologiczny południowej części Kotliny Zakliczyńskiej. Fragmenty powierzchni zrównania: 1 — śródgórskiej (wczesny pliocen ?), 2 — pogórskiej (późny pliocen?). Grzbiety utworzone na przecięciu zboczy dolinnych: 3 — szerokie, zaokrąglone, 4 — wąskie, zaokrąglone, 5 — grzbiety izoklinalne. Wierzchołki: 6 — stożkowe, 7 — kopiaste, 8 — kopulaste (duże, małe), 9 — przełęcze, 10 — załomy strukturalno-denudacyjne, 11 — niecki zboczowe, doliny nieckowate, 12 — nisze i tylne progi osuwisk, 13 — drobne osuwiska i zerwy, 14 — koluwia

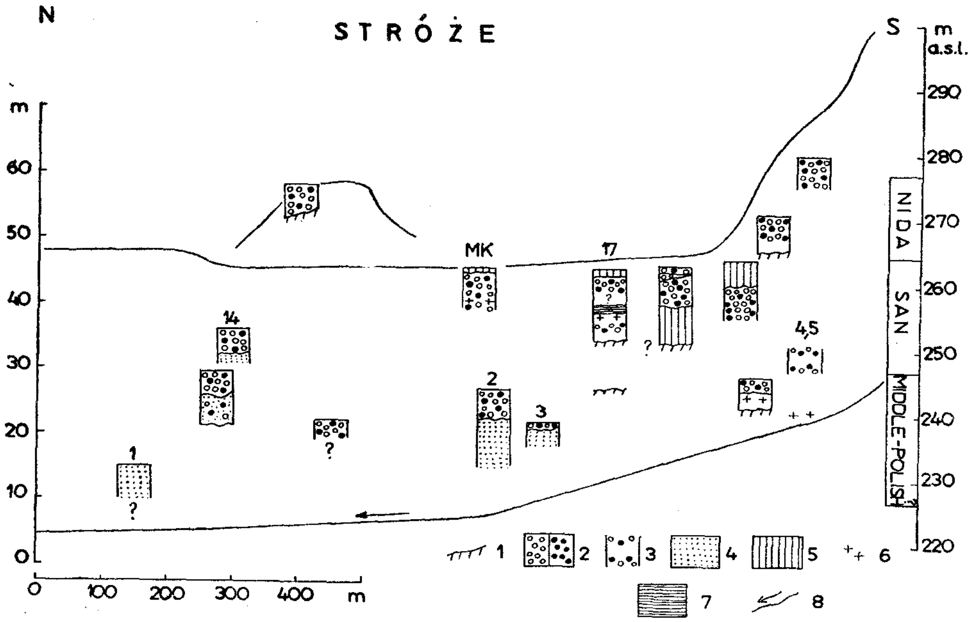

Fig. 4. Synthetic section across the Stróże meander spur, showing distribution of Pleistocene alluvial covers (for localization — see Fig. 2): 1 — rock socle, 2 — fluvial cobbles (flysch-derived, Tatra-derived), 3 — redeposited gravel series, 4 — slope-wash (deluvial) sands, 5 — loams, 6 — erratic boulders, 7 — munds, 8 — Stróżanka river channel; MK — section described by Klimaszewski (1961). Numbers refer to sections shown in Fig. 2

Ryc. 4. Przekrój syntetyczny przez ostrogę meandrową w Stróżach (lokalizacja — por. Ryc. 2): 1 — cokół skalny, 2 — otoczaki (fliszowe, tatrzańskie), 3 — redeponowane serie żwirowe, 4 — piaski deluwialne, 5 — gliny, 6 — erratyki, 7 — muły, 8 — profil podłużny koryta Stróżanki; Mk — profil opisany przez Klimaszewskiego (1961). Numery odpowiadają profilom zlokalizowanym na Ryc. 2.

Erratic boulders associated with the stagnation and recession of the Sanian (Elsterian-2) icesheet have been preserved on northern slopes of the Patria—Mogiła ridge and on flat-topped crest of the Stróże spur. Recycled erratic material can also be found in the Stróżanka river valley and its tributaries. These are Scandinavian red and pink granitoids, rapakiwi granites, gneisses, and red porphyries, ranging in

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osuwiskowe, 15 — pokrywy soliflukcyjno-deluwialne, 16 — osady lessopodobne i lessy, 17 — koryta rzeczne wycięte w skale, 18 — koryta rzeczne wycięte w aluwiach, 19 — starorzecza, 20 — progi u wylotu dolin zawieszonych, 21 — podcięcia erozyjne, 22 — krawędzie teras i stożków napływowych, 23 — wypełnienia den małych dolin. Terasy: 24 — holoceńskie równiny zalewowe, 25 — wyższe terasy holoceńskie, 26 — z ostatniego glacjału, 27 — z piętra środkowopolskiego, 28 — z piętra Sanu, 29 — z piętra Nidy, 30 — wczesnoczwartorzędowe, 31 — stożki napływowe, 32 — erratyki. Zbocza przełomów strukturalnych: 33 — symetryczne, 34 — asymetryczne. Małe doliny: 35 — wąwozy, debrze, 36 — wciosy, 37 — parowy size from 15 × 10 × 20 cm to 55 × 45 × 38 cm. These cobbles can be found in valley bottoms at 235—264 m a.s.l., rising up on slopes and ridge crests up to 310—335 m a.s.l. (Klimaszewski 1937, 1948), and even 360 m a.s.l. The author cited interpreted large erratics (∅ 1—1.5 m) of the 270—300 m a.s.l. level as remnants of the degraded (washed-out) moraine of the Cracovian glaciation.

Pleistocene terraces found at Stróże (23—29 m, 40—45 m, 55—58 m) are equivalents of those reported from the Czchów—Piaski Drużków area (Zuchiewicz, Butrym in print), situated further up the Dunajec river valley, and related to the Odranian (25—30 m), Sanian (37—40 to 40—50 m) and Nidanian (55—60 m) glacial stages.

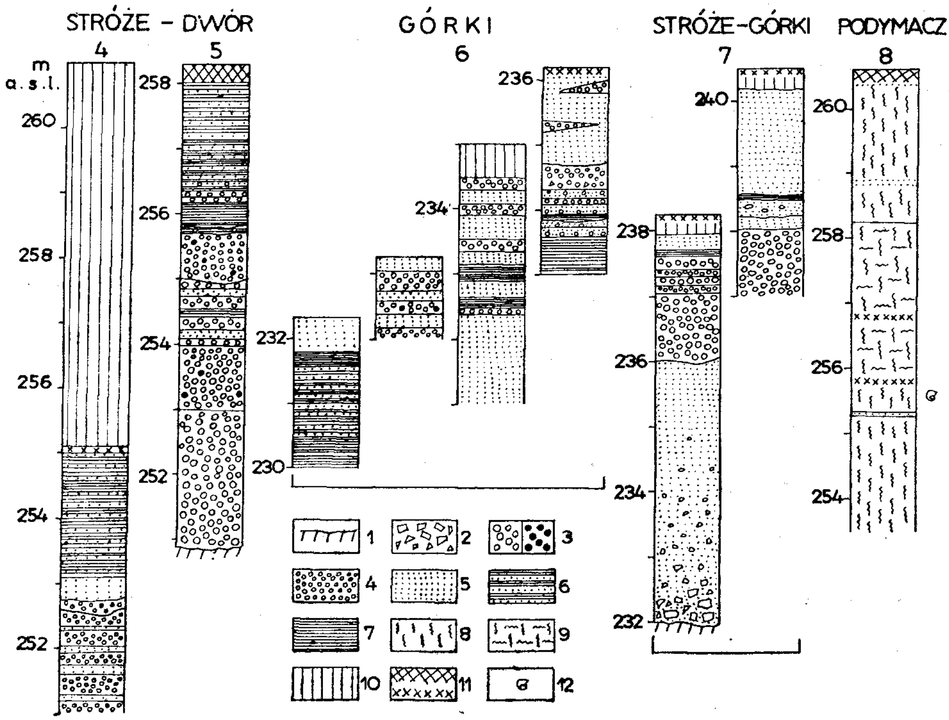

Fig. 5. Selected sections of Quaternary deposits of the southern margin of the Zakliczyn Depression, close to Stróże (for localization — see Fig. 2): 1 — rock socle, 2 — rock debris, 3 — fluvial cobbles (flysch-derived, Tatra-derived), 4 — gravels and granules, 5 — sands, 6 — silty sands and sandy muds, horizontally laminated, 7 — muds, 8 — sandy silts, 9 — loess, 10 — sand-silty loams, 11 — fossil soil horizons, 12 — occurrences of malacofauna.

Ryc. 5. Wybrane profile utworów czwartorzędowych południowego obrzeżenia Kotliny Zakliczyńskiej w rejonie Stróż (lokalizacja — por. Ryc. 2). 1 — cokół skalny, 2 — rumosz, 3 — otoczaki (fliszowe, tatrzańskie), 4 — żwiry, 5 — piaski, 6 — piaski pylaste i pyły piaszczyste poziomo laminowane, 7 — mułki, 8 — pyły piaszczyste, 9 — less, 10 — gliny piaszczysto-pylaste, 11 — poziomy gleb kopalnych, 12 — znaleziska malakofauny.

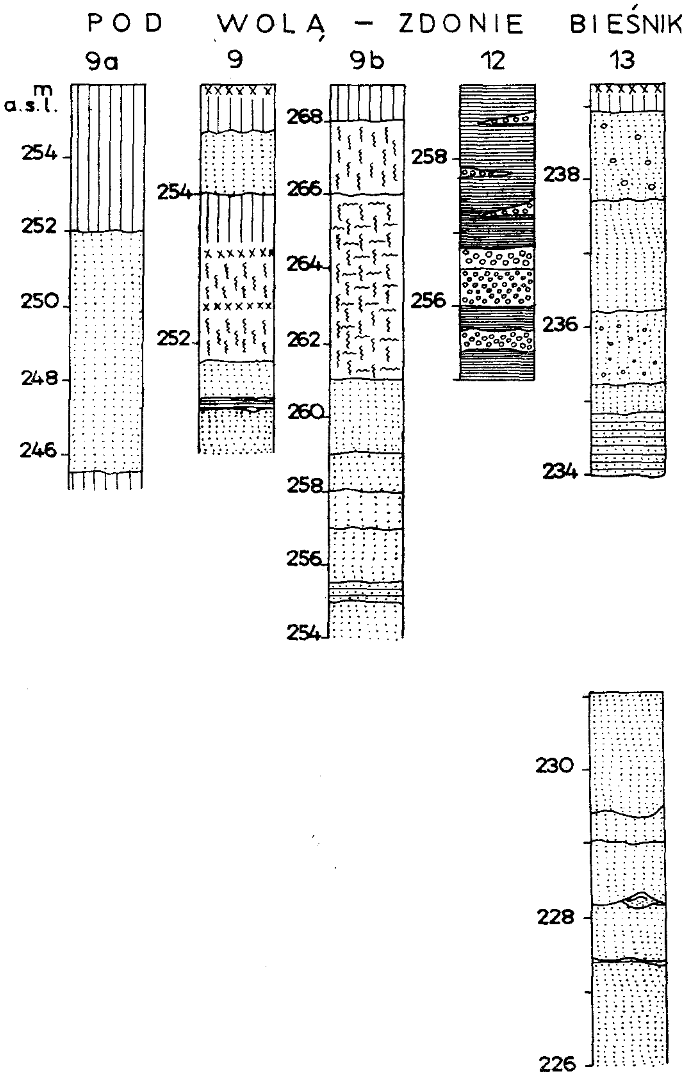

Fig. 6. Selected sections of Quaternary deposits of the southern margin of the Zakliczyn Depression, close to Wola Stróska and Zdonie villages (for localization — see Fig. 2): Explanations — see Fig. 5.

Ryc. 6. Wybrane profile utworów czwartorzędowych południowego obrzeżenia Kotliny Zakliczyńskiej w rejonie wsi Wola Stróska i Zdonie (lokalizacja — por. Ryc. 2). Objaśnienia — patrz Ryc. 5.

SLOPE-WASH DEPOSITS

Slope-wash deposits occur at talus feet and build low hills (250——280 m a.s.l.) of the southern margin of the Zakliczyn Depression (Fig. 3), occupying vast areas between Stróże and the Paleśniczanka stream valley. The measured thickness of these deposits changes from

4.5—5 m at Stróże (Figs. 5, 8, 10), 6 m at Górki and Pod Wolą (Figs. 5, 6), to 14—15 m on western side of the Paleśniczanka stream valley (Fig. 6) and even 20 m at Wola Stróska (Figs. 6, 13). Deluvia rest on exposures of sandstones of the lower Istebna beds (Stróże), the Ciężkowice sandstones (Podymacz) and shale-sandstone complexes of the Krosno beds (Stróże Dwór). At Stróże, slope-wash deposits underlie gravel series deposited during the Middle Polish (Saalian) glacial stages (Figs. 3, 8, 10) and overlie alluvial fan and terrace deposits assigned to the Vistulian (Figs. 3, 5). At Wola Stróska, in turn, these covers overlie alluvial fans of right-hand tributaries to the Dunajec river and underlie either loess-like deposits or fluvial gravels dated back to the Sanian and Nidanian stages (Figs. 3, 5, 6). On western side of the Paleśniczanka stream valley, slope-wash sands and silts overlie fluvial series of the penultimate and last glacial stages (Figs. 3, 6).

Structure of sand-silty deluvia could be well illustrated by the section Stróże-2 (Fig. 10), cut into the western escarpment of the Stróże meander spur. Its base is situated at 232 m a.s.l., i.e., 15 m above the Dunajec river bed. From the bottom upwards, the following section can be examined:

0.00—0.10 m	laminated grey muds
0.10—0.47	fine-grained rusty sands, horizontally laminated, strongly weathered, bearing minor clasts of carbonate rocks. At the contact of these two layers, isolated well rounded fluvial cobbles, ⌀ 5—6 cm, occur
0.47—1.30	grey siltstones, horizontally laminated, interlayered with fine-grained sands, 1—2 cm thick. Boundaries of laminae underlain by rusty effervescences
1.30—1.85	fine-grained sands, horizontally laminated, alternating with medium-grained sands (0.5—1 cm) and clays (0.5 cm), strongly limonitized
1.85—1.88	medium-grained, rusty sands, bearing quartz granules ⌀ 3—5 mm
1.88—2.11	fine to very fine-grained sands, compact, ferrugineous, cross-laminated, bearing isolated quartz clasts, ⌀ 5 mm
2.11—2.27	laminated sandy silts bearing two interlayers of very fine-grained sands, 0.5—1 cm thick, showing low-angle cross lamination
2.27—2.42 m	very fine-grained sands, horizontally laminated, bearing small quartz and feldspar granules at the top
2.42—2.46	fine to very fine-grained sands bearing quartz and sandstone granules, ⌀ 0.3—1 cm, moderately rounded
2.46—3.16	very fine-grained and silty sands, compact, grey, showing inverse grading, rusty at the top

3.16—3.58	horizontally laminated grey siltstones, passing upwards into very fine-grained and silty sands
3.58—3.76	horizontally laminated, fine to very fine-grained sands, brown-rusty, bearing at the top infrequent cobbles of Tatra- and flysch-derived rocks, ∅ 0.5—3 cm, strongly limonitized
3.76—4.26	gravel series of the paleo-Dunajec river, ∅ 2—6 cm, averaging at 3—4 cm in diameter, well to moderately rounded, poorly sorted, dominated by the Tatra-derived rocks

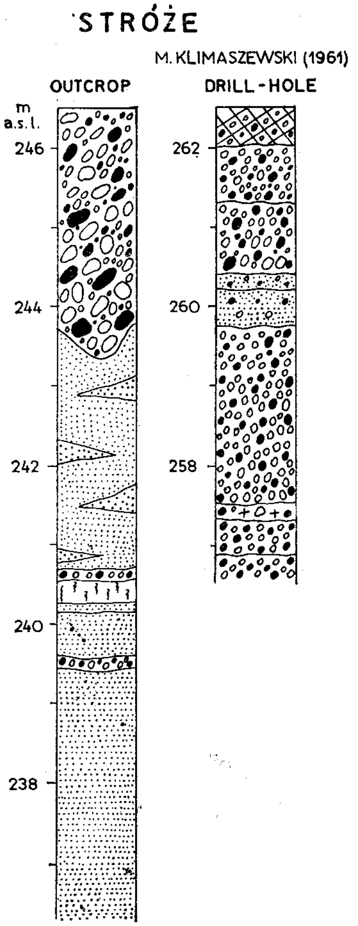

Fig. 7. Section of Quaternary deposits of the Sanian (?) stage, occurring on top of the Stróże meander spur, drawn according to Klimaszewski's (1961) description. For explanations — see Fig. 5, localization — cf. Fig. 2, 4. Crosses denote erratic boulders and cobbles.

Ryc. 7. Profil utworów czwartorzędowych wieku sańskiego (?) na ostrodze meandrowej Stróż, wg opisu Klimaszewskiego (1961). Objaśnienia — por. Ryc. 5, lokalizacja — patrz Ryc. 2, 4. Krzyżyki oznaczają położenie erratyków

4.26—8.00 gravel series infilling a 1.5 m deep channel, $\phi_{av.}$ 3 cm, ϕ_{max} 8—10 cm, resting within fine gravel ϕ 0.5—2 cm. On top of the channel, horizontally oriented, densely packed flat cobbles occur within fine to very fine-grained sands.

Sandy deluvia developed on thick-bedded Istebna beds are best exposed on left side of the Paleśniczanka river valley at Bieśnik (Bieśnik-13, cf. Figs. 2, 5). The base of the outcrop is situated 226 m a.s.l.,

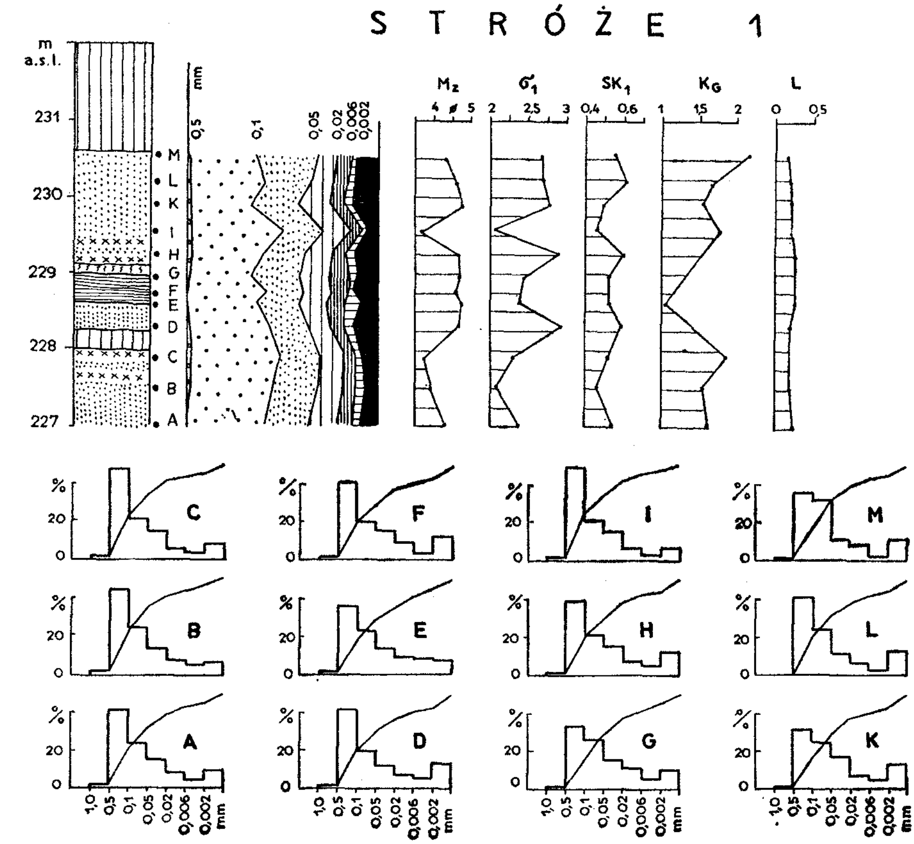

Fig. 8. Section of slope-wash (deluvial) deposits underlying a gravel series of the Middle-Polish (Saalian) age et Stróże-1. For explanations — see Fig 5, localization — cf. Fig. 2.

M_z — graphic mean, σ_1 — inclusive graphic standard deviation, SK_I — inclusive graphic skewness, K_G — graphic kurtosis, L — loess index (sensu Nowak 1977—78), L $= d_{0.05-0.02}: d > _{0.05\ mm}$; A—K: diagrams of grain-size distribution of individual samples.

Ryc. 8. Profil utworów deluwialnych podścielających serię żwirową wieku środkowopolskiego w Stróżach-1. Objaśnienia — patrz Ryc. 5, lokalizacja — por. Ryc. 2 M_z — średnia średnica, σ_1 — graficzne odchylenie standardowe, SK_I — graficzna skośność, K_G — graficzna kurtoza, L — wskaźnik lessowy (sensu Nowak 1977—78), L $= d_{0.05-0.02}: d > _{0.05\ mm}$; A—K: diagramy uziarnienia kolejnych próbek.

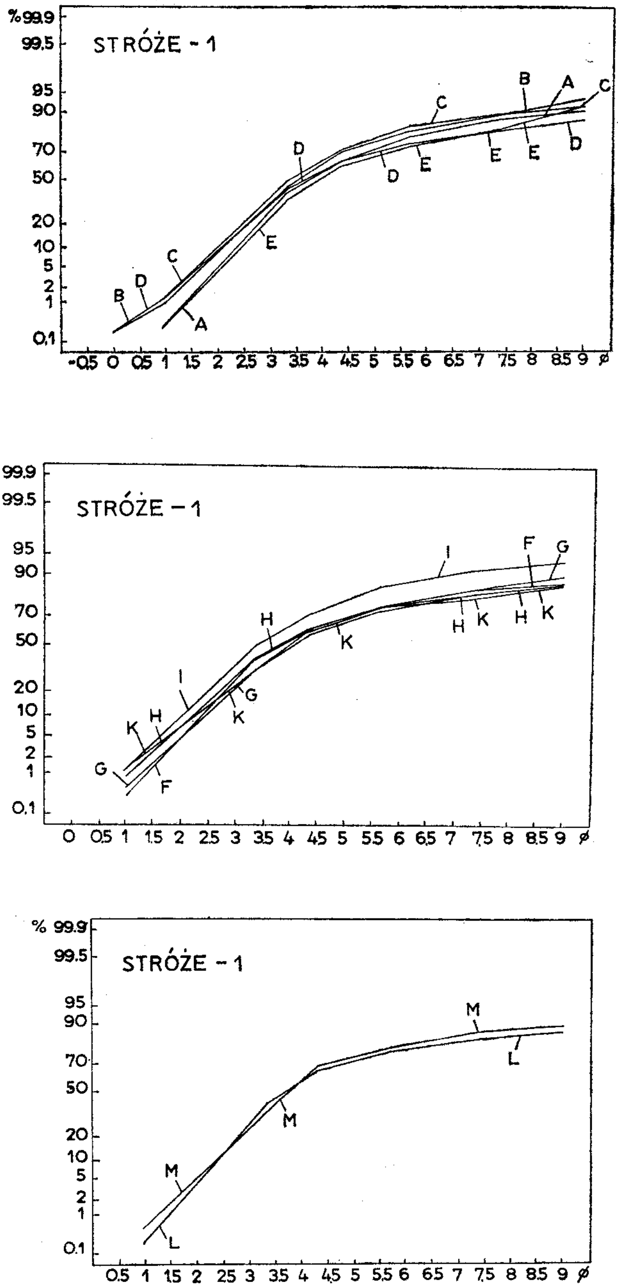

Fig. 9a, b, c. Cumulative-frequency curves of slope-wash deposits of the Stróże-1 section.

Ryc. 9a, b, c. Krzywe granulometryczne deluwiów profilu Stróże-1.

i.e. 17 m above the Dunajec river bed. Higher up, there fellow:

0.00—1.40 m	very fine-grained to silty sands, horizontally laminated, slightly calcareous. Wavy and lenticular lamination can be seen at places
1.40—1.43	strongly calcareous grey muds, bounding surfaces being highly limonitized
1.43—1.63	medium- to fine-grained sands, ferrugineous, cross-laminated. Laminae, 1 to 3 mm thick, dip 160/18
1.63—2.10	fine to very fine-grained sands, cross-laminated, calcareous
2.10—2.23	light-grey muds, strongly calcareous, composing distorted laminae, 0.5—1 cm thick, forming 70 cm long and 13—20 cm thick lense. Distorted muds are interlayered with calcareous very fine-grained and silty sands at the bottom and medium to fine-grained sands at the top. Sands are cross- and parallel laminated. Structures of this type seem to record episodes of slumping and flow of slope material during the deposition of deluvia
2.23—3.00	fine to very fine-grained and silty sands, calcareous, showing parallel and wavy lamination. Low-angle cross-lamination can also be encountered. Boundaries to individual laminae are limonitized
3.00—3.40	alternating light-grey fine and very fine-grained sands, showing horizontal lamination. Thickness of laminae from 0.5 to 3 cm. Uneven erosional surface visible at the top
3.40—5.00	very fine-grained and silty sands, light-grey, horizontally laminated
5.00—8.00	as above, poorly exposed
8.00—8.80	very fine-grained sands and silty sands, dark-yellow, interlayered with 1—2 cm thick light-grey muds
8.80—9.20	fine to very fine-grained sands, light-grey, bearing muscovite and kaolinized feldspar grains. Thickness of laminae from 0.5 to 1 cm
9.20—10.20	very fine-grained sands, poorly cemented, clayey, brown-rusty when weathered, forming 2—4 cm layers alternating with fine to very fine-grained sands, nearly horizontally laminated (110/04). Single laminae of medium to coarse-grained sands, bearing ∅ 1—2 mm quartz and lidite grains, can also be seen. Some of laminae composed of fine-grained sands display small-scale low-angle cross lamination
10.20—10.70	horizontally laminated deposits, composed of alternating beds of very fine-grained, clayey sands, 3—4 cm thick, ferrugineous, and loose, fine or very fine-grained sands

10.70—11.70 very fine-grained sands bearing muscovite platelets and clayey, compact, very fine-grained laminated sands, forming 4—4.5 cm thick layers

11.70—12.90 alternating beds, 4—5 cm thick, of very fine-grained, light-yellow, loose sands and partly clayey, very finegrained to silty sands, compact, light-brownish and rusty, cemented with ferric oxides, forming 5—6 cm thick layers. Yellow sands contain infrequent quartz granules, 3—5 to 17 mm in diameter

12.90—13.30 recent soil; loamy, very fine-grained sands.

Slope-wash deposits are composed of fine to very fine-grained sands, silty sands, sandy silts, sometimes muds and sand-silty loams, showing tabular lamination parallel to slope, rarely low-angle cross and wavy lamination. Individual sections (Stróże-2, Fig. 10, Stróże Dwór — 4, 5, Fig. 5, Górki-6, Fig. 5) reveal the presence of thin lenses of quartz granules, derived from conglomeratic sandstones. All these deposits

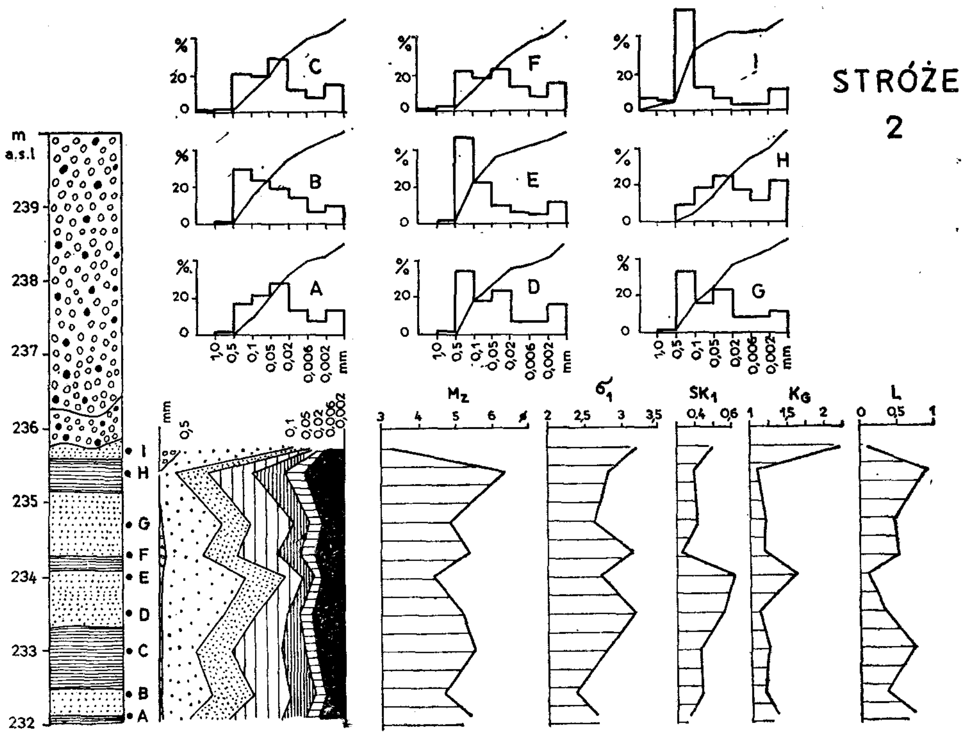

Fig. 10. Section of slope-wash deposits underlying a gravel series of the Middle--Polish (Saalian) age at Stróże-2. For explanations — see Figs. 5 and 8, localization — cf. Fig. 2.

Ryc. 10. Profil utworów deluwialnych podścielających serię żwirową wieku środkowopolskiego Stróże-2. Objaśnienia — por. Ryc. 5, 8; lokalizacja — Ryc. 2.

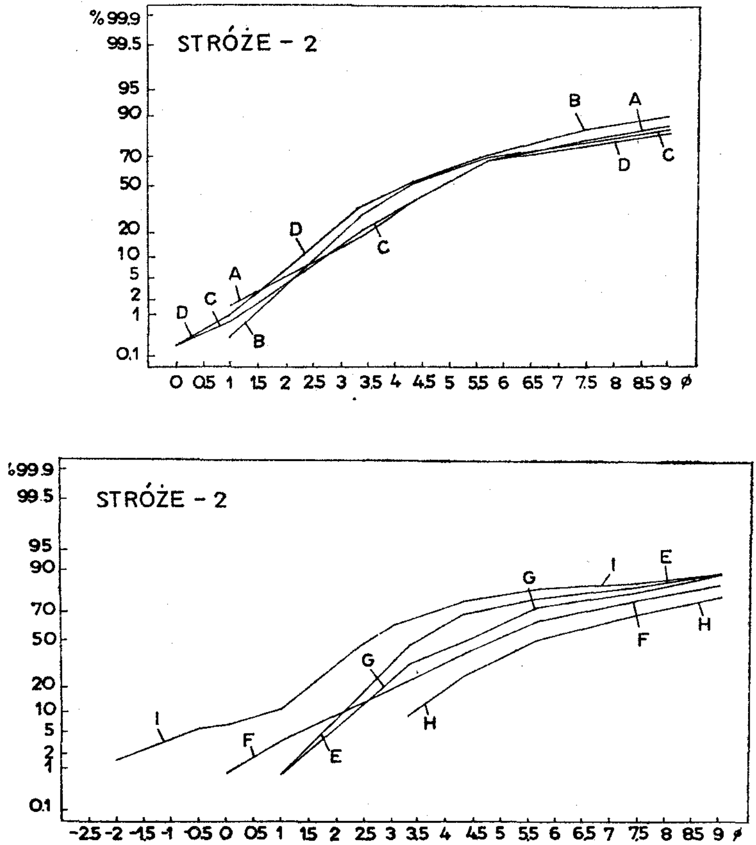

Fig. 11a, b. Cumulative-frequency curves of slope-wash deposits of the Stróże-2 section.

Ryc. 11a, b. Krzywe granulometryczne utworów deluwialnych profilu Stróże-2

show distinct rhythmic lamination, thickness of laminae changing from 5—7 mm (Górki-6, 7) to 10—15 mm (Stróże Dwór-4, 5). Deluvia overlying alluvial fans of Vistulian age at Stróże Dwór (Fig. 5), as well as those underlying gravel series of the penultimate glacial stage, contain recycled gravels of Tatra- and flysch-derived rocks, eroded from older Pleistocene alluvial covers.

Cumulative-frequency curves of slope-wash sands and silts display similar shape and segment-like pattern (Figs. 9, 11, 17), being indicative of 3 to 6 sediment subpopulations represented on V i s h e r diagrams by gently inclined stretches. They differ remarkably from diagrams presenting fluvial sands (cf. Fig. 12) or solifluction loams (Fig. 17). Deluvia of the Stróże-1 section (Figs. 8, 9) are slightly better sorted as compared with those of the Stróże-2 section (Fig. 11), situated more closely to the alimentary zone.

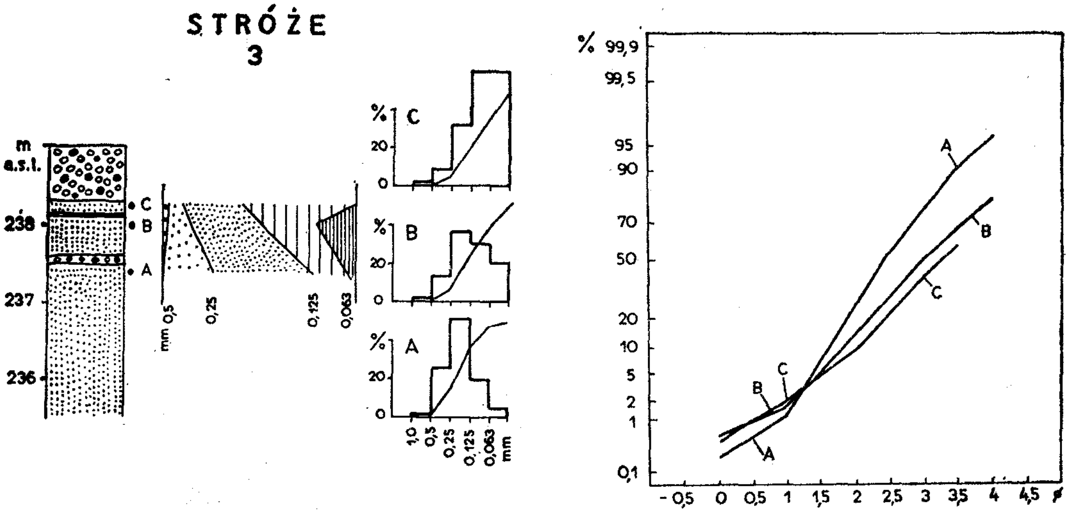

Fig. 12. Section of deposits occurring at the bottom of a fluvial series of the Middle-Polish (Saalian) age at Stróże-3. For explanations — see Figs. 5 and 8, localization — cf. Fig. 2.

Ryc. 12. Profil utworów występujących w spągu serii żwirowej wieku środkowopolskiego Stróże-3. Objaśnienia — por. Ryc. 5, 8; lokalizacja — Ryc. 2.

Graphic mean diameters fall within the limits of 3.8—4.5 Ø (Stróże-1) and 3.3—6.2 Ø (Stróże-2). Inclusive graphic standard deviations range from 2.0 to 2.9 (Stróże-1) to 2.5—3.2 (Stróże-2), averaging at 2.3—2.7. They point to very poor sorting of the discussed deposits. Slope-wash sands display better sorting in respect to silts and muds. Inclusive graphic skewness attains positive values (0.4—0.6) whereas graphic kurtosis changes from 1 to 2, averaging at 1.5—1.7.

Following decreasing values of the graphic mean diameter (Fig. 18), one can take notice of an increase of standard deviation measures. This may testify to the predominance of sorting within coarser fractions and may indicate a periodic supply of poorly sorted suspended material, under relatively low energy. Low differentiation of grain-size distributions seems to reflect uniform hydrodynamic conditions.

Frequency distribution curves of slope-wash deposits exposed at the section Stróże-1 represent unimodal, positively skewed curves, of upward increasing peakedness. Curves representing samples of laminated muds and fossil weathering horizons resemble truncated cones of rounded edges. Modal intervals include either very fine-grained sands (3—4 Ø) or very coarse-grained silts (4—5 Ø), attaining frequencies ranging from 20 to 25%, and increasing upwards to 32% (Fig. 19).

Frequency distribution curves of slope-wash deposits of the Stróże-2 section display greater variability and are more flattened. Samples collected from laminated silts and muds are represented by curves resem-

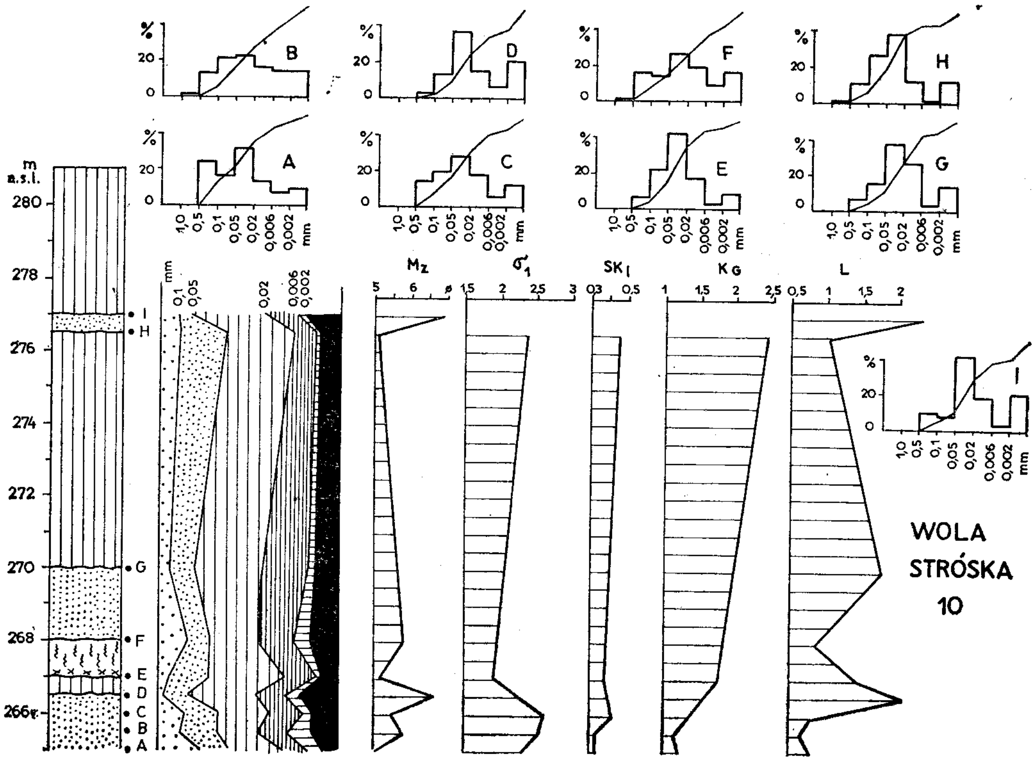

Fig. 13. Section of slope-wash and loess-like deposits at Wola Stróska-10. For explanations — see Figs. 5 and 8, localization — cf. Fig. 2.
Ryc. 13. Deluwia i utwory lessopodobne profilu Wola Stróska-10. Objaśnienia — por. Ryc. 5, 8; lokalizacja — Ryc. 2.

bling flat, truncated cones, symmetric or positively skewed (Fig. 20), of peaks falling into the class of very coarse and coarse-grained silts (18—21%). Laminated silty sands are presented by unimodal, slightly asymmetric curves, of modal classes related to either very coarse-grained silts or very fine-grained sands (18—22%). Only the sample I, collected from sands immediately underlying the gravel series, does reveal a sharp peak, associated with fine-grained sands (33%).

A comparison among frequency distribution curves of the Stróże-1 and 2 sections points to poorer sorting measures and higher grain-size differentiation of the latter, resulting probably from a close proximity of the Stróże-2 section to the source of deluvial material.

Samples collected from slope-wash deposits both underlying (Ostra Góra-14) and overlying (Ostra Góra-15, cf. Fig. 22) gravel series of Sanian (Elsterian-2) age, display unimodal, nearly symmetric frequency distribution curves, of modal classes referring to very coarse-grained silts (24—26%). Laminated slope-wash silts exposed at Wola Stróska (19 A, B — cf. Fig. 22) display curves of similar shape, although being

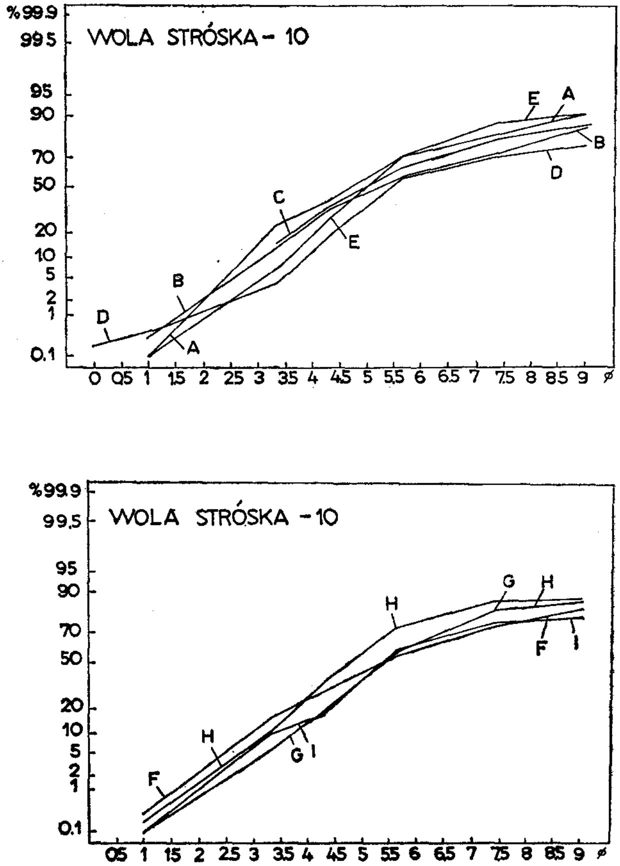

Fig. 14. Cumulative-frequency curves of slope-wash and loess-like deposits of the Wola Stróska-10 section.

Ryc. 14. Krzywe granulometryczne utworów deluwialnych i lessopodobnych profilu Wola Stróska-10.

more steeper, distinctly symmetrical and showing higher frequency values of modal classes (very coarse-grained silts, 32%).

Another type represent curves constructed for fluvial sands (Stróże-3), Fig. 20), deposited during the penultimate glacial stage. These curves testify to a much better sorting and strong peakedness, the peaks being related to fine-grained sands (40—50%). On the contrary, curves representing solifluction deposits (Stróże-16, 17, cf. Fig. 22) are bimodal (fine-grained sands, coarse- or medium-grained silts) and strongly flattened, the modal values ranging from 14 to 20%.

LOESS-LIKE DEPOSITS

Loess-like deposits and loesses crop out along the southern margin of the Zakliczyn Depression, forming several isolated patches of small size, situated at 254—262 m a.s.l. (Stróże—Podymacz), 261—267 m a.s.l. (Pod Wolą) and 270—293 m a.s.l. (Wola Stróska, cf. Figs. 3, 5, 6, 13, 15). The thickness of typical loesses ranges from 3 to 5 m, that of loess-like sandy silts and silt-sandy loams changing between 2—3 and 6—12 m. The latter show sometimes subtle lamination, lenticularity and limonitic concretions.

Typical loesses are represented by calcareous and poorly calcareous, structureless silts and sandy silts, containing disintegrated mollusc shells. These deposits crop out SW of Stróże near Podymacz, at a height of 35 to 42 m above the Dunajec river bed (Figs. 2, 3, 5). From the bottom (253 m a.s.l.) upwards, the following sequence may be examined — see page 77:

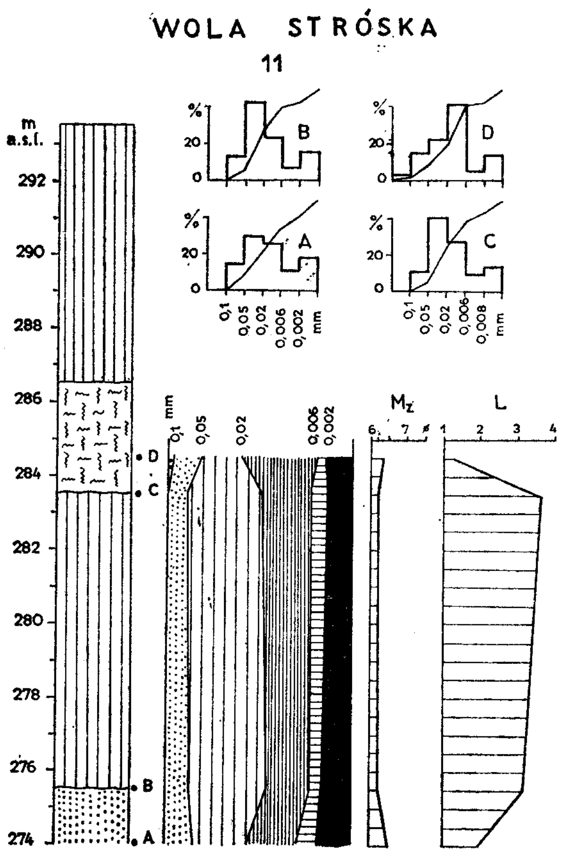

Fig. 15. Section of loess-like deposits at Wola Stróska-11. For explanations — see Figs. 5 and 8, localization — cf. Fig. 2.

Ryc. 15. Profil utworów lessopodobnych Wola Stróska-11. Objaśnienia — por. Ryc. 5, 8, lokalizacja — Ryc. 2.

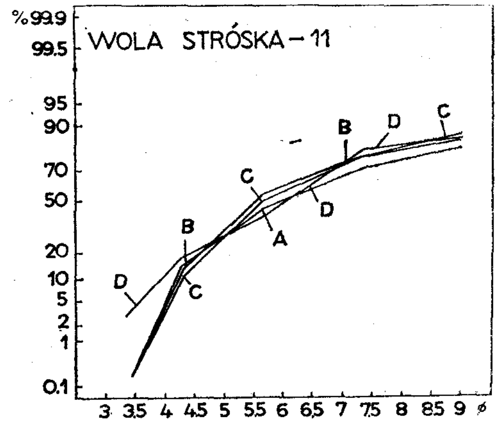

Fig. 16. Cumulative-frequency curves of loess-like deposits of the Wola Stróska-11 section.

Ryc. 16. Krzywe granulometryczne utworów lessopodobnych profilu Wola Stróska-11.

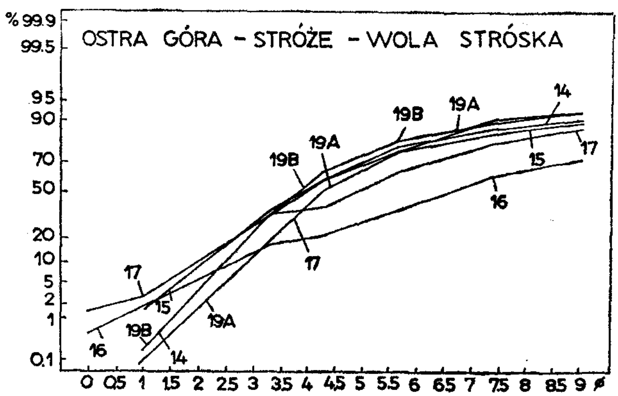

Fig. 17. Cumulative-frequency curves of slope-wash sands underlying (14) and overlying (15) gravel series of the Sanian age, solifluction loams intertonguing with the latter (16), muds underlying the Sanian fluvial cover (17), and sand-silty deluvia underlying loess-like deposits at Wola Stróska (19A, 19B). For localization — see Fig. 2.

Ryc. 17. Krzywe granulometryczne piasków deluwialnych podścielających (14) i przykrywających (15) serie żwirowe wieku sańskiego, glin soliflukcyjnych zazębiających się z pokrywami rzecznych z piętra Sanu (16), mułków podścielających żwiry rzeczne wieku sańskiego (17) oraz deluwiów piaszczysto-pylastych podścielających utwory lessopodobne w Woli Stróskiej (19A, 19B). Lokalizacja — por. Ryc. 2.

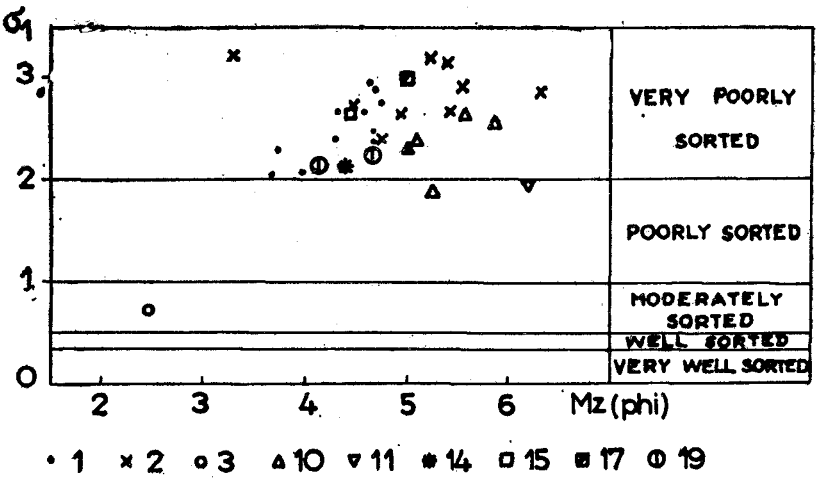

Fig. 18. Scatter diagram showing relationship δ_1 vs M_z for Quaternary deposits of the analyzed sections. For localization — cf. Fig. 2.

Ryc. 18. Diagram przedstawiający zależność δ_1 — M_z dla utworów czwartorzędowych w analizowanych profilach. Lokalizacja — por. Ryc. 2.

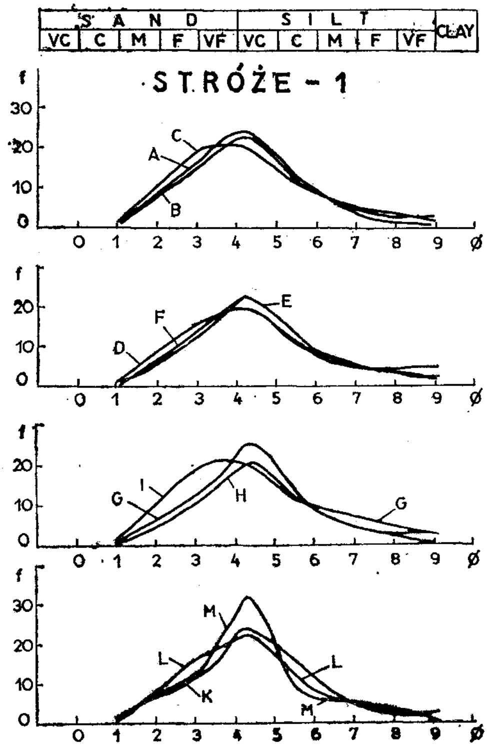

Fig. 19. Frequency distributions of slope-wash deposits at Stróże-1.

Ryc. 19. Krzywe częstości uziarnienia deluwiów profilu Stróże-1.

0.00—1.00 m	sandy silts, faintly laminated, thickness of laminae from 2 to 4 mm
1.00—1.80	sandy silts as above, calcareous, thickness of laminae from 2 to 6 mm
1.80—1.82	very fine-grained to silty sands, calcareous, rusty when weathered
1.82—2.32	laminated sandy silts, light-yellow, bearing irregular intercalations of rusty silts, 1—2 cm thick, strongly calcareous. Fine, disintegrated mollusc shells are relatively abundant
2.32—2.80	loess-like sandy silts, structureless, pale-yellow, calcareous
2.80—3.30	structureless silts, pale-yellow and light-grey, calcareous
3.30—3.32	as above, weathering horizon, rusty in colour
3.32—3.64	structureless silts, pale-yellow and light-grey, strongly calcareous

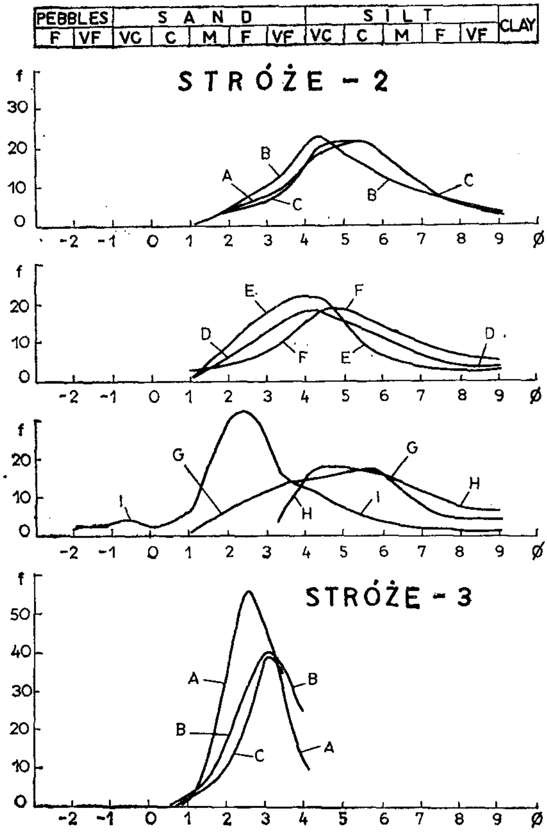

Fig. 20. Frequency distributions of slope-wash deposits at Stróże-2 and fluvial sands at Stróże-3.

Ryc. 20. Krzywe częstości uziarnienia deluwiów profilu Stróże-2 oraz piasków rzecznych profilu Stróże-3.

3.64—4.75	compact sandy silts, pale-yellow, strongly calcareous
4.75—5.35	compact sandy silts, pale-yellow, subtly laminated, decalcified
5.35—5.85	sandy silts and very fine-grained and silty sands, laminated, pale-yellow to dark-yellow, thickness of laminae 2 to 4 mm, decalcified
5.85—7.10	as above, Holocene soil.

Decalcified loesses devoid of malacofauna occur south of Stróże (Stróże Dwór, Figs, 2, 3, 5), as well as close to Pod Wolą and Zdonie villages (Figs. 2, 3, 5, 6). All these sections display 2 to 4 weathering horizons (Subarctic fossil soils?), visible at 252, 253, 256 and 257 m a.s.l. Loesses overlie slope-wash sands and silts, the total thickness of these deposits exceeding 30 m at Wola Stróska.

Typical loess (Podymacz, Stróże Dwór) is composed of calcareous and strongly calcareous sandy silts, pale-yellow and light-grey, structureless, massive, interlayered with 0.5—0.6 m thick yellow sandy silts, faintly laminated (thickness of laminae being 2—4 mm), and containing irregularly spaced rusty-brownish effervescences and 1—2 cm thick laminae cemented with ferric oxides. Top parts of loess sections are decalcified down to 2.0—2.5 m. The influence of Holocene pedogenetic processes within laminated sandy silts and silty sands can be traced down to a depth of 0.6—1.0 m.

Loess-like sand-silty loams and laminated silty sands (Wola Stróska, Pod Wolą, cf. Figs. 13, 15) bear numerous limonitic concretions and ferrugineous effervescences which frequently underlie boundaries to individual laminae.

Grain-size parameters of loess-like deposits differ remarkably from those of slope-wash silts and sands. Graphic mean diameters range from 5—6 ϕ to 6.5 ϕ, standard deviations attain 2—2.5, values of inclusive graphic skewness fall within the limits of 0.3—0.47, whereas graphic kurtosis measures increase from the bottom upwards, from 1.2 to 2.5. Values of the „loess-index" (as defined by Nowak 1977—78) range from 1.0—2.2 to 2.0—4.0 (cf. Figs. 13—16), being of one order of magnitude greater in respect to those of slope-wash deposits.

Frequency distribution curves are unimodal and nearly symmetrical, their modal classes embracing either coarse-grained or very coarse-grained silts (27—30%). Samples collected from loess-like silt-sandy loams (Wola Stróska-11, cf. Fig. 21) give bimodal curves with peaks pointing to fine-grained silts and very coarse-grained silts (15—23%), whereas curves constructed for loamy sandy silts resemble truncated cones of rounded edges, showing peaks falling within the size range of very coarse- to coarse-grained silts (21—28%).

HEAVY MINERAL COMPOSITION

Heavy mineral composition of grains smaller than 0.5 mm has been analyzed for three sections of slope-wash sands and silts underlying (Stróże-1, Stróże-2) and overlying (Bieśnik-13) fluvial gravel series of the penultimate cold stage. Each time 5 samples have been considered. Mineral composition of loesses (Podymacz-8) and loess-like silts (Wola Stróska-10), as well as sands forming intercalations within gravels of the Middle-Polish (Saalian) terrace at Stróże (Stróże-3) has also been determined. For comparative purposes, we have analyzed as well heavy mineral composition of 5 selected lithostratigraphic members of underlying flysch deposits. The results are presented in Tables 1—3 and in Fig. 23.

S l o p e-w a s h d e p o s i t s exposed at Stróże (1—2) display similar composition, being characterized by a predominance of garnet

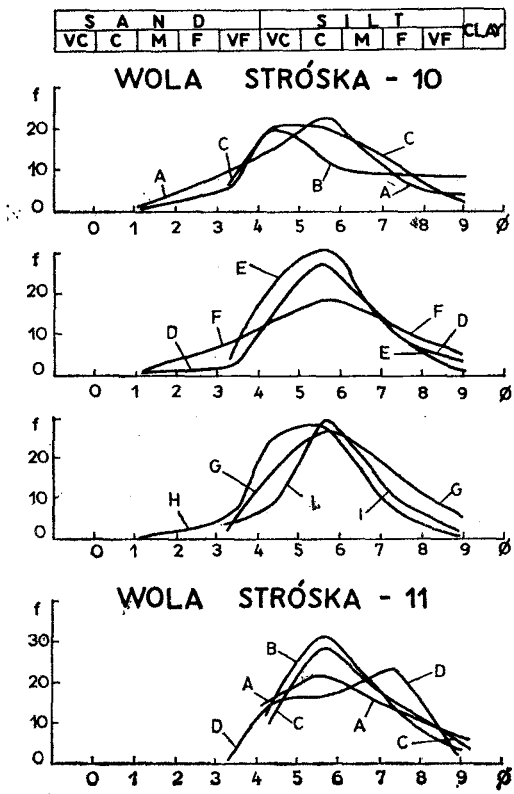

Fig. 21. Frequency distributions of silty deluvia and loess-like deposits at the sections Wola Stróska-10 and 11.

Ryc. 21. Krzywe częstości uziarnienia deluwiów pylastych i utworów lessopodobnych w profilach Wola Stróska-10 i 11.

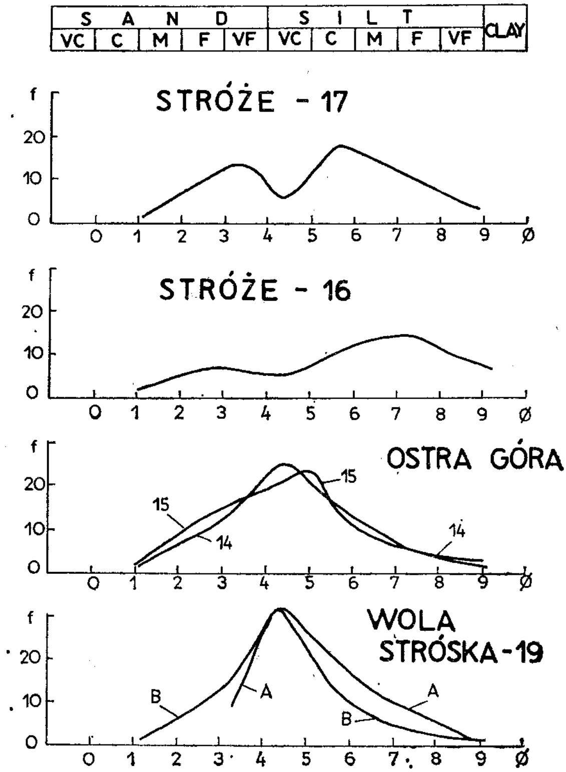

Fig. 22. Frequency distributions of solifluction (16, 17), regolith (14) and slope--wash (15, 19) deposits of the southern margin of the Zakliczyn Depression. For localization — see Fig. 2.

Ryc. 22. Krzywe częstości uziarnienia utworów soliflukcyjnych (16, 17), pokryw zwietrzelinowych (14) oraz deluwialnych (15, 19) południowego obrzeżenia Kotliny Zakliczyńskiej. Lokalizacja — por. Ryc. 2.

(22—40%) and zircon (23—45%) over rutile (8.5—19%), tourmaline (4—11%) and epidote (2.5—11%). Titanite, apatite, amphibole and staurolite are less frequent, whereas topase and zoisyte occur sporadically. Few traces of cyanite and syllimanite have been found. Differences in proportions between garnet and zircon seem to result from grain-size composition of the analyzed layers (sand-silt) and, indirectly, reflect environmental dynamics of deluvial deposition. The share of garnet increases with increasing average grain-size diameter. Among heavy minerals, grains of Ø 0.15 mm dominate, the largest grains at Stróże-1 attaining 0.22—0.30 mm, and at Stróże-2: 0.18—0.37 mm. Values of the maturity index (MI), calculated as a ratio of resistant to moderately and nonresistant minerals, range from 0.72 to 1.56, decreasing towards the top of these sections. Slopewash deposits are here enriched in staurolite, amphibole and pyroxene, showing a lowered amount of epi-

Table 1

Heavy mineral composition of Quaternary deposits of the Zakliczyn Depression
Skład minerałów ciężkich utworów czwartorzędowych Kotliny Zakliczyńskiej

	garnet	zircon	tourmaline	staurolite	rutile	cyanite	epidote	zoisyte	titanite	topase	apatite	amphibole	pyroxene	syllimanite	maturity index
Stróże-1															
M	35.0	26.0	7.0	2.0	9.0	—	11.0	—	8.0	—	1.0	1.0	—	—	0.72
K	22.5	45.0	4.0	4.0	13.0	—	6.5	—	2.0	—	2.5	1.0	—	—	1.66
F	32.0	32.5	6.0	trace	19.0	—	7.0	1.0	2.0	0.5	—	trace	—	—	1.35
C	30.5	37.0	8.0	0.5	8.5	1.0	5.5	2.0	3.5	2.0	0.5	0.5	—	0.5	1.15
A	32.0	36.0	9.0	—	10.0	—	6.0	—	4.0	—	3.0	—	—	—	1.22
Stróże-2															
I	42.0	29.0	4.0	—	10.0	—	4.0	0.5	6.0	—	3.0	1.5	—	—	0.75
G	39.5	33.0	6.5	1.0	11.5	—	3.0	—	3.0	—	1.5	1.0	—	—	1.04
E	40.0	23.5	11.0	2.5	10.5	—	3.0	—	3.0	2.0	4.5	—	0.5	—	0.81
C	27.0	33.0	10.0	0.5	14.5	—	8.0	—	2.0	—	3.5	1.0	—	—	1.38
A	22.0	37.0	10.0	1.0	14.0	—	2.5	—	4.5	1.0	5.5	2.5	—	—	1.56
Stróże-3															
C	36.5	31.0	4.5	1.5	12.5	—	3.0	—	1.5	—	8.0	1.0	0.5	—	0.92
A	50.0	22.0	5.0	—	6.0	—	3.0	—	4.0	—	8.5	1.0	0.5	—	0.49

Table 2

Heavy mineral composition of Quaternary deposits of the Zakliczyn Depression — continued

Skład minerałów ciężkich utworów czwartorzędowych Kotliny Zakliczyńskiej — cd.

	garnet	zircon	tourmaline	staurolite	rutile	cyanite	epidote	zoisyte	titanite	topase	apatite	amphibole	pyroxene	syllimanite	maturity index
Podymacz-8															
10	46.0	31.0	2.5	—	5.5	—	7.0	1.5	3.0	2.0	1.0	0.5	—	—	0.63
8	54.0	24.0	3.0	1.0	4.5	—	9.0	—	1.0	1.5	1.0	1.0	—	—	0.39
5	53.0	18.0	1.0	1.0	9.0	—	7.0	—	4.0	4.0	1.0	2.0	—	—	0.38
3	56.0	15.0	5.0	1.0	3.0	—	10.0	—	5.0	2.0	2.0	0.5	—	—	0.29
1	50.0	18.0	4.0	1.0	7.0	—	6.0	—	3.0	5.0	4.0	2.0	—	—	0.40
Wola Stróska-10															
I	20.0	56.0	1.0	1.0	8.0	—	6.0	—	2.5	0.5	3.0	2.0	—	—	1.85
H	19.0	34.0	5.0	1.0	13.0	0.5	18.0	—	3.5	2.5	2.0	1.5	—	—	1.08
F	56.0	19.0	6.5	0.5	7.5	—	2.5	—	3.0	1.5	3.0	0.5	—	—	0.49
B	47.0	36.0	1.5	—	10.0	—	2.0	—	0.5	0.5	1.5	1.0	—	—	0.90

dote and topase, in relation to the underlying upper Istebna shales (Stróże-20) and the Krosno sandstones (Stróże-21, Tables 1 and 3), the latter being one of main alimentary sources of the material.

Sand-silty deluvia of the Stróże area (Table 1) show, as compared to sandy deluvia at Bieśnik (Table 3), a slightly reduced amount of garnet, zircon and topase, that of tourmaline, rutile and apatite being a little higher. The maturity index (MI) of sandy deluvia at Bieśnik-13 changes from 0.30 to 1.08, being much less differentiated throughout the section than at Stróże. Low MI figures testify to a relatively short transport of the material and the proximity of alimentary zone, being composed mostly of the Istebna sandstones. The latter (Bieśnik-24, cf. Table 3) reveal predominance of tourmaline (35%) over garnet and zircon, occurring in equal proportions (17—21%). Deluvial sands are, in turn, dominated by garnet (43—56%), whereas the share of tourmaline is from 1 to 6%.

Contrary to slope-wash deposits, fluvial sands exposed at Stróże-3 (Table 1, Fig. 23) display a lowered amount of zircon and epidote, that of apatite being higher. In addition, there also occur pyroxenes. Among heavy minerals, grains of ϕ 0.22 mm dominate, the largest ones not exceeding 0.30 mm in diameter. Maturity indices MI increase from the bottom upwards, from 0.49 to 0.92. A considerably different composition show sands forming intercalations within gravel series of the Sanian (Elsterian-2) age (cf. Klimaszewski 1961). These are dominated by gedrite (up to 72%), typical for metamorphic rocks of the Western Tatra Mts.

Loess-like loams and slope-wash silts of the Wola Stróska-10 section display variable proportions between main components (Table 2), i.e., garnet and zircon (19—56%). Heavy mineral composition is fairly similar to that of deluvial loesses exposed in upper part of the loess section at Sienna, Rożnów Foothills, described by Butrym *et al.* (in print). One can observe a slight predominance of zircon over garnet. However, the Wola Stróska section does not contain pyroxene, monazite and zoisyte, the share of cyanite being also considerably lower. The maturity index (MI) increases up the section, from 0.9 to 1.85, attaining figures higher than those typical of loesses (cf. Podymacz-8, Table 2, Sienna, cf. Butrym *et al.*, in print).

The loess section at Podymacz-8 (Table 2, Fig. 23) shows heavy mineral composition nearly identical with that of loesses of the Rożnów Foothills (Butrym *et al., op. cit.*). Differences consist in the lack of monazite and pyroxene, as well as in an increased amount of apatite and amphibole. The share of garnet is 1.5 to 3 times higher than that of zircon. Maturity indices range from 0.29 to 0.63, increasing slightly towards the top of the section. The high amount of garnet may result from the close proximity of that section to outcrops of the

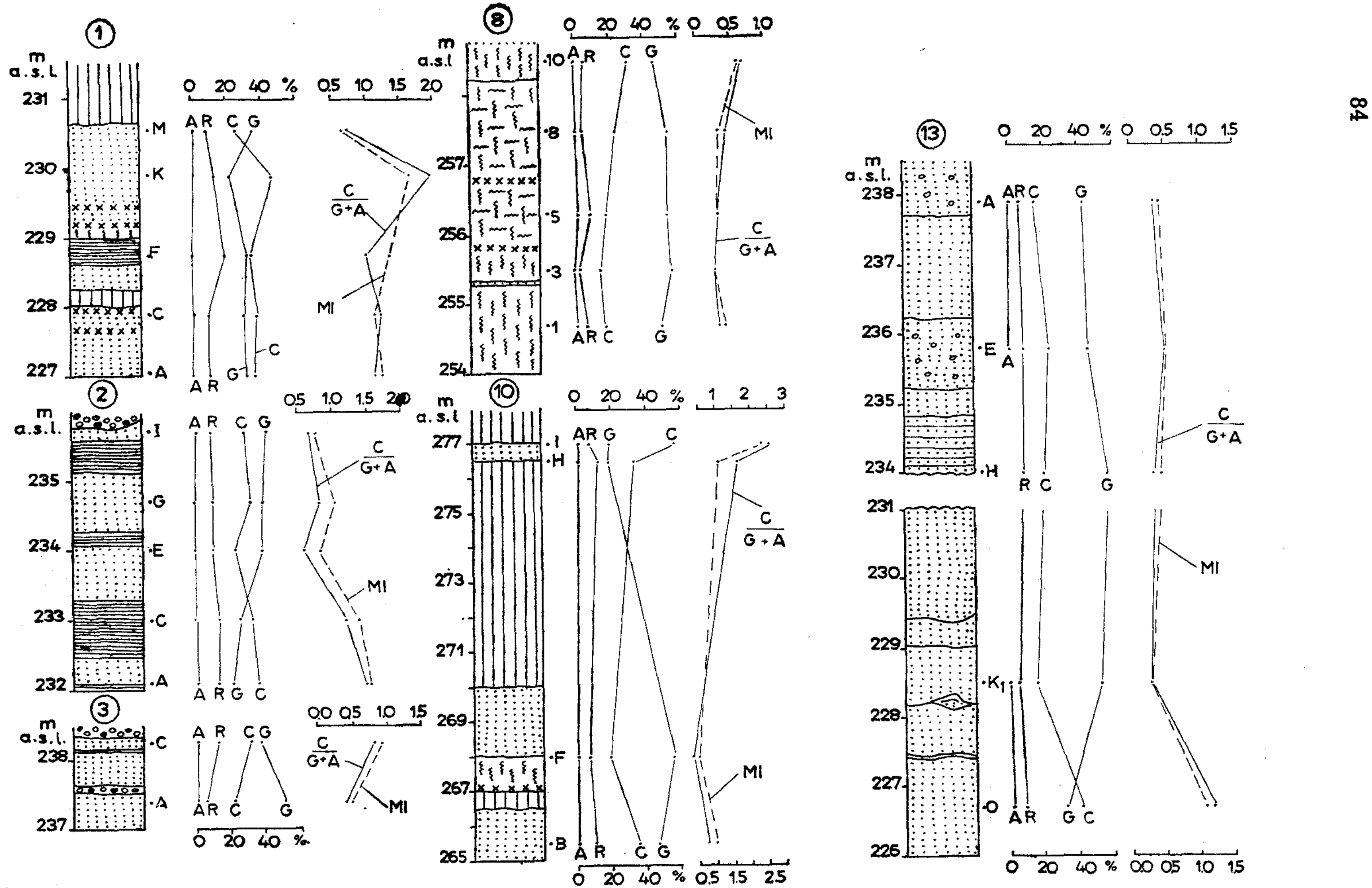

Fig. 23. Heavy mineral composition of slope-wash (1, 2, 13), loess-like (10), loess (8) and fluvial (3) deposits of the southern margin of the Zakliczyn Depression. A — amphibole, R — rutile, C — zircon, G — garnet; MI — maturity index. For other explanations — see Fig. 5; localization — cf. Fig. 2.

Ryc. 23. Zmienność składu minerałów ciężkich w utworach deluwialnych (1, 2, 13), lessopodobnych (10), lessach (8) oraz osadach rzecznych (3) południowego obrzeżenia Kotliny Zakliczyńskiej. A — amfibol, R — rutyl, C — cyrkon, G — granat; MI — wskaźnik dojrzałości. Pozostałe objaśnienia — por. Ryc. 5; lokalizacja — Ryc. 2.

Table 3

Heavy mineral composition of Quaternary deposits and underlying solid rocks of the Zakliczyn Depression

Skład minerałów ciężkich utworów czwartorzędowych i skał podłoża Kotliny Zakliczyńskiej

	garnet	zircon	tourmaline	staurolite	rutile	cyanite	epidote	zoisyte	titanite	topase	apatite	amphibole	pyroxene	syllimanite	maturity index
Bieśnik-13															
A	43.0	16.0	6.0	1.0	7.0	—	11.0	—	8.0	6.0	1.0	1.0	—	—	0.40
E	45.0	23.0	3.0	0.5	8.5	—	6.0	—	7.0	5.5	1.0	0.5	—	—	0.52
H	56.5	20.0	2.0	—	8.5	—	6.0	—	1.5	4.0	1.5	—	—	—	0.43
K_1	52.5	15.5	3.0	1.5	5.0	—	12.0	—	2.0	5.0	2.5	1.5	—	—	0.30
O	33.5	41.5	1.0	1.5	9.5	—	5.0	—	2.0	1.5	2.5	2.0	—	—	1.08
upper Istebna shales															
Stróże-20	34.5	23.0	—	—	11.5	—	15.0	—	—	8.0	8.0	—	—	—	0.51
Krosno sandstones															
Stróże-21	48.0	20.0	8.0	—	4.0	—	14.0	—	6.0	—	—	—	—	—	0.47
Ciężkowice sandstones															
Podymacz-22	71.0	10.5	6.5	1.5	6.5	1.5	1.0	—	2.0	—	—	—	—	—	0.30
lower Istebna sandstones															
Podymacz-23	25.0	51.0	11.0	—	7.5	—	3.0	—	—	2.5	—	—	—	—	2.27
Istebna sandstones															
Bieśnik-24	17.0	21.0	35.0	4.0	2.0	1.0	10.0	—	8.0	0.5	1.5	—	—	—	1.38

Eocene Ciężkowice sandstones (cf. Podymacz-22, Table 3), wherein garnet attains 70%. The loess-like deposits in question are characterized by a relative stability of heavy mineral composition throughout the section owing, most probably, to aeolian deposition.

The content of heavy minerals within Quaternary deposits of southern part of the Zakliczyn Depression is more or less uniform. The only differences consist in varying proportions among dominant minerals, resulting from the type and dynamics of depositional processes. None of the sections studied does reveal the influx of Scandinavian material. Of particular interest are changes in MI values throughout sections of different deposits (Fig. 23). Within loesses, loess-like deposits and fluvial sands, these figures increase towards the top. Silt-sandy deluvia of the Stróże area display highly diversified values of MI diminishing, however, up the sections. Sandy deluvia at Bieśnik, in turn, show relatively stable values, decreasing insignificantly towards the top. All these changes seem to depend on the amount of zircon.

FINAL REMARKS

Slope-wash deposits exposed on the southern margin of the Zakliczyn Depression were being formed throughout the middle and late Pleistocene in different morphological settings. These deluvia both under- and overlie fluvial series deposited during the Elsterian-1, Elsterian-2 and Saalian stages; encroach upon terraces and alluvial fans of the Vistulian age being, in turn, overlain by young Vistulian loess and loess-like silts. Relatively great thickness of slope-wash covers results from favourable geologic and morphologic conditions. The deluvia mantle talus feet on the southern margin of a longitudinal depression, cut into low resistant shale and shaly-sandstone complexes of the upper Istebna shales and the Krosno beds, being surrounded on the south by long, gentle slopes truncating flysch, mostly sandstone-dominated, complexes of the Upper Cretaceous-Palaeocene age, supplying abundant sandy material. Episodes of intensive slope-wash seem to have pre- and post- dated phases of fluvial accumulation, confined to cold Quaternary stages. This is in perfect agreement with the models of deposition at the valley bottom/slope subsystem interface in the temperate zone during a glacial stage (cf. Schumm 1977; Starkel 1983, 1986, 1988). Each glacial cycle is believed to have commenced and terminated with episodes of increased deluvial deposition, being associated with climatic changes of the interglacial-glacial and glacial--interglacial transitions.

Grain-size composition, sedimentary structures and heavy mineral content clearly distinguish slope-wash covers from loess-like deposits. Intervals of fine rhythmic lamination parallel to the slope, alternating with those showing either low-angle cross, wavy and, sometimes, lenticular lamination disturbed, at places, by minor slump or flow structures, are the most typical features of these deluvia. One should take notice, as well, of the segment-like pattern of cumulative-frequency curves. Rhytmic changes in the trend of heavy mineral composition and, especially, oscillating values of the maturity index, are also characteristic. The lack of Scandinavian material within heavy minerals of the post-Elsterian deluvial covers testifies to relative stability of transport routes of the material, supplied constantly from the south, i.e. the extraglacial zone.

Future studies in the area in question should concentrate on thermoluminescent datings and magnetostratigraphic determinations of distal parts of slope-wash covers.

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Institute of Geological Sciences,
Jagiellonian University,
2A Oleandry Str., 30-063 Kraków

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STRESZCZENIE

M. K r y s o w s k a-I w a s z k i e w i c z, W. Z u c h i e w i c z

OSADY DELUWIALNE KOTLINY ZAKLICZYŃSKIEJ W KARPATACH ZACHODNICH: ASPEKTY SEDYMENTOLOGICZNE I MINERALOGICZNE

Deluwia piaszczysto-pylaste południowego obramowania Kotliny Zakliczyńskiej na Pogórzu Wielickim (Ryc. 1—3) były deponowane w środkowym i późnym plejstocenie w różnych sytuacjach morfologicznych. Osady te zarówno podścielają, jak i nadbudowują serie rzeczne z pięter Nidy, Sanu oraz środkowopolskiego, wkraczając także na terasy i stożki napływowe ostatniego piętra chłodnego (Vistulian). Pokrywy deluwialne, 5—20 m miąższości, są niekiedy przykryte przez lessy i pyły lessopodobne (Ryc. 4—15). Stosunkowo znaczna miąższość piasków i pyłów deluwialnych jest efektem sprzyjających warunków geologicznych i morfologicznych. Kotlinę Zakliczyńską, wypreparowaną w małoodpornych seriach łupkowych i łupkowo-piaskowcowych, obramowują od południa długie, łagodne stoki ścinające kompleksy fliszu kredowo-paleogeńskiego, zdominowanego przez rozsypliwe piaskowce.

Epizody intensywnej depozycji deluwiów poprzedzały i zastępowały fazy akumulacji fluwialnej, związane z chłodnymi piętrami czwartorzędowymi. Każdy cykl glacjalny, zapisany w osadach gromadzonych na granicy stok/dno doliny, rozpoczynał się i kończył utworami deluwialnymi o zróżnicowanej miąższości.

Parametry uziarnienia, inwentarz struktur sedymentacyjnych oraz skład minerałów ciężkich (Ryc. 8—23) wyraźnie różnicują pokrywy deluwialne i utwory lessopodobne. Dominuje laminacja równoległa do stoku, rzadziej niskokątowa laminacja przekątna, smużysta i soczewkowa, zaburzona niekiedy przez drobne struktury spływowe. Segmentowy układ krzywych uziarnienia oraz oscylacyjny charakter zmian składu minerałów ciężkich, a zwłaszcza wartości wskaźnika dojrzałości materiału detrytycznego MI (Tabele 1—3, Ryc. 23), również wskazują na rolę spłukiwania w depozycji stokowych osadów piaszczysto-pylastych. Brak materiału skandynawskiego w minerałach ciężkich pokryw stokowych młodszych od piętra Sanu dowodzi stałości kierunków dostawy materiału, pochodzącego ze strefy ekstraglacjalnej.